



CREW ENDURANCE HANDBOOK

A Guide to Applying Circadian-Based Watchbills





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EXECUTIVE SUMMARY

A circadian-based watchbill is the term used for a work and rest schedule that conforms to a 24-hour day, allowing individuals to work, eat, and sleep at approximately the same time each day. When you combine the number of hours spent on watch with the number of hours off watch (whether doing other work, eating or sleeping), a circadian-based system will add up to 24 hours. The system aligns with the naturally-occurring 24-hour rhythm which drives all biological processes, down to the cellular level.

Research conducted by the Crew Endurance Team at the Naval Postgraduate School over the past several years has

demonstrated how circadian-based watchbills are superior to non-circadian watchbills in terms of crewmember preference and individual Sailor performance.

This handbook is being provided to commanders and their staff to share some of the valuable lessons learned through scientific investigation and trial and error by other Naval commanders. It is not meant to be prescriptive but gives examples of some past watchbills that have been used effectively.

For more information or to provide feedback, please visit the Crew Endurance website.

<http://my.nps.edu/web/crewendurance>



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WHAT IS CREW ENDURANCE?

The ability to maintain optimal warfighting performance while enduring job-related physical, psychological, and environmental challenges.

WHY CREW ENDURANCE MATTERS

Operational effectiveness depends on crew endurance. If crewmembers are overly fatigued, mission accomplishment, performance and safety are in jeopardy. Morale suffers. Chronic sleep debt has long-term physical and mental health consequences and degrades human performance.

Sleep is a Weapon.

A Clear Mind is a Combat Edge.

Fatigue Increases Operational Risk.

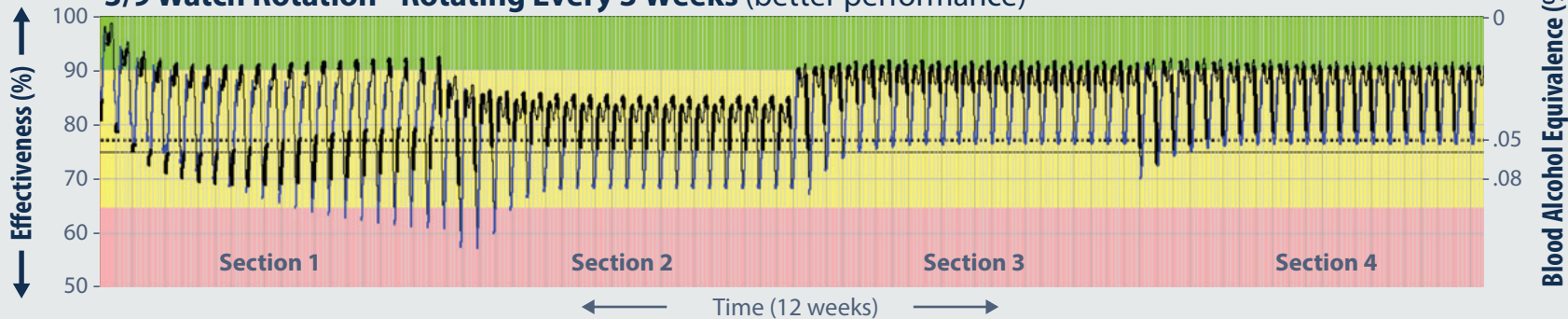
The figures shown on the following page come from the Fatigue Avoidance Scheduling Tool (FAST®). They represent predicted effectiveness over a 12-week period for an individual Sailor on two different watchbills, the 3/9 and the 5/10. The figures illustrate how a Sailor performs when rotating through all watch sections while receiving 7 hours of sleep each day.

The GREEN horizontal band represents 90% and above predicted effectiveness; the YELLOW band is the cautionary zone and represents 65 to 90% predicted effectiveness; the RED band is the danger zone and represents 65% and below predicted effectiveness.

