

Furniture Design and Standardization For Indian Navy

Susovan Gupta

Guided By Prof. B. K. Chakravarthy



Acknowledgment

To start with, I would like to thank my Guide Prof. B. K. Chakravarthy for his constant motivation and invaluable advice. His guidance and time-to-time inputs gave me a larger perspective to look at.

I would also like to take this opportunity to sincerely express my deepest gratitude to those persons who full-heartedly supported and helped me achieve the success of this project.

Also, I like to convey great respect and gratitude to Prof. Purba Joshi and Prof. Avinash Shende for such invaluable insights and ideas.

My special thanks to my friend Mugdha Dengle, Hazique Kola and my parents for supporting me throughout this project journey.

In the end, I would like to thank the workshop staff of IDC for their kind cooperation and help.

Signature:

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Roll No.: 2161300006

Date: 05/06/2023

Introduction

The Indian Navy is the fifth largest navy in the world, with a vast and complex operation and outreach beyond just the Indian Ocean. They have 67,252 active personnel and 75,000 in reserve, and conduct numerous training operations every year, including more than 140 international joint war practices over the years. The Indian Navy plays a crucial role in protecting maritime security, and it is essential to prioritize the well-being and comfort of the men and women who serve at sea.

It is important to note that India is a fast-growing country and its defense organizations, such as the Navy, Airforce, and Army, need to be constantly updated and maintained. However, the problem arises with the organic growth of the defense supply and indigenously built defense equipment.

As India now starts making indigenous defense equipment, the requirement of a standard is more important than ever. The basis of Indian defense standards is heavily influenced by UK standards. However, as India continued to import from Russia and other countries, the inconsistency in standards became very clear. Furthermore, there is a need for Indian mind-set-based design considerations.

To address these issues, in collaboration with naval experts, interior designers, and manufacturing partners, we embark on a comprehensive exploration of modern furniture design principles that align with the rigorous requirements of naval vessels. By incorporating cutting-edge aesthetics, ergonomics, and functionality, our furniture solutions will create a more inviting and functional environment within the limited space available.

About Hindustan Shipyards



Hindustan Shipyard Ltd (HSL), set up in the year 1941, strategically located on the East Coast of the Indian peninsula, at Visakhapatnam, Andhra Pradesh, is the nation's premier ship-building organization catering to the needs of shipbuilding, ship repairs, submarine construction and refits as well as design and construction of sophisticated state-of-the-art offshore and onshore structures. Direct sea access, excellent infrastructure, skilled work force, rich expertise garnered over the years in building 200 vessels, refitting 5 submarines and repairing 2000 vessels of various types enable HSL to offer competent services for the defense and maritime sectors.

Initial Communication

Hindustan Shipyard Ltd. (HSL) extended warm greetings and presents an initial brief for a project aiming to standardize the furniture and hull fittings used on board Indian Naval Ships. As a renowned organization involved in the construction and refit of Indian Naval vessels and submarines, HSL recognizes the need for uniformity in these essential elements across different shipyards. This project seeks to collaborate with IDC of IIT Bombay and the Indian Furniture Manufacturers Association to address key issues and develop standardized solutions.

Objective

The primary objective of this project is to establish standardized furniture and hull fittings for Indian Naval Ships, ensuring consistency and efficiency in their construction and accommodation spaces. By streamlining the design and manufacturing processes, the project aims to enhance habitability, optimize space utilization, and adhere to necessary safety and fire-retardant regulations.

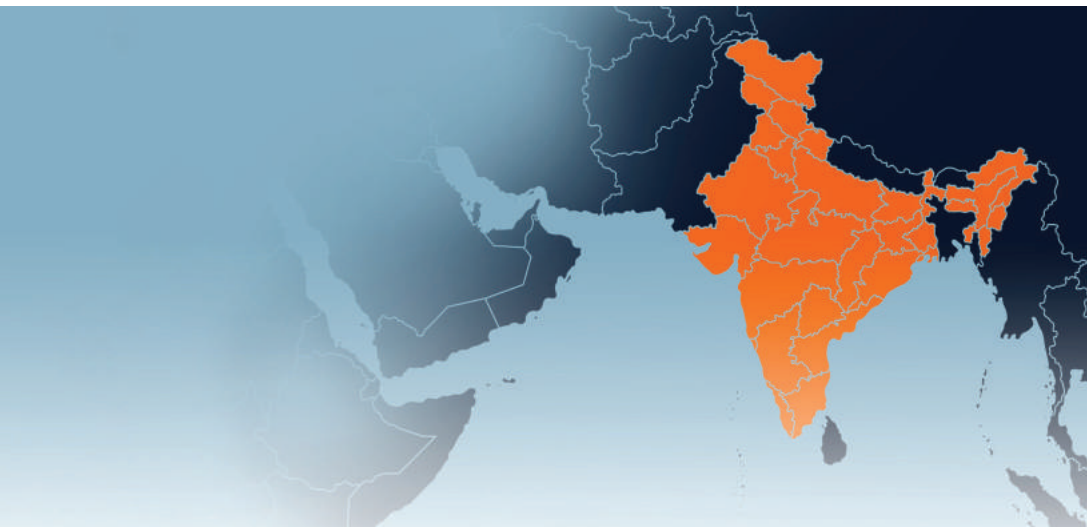
Scope

Standardized Furniture: Develop a comprehensive list of furniture items, along with their specifications, for officers' cabins, sailors' messes, wardrooms, and recreation spaces onboard Naval Ships. The materials used shall comply with the IMO FTP code 2010, with CRCA steel as the preferred choice, accompanied by appropriate marine-grade powder coating. Fire retardant upholstery for sofas, mattresses, and curtains is essential.

Bulkhead-mounted Fittings: Explore the feasibility of transitioning from deck-mounted to bulkhead-mounted fittings, such as bunks, tables, amenity panels, wardrobes, and drawers. This shift will optimize space utilization in the limited accommodation areas of naval ships and minimize the need for rework during construction.

Modular and Multipurpose Furniture: Investigate the potential for developing modular or multipurpose furniture designs that maximize space efficiency without compromising functionality. Such designs will enable multiple applications within a single furniture unit, reducing the overall space requirements on naval platforms.

Standardization of Hull Fittings: Collaborate with Indian Navy and Coast Guard to standardize all hull fittings, including ladders and other essential elements, across Indian Naval Ships. This will ensure consistency and ease of maintenance throughout the fleet.



About Indian Navy

About Navy

Introduction

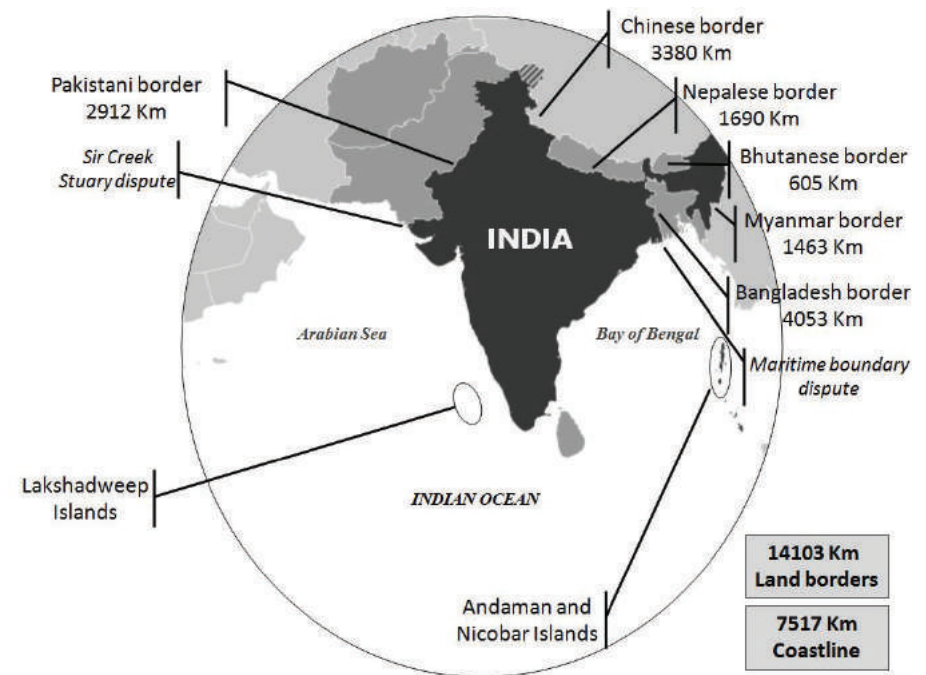
The Indian Navy (IN) stands as a formidable maritime force, upholding the honor and sovereignty of our great nation. Guided by the leadership of the Supreme Commander, the President of India, and commanded by the distinguished Chief of Naval Staff, it represents the epitome of strength and dedication.

As a blue-water navy, the Indian Navy operates across vast oceans, including the Persian Gulf Region, the Horn of Africa, and the Strait of Malacca. With a resolute commitment to ensuring maritime security, the navy conducts anti-piracy operations and engages in collaborative efforts with regional navies. Its presence is felt in the South and East China seas, as well as the western Mediterranean, reinforcing India's standing as a proactive maritime power.

The primary mission of the Indian Navy is to safeguard our nation's maritime borders and protect the interests of the Indian people. In times of both peace and conflict, the navy acts as a deterrent and a resolute force, working in conjunction with the other branches of the Indian Armed Forces. Through joint exercises, goodwill visits, and humanitarian missions, including disaster relief operations, the Indian Navy builds bridges and strengthens bilateral relations with nations around the world.

