FLIGHT SAFETY FOUNDATION

Controlled Rest on the Flight Deck:
A resource for operators

FATIGUE COUNTERMEASURES WORKING GROUP

NOVEMBER 2018

About the Fatigue Countermeasures Working Group

The Fatigue Countermeasures Working Group is comprised of fatigue safety managers from a number of commercial air transport operators, primarily located in the United States; labor representatives from multiple pilot unions; researchers and scientists from Clockwork Research, the National Aeronautics and Space Administration (NASA) Ames Research Center, Washington State University; and various independent fatigue and human performance research organizations.

The Fatigue Countermeasures Working Group would like to offer its sincere gratitude and acknowledgements to the following individuals and organizations who have either participated or have helped in the drafting, review, and publication of this document:

Air France
Air Transat, Jacques Mignault
Alaska Airlines
American Airlines
Antti Tuori, M.D., Ph.D., A320 captain
Aviation Safety Institute, Nick Carpenter
Cathay Pacific Airways
Cherie Love
Clockwork Research, Alexandra Holmes, Ph.D., Alan Gallacher
Delta Air Lines
FedEx Express
Flight Safety Foundation
Hawaiian Airlines
JetBlue Airways
M3 Alertness, Melissa Mallis, Ph.D.
Mark Cameron
Massimo Cniappi, A330 Captain
NASA Ames Research Center, Erin Flynn-Evans, Ph.D., Lucia Arsintescu
Pulsar Informatics, Inc., Daniel Mollicone, Ph.D.
Rega, Swiss Air Ambulance, Benedikt Steiner
San Jose State University Research Foundation, Cassie Hilditch Ph.D., Kevin Gregory
Southwest Airlines
SWISS International Airlines, Loukia Loukopoulou, Ph.D.
The Graeber Group , Curt Graeber, Ph.D.
United Airlines
UPS Airlines
Washington State University, Greg Belenky, Ph.D., Amanda Lamp, Ph.D.

Cover photo credit: Choja | iStockphoto

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Table of abbreviations

ACARS	Aircraft communications addressing and reporting system
AsMA	Aerospace Medical Association
CR	Controlled Rest
CRM	Crew resource management
DGCA	Directorate General of Civil Aviation
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FRM	Fatigue risk management
FRMS	Fatigue risk management system
FSAG	Fatigue safety action group
ICAO	International Civil Aviation Organization
NASA	U.S. National Aeronautics and Space Administration
SMS	Safety management system
TOC	Top of climb
TOD	Top of descent
WAD	Work-as-done
WAI	Work-as-imagined
WOCL	Window of circadian low

1. Introduction

1.1 Defining fatigue and circadian phase

Fatigue is defined by the International Civil Aviation Organization (ICAO) (2015, page xiii) as:

> *A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety-related operational duties.*

Circadian phase refers to the timing of the internal circadian body clock that synchronizes physiological systems to promote wakefulness during daytime, and sleepiness during nighttime. Therefore, fatigue can arise when attempting to maintain wakefulness at night, especially during the window of circadian low (WOCL) that is close to the nadir in body temperature, or as a result of insufficient sleep attempted during the day. The circadian clock is primarily entrained by light exposure. Traveling to different time zones can cause desynchrony between the internal circadian body clock and the external light environment. This desynchrony can cause jetlag symptoms that include fatigue.

1.2 Fatigue risk management in aviation

Flight crew fatigue can negatively affect performance and pose a hazard to flight safety. Fatigue also has a negative impact on learning, morale, and health. Regulators are increasingly requiring operators to do more than comply with flight and duty time limitations to manage crew fatigue. Such requirements include demonstration of effective fatigue risk management (FRM) within a safety management system (SMS), or with a dedicated fatigue risk management system (FRMS).

The extent to which an operator effectively manages fatigue, like any risk, depends on the effectiveness of the system of controls that are in place. The necessary controls usually include:

- Fatigue management training for crew, schedulers, and managers;
- A crew fatigue reporting system;
- Fatigue–risk-based scheduling rules; and,
- A fatigue safety action group (FSAG) that coordinates the identification, assessment, and mitigation of fatigue risks, and continuously monitors and evaluates the effectiveness of the fatigue risk management controls and FRMS.

Despite the best efforts of operators and flight crew, there will always be situations in which flight crew experience unanticipated elevated fatigue in-flight. Alertness levels can vary considerably during the course of a flight, particularly a long flight, or a flight during the WOCL. In addition, research that evaluates augmented long-haul flights has shown that crew are not always able to obtain sleep during scheduled rest periods in on-board rest facilities. In addition, unexpected events such as delays and high workload due to weather can increase the risk of an error due to fatigue.

To manage fatigue on the flight deck, flight crew utilize countermeasures such as strategic use of caffeine and activity breaks. Flight crew also use crew resource management (CRM) principles to manage fatigue, such as:

- Communicating openly about individual fatigue levels;
- Verbalizing all actions;
- Not accepting changes to the flight plan;
- Workload management; and,
- Taking steps to configure and stabilize the aircraft early in the approach phase of flight.

In some operations, there is another tactical in-flight fatigue management strategy — a flight crewmember can take controlled rest (CR). In accordance with an approved CR procedure, one flight crewmember is temporarily relieved of operational duties, and takes a short, in-seat rest break, during which he or she closes his (or her) eyes and attempts to sleep. CR enables a flight crewmember to use a period of low workload to obtain a brief period of sleep and thereby improve alertness and performance, particularly for later, more critical phases of flight such as descent and landing.

CR is recommended by ICAO (2015) and the Aerospace Medical Association (AsMA; Caldwell et al., 2009) as an effective fatigue management strategy, and is practiced in regions including in Europe, Canada, Australia, Singapore, Hong Kong, and the Middle East. The European Aviation Safety Agency (EASA, 2014) states that, "the use of controlled rest has been shown to significantly increase the levels of alertness during the later phases of flight, particularly after the top of descent, and is considered to be good use of CRM principles." However, in some countries, including the United States, Japan, and Brazil, regulators do not endorse the use of CR in commercial air transport.