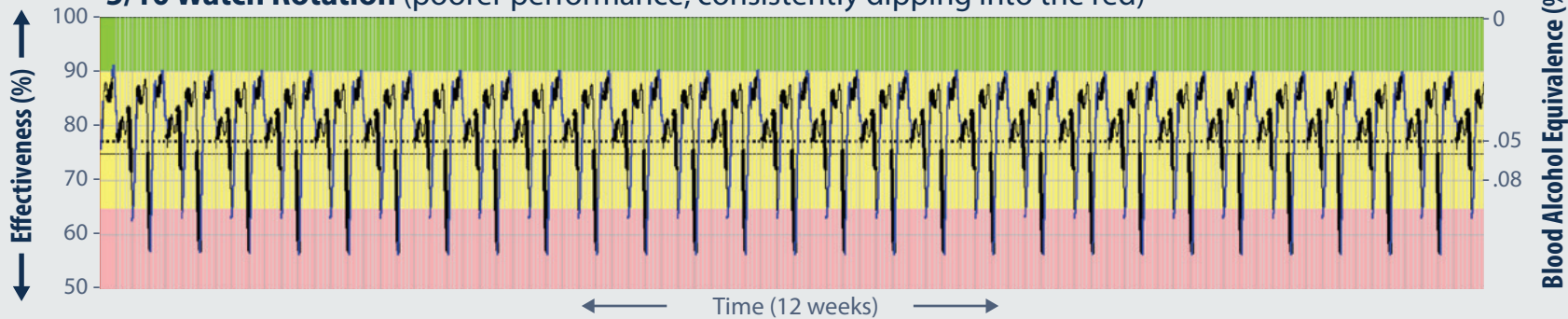
During waking hours for an individual who is getting adequate sleep, predicted effectiveness should remain in the green band, dipping into the yellow zone during sleep periods. Blood Alcohol Equivalence is shown on the right axis.

FATIGUE AVOIDANCE SCHEDULING TOOL (FAST©)

3/9 Watch Rotation - Rotating Every 3 Weeks (better performance)



5/10 Watch Rotation (poorer performance, consistently dipping into the red)



Work (black) / Sleep (blue) Predicted Effectiveness (>90%) Cautionary Zone (65-90%) Danger Zone (<65%)



HOW TO INCREASE SAILORS' ENDURANCE

One method with proven results is the Circadian-Based Watchstanding Schedule. Numerous shipboard studies have shown how a circadian watchbill and schedule can improve operational readiness, enhance productivity, reduce stress and improve morale, especially over a long deployment.

- Focus on alert and engaged watchstanders.
- Learn and understand the effects of good sleep practices.
- Use the 24-hour circadian rhythm to set the foundation.
- Build a stable daily work schedule **including the watch bill** that maximizes rest opportunities at the same time each day (fixed schedule).
- One size does not fill all—consider tradeoffs.
- Get supporting analysis.

PLANNING FACTORS

- Type of rotation
 - » Circadian is better
- Length of watches
 - » Shorter is usually better
- Number of sections
 - » More is usually better
- Rotation times
 - » Cardinal points (3, 6, 9, 12) are simpler
- Direction of rotation
 - » Forward is usually better
- Designated sleep times
 - » Sleep and awaken at same time each day
- Number of days in each rotation
 - » Three weeks or more is better
- Day of turnover
 - » Weekends may work better. Port visits allow flexibility.

CONSTRAINTS TO CONSIDER

- Heat stress limitations (PHEL curves)
- Drills, briefs and debriefs
- Watch turnover SOP
- Pre-watch plant tours
- Watch team cohesion
- Meal hours
- Daily routine
- Berthing arrangements
- Special Evolutions
 - » Underway Replenishments
 - » Flight Quarters
 - » Well deck operations