With a commendable strength of active and reserve personnel, the Indian Navy boasts an impressive fleet comprising 150 ships and submarines, along with 300 aircraft. Notably, it possesses two active aircraft carriers, amphibious transport docks, destroyers, frigates, submarines, corvettes, and other advanced vessels. This multi-regional power projection capability underscores the navy's ability to operate effectively across vast maritime domains.

The Indian Navy's indomitable spirit, professionalism, and unwavering commitment to excellence make it an indispensable component of our national defense. It stands as a symbol of our maritime heritage, protecting our maritime borders, advancing our interests, and upholding the values and aspirations of a resurgent India.



The Navy has the following three Commands, each under the control of a Flag Officer Commanding-in-Chief:-

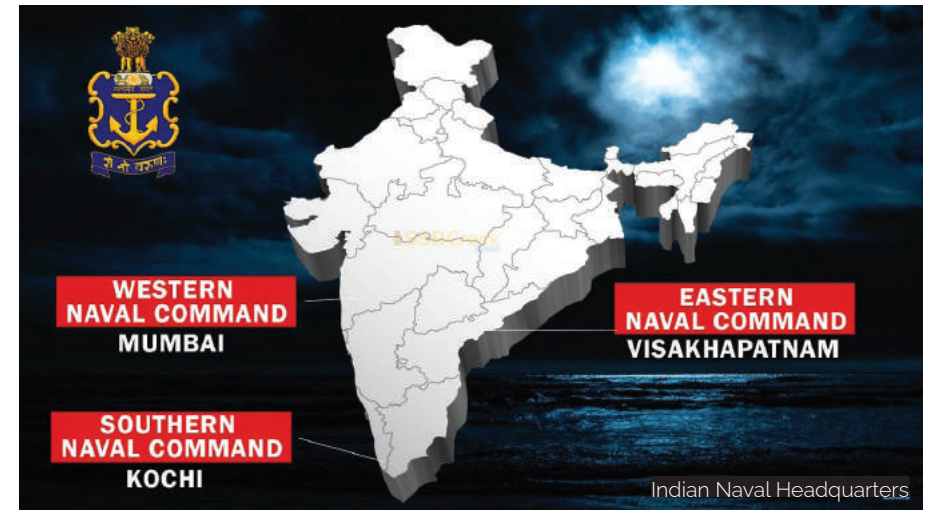
The Western Naval Command (Headquarters at Mumbai).

The Eastern Naval Command (Headquarters at Visakhapatnam)

The Southern Naval Command (Headquarters at Kochi)

Command and organization

The Indian Navy is headed by the Chief of Naval Staff (CNS), who holds the rank of Admiral, with the President of India serving as the Supreme Commander of the Armed Forces. The CNS is supported by the Vice Chief of Naval Staff (VCNS) and other principal staff officers. The navy operates with two operational commands, Eastern and Western, each headed by a Flag Officer Commanding-in-Chief (FOC-in-C) of the rank of Vice Admiral. These commands have fleets commanded by Rear Admirals and Commodores commanding submarines. The Andaman and Nicobar Command, a unified theater command, includes the Navy, Army, Air Force, and Coast Guard under the Commander-in-Chief, reporting to the Chairman Chiefs of Staff Committee (COSC). The Southern Naval Command is home to the Flag Officer Sea Training (FOST). The organizational structure also includes key positions such as the Deputy Chief of Naval Staff, Chief of Personnel, Chief of Materiel, and Director General Medical Services (Navy).



Guard of honor at the INA, 2012.



Rank structure

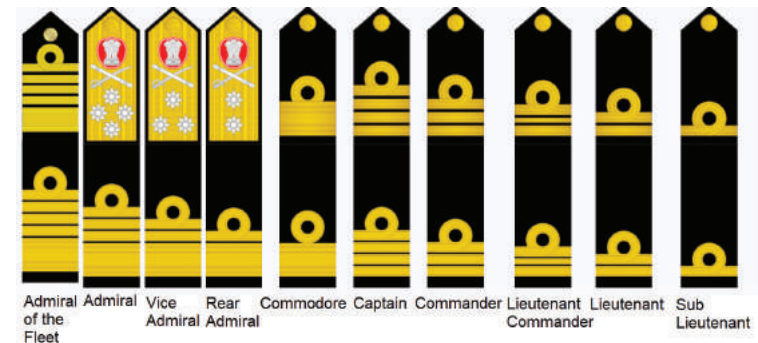
COMMISSIONED RANKS OF INDIAN NAVY

- Admiral of the Fleet: Highest honorary rank in the Indian Navy, no officer has held this rank yet.
- Admiral: Commander-in-Chief and highest-ranking officer in the Indian Navy.
- Vice Admiral: Senior flag officer rank, senior to Rear Admiral and junior to Admiral.
- Rear Admiral: Lowest "admiral" rank, superior to Commodore and below Vice Admiral.
- Commodore: Naval rank superior to Captain and below Rear Admiral.
- Captain: Rank equal to the army's colonel, used for naval officers commanding a ship.
- Commander: Rank equal to an army lieutenant colonel, officer commanding any armed forces unit.
- Lieutenant Commander: Commissioned officer rank above Lieutenant and below Commander.
- Lieutenant: Commissioned officer rank, typically the most senior junior officer rank.
- Sub Lieutenant: Commissioned officer rank below Lieutenant.



NON-COMMISSIONED RANKS OF INDIAN NAVY

- Petty Officer: A petty officer is a non-commissioned officer in the Indian Navy. This rank is equivalent to a sergeant in the Indian Army and Indian Air Force.
- Leading Seaman: Leading seaman is a non-commissioned rank i.e. equivalent to the air force rank of corporal.
- Seaman 1 and 2: Seaman is a naval rank and is the lowest ranks in most navies around the world.



JUNIOR – COMMISSIONED RANKS OF INDIAN NAVY

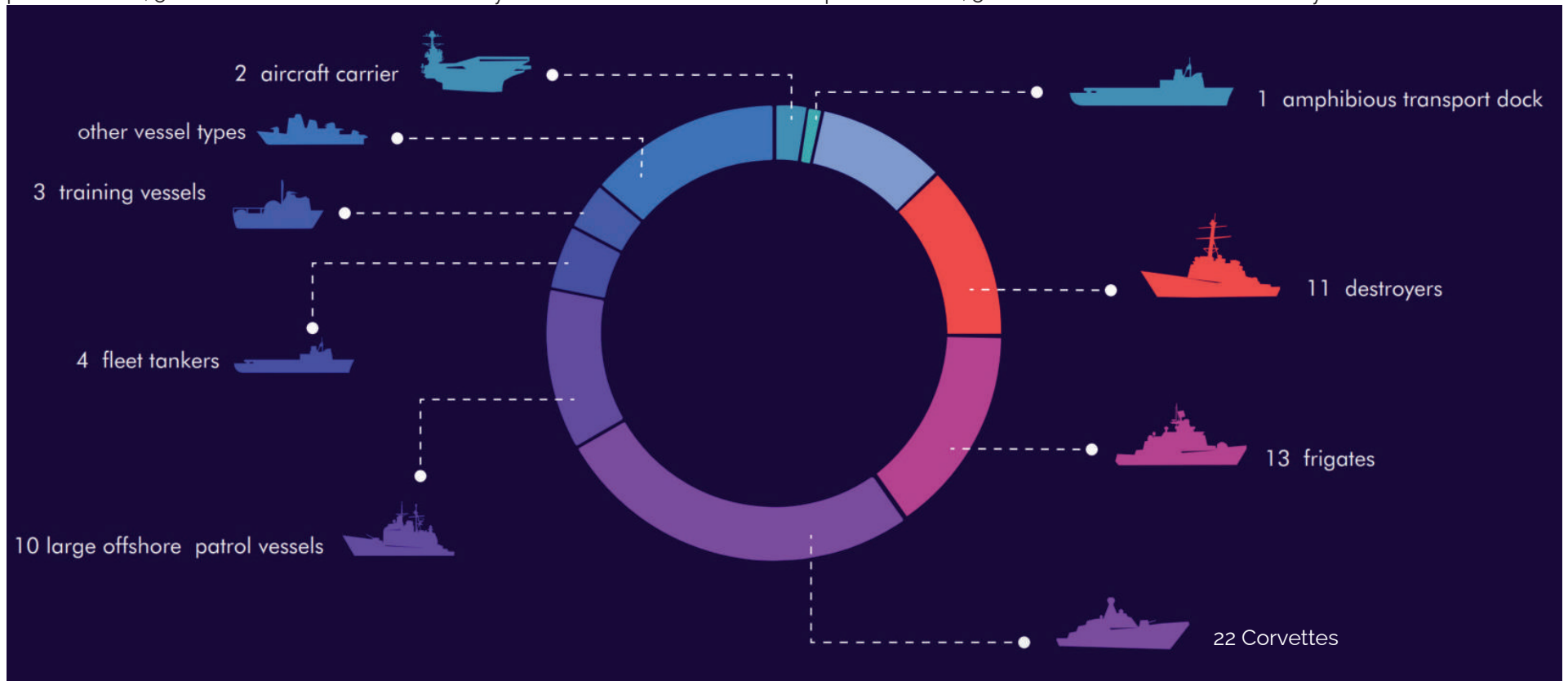
- Master Chief Petty Officer (1st Class): Highest rank of junior commissioned officer in the Indian Navy.
- Master Chief Petty Officer (2nd Class): Junior commissioned officer rank based on seniority.
- Chief Petty Officer: Lowest junior commissioned rank, responsible for training junior officers and leading their division.