1.3 What is the purpose of this document?

The first CR procedures were introduced by airlines over 20 years ago (Holmes and Okuboyejo, in press). To date, however, there has been no review of the practice of CR, and there is limited guidance available for operators on how to effectively utilize CR. Therefore, the purpose of this document is to:

- Provide the first overview of the practice of CR;
- Provide an up-to-date overview of the scientific research on napping, sleep inertia, and CR;
- Assist operators new to CR in deciding whether to introduce a CR procedure;
- Assist operators in documenting and implementing an effective CR procedure;
- Assist operators with an existing CR procedure in reviewing and improving the procedure; and,
- Provide guidance on how to monitor and continuously improve CR as part of an FRM program.

The current document considers the following information sources:

- Relevant scientific, peer-reviewed research on sleep, napping, and fatigue, and CR regulations and guidance pertaining to CR published by ICAO, EASA, the Directorate General of Civil Aviation (DGCA) of India, and Transport Canada; and,
- Examples of current operator CR procedures, most of which are from European operators (71 percent, n=15). The remainder are from operators based in Asia, Australia, Canada, and the United States (Coast Guard and Air Force).

1.4 Who is the intended audience for this document?

Operators considering implementing a CR policy will find this document useful in helping to determine whether CR is practical and appropriate for their specific operation, as well as in providing guidance on how to document and implement the procedure. For those operators with a CR procedure already in place, the document will assist in undertaking a review of the procedure to identify possible improvements and integration of CR into an FRMS. This document is not intended to provide a comprehensive checklist, but rather a discussion of factors that need to be considered when developing or reviewing an operator-specific CR procedure.

This document is broad in scope and addresses all fixed-wing operations with at least two operating pilots. As CR is not appropriate for all operations, section 4.1 provides information on how to first determine whether CR should, or can, be utilized in an operation.

The intended document audience includes:

- Flight operations managers;
- Safety and FRM managers;
- Fleet chiefs;
- Union representatives;
- Crewmembers; and,
- Regulators.

1.5 What is CR?

CR on the flight deck is a short sleep opportunity, defined by ICAO (2015) as an effective mitigation strategy to be used as needed in response to unanticipated fatigue experienced during flight operations. It should not be used as a scheduling tool, i.e., as a planned strategy to enable extended duty periods. ICAO (2015) lists the following basic principles of CR:

- It should be considered a safety net.
- The FSAG should be able to monitor the use of CR on the flight deck to evaluate whether existing mitigation strategies are adequate; crew reports are encouraged.
- It should only be used on flights of sufficient length so that it does not interfere with required operational duties.
- It should only be used during low workload phases of flight (e.g., during cruise flight).
- It should not be used as a method for extending crew duty periods.
- Procedures for CR on the flight deck should be published and included in the flight operations manual.

Appendix 1 of this document provides the complete "Recommended Procedures for Controlled Rest on the Flight Deck"' guidance provided by ICAO (2015). The ICAO procedure is complete, except that it is missing information on the recovery period that must be taken at the end of CR. The recovery period should be at least 20 minutes in duration, during which time the resting pilot should not undertake flight duties or briefings while sleep inertia dissipates (see section 2.2).

1.6 How does CR differ from in-flight rest?

In-flight rest is planned before a flight and only occurs on augmented flights crewed by three or four flight crewmembers. In-flight rest involves individual flight crew taking turns leaving the flight deck, usually for multiple hours, to rest and sleep in blocked-off cabin seats or a designated rest facility. In contrast, CR is not planned before a flight, is taken in-seat on the flight deck, and involves a short period of rest (usually about 40 minutes) during which a nap is taken.

2. Overview of the relevant science on CR

2.1 Napping benefits and considerations

Sleep loss, due both to a bout of extended wakefulness (acute sleep loss) and repeated insufficient sleep (cumulative sleep loss), leads to degradation in alertness and cognitive performance. In addition, individuals who are sleepy but not permitted to nap are more likely to experience unintentional lapses in alertness and attention (Sallinen et al., 1998; Macchi et al., 2002). Unintentional napping (i.e., falling asleep without planning to) has been objectively observed and self-reported in various shiftwork populations, with up to 20 percent of nightshift workers falling asleep at work (Coleman and Dement, 1986; Torsvall and Åkerstedt, 1987; Torsvall et al., 1989; Kecklund and Åkerstedt, 1993; Åkerstedt et al., 2002).

In aviation, Rosekind et al. (1994) measured objective alertness using electroencephalography (EEG) in the cockpit and found that, compared to flight crew who were afforded a 40-minute in-seat nap opportunity, those not provided with a nap opportunity were twice as likely to have a micro-sleep event during critical phases of flight, including descent and landing. During cruise, four of the nine observed flight crew who did not have a nap opportunity, unintentionally fell asleep on five occasions, sometimes for more than 10 minutes. Together, these studies highlight the prevalence of sleepiness and unintentional sleep when at work, and highlight the potential benefit of CR to maintain alertness and performance, and to reduce the risk of unintentional events.

Taking a nap *before* a duty to manage fatigue can help to reduce sleep pressure and resulting fatigue during work (Gillberg, 1984; Härmä et al., 1989; Garbarino et al., 2004). However, it is important to recognize that under certain conditions (for example, a long night duty), pre-duty naps may not confer benefits throughout the whole duty; therefore, a nap during a duty may also be needed to maintain alertness and performance (Bonnet, 1991; Howard et al., 2010). Thus, even though a flight crewmember may have prepared for a duty as well as possible, unexpected fatigue may occur later in the duty, requiring additional fatigue countermeasures such as CR to maintain alertness.

Laboratory and field research have demonstrated that napping can counteract the adverse effects of sleep loss on alertness and performance (Milner and Cote, 2009; Ruggiero and Redeker, 2014). For example, an approximately 30-minute nap taken around 0300 during a night shift has the potential to improve performance for the remainder of the shift that might end at 0600 or 0700 (Purnell et al., 2002; Smith et al., 2007; Lovato et al., 2009), but this finding is not consistent (Centofanti et al., 2016). The duration and magnitude of nap benefits, and the results of these studies, depend on a number of factors including the length, timing, and quality of the nap, as well as the prior sleep-wake history of the individual.