CHOOSING THE RIGHT WATCHBILL

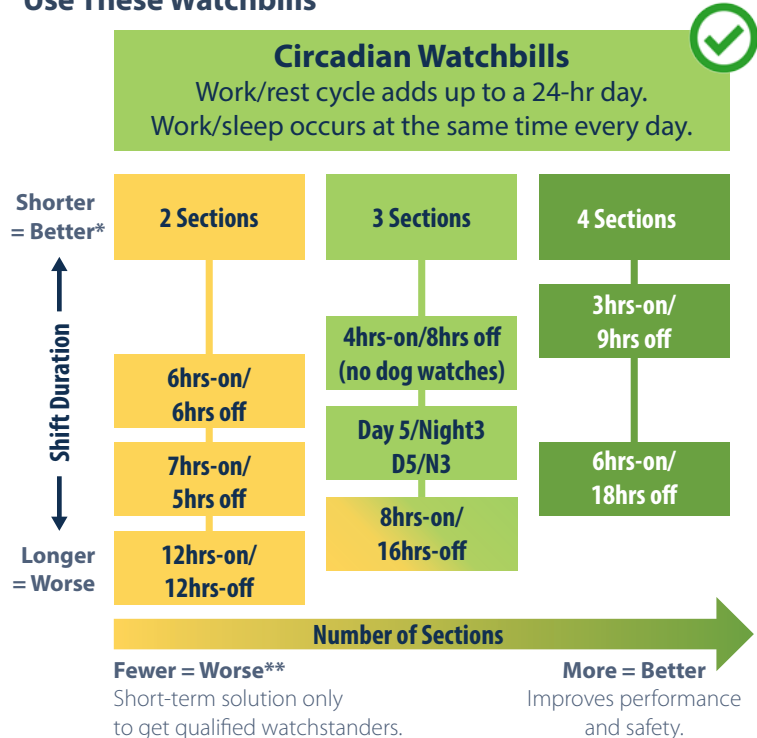
Several alternative circadian schedules exist to help ensure that crew and staff are well rested and better prepared to perform their duties. Numerous shipboard studies have shown the value of a circadian watchbill and schedule to operational readiness, productivity, reduced stress and improved morale, especially over a long deployment.

No One Size Fits All. Consider Tradeoffs.

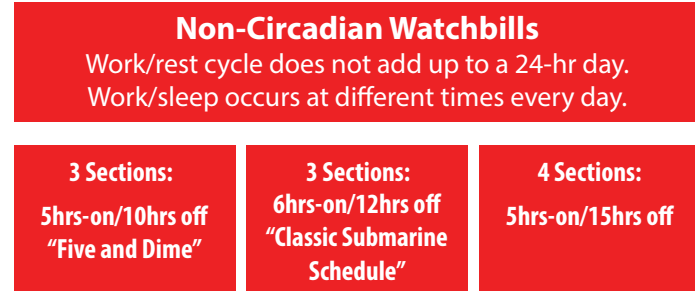
There are several common variations of watch schedules, each with its own merits and tradeoffs. Become familiar with some of the considerations (next page) before choosing a schedule for your crew. The NPS Crew Endurance Team is also available for further consultation.

NUMBER OF AVAILABLE SECTIONS

Use These Watchbills



Avoid These Watchbills



Circadian Watchbills (Shift Duration and # of Sections)

*Shorter shifts are better for cognitively demanding duties such as those that require sustained attention or work in adverse environmental conditions (heat, motion, etc.). Longer shifts may be acceptable for roving watches.

**Fewer watch sections are acceptable ONLY as part of a short term solution to get more qualified watchstanders. More watch sections will result in faster reaction times and fewer errors.

BEST PRACTICES (Based on actual success stories from ships implementing circadian watch rotations)