Indian Navy Fleet

List of active Indian Navy ships is a list of ships in active service with the Indian Navy. In service ships are taken from the official Indian Navy web-site. As of July 2022, the Indian Navy possesses 2 aircraft carriers, 1 amphibious transport dock, 8 Landing ship tanks, 11 destroyers, 12 frigates, 2 Nuclear-powered ballistic missile submarine, 16 conventionally powered attack submarines, 22 corvettes, 8 Landing Craft Utility, 10 large offshore patrol vessels, 5 fleet tankers and various auxiliary vessels and small

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Arihant Class Submarine



Sindhughosh class Submarine



INS Mumbai (Delhi Class Destroyer)



INS Kolkata (Kolkata Class Destroyer)



INS Vikrant (Aircraft Carrier)



INS Vikramaditya (Aircraft Carrier)



INS Satpura(Shivalik Class Frigate)



INS Talwar (Talwar Class Frigate)



INS Jalashwa (Amphibious warfare ships)



INS Shardul (Landing ship tanks)



INS Kavaratti (Kamorta Class Corvette)



INS Kulish(Kora Class Corvette)

Future of the Indian Navy

The Indian Navy is focusing on developing indigenous platforms, systems, sensors, and weapons to modernize and expand its maritime forces. Currently, it has 45 vessels of various types under construction, including destroyers, frigates, corvettes, submarines, and other ships. The goal is to build a strong navy of 200 vessels and 500 aircraft by 2050. The Indian Navy has transitioned from being a buyer's navy to a builder's navy.

Due to increased Chinese naval activity in the Indian Ocean region, the Indian Navy is investing more in anti-submarine ships like the Kamorta-class corvette, long-range maritime reconnaissance aircraft such as the Boeing P-8 Poseidon, and vessels like the Saryu-class patrol vessel. Unmanned aerial vehicles like the IAI Heron-1 are also being utilized. However, the lack of a strong submarine fleet has somewhat limited its capabilities.

Following Chinese intrusions into Ladakh in 2020, the Indian Navy plans to upgrade military facilities in the Andaman and Nicobar Islands and Lakshadweep. The aim is to establish a network of island airbases in the Arabian Sea and the Bay of Bengal, ensuring freedom of navigation and overflight for all Indian territories.



Nuclear Submarines:

Arihant class - Ballistic missile submarine - 1 planned
S5 class - Ballistic missile submarine - 3 planned
Chakra III (Akula) class - Nuclear-powered attack submarine 1 planned
Project 75 Alpha - Nuclear-powered attack submarine - 6 planned

Conventional Submarines:

Kalvari class - Attack submarine - 1 planned
Project 75I class - Attack submarine - 6 planned
Project-76 class - Attack submarine - under design phase

Aircraft carriers:

IAC-1 Class - 1 planned
INS Vishal - planned

Amphibious warfare ships:

Future Landing Platform Dock (LPD) - 4 planned
High Speed Landing Craft - 6 planned

Destroyers:

Project 18 - 8 in service
Visakhapatnam class - 2 in service, 2 launched

Frigates:

Nilgiri class - 7 (5 launched, 2 under construction)
Talwar class - 4 (1 launched, 3 under construction)

Corvettes:

Anti Submarine Warfare Shallow Water Craft - 16 (3 launched, 13 under construction)
Next Generation Missile Vessels - 6 planned
NGC (Next-Gen Corvette) - 8 planned

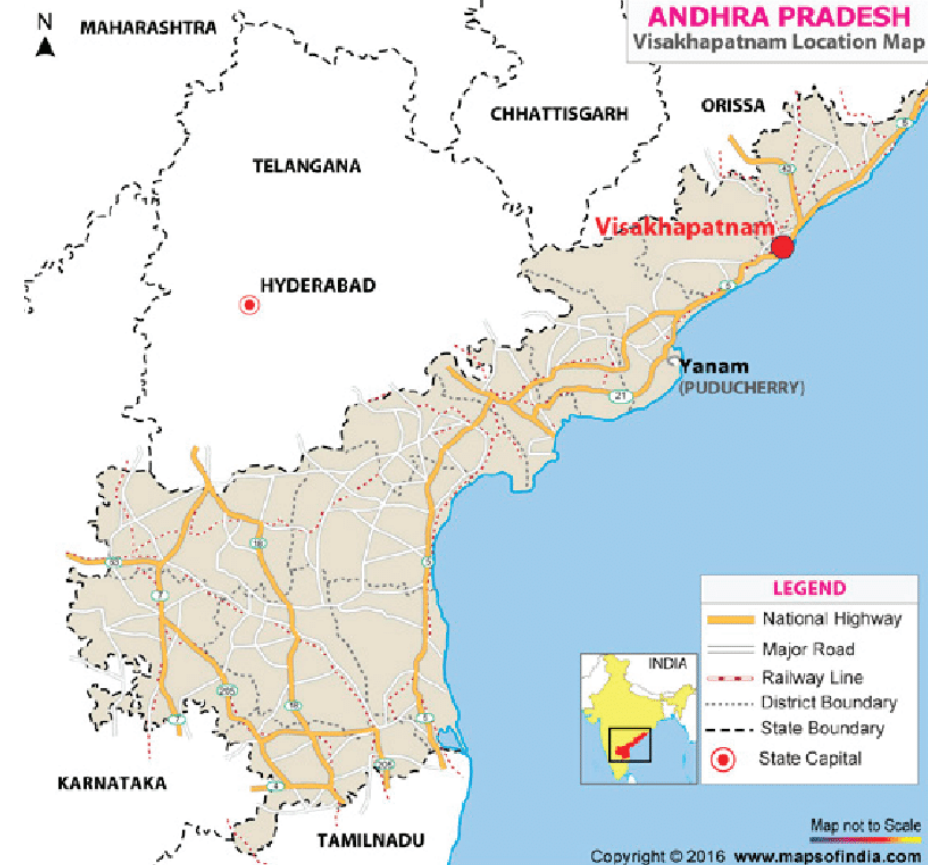
Visit to Vizag

Visit to Visakhapatnam

My visit to the Hindustan Shipyard Limited in Vizag was an eye-opening experience that greatly enriched my understanding of ship habitability and the construction of surface warships. I had the privilege of engaging in direct discussions with the Deputy General Manager and lead designers, which provided valuable insights into their expertise. Furthermore, I had the unique opportunity to experience life onboard a submarine and a Support Vessel of Indian Naval Ships, which offered a firsthand understanding of their operational environments. Additionally, meeting with Navy Officer Lt. Crd. Sai Sabarish and receiving input from Admiral Sreenivas (Retd.) added significant depth to my project. Overall, this visit was truly remarkable and has broadened my perspective in numerous ways.

Key Experiences

- I had direct discussion with DGM and Lead designers of Hindustan Shipyard
- Onboard experience inside submarine
- Onboard experience inside Support Vessel of Indian Naval Ships.
- Had a meeting with Navy Officer Lt. Crd. Sai Sabarish.
- Had great input from meeting with Admiral Sreenivas (Retd.) Regarding this project.



On board S61 Sindhukirti

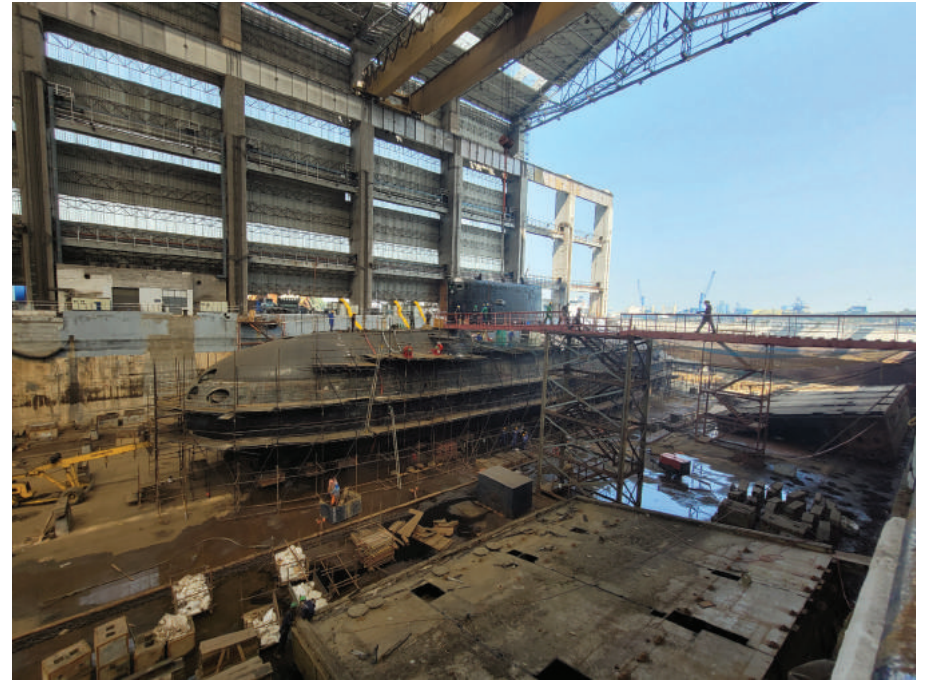
India's Kilo-class submarine, INS Sindhukirti, holds a significant place in the country's naval fleet. Derived from a design that originated during World War II, the Kilo-class submarines are known for their exceptional underwater capabilities. It is a product of Russian design and manufacturing excellence. The submarine was originally built in Russia and commissioned into the Indian Navy in 1990 as part of a series of acquisitions from Russia during the 1980s and 1990s. The Kilo-class submarines are known for their stealth capabilities and advanced technology. With its excellent underwater endurance and firepower, INS Sindhukirti has played a crucial role in strengthening India's maritime defense capabilities. Its history and Russian design heritage make it a formidable asset in India's naval fleet, contributing to the nation's security and strategic interests.

