

### Managing the Effects of Crew Endurance Degradation on Operational Hazard Exposure

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Search and rescue (SAR), medical evacuation, medical emergencies, and fire rescue are few of the **many on-demand operations** where dynamically changing contextual variables contribute to mission hazard exposure level.





### CREW ENDURANCE MANAGEMENT (CEM)

- A method of <u>identifying and controlling hazards</u> that degrade crewmember alertness, rest, and recovery:
  - Assess operations to identify crew endurance hazards
  - Implement shipboard and organizational practices to protect crewmember endurance







### CREW ENDURANCE RISK FACTORS

- <u>Core</u> Endurance Risk Factors directly impact the ability to produce and restore physical and cognitive resources:
  - Insufficient Daily Sleep
  - Poor Sleep Quality
  - Fragmented Sleep
  - Main sleep during the day night work
  - Changing work/rest schedules
  - Long work hours



No Opportunities to Make Up Lost Sleep











TOOL OVERVIEW

COAST

START

### **SET:** Schedule Entry

**Schedule Entry Instructions** 

Save Schedule

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ion:	1	2 on 1	12 off	mids																					
of Days:	Days: 14 🗄 🕕 Initial Wakeup: 06:45 🕂 🚺																								
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Off 📕 Watch 📃 Work 📒 Evolution egend color box to change a display color.





Sleep

# **SET:** Schedule Entry

### **Schedule Entry Instructions**

\_ \_

File Name: 12on-12off stable

escription:	12on/12off stable
umber of Days:	14 \Xi 🚺 Initial Wakeup: 07:00 🕂 🚺
irst Day of Week:	Tuesday 💽 🚺 Average Sunrise: 06:00 😤 🚺

rew Endurance Management: Implemented

ented 🔽 🚺

Nick a time period column heading to expand or collapse the column display. Nick a risk factor column heading for information about the risk factor and the color codes.





### **Schedule Entry Instructions**

File	File Name: 12 hr rotating															
Des	Description: 12 hour rotating															
Num	lumber of Days: 31 🕂 🚺 Initial Wakeup: 05:00 🕂 🕕															
First	First Day of Week: Sunday 🔽 🚺 Average Sunrise: 06:30 🛨 🚺															
Crev	v Enduran	ice Manage	ment: Not I	Implemente	d 🖵 (i	(This option the days ha	n may be set w ive sleep time:	hen at least 85 s entered)	% of							
Click Click	Click a time period column heading to expand or collapse the column display. Click a risk factor column heading for information about the risk factor and the color codes.															
	Week	0	3	6	9	12	15	18	21	24 Body	>12 H Work Main In 2	rs ed 4 Wake-	Long Work	Sun- light	Night	-
Day	Day									Clock	Sleep Hrs	fulness	Period	Exp.	Work	

	Week	U	3	6	9	12	15	18	21	24 Bo	dv Main	In 24	Wake-	Work	liaht	Night	
Day	Day									Clo	ck Sleep	Hrs	fulness	Period	Exp.	Work	
1	Sun																
2	Mon																
3	Tue																
4	Wed																
5	Thu																
6	Fri																
7	Sat																
8	Sun																
9	Mon																
10	Tue																
11	Wed																
12	Thu																
13	Fri																
14	Sat																
15	Sun																-



### **Schedule Entry Instructions**

File Name: 12 hr rotating

8 hour nighttime with rotating start time

Number of Days: 25 🛨 👔 Initial Wakeup: 06:00

First Day of Week: Sunday

Description:

i) Initial Wakeup: 06:00 🕂 (i) (i) Average Sunrise: 06:30 🕂 (i)

Crew Endurance Management: Not Implemented

nplemented 💌 🚺

Click a time period column heading to expand or collapse the column display. Click a risk factor column heading for information about the risk factor and the color codes.

																							>12 Hrs		1	Dec.		
	Week	0		3			6		9	 1	12	 1	5	 	18	 	21	 	2	24	Body	Main	In 24	Wake-	Work	Sun- liaht	Niaht	
Day	Day																				Clock	Sleep	Hrs	fulness	Period	Exp.	Work	
1	Sun																											
2	Mon																											
3	Tue																											
4	Wed																											
5	Thu	Ш	Ш	Ш	Ш																							
6	Fri	Ш	Ш	Ш	Ш																							
7	Sat	Ш	Ш	Ш																								
8	Sun		Ш	Ш					Ш																			
9	Mon	Ш	Ш																									
10	Tue	Ш	Ш	Ш																								
11	Wed		Ш	Ш																								
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13	Fri	Ш	Ш	Ш	Tim	e: 03:	00 - 03	15							Ш	Ш												
14	Sat					6. 03.	00-03	10																				
15	Sun																											$\mathbf{T}$



