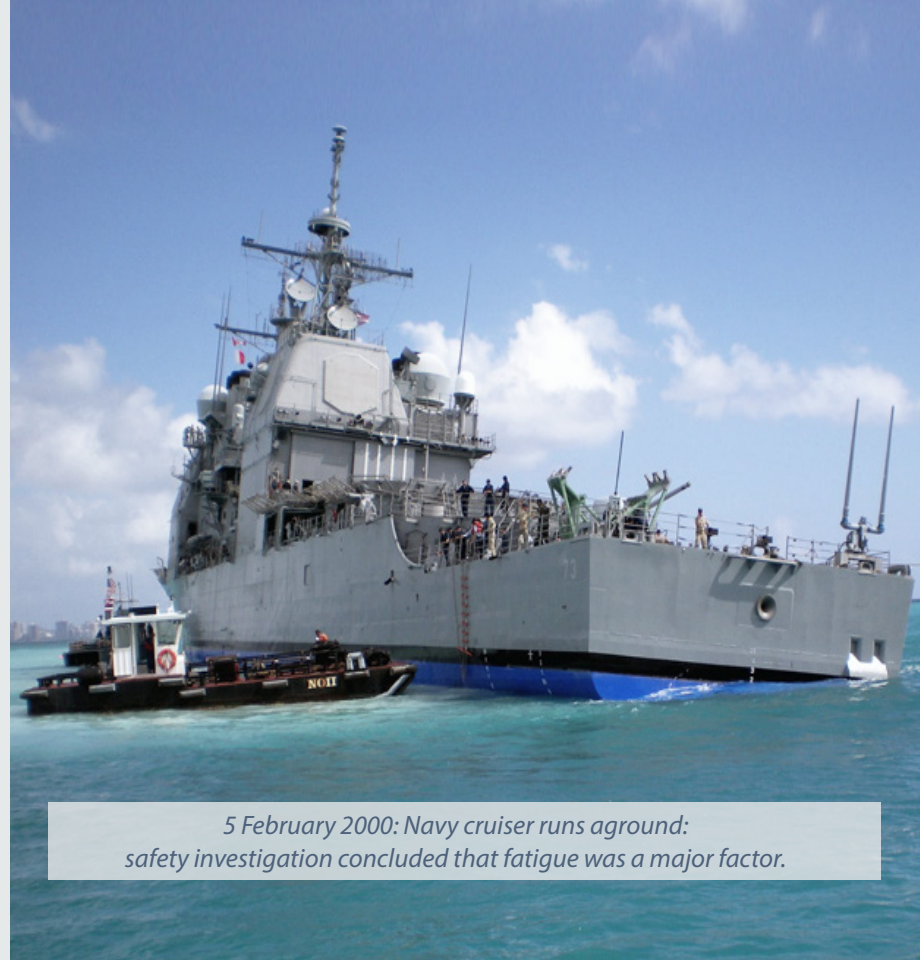
- Hold quarters later in the day—before lunch.
Or, do not require quarters in the mornings for all hands.
Consider midday quarters/Officers-call.
- Establish mandatory “protected sleep” periods for each watch rotation, i.e., “protected” from scheduled meetings, training, drills, etc.
- Maximize protected sleep periods prior to night watches.
- For divisions with less manning, consider splitting the division between “pure” watchstanders and standard “work force” for PMS and maintenance. These roles (not the watch schedule) can be swapped every week to maintain proficiency.
- Eliminate reveille call to allow early morning watchstanders to sleep in.
- Eliminate taps, allowing watchstanders who are sleeping to remain asleep.
- Move evening prayer to lunchtime.
- Hold admin meetings between 0900 and 1600. Meal hours need to cover turnover times, ideally an hour on either side.
- Add a healthy “midnight snack” at 0000 for night watch teams.
- Hold the Ops/ Intel brief in the afternoon.
- Provide individual watchstanders periods for mixed personal and work time.

Codify Business Rules in Ship’s Instruction.
Build Daily Routines to Support Watch Teams—
Vice Asking Watch Teams to “Adapt” to Schedule.

WORST PRACTICES (Based on actual stories & feedback)

...Had bad experiences on “my ship” because I/we:

- Didn't adjust the daily routine to accommodate night watchstanders
- Required the night watch teams to attend morning quarters
- Held meetings right after breakfast or after dinner that require attendance by watch standing personnel who are scheduled to be asleep
- Ignored “off-duty time” by calling off-watch personnel while they are sleeping
- Refused delegation of duties by CO/XO to Department Heads
- Refused to allow delegation of duties by Department Heads to principal assistants
- Tried to apply the same watch template to all situations
- Didn't seek frequent feedback from watch standers and other crew.



*5 February 2000: Navy cruiser runs aground:
safety investigation concluded that fatigue was a major factor.*