- It's a S61 Sindhugosh Class submarine.
- It's a Russian made submarine from World War II.
- It's a diesel electric powered submarine.
- It can host up to 100 men max while training and 65 men in normal sails.
- Maximum endurance up to 45 days.
- Maximum depth 300 meters
- Maximum operational time before charging is 8 hours.
- It has a two hull design for better safety.





- 6 Torpedo tubes
- 2 Retractable fins
- Single propellor
- 74 Meter in length



- It has three main decks
- Top deck is for operations and accommodation
- Mid deck is for weapons and control
- Bottom Deck for Storage

Sailor's Cabin



- 6 Bunk Cabin
- No amenities for sailors
- Extremely short overhead
- Narrow passage
- Bunk to Bunk height is very little

Executive Officer's Cabin



- 2 Bunk in a cabin
- Basic amenities for officers
- Extremely short overhead
- Comparatively broad passage
- Bunk to bunk height is adequate

Chief commander's cabins



- 1 Bunk in a Cabin
- Good amenities for commander
- Decent overhead space
- Comparatively broad passage
- Mostly wooden furniture

WC in Submarine



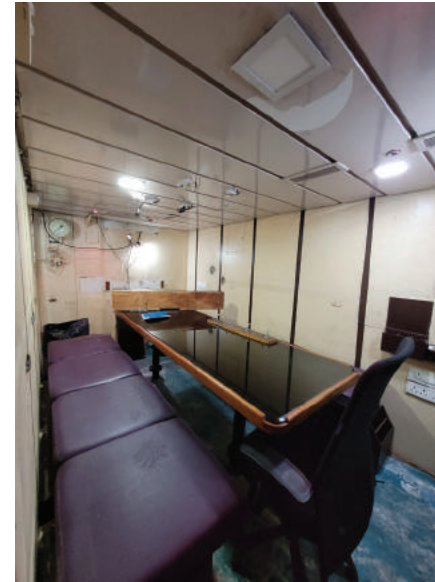
- Only 2 water closet present
- SS panel for easy maintenance
- Extremely cranked up space
- Very risky flushing mechanism
- No luxury of bathing

Sailor's Galley



- Bare minimum Lighting
- Tilted ceiling and no paneling
- Basic SS kitchen Items
- No seating area provided
- Machinery seen everywhere

Officer's Galley & Dining Space



- Better Lighting
- Better paneling all around
- Premium material used
- Comfortable seating area
- Ergonomic chair for CO



On board Diving Support Rescue Vessel

It's a Indian naval ship that is still in the process of making.
After the deck is made the ship is then released to water and then the further making process starts.
This ship is made till bulkheads and basic fittings.
Hatches, ladders and railings are made.
Door openings are made but no door is fitted.
No furniture and equipment are installed till the time I visited.



Inclined Ladders on INS

- Inclination angle 50° to 60°
- Step to step dist. 230mm
- Footrest is 150mm to 250mm
- Shoe hits when stepping down
- Shoe fits only half for tall men
- While going down head touches the hatch
- Bolted ladders are desired
- Bolted ladders can be easily repaired
- Ladder and hatch to be on the opposite plane
- Step to step height can be also adjusted



Vertical Ladders on INS

- Hatch is supposed to be held on bulkhead
- Handles can be installed in the bulkhead
- Step width can be modified
- Ladder and hatch to be on the same plane
- Hatches have mechanism to lock itself



Visit to Mumbai Naval Dockyard

Visit to Mumbai Naval Dockyard

The Mumbai Naval Dockyard, situated in Mumbai, India, is a prominent naval facility that plays a vital role in the operations and development of the Indian Navy. With its rich history dating back to the 18th century, the dockyard has been a cornerstone of maritime defense and shipbuilding in the region. It serves as a strategic base for the maintenance, repair, and refit of naval vessels, providing critical support to the Indian Navy's fleet. The dockyard boasts state-of-the-art infrastructure, advanced shipbuilding facilities, and skilled personnel, enabling it to undertake complex projects and ensure the operational readiness of naval assets. Over the years, the Mumbai Naval Dockyard has undergone continuous modernization and expansion to meet evolving defense requirements and technological advancements. It remains a key institution in strengthening India's maritime capabilities and safeguarding its national security interests.



INS TABAR (Frigate)

INS Tabar (F44), meaning "battle axe," is the third vessel of the Talwar-class frigates in the Indian Navy. It was commissioned on 19 April 2004 in Kaliningrad, Russia, under the command of Captain (later Vice Admiral) Biswajit Dasgupta. Currently, Captain Mahesh Mangipudi serves as the Commanding Officer (CO) of INS Tabar.

After its commissioning, INS Tabar made its way to its home-port in Mumbai on 31 July 2004. Assigned to the Western Naval Command of the Indian Navy, headquartered in Mumbai, it operates alongside its sister ships INS Talwar ("sword" in Sanskrit) and INS Trishul ("trident" in Sanskrit). This frigate is equipped with advanced capabilities to undertake air, surface, and sub-surface missions. It can operate independently or as part of a larger naval task force.

In recent times, INS Tabar has undertaken successful goodwill missions to various ports in the Persian Gulf. It also participated in the International Fleet Review held at Visakhapatnam. Notably, the ship recently visited Port Louis to join in the celebrations of Mauritius National Day. These engagements highlight the ship's role in fostering international relations and showcasing the Indian Navy's capabilities on a global stage.

Design and performance

INS Tabar, with a displacement of 4,035 tons, offers living conditions comparable to the Royal Australian Navy's Adelaide-class frigates for its crew of 28 officers and 232 sailors. Powered by the Zorya/Mashproekt M7N-1E gas turbine plant, consisting of two DS-71 cruise turbines and two DT-59 boost turbines, INS Tabar can achieve speeds of up to 30 knots (56 km/h; 35 mph). It has a maximum range of 4,850 nautical miles (8,980 km; 5,580 mi) at 14 knots (26 km/h; 16 mph), but at 30 knots (56 km/h; 35 mph), the range decreases to 1,600 nautical miles (3,000 km; 1,800 mi).



INS KOCHI (Destroyer)

INS Kochi (D64) is the second ship of the Kolkata-class stealth guided-missile destroyers, which were developed as part of Project 15A for the Indian Navy. Constructed by Mazagon Dock Limited (MDL) in Mumbai, INS Kochi underwent rigorous sea trials before being commissioned into the Indian Navy on 30 September 2015. The Kolkata-class destroyers are renowned for their advanced stealth features, cutting-edge weaponry, and state-of-the-art technology, making them powerful assets for the Indian Navy. INS Kochi plays a vital role in enhancing India's naval capabilities and safeguarding its maritime interests.

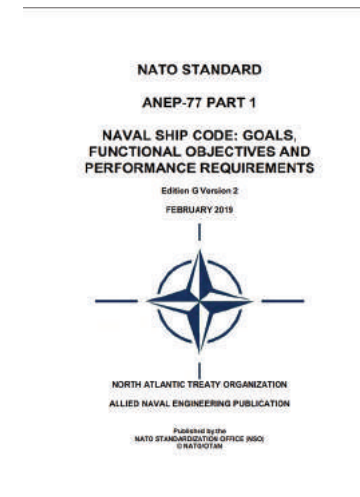
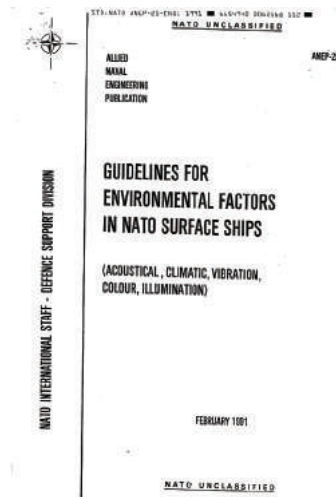
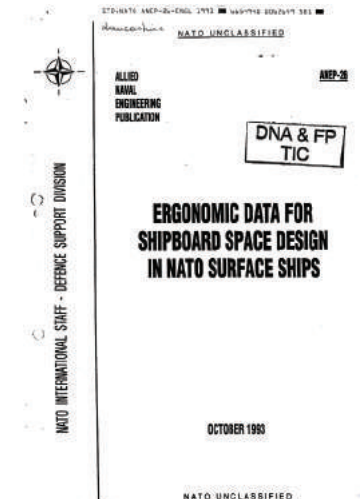
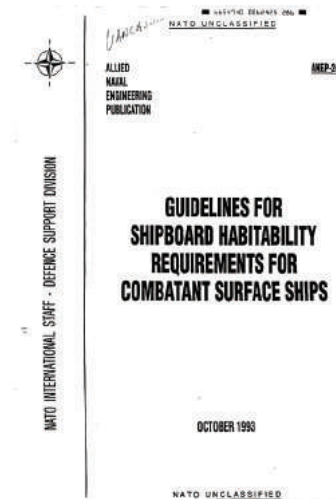
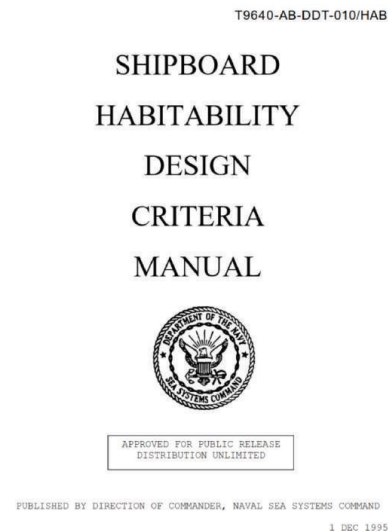
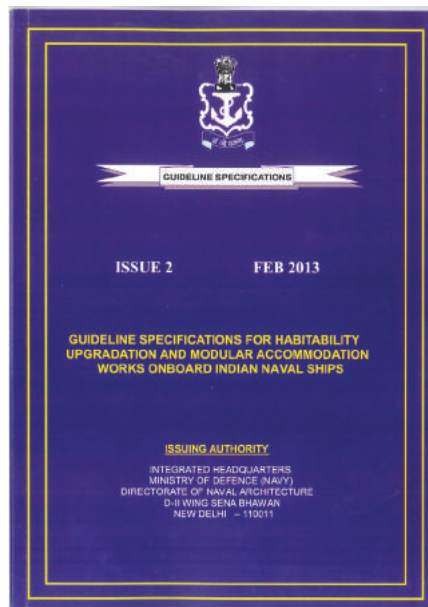