### The Crew Endurance Management System

- Processes/Guidelines
  - Organizational and vessel implementation
  - Crew Endurance Risk Factors Assessment
- Knowledge
  - Education program
- Practices/Controls
  - Controls to mitigate the incidence of endurance risk factors in operations

- Equipment/Tools
  - CEMS tool
  - Crew Endurance Risk Factors Assessment
  - Schedule Evaluation
     Tool
  - CEMS Guide
- Develop Expertise
- Provide Assistance









 Studies of brain function have shown that <u>seven to</u> <u>eight hours of continuous sleep</u> are necessary to restore cell function to normal levels







### DAILY SLEEP REQUIREMENTS

- Varies with age
  - Elementary students normally require 10-12 hours per day;
  - Pre-teens 9-11 hours;
  - Teens 8½-10 hours;
  - Most adults 7-8 hours per day

(For sleep to be restorative, it must be continuous and uninterrupted)







# Daily Minimum Sleep Requirement

### 7-8 Continuous Hours









Figure 4. Mean number of lapses on the psychomotor vigilance task (and standard error) across days as a function of time in bed group.

Belenky et.al. (2003). J. of Sleep Res. 12, 1-12







# **Sleep and Health**

- Obesity
- Cardiovascular Disease
- Hypertension
- High Blood Pressure
- Diabetes
- Depression
- Stroke

### • Immune Deficiencies





### CREW ENDURANCE RISK FACTORS

- <u>Modulating Endurance Risk Factors</u> contribute to "sap" energy levels and worsen the effects of the "core" risk factors
  - High Workload
  - Lack of Control Over Work Environment or Decisions
  - Poor Diet
  - No Opportunity for Exercise
  - High Work Stress
  - Family Stress
  - Isolation From Family

Excessive exposure to extreme environments





### DECLINING ENDURANCE RESULTS IN HUMAN ERROR













' OPNL Tempo















# Circadian Rhythms















**Sleep and Performance** 









24-hour Rhythms

















### Pituitary and Pineal Glands Pineal gland Cerebellum Pituitary gland Pons Medulla oblongata Spinal cord



















# Shifting Circadian Rhythms











### Use of "Monochromatic" Green Light









### 24-hour Rhythms









### **Light Induced Delays**



Time of Day







### **Light Induced Delays**



Time of Day





Rate of shift: app. 1 hr/ day



### **Light Induced Delays**



Time of Day







Light Management

### 24-hour Rhythms









### **Light Induced Advances**



Time of Day







### **Light Induced Advances**



Time of Day









### **15 Minute Exposure by 2 hours Calibration**





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Hazard Exposure as a Function of Operational Complexity

- Each operational environment involves specific
  - Operational objectives,
  - Crew operational proficiency,
  - Crew State
  - Response platform capacities,
  - Platform tolerance thresholds for varying environmental conditions,
  - Variation in coordination of multiple (e.g., shipboard, afloat, aviation, command and control, etc.) assets, and in some cases inter-agency coordination.









' OPNL Tempo





### Hazard Assessment Tool Developmental COPY. NOT FOR DISTRIBUTION.

iviission Setu	P Crew Setup Hazard Ana	alysis			
	PIC Name Mission Date: Take-Off Tim Tail Number CG-	ne 19 🔽 00 🔽	Sur Sur	nrise: 7 💌 30 💌 nset: 17 💌 00 💌	
Mission Type	Simple- Searches: flare, PIW, kayak, overdue. No hoisting; Daytime medevac- flat, unobstructed Medium- Adequate time/information to plan; Ad on scene. Hoisting; Simple/known hoisting area; I medevac to an open field; RS ops; Rougher/more Hard- Strict fuel management (long range); Limit obstructions- towers/cliffs/power lines; Limited t Complex hoist – boat rigging, type of boat, unstab Night-time PIW. Simple- Flying a known route, e.g. E-city to Atlanti few to no surprises on route Complex- Cross-country, e.g. North Bend to Atlant long flights/long days	ed terrain. equate fuel margin; Adequat Daytime medevac from or to e mountainous terrain. ted time to prep boat on scen time/information to plan; Lo ble platform, vertical surface ic City; close to AOR, know co ntic city; unfamiliar areas; a k	te time to prep boat ship; Nighttime ne; Terrain includes w margin of error. (e.g. cliff face); ourse rules; ot of map work;	<ul> <li>Training: Recon</li> <li>Training: GUNEX</li> <li>Training: Tactics</li> <li>LE/PWCS</li> <li>Surveillance Recon</li> <li>Training: Formations</li> <li>Training: Demonstrations</li> </ul>	<ul> <li>RWAI Operational</li> <li>Training: RWAI</li> <li>RT-1 Day Land</li> <li>RT-2 Day Water</li> <li>RT-3 Night Land/NVG/HUD</li> <li>RT-4 Night Water</li> <li>RT-5 Instrument/Cross Country</li> <li>RT-6 Ship/Helo Operations</li> </ul>
C External Load	Simple- Weight well within platform limits; size, s Complex- Weight may come closer to platform lin prone to sailing, other maneuvering/aerodynamic	shape and materials of ext. Ic mits; size, shape and materia c challenges	ad not challenging al of ext. load	O Test Flight	C RT-7 Confined Area/Ext. Load ops
Environmental Flig	kt Conditions	Weather Conditions			
		Weather Simple- Weather Moderate-	•Within local mins (i.e. lo •Exceeding local mins (i.e	ocal 3710/read and initial file) a e. local 3710/read and initial fil	and CG 3710 mins le) , but within CG 3710
CLow	C Adequate 💿 Good	🔿 Weather Hard-	•Exceeding local mins (i.e	e. local 3710/read and initial fil	e) and approaching but NOT
Aircraft Status All equipment oper Loading: What is mission?	ational. ACMS up to date. the expected loading condition during the «tra equipment or passengers expected.	◯ Weather Extreme-	exceeding CG 3710 mins •Any of the following (pri- icing; IVO thunderstorms •Exceeding both local min •Require waiver from Cor •Any of the following (pro- embedded thunderstorm	edicted/known/forecasted): m ; high seas; high winds ns (i.e. local 3710/read and init mmand to begin or continue m edicted/known/forecasted): se ms; extreme sea conditions; ap	oderate turbulence; light tial file) and CG 3710 mins hission evere turbulence; severe icing; oproaching/at hurricane-force winds