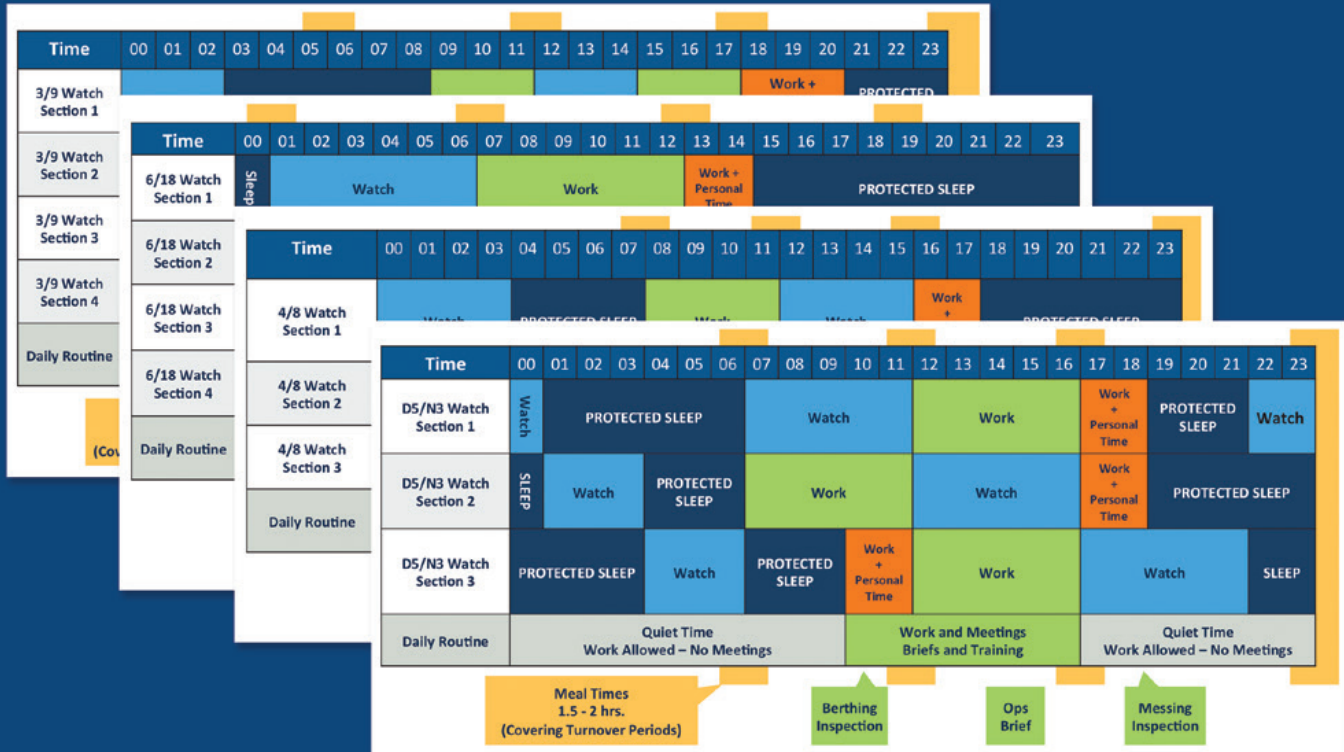
TEMPLATES FOR THE CIRCADIAN WATCH ROTATIONS

In the next several pages, we present the basic templates for some circadian watch rotations, the 3/9, 6/18, 4/8, and D5/N3. For each watch rotation, we describe its basic characteristics, we show a diagram with the notional workday routine for each section, and identify basic pros and cons.

The watch rotation diagrams split the daily routine into watch/work periods, protected sleep periods, and personal time.

A Watch-Rotation Template Can Help with Implementation Aboard Your Ship.

- Meal hours are adjusted to cover turnover times with 1.5 - 2 hour duration.
- Recommended Messing and Berthing times—may need to be adjusted for meal times.
- Recommended Ops Brief times—hold in afternoon.
- Watches (Blue)—does not include pre-watch tour and turnover time.
- Work period (Green) may vary slightly by division or based on tasking.
- Personal Time (Orange) may need to be tailored by division.
- Protected Sleep periods (Dark Blue)—no meetings or routine training events. Consider scheduling UNREPS/Flight Ops, etc., around these periods.



THE 3/9 CIRCADIAN WATCH ROTATION

Characteristics

- Requires 4 watch sections. If the entire ship cannot support 4 sections, focus on control stations—OOD, EOWW, TAO to ensure there are well-rested decision makers.
- Teams stand same 2 watches each day (for example, 12-03 and 00-03).
- When rotating to a new shift, each shift rotates forward one watch by extending watches by 1 hour on rotation days. Limit the “spin” of the rotations or align with port visits so that everyone gets into the routine. Three weeks or more is better.
- Protect the sleep periods of day sleepers and encourage crew to sleep at least 7 hours each day.
- Meal hours may need to be adjusted to support hot meals for all rotations. Consider a late night hot meal too.

