Human Fatigue in Commercial Cockpit Crews: It's causes, impact, potential countermeasures, and the implications for organizational management in commercial aviation.

Abstract

A brief survey of the major causes of human fatigue in commercial flight crews is conducted. Following this the impact of human fatigue is discussed and a range of potential countermeasures is discussed. Finally these causes of fatigue and the organizational implications, primarily economic cost, are examined.

Introduction

In recent years increasing attention has been focused on the effects of fatigue on human performance in the aviation sector as part of the study of the causes of so called 'human error' (Strauss, 2005). With the majority of commercial aviation accidents now being attributed to human error there is increasing evidence to support study in this area (Reason, 1997). I have limited my discussion of fatigue to commercial cockpit crews as each area within the aviation sector has its own key contributors to fatigue making a sector wide approach too broad for the scope of this assignment.

Human fatigue in cockpit crews derives from factors both within the cockpit and outside of it (Strauss 2005, Orlady & Orlady, 1999). Several of the main causes of fatigue will be examined, and following a brief discussion of the impact of fatigue on commercial aviation several available countermeasures and there implications for organizational management will be discussed.

Causes of human fatigue in modern commercial cockpit crews

Fatigue, or the degradation of the ability of a person to perform tasks due to the deleterious effects of various factors over time, can be classified into several broad areas of cause (Orlady &

Orlady, 1999). These areas include excessive workload, physical exertion, environmental factors, and lack of familiarity among others.

Perhaps the most easily recognized cause of fatigue is excessive workload. Within the cockpit environment examples of potential causes of excessive workloads that can result in fatigue include the additional workload required during takeoff and landing which has greater impact on short haul pilots who conduct many short segments during a shift will have a higher percentage of time in these modes and hence will build up fatigue faster over a given period of time than long haul pilots who spend the majority of there time in lower workload cruise (Kantowitz & Casper, 1988), manual flight controls prevalent in older generations of aircraft which are more labor intensive requiring more steps to perform many tasks (Gunn, 1999), and are less intuitive often utilizing audio or visual codes that are not immediately intelligible (Noyes & Starr, 2000), and inclement weather which increases workload during any phase of the flight (Porterfield, 1997), as well as the general cognitive and decision making requirements of flight.

Less important than in the past, another cause of fatigue is physical exertion. While modern aircraft hydraulic or fly-by-wire controls have removed the need for physical strength when flying modern airliners (Gunn, 1999) there remain several causes of physical fatigue for cockpit crews. Among these are the effects of altitude (Jackson & Sharkey, 1988) - evidence shows that humans have a lower capacity for physical activity at altitude so pilots who spend most of there time at the equivalent of 10,000 feet are likely to be effected by this phenomenon, the physical placement of control interfaces and the need to stretch to utilize these (Lusted et al, 1994), the physical strain of remaining seated in a fixed position for long periods of time (Orlady & Orlady, 1999), and the requirements of crews outside the plane such as walking between gate, conducting aircraft checks outside etc (Wynbrandt, 2004).

The environment can also play a noticeable role in causing fatigue. Long haul pilots must deal with time zone changes and hence changes in day/night cycle (Orlady & Orlady, 1999), temperature and weather / humidity changes (Hengi, 2003), increased exposure to contagious diseases, variable and disrupted sleep patterns (Orlady & Orlady, 1999), variable work scheduling, and variation of meal types (Wilson, 2002). Short haul pilots also experience some of these environmental factors in certain circumstances (Wynbrandt, 2004).

Largely unrecognized as a common source of fatigue is the increased cognitive demand caused by lack of familiarity (Kantowitz & Casper, 1988). While aircraft crews are certified in specific models of aircraft and therefore can be assumed to be familiar with the controls necessary for flight in most cases (Frawley, 2003), airline scheduling policies usually result in a constantly changing rotation of co-workers in the cockpit as well as travel on unfamiliar routes to unfamiliar airports (Strauss, 2005). The increased cognitive demand needed to consciously communicate critical information to a co-worker without a pre-existing framework of understanding as well as in absorbing all the necessary information to make an approach to an unfamiliar airport can place great mental strain on cockpit crews and therefore add another potential cause of fatigue (Orlady & Orlady, 1999). Linguistic barriers can also play a role when flight crews and / or air traffic control are required to communicate in a language other than their native tongue (Porterfield, 1997).

Finally, pilots of regional prop-liners, have greater exposure to vibration and noise which have also been shown to cause fatigue with prolonged exposure (Gunn, 1999).

Impact of human fatigue on commercial aviation

Fatigue impacts the ability of humans to perform necessary roles in commercial aviation (Strauss, 2005). While the causes of fatigue vary the general effect is the same. Increasing levels of fatigue result in a diminished ability to focus on necessary tasks, a greater tendency to ignore secondary tasks, a tendency to focus on a single input source over all others, and, in the context of commercial pilots, ultimately the increased likelihood of a significant accident resulting in loss of property or life (Kantowitz & Casper, 1988). At an organizational level fatigue also impacts on the availability of staff and hence the ability of the airline to confidently schedule staff, to maintain an appropriately sized workforce, and to react to changing circumstances efficiently (Reason, 1997).

Available countermeasures to reduce the amount of fatigue experienced by cockpit crews

Just as there are many factors leading to fatigue in commercial flight crews so are there many proposed countermeasures available to minimize fatigue.