Naps of varying duration (for example, from 10 minutes to two hours) have been shown to provide some improvement to alertness (Tietzel and Lack, 2001; Brooks and Lack, 2006; Kubo et al., 2007). The benefits tend to be time-dependent, with longer naps resulting in longer-lasting improvements to alertness and performance (Kubo et al., 2007; Mulrine et al., 2012). In a study of 10-, 20-, and 30-minute naps taken in the afternoon following insufficient overnight sleep, benefits from the 10-minute nap lasted for up to 1 hour, whereas the 20- and 30-minute naps were associated with improvements in alertness lasting up to 2 to 2.5 hours (Tietzel and Lack, 2001; Brooks and Lack, 2006).

It is important to acknowledge that the same-length nap taken at different times of the day, or under different prior sleep-wake conditions, can have very different outcomes. For example, a 10-minute nap taken in the afternoon conferred significant improvements in performance (Brooks and Lack, 2006), but when taken at

0400, it was only able to stabilize performance relative to pre-nap (Hilditch et al., 2016a), and when taken at 0700, it resulted in a decrease in performance immediately after waking (Hilditch et al., 2017a).

Similarly, the length of time awake before a nap can influence the effectiveness of the nap (Lovato and Lack, 2010). A study of two-hour naps taken at 12-hour intervals across simulated sustained operations found that naps taken before sleep deprivation occurred (i.e., at six and 18 hours after waking) were more effective than naps taken after longer periods of wakefulness (Dinges et al., 1987). The amount of wakefulness before a nap can also determine the amount of sleep obtained. For example, a sleep opportunity taken later in a night shift is often more likely to result in sleep than one taken earlier (Sallinen et al., 1998; Kubo et al., 2007). The amount and quality of sleep obtained during a nap opportunity, and subsequent benefits, can also depend on the sleeping environment and individual differences (Fallis et al., 2011; Jay et al., 2014).

While there are many factors to consider when estimating the benefits of a napping opportunity, sleep is still the best countermeasure to fatigue due to sleep loss, the time of day, or extended wakefulness. Although the effects of sleepiness on alertness and performance can be temporarily suppressed by caffeine, the benefits of a nap can be longer-lasting (Bonnet et al., 1995). However, the comparison of these effects also depends on the dose/duration of the caffeine/nap, timing of administration (e.g., single dose versus multiple doses), and individual sensitivity to caffeine. For example, a comparison of 150 mg of caffeine with a 15-minute nap opportunity showed comparable improvements to performance on a driving task compared to no-nap and placebo (Horne and Reyner, 1996). The authors conducted a similar study in which they proposed that combining the effects of caffeine and a nap may provide an additional boost to alertness and performance (Reyner and Horne, 1997). Another point to take into account when considering the use of caffeine is that as a stimulant with a relatively long half-life, caffeine may disrupt future sleep opportunities (Juliano and Griffiths, 2004; Carrier et al., 2007).

The scientific literature on napping is broad and relatively comprehensive. While the myriad combinations of study methodologies make direct comparisons difficult, it appears that the majority of studies have reported significant benefits to alertness and performance under a range of conditions. Generally, where operational constraints permit, a nap is often the most effective countermeasure to the effects of fatigue induced by sleep loss, the time of day, and extended wakefulness.

2.2 Understanding and managing sleep inertia after a nap

Sleep inertia refers to the sleepiness, disorientation, and impaired cognitive performance that is often experienced upon waking from sleep.

When considering the optimal timing and duration of a nap in order to maximize benefits, consideration must be given to the potential delay in the emergence of these benefits. For example, a brief afternoon nap of 10 minutes following insufficient sleep can improve objective and subjective alertness within five minutes of waking (Tietzel and Lack, 2001; Brooks and Lack, 2006); however, a 30-minute nap taken under the same conditions may not provide significant improvements until 30 minutes after waking (Brooks and Lack, 2006). The delayed benefits and the potential short-term negative impact on alertness that typically follows longer naps indicate sleep inertia.

The intensity and duration of sleep inertia depends on several factors. When planning a nap, consideration should be given to these factors in order to minimize sleep inertia effects:

Duration of the sleep episode

Sleep is typically light during shorter naps, which reduces the risk of sleep inertia upon waking. Keeping naps shorter than 30 minutes to minimize the likelihood of entering into deep sleep can reduce the intensity and duration of sleep inertia (Dinges et al., 1985).

History of prior sleep loss

An extended period of wakefulness before the sleep episode, or chronic sleep loss due to repeated sleep restriction across several days, can increase sleep pressure and subsequently lead to a faster transition to, and longer duration of, deep sleep during a nap. This increased likelihood of deep sleep can result in more severe or longer-lasting sleep inertia (Dinges et al., 1985; Balkin and Badia, 1988; Tassi et al., 2006).

Time of waking

Waking from sleep during the night, or when the body clock is promoting sleep (for example, during the WOCL) can exacerbate the effects of sleep inertia (Scheer et al., 2008).

Although the time course of sleep inertia effects can vary, as described above, symptoms typically dissipate within 20 to 30 minutes of waking, especially following short naps taken outside the WOCL (Tietzel and Lack, 2001; Brooks and Lack, 2006). However, it is important to note that under different conditions, or in certain individuals, the time course of sleep inertia may last longer than 30 minutes (Achermann et al., 1995; Jewett et al., 1999). The most severe sleep inertia symptoms typically occur immediately after waking, with an initial rapid recovery period in the first 10 to 15 minutes (Kaida et al., 2003; Ikeda and Hayashi, 2010; Signal et al., 2012). Therefore, considering the factors described above, a recovery period of at least 20 minutes following a CR nap of less than 30 minutes duration should be a minimum requirement.

In cases in which the factors described above are unavoidable (for example, napping during a night flight), this recovery period may need to be extended. In addition, CRM strategies should always be utilized in order to mitigate the risk of errors during this period (for example, cross-checking information, using checklists, and engaging in open communication between flight crewmembers about their fatigue level. While there is currently little literature on effective countermeasures to sleep inertia (Hilditch et al., 2016b), some studies have demonstrated that strategic use of caffeine can help to minimize the burden of sleep inertia following a nap (Van Dongen et al., 2001; Newman et al., 2013).

Generally, the long-term benefits of a nap outweigh the short-term impairments associated with sleep inertia. However, it should be noted that sleep inertia can still occur after any sleep period, including short naps, daytime naps, under well-rested conditions, and in the absence of deep sleep (Achermann et al., 1995; Wertz et al., 2006; Signal et al., 2012; Hilditch et al., 2017b). Therefore, a recovery period of at least 20 minutes, during which the resting pilot does not undertake flight duties or briefings, should always be observed following *any* CR period.