Pros

- Meals every 6 hours
- Shorter watches so watch standers are more alert
- Sailors in 3 of the 4 Watch Sections have the opportunity for a single sleep period of 7 hours or more.

Cons

- More frequent watch turnover
- Split sleep periods are required for Watch Section 1.

Example 3/9 Circadian Watch Rotation and Daily Routine

Time	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3/9 Watch Section 1	Watch			PROTECTED SLEEP						Work			Watch			Work			Work + Personal Time			PROTECTED SLEEP		
3/9 Watch Section 2	PROTECTED SLEEP			Watch			Work + Personal Time		Work						Watch			PROTECTED SLEEP						
3/9 Watch Section 3	PROTECTED SLEEP						Watch		Work						Work + Personal Time			Watch		PROTECTED SLEEP				
3/9 Watch Section 4	PROTECTED SLEEP									Watch			Work						Work + Personal Time			Watch		
Daily Routine	Quiet Time Work Allowed – No Meetings									Work and Meetings Briefs and Training									Quiet Time Work Allowed – No Meetings					

Meal Times
1.5 - 2 hrs.
(Covering Turnover Periods)

Berthing
Inspection

Ops
Brief

Messing
Inspection

THE 6/18 CIRCADIAN WATCH ROTATION

Characteristics

- Requires 4 watch sections.
- Teams stand same watch each day (for example, 01-07).
- When rotating to a new shift, each shift rotates forward.
- Limit the “spin” of the rotations or consider aligning rotation with port visits so that everyone gets into the routine. Three weeks or more is better.
- Protect the sleep periods of day sleepers and encourage crew to sleep at least 7 hours each day.
- Meal hours may need to be adjusted to support hot meals for all rotations. Consider a late night hot meal too.