INS Kochi, during its sea trials, showcased its impressive design and features. As the largest warship built in India at the time of its commissioning, INS Kochi boasted a displacement of 7,500 tons. The Navy's in-house organization, the Directorate of Naval Design, spearheaded its design. The ship measures 164 meters (538 ft) in length and 17 meters (56 ft) at the beam. It is powered by four gas turbines, enabling it to achieve speeds exceeding 30 knots (56 km/h). Notably, INS Kochi incorporates advanced stealth features achieved through hull shaping and the use of radar-transparent deck fittings. To enhance sonar acoustic performance, the ship is equipped with a bow-mounted sonar dome, the second of its kind on an indigenous naval platform. With a complement of approximately 40 officers and 350 sailors, INS Kochi stands as a formidable vessel in the Indian Navy.

Literature Study

Standards from different organizations

During the research process I went through several Design Standards from different Organizations. This includes US Navy Testing Standards, NATO Design Standards, American Bureau of Shipping Standards etc. These standards made me understand the defining complexities and lacking in our design standards. I majorly focused on the sailor's mess area for better understanding of the living compartment layout and other quantifying factors like the number of beds and other amenities provided



ANEP 24



VANCAS

NATO UNCLASSIFIED

ANEP-24

GUIDELINES FOR SHIPBOARD HABITABILITY REQUIREMENTS FOR COMBATANT SURFACE SHIPS

OCTOBER 1993

NATO UNCLASSIFIED

STD-NATO ANEP-24-ENGL 1993 ■ 6654940 0062441 429

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ANEP-24

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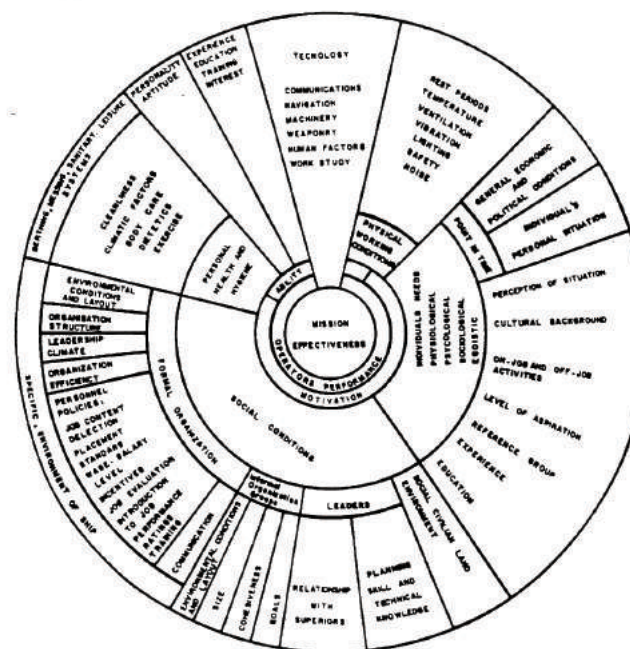


Figure 1.2.2.2

1-6

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Tables

4. Tables should be provided in all dining areas sufficient to provide seating on the following scale:

<u>CO</u>	<u>OFF.</u>	<u>CPO</u>	<u>SEAMEN</u>
8	1 per 1	3 per 4	1 per 2

5. Standard units should be used, seating four, six or eight men and must be capable of being secured to the deck.

6. Small, optionally low level, tables should be provided in recreational spaces on the following scale:

<u>CO</u>	<u>OFF.</u>	<u>CPO</u>	<u>SEAMEN</u>
1	1 per 12	1 per 1	1 per 20

<u>ITEM</u>	<u>CO OFFICERS</u>	<u>CPOs & POs</u>	<u>SEAMEN</u>
<u>Seating</u>			
Chair, dining	8 1 per 1	3 per 4	1 per 2
Chair, recreational	N/A	1 per 3	1 per 6
		(7)	(7)
Settee (600 mm per man)	1 1 per 2	1 per 3	1 per 2

7. Chairs should be capable of being stacked.
8. Non-stacking chairs should be capable of being secured to the deck.

1. All berths to be provided with individual reading light.

<u>ITEM</u>	<u>CO OFFICERS</u>	<u>CPOs & POs</u>	<u>SEAMEN</u>
<u>Kit Stowage (Vol m3)</u>			
Drawer Stowage	0.50 0.45	0.25	0.22
Hanging Stowage	0.55 0.45	0.25	0.15(2)

2. If hanging space for long coats is required add 0.06 m3

2.1.0.4 Personal Stowage.

Sufficient stowage shall be provided for personnel to permit good, secure stowage of:

military effects, including sea and work clothing, gas mask, life preserver, etc.

civilian effects of personnel authorized to retain such on board: and

personal belongings (books, records, musical instruments, cameras, mail, etc.).

In seamen and PO berthing areas each berth shall be provided with a small key-locked locker for small personal items.

Special separate stowage spaces shall be provided for:

footwear;

environmental clothing;

dirty laundry, and

one "aircraft cabin luggage" type bag per man; this shall be independent of the sea bag locker, which shall also be provided.

ANEP 25

NATO INTERNATIONAL STAFF - DEFENCE SUPPORT DIVISION



STD-NATO ANEP-25-ENGL 1991 ■ 6654940 0062568 552 ■

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ALLIED
NAVAL
ENGINEERING
PUBLICATION

ANEP-25

GUIDELINES FOR ENVIRONMENTAL FACTORS IN NATO SURFACE SHIPS

(ACOUSTICAL, CLIMATIC, VIBRATION,
COLOUR, ILLUMINATION)

FEBRUARY 1991

NATO UNCLASSIFIED

STD-NATO ANEP-25-ENGL 1991 ■ 6654940 0062603 487 ■

NATO UNCLASSIFIED

ANEP-25

4-6

4.4 THE PSYCHOPHYSICAL EFFECTS OF COLOUR

a. Colour effects the performance of visual tasks through its effect on brightness, on the perception of colour, and on the creation of visual after images.

b. The prime psychophysical consideration is to create a good level, and a good balance of the light needed to do the task. The luminosity of the colours is therefore of importance in controlling the brightness of the working or living space. Colour and lighting must therefore be considered as inter-related design factors.

c. In addition to light sources and lighting fixtures commonly used in compartment lighting, a large portion of the illumination on work planes is provided by light which has been reflected one or more times from overheads, bulkheads and decks. As a result, the reflectance of the compartment surfaces greatly affects the overall efficiency of the compartment in delivering light to the work. It should be noted that the higher the reflectance, the higher the utilization of light. In fact, a compartment in which all surfaces are flat white would produce the highest possible light utilization. But judged from a practical and psychological standpoint, this type of environment is seldom desirable.

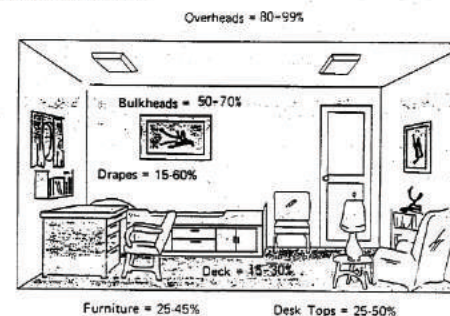


FIGURE 2

Recommended Reflectances for Interior Finishes

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4-6

b. The following four basic psychological response characteristics are perhaps most important to the development of appropriate colour and lighting schemes aboard ship:

- (1) Certain colours make a space appear larger than it actually is, while others cause the space to "close-in" on the observer;
- (2) Certain colours cause a space to seem warm, while others make it seem cooler;
- (3) Some colours appear to have a definite effect on the mood of the observer, i.e., some colours may be stimulating, others calming;
- (4) Some colours seem to clash with each other and therefore produce a feeling of irritation to observers especially sensitive to colour incompatibilities.