2.3 Studies of CR on the flight deck

In the late 1980s, the first study of the "NASA Nap," involving three minutes of preparation, a 40-minute nap opportunity, and a 20-minute recovery period, was undertaken (Rosekind et al., 1994). NASA researchers studied 21 pilots during transoceanic flights 9.7 to 13.8 hours in duration, crewed by two pilots and one flight engineer. Participants in the nap group were given a planned 40-minute nap opportunity in their flight deck seats during a low-workload portion of the cruise phase of flight. One pilot rested while the other pilot and flight engineer maintained their regular duties. Pilots slept during 93 percent of these nap opportunities, took approximately five minutes to fall asleep, and slept, on average, for 26 minutes. Performance on a psychomotor vigilance task after the nap and recovery period showed improvements in median reaction time and a reduction in lapses when compared to results of the control (no-nap) group.

Valk and Simons (1997) studied a similar NASA Nap protocol among 59 pilots in North Atlantic operations, crewed by two pilots and one flight engineer on flights that ranged from 6.5 to 8.7 hours in duration, including analysis of CR during a day and night flight. In this study, flight crew obtained approximately 15 minutes of sleep during an average 40-minute CR opportunity irrespective of direction of travel. Sleep was obtained in less than 60 percent of the planned nap opportunities, but pilots who slept during their CR reported reduced sleepiness at top of descent, and had improved performance relative to the pilot who remained awake during the CR opportunity. The authors note that despite the benefits observed in cases in which pilots obtained sleep, the cockpit environment included many factors that led to inability to sleep or poor sleep quality, such as noise, lack of a headrest, insufficient leg room, and lack of recline in the cockpit seat. This study highlights the importance of providing pilots with an environment conducive to sleep in order to allow for the maximal benefit of the CR episode.

The proportion of rest opportunities converted into sleep may vary due to many factors, including the flight deck environment. Spencer and Robertson (2000) studied the duration and quality of sleep obtained in a seat located at the rear of the flight deck of a Boeing 767 during flights of nine to 10 hours. When the seat was reclined, the pilot's legs were in front of the flight deck door, which meant that rest was disturbed by anyone using the door, and crew improvised their leg support with flight bags. Despite these issues, 65 percent of pilots were able to sleep in the seat, and those who did averaged 54 minutes of sleep. Self-ratings of alertness were improved following naps in the seat.

While there are few studies of CR in practice, those reviewed above demonstrate the potential for improved alertness and performance following CR, especially when sleep is achieved. In order to maximize the benefits of CR, consideration should be given to improving the in-seat sleeping environment.

2.4 Considerations for using CR

Studies of CR on the flight deck have demonstrated that when used appropriately, sleep during CR is an effective strategy for countering sleepiness and improving performance. These studies have also informed considerations for how CR is practiced today, including:

Crew should have adequate sleep before flight

The studies found that CR reduced, but did not eliminate, fatigue. Furthermore, sleep was not always achieved during CR opportunities. To manage fatigue, and to limit the need to take CR, crew should aim to obtain adequate sleep before duties (for example, by taking a nap in the afternoon before a night duty).

There should be a minimum recovery period of 20 minutes

While the profile of sleep inertia following CR can vary, in prior studies, performance tests were taken at 10 minutes (Rosekind et al., 1994) and 15 minutes (Valk and Simons, 1997) after the end of the rest period. In each of these studies, performance was better on average relative to the control group at the same relative time during the flight. This supports the practice of a minimum 20-minute recovery period after the end of a CR period.

Utilize safeguards for the alertness of the non-resting pilot

When one pilot is resting, the non-resting pilot may have difficulty maintaining alertness. Therefore, before CR is initiated, flight crew should have an open discussion about their alertness levels, to determine whether/when CR will be taken. When CR is practiced, it is essential to use safeguards to ensure the non-resting pilot maintains adequate alertness. This may include informing cabin crew when CR is being used (see 4.6b).

The resting pilot should be seated comfortably

Studies of naps on the flight deck have shown that sleep can be difficult to obtain. Depending on the seat design, pilots may experience some discomfort (for example, when there is a lack of a headrest, limited ability to recline, and noise). Therefore, these considerations, as well as further accommodations, such as eye masks and support pillows, may be useful for increasing the likelihood of obtaining sleep during CR.

The recuperative value of naps, and the severity of sleep inertia, are variable

Valk and Simons (1997) found that the duration of the rest period and the amount of sleep obtained depended on the duration of the flight, the time of day, and the timing within the flight when the nap was attempted. Furthermore, compared to naps taken on daytime flights, naps taken on overnight flights were associated with a significantly higher percentage of deep sleep (11.6 percent versus 4.3 percent; Rosekind et al., 1994). As described in section 2.3, research has shown that the length, timing, and depth of a nap can influence sleep inertia severity and duration. These findings highlight the fact that not all naps taken during CR are equivalent in terms of sleep efficiency, alertness benefits, and sleep inertia. As a result, it is important to provide pilots with CR training describing how napping varies, based on these factors.

3. Evidence that supports a policy to permit CR

Scientific research both in the laboratory and on the flight deck has demonstrated the potential for a napping opportunity to improve alertness and performance, and to reduce unintentional sleep episodes. Operators with many years of experience using CR are also generally supportive of the use of napping on the flight deck as a fatigue countermeasure. A recent survey of managers and flight crew employed at operators with a CR policy revealed the following proportions of individuals who agreed or strongly agreed with three statements regarding CR in their operations (n = 35; Holmes and Okuboyejo, in press):

- 90 percent: "CR has provided significant benefits for flight safety."
- 87 percent: "CR has reduced fatigue-related performance decrements during safety-critical phases of flight."
- 83 percent: "CR has reduced the incidence of uncontrolled napping."

While there are currently limited data on the use of CR, one survey of 253 pilots operating regional and international flights reported that 53 percent of respondents stated they had used CR in the prior 12 months (Petrie et al., 2004). Anecdotally, two operators with a fatigue reporting system and CR policy for over five years indicated that up to 30 percent of all fatigue reports cite the use of CR (Holmes and Okuboyejo, in press). Thus, it appears that where CR policies exist, they have been a useful tool for many flight crew.