Fatigue caused by excessive workload has been progressively addressed in a number of ways. Increased automation of systems has reduced the amount of manual processes required by flight crews (ICAO, 1992) although there is some suggestion that increased automation leads to an increased cognitive demand on flight crews often centered around the question of 'what is it doing now?' (Funk et al, 1999). In addition to automation, redesign of flight controls and indicators following ergonomic principles of placement and form-function intelligibility has been shown to reduce cognitive demands that may lead to fatigue (Dinadis & Vincente, 1999). As long as human pilots are employed in commercial aviation it seems likely that take-off and landing and inclement weather will continue to be periods of fatigue inducing high workloads with the only currently available countermeasures being organizational – i.e. the reduction of flight hours or segments flown by a crew in a shift based on segment length and weather.

Fatigue produced by physical exertion is perhaps the most studied cause of fatigue in commercial aviation with some clearly defined countermeasures available. As mentioned previously, modern commercial transport aircraft have reduced substantially the physical strength required in flying through fly-by-wire and hydraulic assisted flight controls (Frawley, 2003). Ergonomic studies and increased automation (Skitka et al 2000 & Tenney et al 1998) will continue to reduce the physical demands on pilots through the better placement of controls and the use of 'glass-cockpit' interfaces with multiple modes (Dinadis & Vicente, 1999). Beyond flight controls fatigue caused by between flight exercise requirements – walking between aircraft, outside checks etc, can be partially mitigated through appropriate scheduling however this outside exercise can also be seen as desirable as it provides needed breaks from the long periods of relative immobility experienced by pilots (Strauss, 2005). Short ergonomic breaks in which pilots get up and walk around during cruise are desirable to minimize the fatigue caused by immobility (Lusted et al, (1994). The effect of altitude has not been extensively studied in crew performance however aircraft pressurization could be relatively easily adjusted to other pressure points to minimize its effects (Jackson & Sharkey, 1988).

The detrimental effects of the environment are perhaps the hardest cause of flight crew fatigue to influence. Long-haul pilots will naturally experience time-zone changes (Concorde pilots by virtue of the speed of flight and the return in a day nature of the flights were unique exceptions) with corresponding effects on sleep patterns (Frawley, 2003). General sleep disruption caused by varying schedules can be addressed by the introduction of long term fixed schedules allowing crew members to establish a fixed cycle of activity over time (Orlady & Orlady, 1999). This may be less effective for crew member's allocated 'night shift' as there is a tendency to alter cycle during day's off to accommodate social activities (Wynbrandt, 2004).

Other environmental effects such as exposure to contagions and the effect of meal variation can be combated through increased awareness and a conscious attempt to minimize the risks in this are (Orlady & Orlady, 1999). Placing crews on fixed routes would also reduce detrimental environmental effects as this practice would in effect create two environmental 'home bases' over time (Wynbrandt, 2004).

The cognitive fatigue resulting from lack of familiarity can be addressed in a number of ways. Intra-crew familiarity issues can be addressed by scheduling whole crews as a unit rather than scheduling individuals thereby allowing the development on inter-crew rapport and a mutual communications framework (Porterfield, 1997). Similarly, establishing fixed route scheduling would minimize the fatigue generated when dealing with unfamiliar routes and airports by reducing these occurrences to a minimum (diverts due to weather, emergency etc).

It should be noted that not all causes of fatigue have had countermeasures identified and that the countermeasures that have been identified are not universally agreed as being suitable in all contexts (Orlady & Orlady, 1999). Certain situations have had multiple potential countermeasures identified and only further study will enable identification of the best-fit countermeasures for specific systems.

Implications on organizational management of the implementation of countermeasures

In examining the suitability of countermeasures in specific organizations it is necessary to conduct some form of risk analysis. Clearly each countermeasure has a direct or indirect economic cost associated with its implementation and this cost must be balanced against the resources available to the organization and the potential costs of the fatigue generated if countermeasures are not utilized (ICAO 1992, Wynbrandt 2004). With the exception of a very few non-standard organizations (such as the USAF operated Air Force One) each organization must choose which countermeasures can be implemented for the lowest cost.

Alterations to aircraft such as redesigned interfaces represent a large up front cost however as few aircraft have there flight decks overhauled - Ansett Australia's original 767's which were converted from 3 crew decks to 2 crew decks (Wilson, 2002) and the DC-10 to MD-10 conversions performed for FedEx to similarly reduce crew requirements (Frawley, 2003) being the only ones known at this time, this change happens through standard fleet renewal and therefore the cost is largely born by the aircraft manufacturers, although the individual airline will incur the costs associated with retraining pilots to operate the new interfaces (Redding & Yenne, 1983).

Operational changes such as fixed scheduling and fixed crews carry little upfront cost however in most airlines operating more than one aircraft type the introduction of these practices drastically reduces the organizations ability to rapidly alter operations as needed by the business to meet altered passenger demands such as reacting to a market change such as the grounding of a competitor, weather disruptions, higher or lower demand requiring a change of aircraft types (Wynbrandt, 2004). Similarly fixed routing drastically limits the ability of an airline to respond to changed demands in the marketplace (Wilson, 2002). Fixed crews also would reduce the amount of knowledge transfer among flight crews which may place a greater burden on formal training as well as reducing the ability of flight crews to deal with unfamiliar airports when needed (during weather diversions for instance).

Conclusion

Commercial aviation is a taxing profession with flight crews in charge of a highly complex and demanding system. In this context the management of fatigue in order to reduce the likelihood of human error occurring is critical. Increased understanding of human fatigue has led to industry wide improvement of aircraft instrumentation and controls just as the understanding of metal fatigue resulted in improvements to jet aircraft design. By understanding the sources of fatigue and the overall effect that it has on the performance of flight crews it is possible to introduce a range of countermeasures to help manage this fatigue to an appropriate level with consideration for the economic impact the introduction of these countermeasures will have.

Continued study on human fatigue in commercial aviation is warranted and further understanding of this field will continue to provide potential countermeasures to reduce the likelihood of human error caused aviation accidents even further.

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