- (1) Blue Family: Blue with Royal Blue, or Blue with Greenish Blue
- (2) Brown Family: Brown with Reddish-Brown, or Brown with Yellowish-Brown
- (3) Yellow Family: Yellow with Orangish-Yellow, or Yellow with Greenish-Yellow
- (4) Red Family: Red with Yellowish-Red, or Red with Purplish-Red

Colour	Standard Cool White	De Luxe Cool White	Standard Warm White	De Luxe Warm White	Incandescent Lamps
Red	dull	dull	fair	good	good
Brown	fair	good	good	fair	good
Yellow	fair	good	good	dull	fair
Green	good	good	fair	dull	dull
Blue	fair	dull	dull	dull	dull
Grey	good	fair	soft	soft	dull

TABLE IV. Rating of Colours

COMPARTMENT	DESIRED MOODS
BERTHING	Restful, comfortable, quiet, private secure. Use colours that will enhance appearance of skin, provide touch of cheerfulness and minimize institutional look.
SANITARY	Clean, sanitary, cheerful. Use colours that enhance appearance of skin, de-emphasize distasteful odours, effects of heat and humidity.
MESSING	Cheerful, comfortable, socially stimulating. Choose colours that enhance appearance of skin and food.
LOUNGE & RECREATION	Active Recreation: cheerful, bright, socially stimulating. Use colours that maximize visibility. Sedentary Activities: warm, cheerful, comfortable. Choose colours that stimulate medium level of sociability but do not emphasize confusion, or institutional look. Consider activity mix carefully and provide logical identifications of areas that have differing mood requirements, e.g. T.V., stereo listening, games, casual reading.
MISCELLANEOUS AREAS	Barbershop: efficiency, cleanliness, visual performance effectiveness. Choose colours that enhance skin appearance and maximize visibility. Training Area: cheerfulness, alertness, motivation, efficiency. Choose colours that increase visual performance efficiency.

TABLE V. Suggested Mood Objectives for Standard Spaces

ANEP 26

NATO INTERNATIONAL STAFF - DEFENCE SUPPORT DIVISION



STD-NATO ANEP-26-ENGL 1993 6654940 0062649 581

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ERGONOMIC DATA FOR SHIPBOARD SPACE DESIGN IN NATO SURFACE SHIPS

OCTOBER 1993

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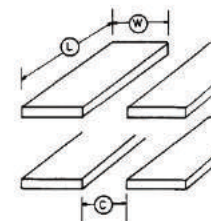
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9-2

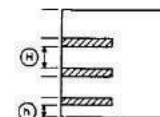
9.1 Dimensions.

See paragraph 10 item (iii) for details of Sick Bay berths

Min. Length L	2100 mm
Min. Width W	750 mm
Min. Spacing between opposing berths C	800 mm



Min. Vertical Separation between bunks, or bunks & deckhead H	700 mm
Min. Clearance between bunks & deck h	250 mm

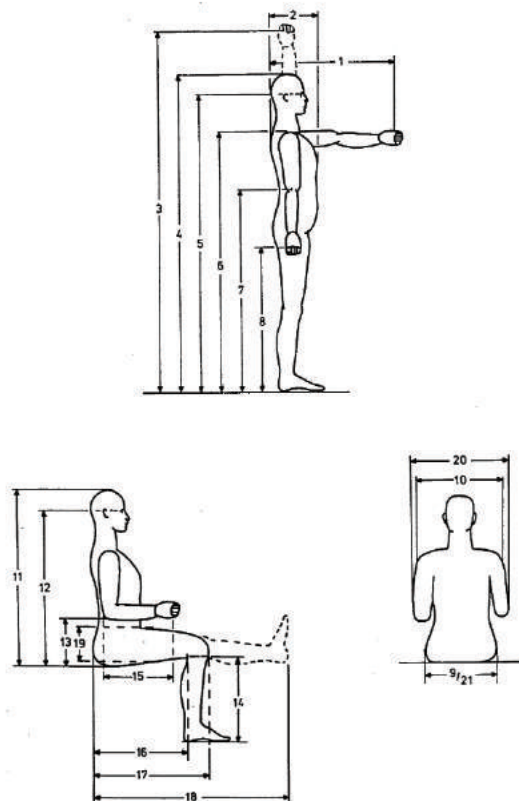


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2-3

2.1.2 Human body dimensions, nude.
Selected dimensions of the human body suitable for initial design of crew space and equipment.

Table 2.1.2: Body dimensions and clothing additions for northern European men (nude). The 1st and 5th percentile are based on a database of 26-40 year old men; the 95th and 99th percentile are of 18-19 year old men.

Nr.	Body dimension	Percentiles and dimensions (mm) for northern European men (nude)				Addition for light and heavy clothing		
		1	5	95	99	garment	light	heavy
1	Horizontal reach (grip)	666	683	821	830	b	5	25
2	Chest depth	209	215	315	365	b	5	50
3	Vertical reach (grip)	1935	1990	2280	2356	d	35	35
4	Stature	¹⁾ 1625	¹⁾ 1678	1933	1956	a + d	55	70
5	Eye height	¹⁾ 1495	¹⁾ 1532	1796	1832	d	35	35
6	Shoulder height	¹⁾ 1317	¹⁾ 1370	1588	1635	b + d	40	50
7	Elbow height	¹⁾ 1022	¹⁾ 1041	1205	1240	d	35	35
8	Hand height (grip)	709	737	873	894	d	35	35
9	Hip breadth (standing)	314	316	382	395	b + c	10	60
10	Shoulder breadth	385	421	527	548	b	5	50
11	Sitting height	¹⁾ 848	¹⁾ 870	996	1027	a + c	25	45
12	Eye hgt. sitting	¹⁾ 722	¹⁾ 742	875	908	c	5	10
13	Elbow hgt. sitting	¹⁾ 184	¹⁾ 195	284	296	b + c	5	10
14	Popliteal height	¹⁾ 400	¹⁾ 419	510	528	d	35	35
15	Elbow-grip length	322	329	396	407	b	5	25
16	Buttock-poplit. length	449	465	559	588	b + c	5	15
17	Buttock-knee length	552	563	659	684	b + c	5	35
18	Buttock-foot length	963	973	1149	1170	b + d	40	60
19	Thigh thickness	119	126	171	183	c	5	15
20	Elbow-to-elbow width	379	390	547	561	b + c	25	130
21	Hip breadth sitting	293	308	413	434	b + c	10	66

¹⁾ relaxed posture = - 25 mm
²⁾ relaxed head position = - 30 mm
³⁾ relaxed posture = - 45 mm
⁴⁾ seat height = - 20 mm
 a = cap (light) or helmet (heavy)
 b = coat
 c = trousers
 d = boots

Please take note that increments must be added for personal equipment such as a headset, oxygenmask.

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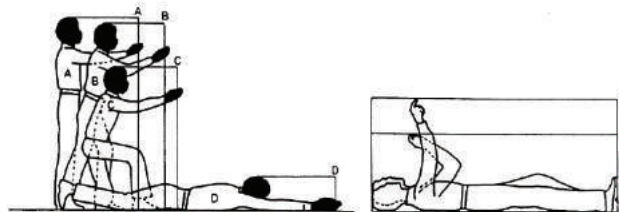
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6.1 Required body space.



Working position:	Minimum dimensions	
	Vertical (mm)	Horizontal (mm)
A Standing	2100	750
B Standing, legs braced	2100	1000
C Kneeling	1200	1200
D Prone	680	2400

Working positions:		
	Vertical (mm)	Horizontal (mm)
1 Light mechanical activity	680	2100
2 More heavy mechanical activity with 200 mm long tools	880	2100

Fig. 6.1a: Minimal Working Space (mm) for maintenance.

When (apparatus) drawer is pulled out the minimal required body space is 450 mm. Drawers and doors should be locked.

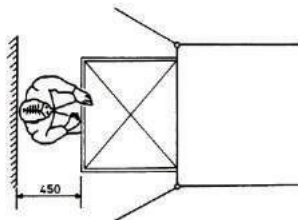


Fig. 6.1b: Required working space behind drawers (mm).

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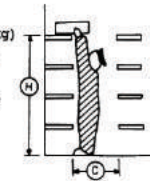
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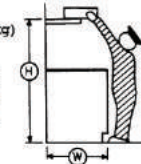
3-15

3.8.2 Recommendations.

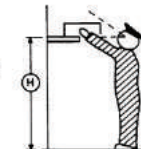
- (i) Max. height H, light objects (10 kg)
standing close to shelf 1950 mm
Clearance to bulkhead or
opposing shelves C 650 mm*
* = + depth of the material



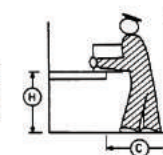
- (ii) Max. height H, light objects (10 kg)
Reaching over bench
W 350 mm H 1900 mm
W 600 mm H 1800 mm
W 800 mm H 1700 mm



- (iii) Max. height H
to see into shelf 1550 mm



- (iv) Max. height H, for objects Wt,
Min. width for aisle, C
Wt 16 kg H 1500 mm C 600 mm
Wt 20 kg H 1200 mm C 600 mm
Wt 25 kg H 900 mm C 900 mm



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T9640-AB-DDT-010/HAB

SHIPBOARD HABITABILITY DESIGN CRITERIA MANUAL



APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND

1 DEC 1995

3.0 Habitability Facilities.

3.1 General. The number of accommodations referred to herein shall be that number stated in the ORD.

3.2 Berthing. (Surface Ships and Submarines)

3.2.1 There shall be at least one berth per accommodation.

3.2.2 Type. Berths shall be of the pan bottom or locker bottom type, and shall be permanently installed, except where designated as surge berthing in excess of designed accommodations. Surge berths shall be of a removable type to allow for expansion of recreation and lounge space during periods when not occupied.