It is perhaps not surprising that 90 percent of managers and crew surveyed from operators with a CR policy indicated that they disagreed or strongly disagreed with the statement "Prohibiting, or not allowing CR on the flight deck, is an effective method for ensuring that crew do not sleep or nap on the flight deck." This perspective is supported by studies of flight crew who work for U.S. operators, who are prohibited from practicing CR. The following studies report the prevalence of uncontrolled, intentional napping on the flight deck (i.e., napping by choice, but without following a standardized CR policy). In a study of long-haul flight crew, 11 percent (n = 3) took the opportunity to nap on the flight deck, with an average nap duration of 46 minutes (range 10 to 130 minutes) (Gander et al., 1991). Similarly, surveys of U.S. flight crew have shown that they take uncontrolled naps on the flight deck. For example, 56 percent of flight crew who responded to a survey of regional airline operations (Co et al., 1999), and 39 percent of flight crew who responded to a corporate/executive pilot survey (Rosekind et al., 2000), said they had been on a flight during which one pilot had arranged to take a nap. It appears that despite scheduling within duty limits, flight crew are using a non-standardized and unapproved countermeasure to manage their fatigue and to maintain alertness on the flight deck (Hartzler, 2014).

Unintentional napping may also be prevalent within the industry. Uncontrolled and unintentional napping that occurs in the absence of a CR policy poses a significant risk to flight safety. For example, an uncontrolled nap can occur without discussion or agreement between the pilots on the flight deck, leading to potential misunderstandings about the delegation of flight duties. Additionally, there are no agreed-upon standards for what is operationally acceptable, such as in what circumstances naps should be taken, the length of a nap, management of sleep inertia, etc. In the event of either uncontrolled or unintentional naps, the safety of the flight can be compromised.

Considering the strength of the science demonstrating the benefits of naps to manage fatigue, the common occurrence of uncontrolled or unintentional sleep where CR is not currently allowed, and the positive feedback on CR from operators who are already experienced, CR should be considered a beneficial tool to help manage unanticipated fatigue. A formal CR policy and a supporting relevant procedure describing how to undertake CR are necessary to harness the benefits of napping while limiting the potential for unintended, negative consequences.

4. Designing and reviewing a CR procedure

This section is intended to assist operators to design and review a CR procedure. There is no single "gold standard" CR procedure that can be copied and pasted; therefore, each operator must construct a procedure aligned to the characteristics of its flight operations. For that reason, this section does not present a comprehensive checklist, but rather a discussion of factors that should be considered when developing or reviewing an operator-specific CR procedure.

4.1 Regulatory considerations

Operators should first check with their regulatory authority about whether CR can be practiced in their type of operation. Examples of regions and countries where regulators permit CR for some or all operators include: Australia, Bolivia, Canada, China, Europe, Israel, New Zealand, Turkey, and the United Arab Emirates.

Some regulators, for example the DGCA of India (2013), have published detailed prescriptive requirements for CR, and EASA (2014) has published guidance material for the practice of CR. In some countries, such as Australia and New Zealand, regulators approve CR as described by individual operators in their operations manuals, but have not published regulatory requirements or guidance.

Of the four regulatory and guidance documents relating to CR that the Fatigue Countermeasures Working Group reviewed, none stated that CR could only be practiced on augmented or long-haul flights. Only the Office of the DGCA in India explicitly stated that CR could not be used on flights less than three hours in duration and on flights that require the use of decompression escape routes. It therefore seems to be largely up to individual operators to undertake a risk assessment and determine on which flights CR is and is not appropriate.

In the United States, CR is permitted by the Coast Guard (2013) and Air Force (2017), but the Federal Aviation Administration (FAA) has not been able to endorse it in commercial air transport. CR was considered when the latest FAA rules were developed beginning in 2010, but it was excluded from the final regulations. FAA Advisory Circular 120-100 (FAA, 2010, page 11) states:

> *Although a number of foreign air carriers authorized in-seat cockpit naps during flight, the FAA does not authorize such in-seat cockpit naps.*

4.2 CR is not a means of avoiding more effective fatigue management

Almost all of the reviewed regulations, guidance, and operator procedures indicate that CR should not be planned pre-flight, but should instead only be used in-flight to mitigate unanticipated low levels of alertness (e.g., CAA, 2003). CR may be a useful strategy to help manage scenarios in which it is difficult to fall asleep during planned in-flight rest opportunities in the bunk or cabin — for example if in-flight rest is scheduled when fatigue levels are low (Roach et al., 2011).

The Office of the DGCA in India states:

> *Controlled rest is one more element in a fatigue management program and another line of defence to manage fatigue risk.*

CR should only be used as an addition to, and not as a substitute for, more robust fatigue management strategies. CR is not an excuse for operating at an elevated level of fatigue risk and avoiding more effective fatigue mitigation strategies — for example, schedule adjustments or utilizing a nap opportunity before late or night flights. Before a flight, if a flight crewmember does not think he is fit to complete the flight, it is his responsibility to report "not fit for duty.'" Crew should not commence a duty when they are fatigued, expecting to rely on CR to mitigate their fatigue.

4.3 An effective CR procedure

As is the case with many procedures, potential exists for flight crew to be willfully or unintentionally noncompliant with CR procedures. For example, one operator experienced in CR said:

Some crew have been reported as sleeping for longer than the approved 40 minutes of controlled rest (Holmes and Okuboyejo, in press).

Indeed, in 2011, a breach of CR policy involving a nap lasting longer than 40 minutes and a lack of minimum recovery period was linked to a subsequent pitch excursion due to lack of situational awareness attributed to sleep inertia (Transportation Safety Board of Canada, 2012). Among other operators, survey respondents reported that CR has become normalized, and flight crew frequently use CR to improve their alertness. To maintain safety, it is important for CR to be implemented according to agreed procedures.

The 21 specific operator CR procedures reviewed for this document ranged in length from one paragraph to multiple pages. When writing a CR procedure, a balance should be struck between describing all of the necessary steps in adequate detail, and not providing so much detail that it is frustrating to read and use.