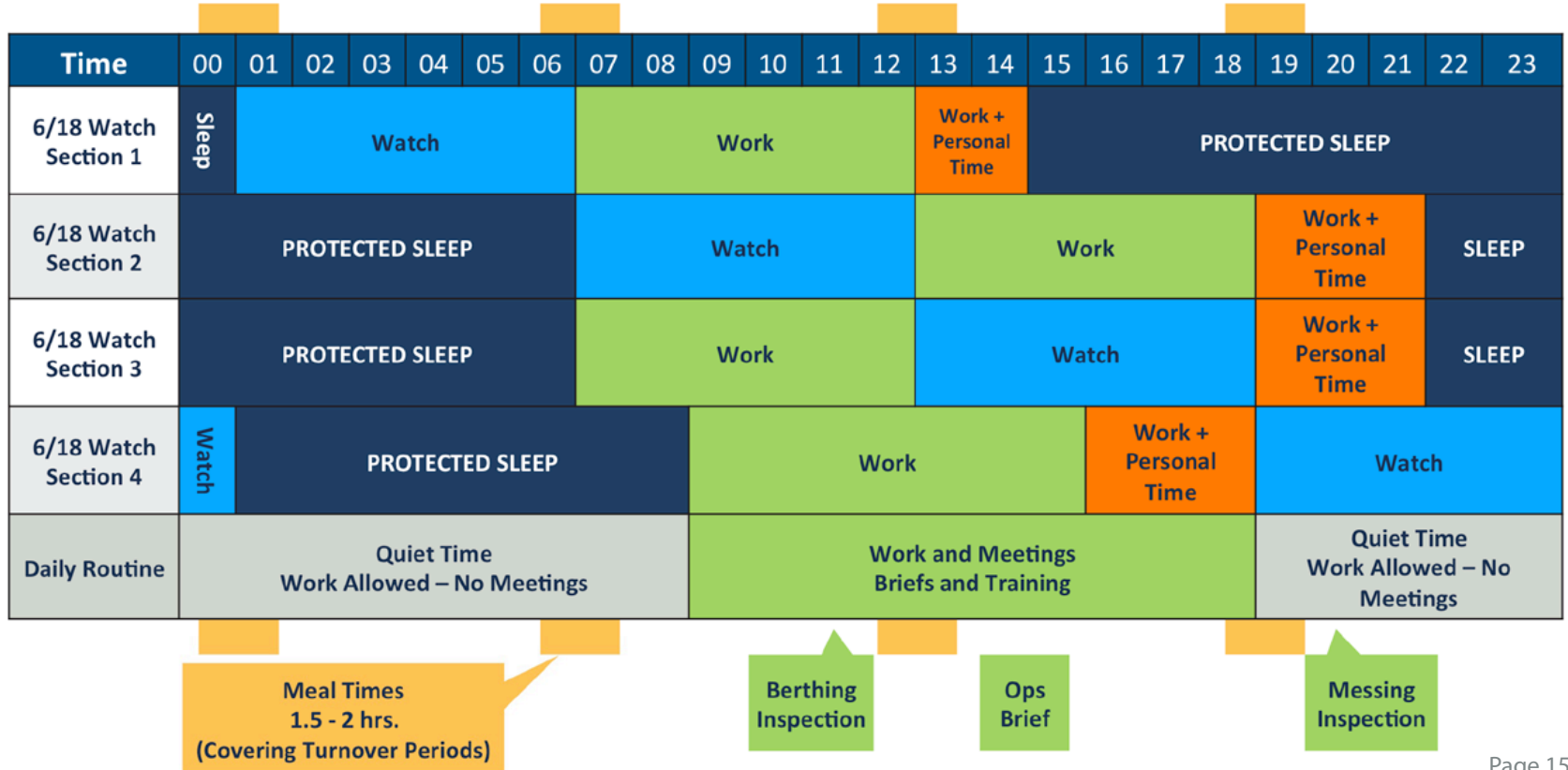
Pros

- Sailors in Section 1 are allowed to get 2 extra hours of sleep to compensate for sleep loss due to night shiftwork.
- Sailors in all sections sleep in one contiguous period.
- Meals every 6 hours.

Cons

- Long duration watches.
 - » Watches are 6 hours long, which may be too long for some watches.

Example 6/18 Circadian Watch Rotation and Daily Routine



THE 4/8 CIRCADIAN WATCH ROTATION

Characteristics

- Requires 3 watch sections.
- Teams stand same 2 watches each day (for example, 00-04 and 12-04).
- When rotating to a new shift, each shift rotates forward by one watch every 3+ weeks or consider aligning rotation with port visits.
- Limit the “spin” of the rotations so that everyone gets into the routine.
- Protect the sleep periods of day sleepers and encourage crew to sleep at least 7 hours each day.
- Meal hours may need to be adjusted to support hot meals for all rotations. Consider a late night hot meal.

Pros

- Sailors in Watch Section 1 are allowed to get 2 extra hours of sleep to compensate for sleep loss due to night shiftwork.

Cons

- Sailors in Watch Section 1 have to split their sleep into 2 periods.
- Meals (breakfast, lunch, dinner) are served every 4 hours rather than the more conventional 6 hour delay between lunch and dinner.
- Early dinner.
- Requirement for mid-rats for Sailors who are sleeping during dinner hours.
- Ops brief after the early dinner.

Example 4/8 Circadian Watch Rotation and Daily Routine

Time	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
4/8 Watch Section 1	Watch				PROTECTED SLEEP				Work				Watch				Work + Personal Time		PROTECTED SLEEP						
4/8 Watch Section 2	PROTECTED SLEEP				Watch				Work				Work + Personal Time				Watch				PROTECTED SLEEP				
4/8 Watch Section 3	PROTECTED SLEEP								Watch				Work				Work + Personal Time				Watch				
Daily Routine	Quiet Time Work Allowed – No Meetings								Work and Meetings Briefs and Training								Quiet Time Work Allowed – No Meetings								

Meal Times
1.5 - 2 hrs.
(Covering Turnover Periods)

Berthing
Inspection

Ops
Brief

Messing
Inspection

THE D5/N3 CIRCADIAN WATCH ROTATION

Characteristics

- Requires 3 watch sections.
- Teams stand same 2 watches each day (for example, 01-04 and 12-17).
- When rotating to a new shift, each shift rotates forward every 3+ weeks or consider aligning rotation with port visits.
- Limit the “spin” of the rotations so that everyone gets into the routine.
- Protect the sleep periods of day sleepers and encourage crew to sleep at least 7 hours each day.
- Meal hours may need to be adjusted to support hot meals for all rotations. Consider a late night hot meal too.

Pros

- Short duration watches at night when Sailors are at their circadian low point and have the most trouble staying alert.
- Section 3 allowed to sleep until 1000 to support working the night shift.