### **Operational Proficiency**

(OPNL Experience (w) + Skill Decay(w)+ AOR Fam(w) + Platform Qual(w)+ Last Flight(w))







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0.442308	0.565385	0.388462	0.25	0.107692	0.442308	0.630769	0.51923	1 0.253846	0.1
0.423077	0.553846	0.384615	0.24	0.106923	0.423077	0.607692	0.49230	8 0.238462	0.1
0.403846	0.542308	0.380769	0.23	0.106154	0.403846	0.584615	0.46538	5 0.223077	0.1
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0.096154	0.265385	0.214615	0.125385	0.1	0.096154	0.276923	0.21923	1 0.1	0.1
0.076923	0.242308	0.197692	0.122308	0.1	0.076923	0.261538	0.21538	5 01	0.1
0.057692	0.219231	0.180769	0.119231	0.1	0.057692	0.246154	0.21153	8 0.1	0.1
0.038462	0.196154	0.163846	0.116154	0.1	0.038462	0.230769	0.20769	2 01	0 1
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0	0.15	0.13	0.11	0.1	0	0.2	0.1	2 0.1	0.1





#### Hazard Assessment Tool

DEVELOPMENTAL COPY. NOT FOR DISTRIBUTION.

Mission Setup Crew Setup	Hazard Analys	is			
Required Position: EmpIID	ops	ops     ops     I Seat     PIC     All Coast Guard     Feter Empl	► BA	Flight Mech	RS
<b>Operational Experience:</b> Estimate years of CG aviation experience	4 years	4 years	4 years	4 years	4 years
Recency: Estimate months since you last used perishable skills critical to this mission	<.5 Months	<.5 Months 💌	<.5 Months 💌	<.5 Months 💌	<.5 Months
Mission Management: Rate cognitive / emotional state and ability to fulfill role in crew coordination, situational awareness, on-scene coordination, risk management, and execution of evolutions critical to this mission	able 90-100%	able 90-100%	less than 50%	able 90-100%	able 90-100%
Platform Experience: Estimate number of hours flown in this platform	300 + hours 💌	300 + hours 💌	300 + hours 💌	300 + hours 💌	300+hours 🔻
Primary Sleep Start: What time did you fall asleep last night? (Nearest 1/2 hour)	22 🔻 00 💌	22 💌 00 💌	22 💌 00 💌	22 💌 00 💌	22 🔽 00 🔽
Primary Sleep End: What time did you wake up this morning? (Nearest 1/2 hour)	6 🔽 00 🔽	6 🕶 00 💌	6 💌 00 💌	6 🔽 00 🖵	6 🔽 00 🔽
Nap 1 Start: What time did you take a nap?         (Nearest 1/2 hour)         Clear All         Nap 1 End: What time did you awake from the nap? (Nearest 1/2 hour)	12 ▼ 00 ▼ 12 ▼ 00 ▼	12 ▼ 00 ▼ 12 ▼ 00 ▼	12 ▼ 00 ▼ 12 ▼ 00 ▼	12 V 00 V 12 V 00 V	12 V 00 V 12 V 00 V
Nap 2 Start: What time did you take a nap? (Nearest 1/2 hour) Clear All	<b>.</b>		<b>•</b> •	<b>•</b>	
Nap 2 End: What time did you awake from the nap? (Nearest 1/2 hour)					
Crew Fatigue at Take Off 19:00					









## Contact Information

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