The AWIC model

Like any procedure, a CR procedure should be written according to the "AWIC" model: that is, the procedure should be *a*ccessible, *w*orkable, *i*ntelligible, and *c*orrect (Reason, 2016). Procedures that do not comply with the AWIC model invite procedural noncompliance into the organization and practical drift. The AWIC principles are:

Accessible

A CR procedure is usually documented in the flight operations manual, or similar document, and is readily available to crew on the flight deck.

Workable

The terms work-as-imagined (WAI) and work-as-done (WAD) help operators to understand that when writing a CR procedure, the way we *think* crew will use the procedure and the way they *actually* use the procedure are not necessarily the same.

One source of disconnect between WAI and WAD cited by operators who have experience with CR is that the procedure (i.e., WAI) was perceived as being overly burdensome and not a reflection of how CR was taken in reality (i.e., WAD). For example, one operator reported that:

The procedure somewhat requires a lot of things to do, like informing the purser, letting them check on the non-resting pilot, etc. So, most of the time, the procedure is not followed properly. (Holmes and Okuboyejo, in press)

To limit the WAI-WAD disconnect, it is necessary to understand the factors that determine how work is done, and to find ways of managing this to keep the work imposed by the CR procedure within acceptable limits. Part of the solution might be to involve flight crew in the writing of a new CR procedure or the review and revision of an existing CR procedure, and to provide training on the rationale behind each critical step in the procedure. Feedback from all stakeholders is essential so that the CR procedure and training can be refined to reflect operational reality.

Intelligible

The CR procedure should be clear and capable of being understood — another reason to involve flight crew in the writing of the procedure.

Correct

The content of the CR procedure must be correct, in terms of both the relevant regulatory requirements and the scientific research regarding naps and sleep inertia.

Considering AWIC principles when designing a CR procedure will help to promote compliance with the written procedure and result in what is, overall, a more effective CR procedure for managing fatigue risk.

4.4 Determining whether and when to use CR

Before initiating CR, the pilot-in-command should determine that flight conditions permit CR. In particular, the following should be considered before taking a CR period:

Open and honest discussion about alertness levels

As discussed in section 2.3, each flight crewmember should monitor his or her alertness level and take this into account during open and honest conversations about whether/when CR could be taken, and by whom. ICAO (2015) states:

> *Controlled rest on the flight deck may be used at the discretion of the captain to manage both unexpected fatigue and to reduce the risk of fatigue during higher workload periods later in the flight.*

When a pilot identifies the need for CR, this should be discussed and usually taken as soon as workload permits, before sleepiness levels of both flight crewmembers increase. This way, the resting pilot will reduce the risk of sleep inertia (Dinges et al., 1985; Hilditch et al., 2017), and the operating pilot will also be more alert.

Flight profile

The flight cruise phase must be of sufficient duration to enable a CR period to be fully completed according to the relevant CR procedure, as demonstrated in section 4.5 on flight profile.

Workload

CR should be utilized only during low workload portions of cruise flight as determined by the flight crew. Considerations by the flight crew in determining workload level should include, but not be limited to:

- Weather conditions;
- Fuel status;
- Positive aircraft separation provided by air traffic control; and,
- Operative status of aircraft equipment.

Aircraft operable equipment

To include CR in an operation, the aircraft operable equipment should include at a minimum:

- Autopilot/autothrottles;
- Weather radar;
- Flight management computer/flight management system;
- Traffic-alert and collision avoidance system; and,
- Appropriate seat with headrest.

In order to ensure the safety of flight while a crewmember is taking CR, the aircraft should have a minimum of one operable autopilot that will remain engaged throughout the CR and recovery period. Two regulators state:

> *Any system intervention which would normally require a cross check according to multi crew principles should be avoided until the resting crewmember resumes his[/her] duties. (EASA, 2014, p. 135; DGCA of India, 2013, p. 2).*

Safeguards

Before commencing a CR period, an external safeguard to the flight crew should be in place. For example, operator procedures may consider including notification of cabin crew when a flight crew-member is engaged in CR (see section 4.6b).

4.5 CR flight profile and timing

CR can only be utilized on flights in which the cruise phase of flight is of sufficient duration. Only the DGCA in India explicitly states this duration to be more than three hours — no other regulations or operator CR procedures reviewed for this document contain prescriptive limits based on flight duration. CR was similarly available for use on augmented and non-augmented operations. While the documents provided very different levels of detail, they essentially described a similar flight profile for the use of CR, including the following key elements:

- CR should only commence after top of climb (TOC).
- The CR period should be a maximum of 30 to 45 minutes.
- After CR, there should be a recovery period of at least 20 minutes, during which the resting pilot should not participate in flight duties or briefings, while sleep inertia dissipates.
- A crew briefing must be conducted after the recovery period.
- The recovery period and crew briefing should be completed at least 30 minutes before top of descent (TOD).

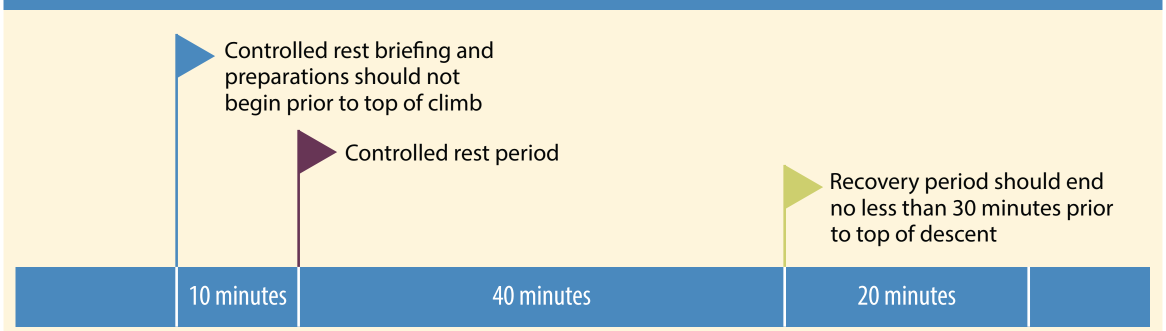
There are benefits to providing a timeline for CR, including:

- To limit the impact of sleep inertia;
- To manage the risk of the non-resting pilot falling asleep;
- To ensure that CR has a standard, pre-determined, and mutually agreed-upon end time; and,
- To enable the structured involvement of cabin crew or dispatch (see section 4.6b).