Cons

- Sailors in all watch sections are required to split their sleep into 2 periods.
- Early dinner.

Example D5/N3 Circadian Watch Rotation and Daily Routine

Time	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
D5/N3 Watch Section 1	Watch	PROTECTED SLEEP						Watch					Work					Work + Personal Time	PROTECTED SLEEP			Watch		
D5/N3 Watch Section 2	SLEEP	Watch			PROTECTED SLEEP			Work					Watch					Work + Personal Time	PROTECTED SLEEP					
D5/N3 Watch Section 3	PROTECTED SLEEP			Watch			PROTECTED SLEEP			Work + Personal Time		Work					Watch				SLEEP			
Daily Routine	Quiet Time Work Allowed – No Meetings										Work and Meetings Briefs and Training							Quiet Time Work Allowed – No Meetings						

Meal Times
1.5 - 2 hrs.
(Covering Turnover Periods)

Berthing
Inspection

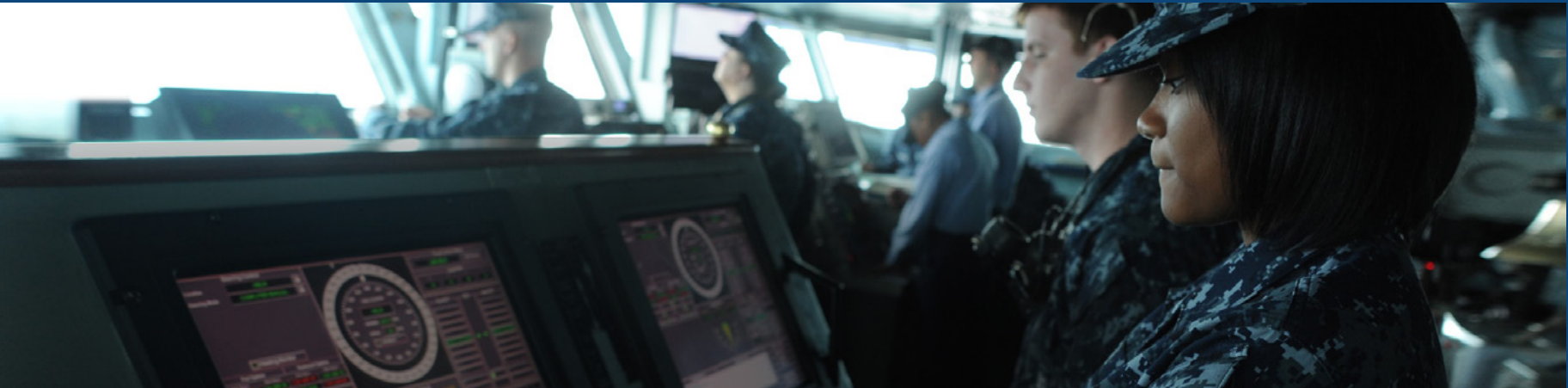
Ops
Brief

Messing
Inspection

OUR VISION

- To enable individuals and their commands to design their daily work and rest schedules to achieve better crew endurance, healthier quality of life, and optimal combat effectiveness.
- To highlight the benefits of establishing a watch schedule, based on circadian rhythms, that improves the work/rest patterns of Sailors, thereby increasing the endurance and readiness onboard Navy ships with minimal cost and disruption to a command.

**Improving Crew Endurance
Using a Circadian Watch Rotation
Optimizes Crew Performance
and Combat Readiness.**



MORE INFORMATION

Visit our Crew Endurance Website—a central resource for Commanders and their staff to identify and implement policies, procedures, and watch rotations proven to reduce fatigue levels.

This site offers tools, resources, and instructions for implementing more effective watch rotations and improving Crew Endurance. Here's a summary of the site content:

- Explanation of circadian rhythms and circadian watch bills
- Best practices and guiding principles to design a schedule tailored to your command
- Sample watch rotations proven to support healthy work and rest schedules
- Sample command instructions for implementing a circadian watch bill
- A Commander's Plan of Action and Milestones
- Resources to help recognize and mitigate stress-related fatigue
- Testimonials and lessons learned from ships using circadian-based watch schedules.

<http://my.nps.edu/web/crewendurance>



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