3.2.3 Personnel Groupings.

3.2.3.1 Officers, CPOs and crew shall be accommodated in separate berthing compartments.

3.2.3.2 On amphibious ships, embarked troop Officers, SNCOs, and other enlisted shall be accommodated in separate berthing compartments.

3.2.3.3 Female officers, CPO and crew berthing accommodations shall be separate from those of their male counterparts.

3.2.4 Sea Cabins.

3.2.4.1 On all surface ships, destroyer/frigate size or larger, a sea cabin shall be provided for the Commanding officer in the immediate vicinity of the bridge/control station if his stateroom is not in the immediate vicinity of the bridge/control station.

3.2.4.2 On all surface ships specifically configured to carry embarked Flag Officers and/or Unit Commanders requiring immediate access to bridge/control stations, such cabins shall be provided if staterooms are not in the immediate vicinity of the respective control station.

3.2.5 Berthing Clearances.

3.2.5.1 Minimum clearance requirements to insure freedom of rotation of individuals in their berths, access to berths and traffic flow between berths, shall be the following:

3.2.5.1.1 Vertical unobstructed clearance above mattress top: 20 inches for crew/troops, 23 inches for CPO/SNCO, 23 inches for officers assigned to three-high berths, and 25 inches for officers assigned to two-high berths. In submarines, hull curvature may reduce the outboard vertical clearance above mattresses for berths fitted along the shell.

3.2.5.1.2 Unobstructed secondary passage width at berth tier ends: 30 inches (18 inches for submarines). The term "tier" as used herein denotes the berth structure of two, three, or four high berths.

3.2.5.1.3 Unobstructed passage width along accessible side of berth: 27 inches (18 inches for submarines).

3.2.5.2 Distance from the underside of the bottom berth mattress to the deck shall be not less than 6 inches, except submarines shall be 2 inches.

3.2.5.3 Access: Means for easy access to all spaces within locker bottom type berths, shall be provided.

3.2.5.4 The number of berths per tier shall not exceed three, except in amphibious ships, on which, in troop spaces, four-high berth tiers may be authorized and the fourth berth used as a surge berth, if all other clearance and access standards are maintained.

3.2.6 Berths. The following features shall be included for each berth except surge berths and as noted:

3.2.6.1 One light per berth.

3.2.6.2 Full privacy partitions between berths and at ends of berth tiers where opening onto passageways.

3.2.6.3 Privacy curtains for each berth, except officer single berths.

3.2.6.4 HVAC terminal within each berth cubicle.

3.2.6.5 Main ship passageways in surface ships shall not bisect berthing spaces. Where this is not feasible, berthing spaces shall be isolated from main passageways by joiner bulkheads.

3.2.7 Space Considerations. Berths shall be oriented primarily fore-and-aft; however, athwartship berthing may be used where the compartment arrangement is improved. Where the

athwartship orientation is used, it shall be limited to not greater than 30 percent of the berths per compartment.

3.2.7.1 Enlisted personnel.

3.2.7.1.1 Berthing spaces shall accommodate the fewest number of personnel, within the constraints of available berthing space and consistent with maintaining, as a minimum, the other berthing standards otherwise established in this instruction.

3.2.7.1.2 In surface ships, berth tiers shall be arranged in cubicles accommodating six or fewer persons per cubicle. All cubicles shall have a secondary means of egress, via a kick-out panel if necessary, which will allow personnel to escape in the event the primary access to the berth cubicle is obstructed.

3.2.7.1.3 In surface ships, ten percent of berth tiers in berthing spaces with 15 or more persons shall be sized to fit an 80 inch long mattress. All other berths shall accommodate at least a standard 76 inch mattress. In submarines, thirty percent of berth tiers in berthing spaces shall fit a 76 inch mattress and all other berths shall accommodate at least a 72-1/2 inch mattress.

3.2.7.2 Officers. Officers shall be accommodated in one- or two-person staterooms (or three-person for submarines) except in unique cases in which bunkroom berthing cannot be avoided. In this event, there shall be no more than six berths per bunkroom (12 berths per transient officer bunkroom). Unobstructed walking and working areas in officer berthing spaces will conform, as a minimum, to Table 2. Columns in Table 2 specifying ship length refer to length overall. Spaces assigned for Commanding Officer, Commanding Officer of Troops, Landing Force Commander, Unit Commanders, and other senior operational commanders shall be commensurate with and appropriate to the rank of the individuals concerned.

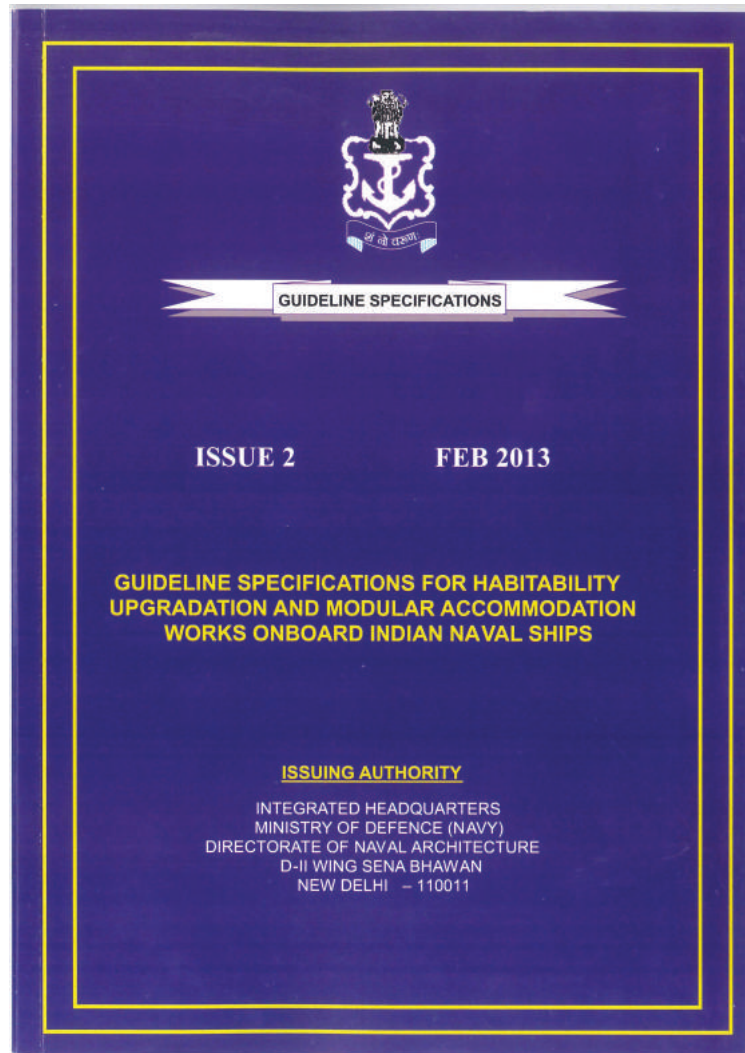
STOWAGE PER ACCOMMODATION

TYPE STOWAGE/ TYPE SHIP	OFFICER			ENLISTED	
	SINGLE STATE ROOM	DOUBLE STATE ROOM ⁽¹⁾	BUNK- ROOM ⁽²⁾	CPO ⁽³⁾	CREW ⁽⁴⁾
<u>Drawer Volume (cu ft)</u>					
Surface Ship	20	15	15	NR	NR
Troops	18	10	6	NR	NR
Submarine	6	6	6	NR	NR
<u>Locker Volume (cu ft)</u>					
Surface Ship	5.5	4.75	4.5	14	7.5
Troops	3.5	3.5	2.5	6.5	4
Submarine	9	8	8	10	3
<u>Hanging Space (in) ⁽⁵⁾</u>					
Surface Ship	24/24	24/12	24/12	12/6	10/0
Troops	12/12	6/6	6/6	3/3	3/3
Submarine	12/12	12/6	6/6	3/3	3/0
<u>Seabag Stowage (cu ft) ⁽⁶⁾</u>					
Surface Ship	3	3	3	2	1
Troops	NR	NR	NR	NR	NR
Submarine	NR	NR	NR	NR	NR
<u>Soiled Laundry Stowage (cu ft)</u>					
Surface Ship	NR	NR	NR	0.75	0.75
Troops	NR	NR	NR	0.56	0.56
Submarine	NR	NR	NR	NR	NR

UNOBSTRUCTED AREA IN SQUARE FEET PER OFFICER BERTH⁽¹⁾

OFFICERS ACCOMMO- DATIONS	SHIP LENGTH 150'-300'	SHIP LENGTH 301'-600'	SHIP LENGTH over 600'	TROOP OFFICERS	SUBMARINE OFFICERS
C. O. Single Stateroom	45-50 ⁽²⁾	55-70 ⁽²⁾	65-90 ⁽²⁾	55-70	12
X. O. Single Stateroom	35-40 ⁽³⁾	40-55	45-70	55 (3)	12 ⁽³⁾
Dept. Head Single Stateroom	30 ⁽³⁾	30-45	45-60	45 ⁽³⁾	NA
Single Stateroom	NA	35 ⁽³⁾	35-50	30 ⁽³⁾	NA
Double Stateroom	20	22	35	18	6 ⁽⁴⁾
Officers Bunkroom	20 ⁽⁵⁾	20 ⁽⁵⁾	20 ⁽⁵⁾	12	5