An example of a CR profile is shown in Figure 1, below:

Figure 1

Example of a CR profile within flight



CR = controlled rest

Source: Fatigue Countermeasures Working Group

4.6 CR briefing, defined role for flight crew, and safeguards

Before initiating the CR period, both flight crewmembers should conduct a briefing to cover the general status of the flight, including:

- Fuel;
- Route;

- Planned duties;
- Review of waking items;
- Review of CR procedures;
- Time of planned waking; and,
- Safeguards.

The roles of each flight crewmember, and individuals acting as safeguards during CR, are described below:

a. Resting flight crewmember

The resting flight crewmember should position his or her seat as far aft as possible, and clear of any control surfaces to avoid inadvertent activation. In addition, shoulder harnesses should be used. The use of personal sleep equipment should be allowed to facilitate quality rest. This may include, but is not limited to, eye masks, neck supports, headrests, and earplugs. Research has shown that the performance benefits of a nap significantly outweigh those of a break without sleep (Reyner and Horne, 1997). Therefore, conducting other activities during a CR period, such as reading, listening to music, or watching a video, is not a substitute for sleep, and should not be allowed.

b. Non-resting flight crewmember and cabin crew

During CR, the non-resting flight crewmember should remain in his seat; complete all of the resting flight crewmember's duties as well as his own duties; consider whether it is possible to switch to headphone mode to reduce noise on the flight deck; and maintain contact with cabin crew, if appropriate. For example:

> *The cabin crew in charge should establish a frequent check on the flight crew by means of the interphone system. Preferably, and in order not to disturb the resting crewmember, the non-resting flight crewmember should call the cabin crew approximately every 20 minutes (night) or 30 minutes (day).*

Eighty-five percent of operators surveyed who had a CR procedure indicated that flight crew was required to inform cabin crew that CR was being taken (Holmes and Okuboyejo, in press). Of the 18 operator CR procedures reviewed from airlines with cabin crew, 11 (61 percent) indicated that cabin crew should be informed that CR was being taken, and three (17 percent) airlines indicated that this was only needed in two-crew operations.

The frequency of checks between the non-resting flight crewmember and cabin crew ranged from 10 to 45 minutes. Some operators allowed checks at a frequency of the pilot-in-command's discretion.

c. Safeguards

Safeguards may depend on the type of operation, but the involvement of cabin crew, dispatch, aircraft communications addressing and reporting system (ACARS), and secondary alarm devices should be considered. None of the operators experienced with CR required a cabin crewmember to sit on the jump seat while a flight crewmember took CR (Holmes and Okuboyejo, in press).

4.7 Resumption of flight duties following a CR period

The non-resting flight crewmember is responsible for waking the resting flight crewmember when required or at a pre-determined time. It is important not to startle or frighten the resting flight crewmember. As explained in section 2.2, a minimum 20-minute recovery period, free from flight duties or briefings, is necessary to manage any potential sleep inertia. This recovery period may also be a good time for an activity break, or addressing physiological needs such as using the restroom or getting a cup of coffee or water.

Crew briefing

After completing the recovery period, possibly using a post-CR checklist, both flight crew should conduct a briefing covering any changes that occurred during the CR period and the general status of the flight. In addition, a full scan of all switches in the flight deck should be completed to verify aircraft condition. These tasks should be completed before the resumption of duties by the resting flight crewmember.

One operator that uses a CR procedure cited several communication loss events after the use of CR because the normal communication channels (speakers) were not correctly re-set after they had been switched to headphone mode to reduce noise on the flight deck during the rest period (Holmes and Okuboyejo, in press). Occurrences such as these can be mitigated by following a formalized checklist, scan, and briefing plan.

Unplanned wake-up

Due consideration should be given to circumstances that would lead to the early termination of a CR period. If at any time it is necessary to turn off the autopilot, the CR period should be terminated. If a system malfunction, or an abnormal, or emergency situation should arise during CR, it is the responsibility of the non-resting flight crewmember to wake the resting flight crewmember. The non-resting flight crewmember should maintain control of the aircraft until both flight crewmembers agree that the resting flight crewmember is sufficiently alert to resume duties.

4.8 Provide effective CR procedure training

Training is key to ensuring adequate understanding and successful implementation of CR as a safety measure. However, a survey of 21 operators that use CR procedures found that only 15 provided training on CR (Holmes and Okuboyejo, in press). Of the operators that provided CR training (operators could select multiple types of training):

- Nine included CR as part of fatigue management training.
- Seven included CR in initial/induction training.
- Five included CR in CRM training.

Limited guidance on CR training is available; in fact, of all the regulations and guidance reviewed by the Fatigue Countermeasures Working Group, only two mentioned training — documents developed by ICAO and Transport Canada. The ICAO (2015) guidance for CR states:

> *Procedures for controlled rest on the flight deck should be published and included in the fatigue training program.*
>
> *Flight crews may only use controlled rest if they have completed the appropriate training.*

CR training should focus on describing the procedure, and explaining the rationale behind its design. Training on the rationale and basic science behind each critical step in the CR procedure may help to reduce the gap between WAI and WAD. Planned content could include, but is not limited to:

- CR should not be relied upon to mitigate fatigue, but rather be used as a tactical tool to improve crew alertness before a critical phase of flight.
- The length, timing, and depth of a nap can influence sleep inertia severity and duration, and not all naps taken during CR are equivalent in terms of sleep efficiency, alertness benefits, and sleep inertia.
- The science on naps and sleep inertia has informed the design of the CR procedure.
- Strategies for managing sleep inertia, especially if an unplanned wake-up occurs.
- Real-world examples that highlight the potential consequences of not following procedures could be used to illustrate the importance of recognizing and managing sleep inertia (e.g., Transport Canada, 2012).
- Reporting the use of CR should be encouraged to enable proactive FRM (see section 4.9, below).

When applicable, cabin crew should be trained during initial training and according to the operator's recurrent training cycle, on the procedures and strategies for safely implementing CR. This training should highlight the importance of flight crew alertness levels during critical phases of flight.

Dispatch and other operational areas of the operator may also require formal fatigue education focusing on CR if that department will be playing a role in the operator's CR policy.

4.9 Reports of the use of CR to enable FRM

ICAO (2015) states:

> *Use of controlled rest on the flight deck should result in a fatigue report to enable the FSAG or SMS process (as applicable) to evaluate whether existing mitigation strategies are adequate.*

A CR report may be as simple as a trip report form or ACARS message stating, "controlled rest was utilized," which has the advantage of being easy, and therefore more likely for crew to complete. In addition, or alternatively, reporting the use of CR may involve the submission of a more detailed fatigue report, or an appendix to an air safety report, via an electronic flight bag application or internet reporting software. Collecting more information will enable a more detailed analysis of CR use — for example, in assessing schedules, time of day, sleep history, and flight crew commentary — but comes with the disadvantage of being more burdensome to the flight crew. Alternatively, to obtain a retrospective snapshot of how often CR is being used by flight crew, some operators have included a question about CR in de-identified online surveys of safety culture and fatigue, and incorporated CR into line operations safety audits.

To encourage the submission of reports of CR, a trusted reporting system is necessary — i.e., a system that is confidential, voluntary, and embedded in a just culture. Operators should also explain why reporting the use of CR is important, in language that makes sense to the crew. For example, if flight crew report using CR consistently on a certain route, this information can help the operator to assess the route to ensure it is not causing high levels of fatigue as currently scheduled. This type of explanation, as part of formal CR training, will help promote a positive reporting culture with higher reporting rates.

Reporting is important for establishing the unique profile of CR use within an operation. This profile may be influenced by safety culture, regional regulations, CR procedures, schedules, etc. It is helpful for an operator to understand why and when CR is used across operations, and to determine acceptable thresholds of CR use that may trigger further FRM actions. One example of using CR data to inform FRMS policy involved an airline that observed more than 20 percent of flight crew using CR on a daytime long-haul operation. The airline FSAG said that there was a need for further fatigue mitigation on this flight, and chose to augment the flight crew with an additional crewmember. This case study highlights the value of a CR reporting system as part of a continually evolving FRMS. If such data were to be shared or published, a database of multiple reports could also be helpful in shaping FRM policy at an industry level.

Conclusion

For over 20 years, operators have been utilizing CR to harness the benefits of napping and limit the disadvantages of fatigue caused by extended hours of wakefulness, sleep loss, and time of day. Sleep studies support the use of naps to improve alertness and performance, and operators that are experienced in CR are supportive of the use of CR.

Although some regulators permit CR, others do not. It is important to recognize that the absence of a CR procedure does not prevent flight crew from napping, let alone from inadvertently falling asleep. Concerns about CR, such as sleep inertia or normalization, can be managed through an effective CR procedure, crew training, and integration into FRM. The current review of CR, both in scientific research and practical operator experience, suggests that a well-designed and monitored CR procedure has the potential to reduce fatigue-related safety risk. By formalizing this countermeasure, flight crew can use an additional effective tool to manage their fatigue, and improve their alertness and performance on the fight deck.

The safety case for CR is strong, in terms of both the science and more than 20 years of operational experience. However, further research, field research, is needed to continually inform best practice guidelines for the safe and effective implementation of CR.

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Appendix 1. ICAO recommended procedures for CR on the flight deck

The content below is a direct transcript of Appendix C of the ICAO Fatigue Management Guide for Airline Operators (ICAO, 2015).

Controlled rest on the flight deck is an effective fatigue mitigation for flight crews. It should not be used as a scheduling tool, but used in conjunction with other fatigue countermeasures, as needed, in response to unanticipated fatigue experienced during operations.

- Use of controlled rest on the flight deck should result in a fatigue report to enable the FSAG or SMS process (as applicable) to evaluate whether existing mitigation strategies are adequate.
- It is only intended to be used during low workload phases of flight (e.g., during cruise flight) at times when it does not interfere with required operational duties.
- It should not be used as a method for extending crew duty periods.
- Procedures for controlled rest on the flight deck should be published and included in the fatigue training programme.

The following recommended procedures are based on a survey of major air carriers. They represent considerable experience in many regions of the globe and include options reflecting variations between different types of operations.

Note — This is not intended to be an all-inclusive list, nor are all of these procedures necessarily required. Each operator should work with its regulator to define appropriate procedures.

C1. Planning

- One pilot only may take controlled rest at a time in his seat. The harness should be used and the seat positioned to minimize unintentional interference with the controls.
- The autopilot and auto-thrust systems (if available) should be operational.
- Any routine system or operational intervention which would normally require a cross check should be planned to occur outside controlled rest periods.
- Controlled rest on the flight deck may be used at the discretion of the captain to manage both unexpected fatigue and to reduce the risk of fatigue during higher workload periods later in the flight.
- It should be clearly established who will take rest and when it will be taken. If the pilot-in-command requires, the rest may be terminated at any time.
- The pilot-in-command should define criteria for when his rest should be interrupted.
- Hand-over of duties and wake-up arrangements should be reviewed.
- Flight crews should use controlled rest only if they are familiar with the published procedures.
- Some operators involve a third flight crewmember (not necessarily a pilot) to monitor controlled flight deck rest. This may include a planned wake-up call, a visit to be scheduled just after the planned rest period ends, or a third flight crewmember on the flight deck throughout controlled rest.
- The controlled rest period should be no longer than 40 minutes, to minimize the risk of sleep inertia on awakening.
- Controlled rest should be used only during the cruise period from the TOC to 30 minutes before the planned TOD. This is to minimize the risk of sleep inertia.
- A short period of time should be allowed for rest preparation. This should include an operational briefing, completion of tasks in progress, and attention to any physiological needs of either flight crewmembers.
- During controlled rest, the non-resting pilot should perform the duties of the pilot flying and the pilot monitoring, be able to exercise control of the aircraft at all times, and maintain situational awareness. The non-resting pilot cannot leave his seat for any reason, including physiological breaks.
- Aids such as eye shades, neck supports, ear plugs, etc., should be permitted for the resting pilot.

C2. Recommended restrictions

- The autopilot and auto-thrust systems (if available) should be operational.
- One pilot shall be fully able to exercise control of the aircraft at all times and maintain situational awareness.
- Only one operating flight crewmember may rest on the flight deck at a time.
- Both operating pilots should remain at their stations.