Insights



Senior Rating Mess

9. Typical inventory of furniture for outfitting Senior Rating are as follows:-
- (a) Two-tier bunk per 2 men
 - (b) One cupboard unit per man
 - (c) A full mirror
 - (d) One desk unit with pull out keyboard tray having swiveling mechanism & tilt adjustment. Desk light also to be provided.
 - (e) Privacy screen for each bunk
 - (f) One Shoe locker per man
 - (g) Two Folding Chairs
 - (h) Two Folding Stools
 - (j) Book Rack
 - (k) Cabin fans 12-16 inch dia
 - (l) Commercial Digital clock
 - (m) Rack for TV , music system
 - (n) Telephone & Communication socket (LAN, TV)

Junior Rating Mess

10. Typical inventory of furniture for outfitting Junior Sailors Messes are as follows:-

- (a) Bunks (Two-tier/Three tier) as per personnel allocated
- (b) One cupboard unit per man
- (c) Full length mirror
- (d) Privacy screen for each bunk
- (e) One Shoe locker per man
- (f) Two Folding Arm chairs
- (g) Two folding Stools

Senior Sailors Dining/Recreation Room

13. Typical inventory of furniture for outfitting Senior Sailors Dining Room
 - (a) Dining tables seating 80% SS
 - (b) Dining Chairs for 80% SS
 - (c) Buffet/Sideboard Unit
 - (d) Clean cutlery collection point
 - (e) Hot and Cold drinks dispenser unit
 - (f) Dirty crockery/cutlery return point
 - (g) Refrigerator for Jams, sauce etc
 - (h) Ice-making Machine
14. Typical inventory of furniture for outfitting Senior Sailors' Recreation Area
 - (a) Upholstered fitted seating for 80% SS
 - (b) Upholstered armchairs/chairs
 - (c) Cupboard and drawer units
 - (d) Notice board
 - (e) TV/Radio/Music Centre
 - (f) Coffee/Occasional tables
 - (g) Magazine/paper Racks
 - (h) Mail Racks

Junior Sailors Dining/Recreation Room

15. Typical inventory of furniture for outfitting Junior Sailors' Dining Room
 - (a) Dining Tables seating 50% JS
 - (b) Dining chair for 50% JS
 - (c) Buffet/Sideboard Units
 - (d) Clean cutlery collection point
 - (e) Hot and Cold drinks dispenser units
 - (f) Dirty crockery/cutlery return point
 - (g) Refrigerator for jams, sauces etc.
 - (h) Ice Making Machine
16. Typical inventory of furniture for outfitting Junior Sailors recreation area
 - (a) Upholstered fitted seating for 70% JS
 - (b) Upholstered armchairs/chairs
 - (c) Cupboard and drawer units
 - (d) TV/Radio/Music Centre
 - (e) Occasional tables
 - (f) Magazine/Paper Racks
 - (g) Notice Board

Appendix D

Specifications for Fittings & Furniture

1. Bunks. The requirements for the bunks are as follows:-

- (a) Shall be manufactured of CRCA Steel with powder coating. (Shall be manufactured in Modular construction with combination of M.S Pipe and CRCA sheet and powder coated).
- (b) In Two-Tier Bunks, the top bunk would be foldable, folding down to double as a sofa when not in use.
- (c) Three-Tier Bunks should be installed only where sufficient deck head height is available. The Modular design is to allow height adjustment between upper bunk- middle bunk and middle- lower bunk during installation onboard.
- (d) Each bunk to be able to withstand 150 kgs uniformly distributed load and a concentrated load of 100 kgs each load being taken separately per bunk. In case of multi-tier bunks, the load is to be applied on each bunk to confirm the strength of the Bunk frame.
- (e) Each bunk is to be provided with a reading light and facility to use personal audio equipment. A 230 V Power socket to be provided to each bunk and the same to be flushed inside the side panel.
- (f) In multi bunk configurations, privacy screens are to be provided.
- (g) Bunks shall normally be sited in the fore and aft direction with the head end forward. Where bunks are fitted athwart ships the head-end of the bunk shall be inboard.
- (h) The minimum inside dimension of bunks shall be at least 1900mm. Mattresses should be of appropriate dimension. (Mattresses size should be 1830x600 mm minimum for sailors and 1830/1905 x750/600 for officers).
- (i) In double tier bunk, the vertical space between the bunks and above the top bunk shall be sufficient to allow a sitting position in comfort for the individual.

(k) In multi-berth sleeping cabins, where bunks abut each other, rigid screens made of wood or other suitable opaque material shall separate them. In addition, privacy screens or other arrangements are to be fitted to all bunks in multi-berth sleeping cabins. Privacy curtains are to be in the colour specified in the Master Décor Scheme (MDS).

(l) Where double/three tier bunk is fitted, a suitable facility shall be provided to enable easy access to the upper berth. Where jumping bars are provided to facilitate access to and egress from bunks, the jumping bars are to be sited approximately 700mm from the bunk head and 230mm outside the bunk edge to provide a natural point of assistance when entering or exiting top bunks.

(m) The framework of each bunk, and its leeboards or lee rails, shall be constructed of metal or some other material, which is hard, smooth and unlikely to be corroded. If the bunk is constructed of tubular frames, the frames shall be completely sealed with rounded corners.

(n) A bunk light shall be fitted and sited at the head-end of all bunks at a height that allows reading and writing in the sitting up position.

(p) The grouting for bunks to be made of M.S with red oxide painted to prevent corrosion. The grouting angle is to be welded on the deck and then painted with Epoxy paint, whereas on the deck head, design to be used to absorb the vibration of the deck during rolling and pitching.

(q) The bunk to be provided with maximum three drawers below. High quality telescopic ball sides with a load carrying capacity of 20 kg. Provision for life jacket stowage is to be designed in the drawer. The drawers should have snap shut arrangement for locking.

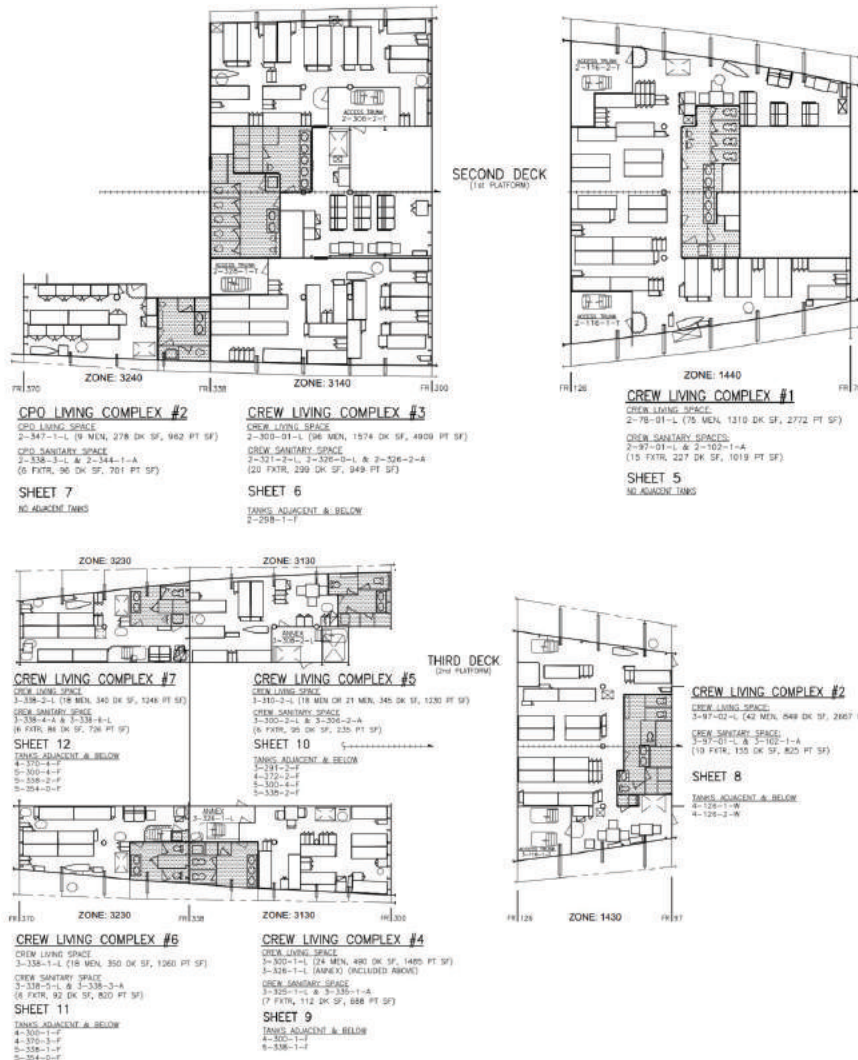
(r) Mattresses to be made of 32-40 kg/m³ upholstered with removable FR treated fabric/leatherlite.

(s) Individual curtains to be provided for each bunk. The fabric to be FR treated. Suitable arrangement to be provided for securing the curtain while folding the middle bunk.

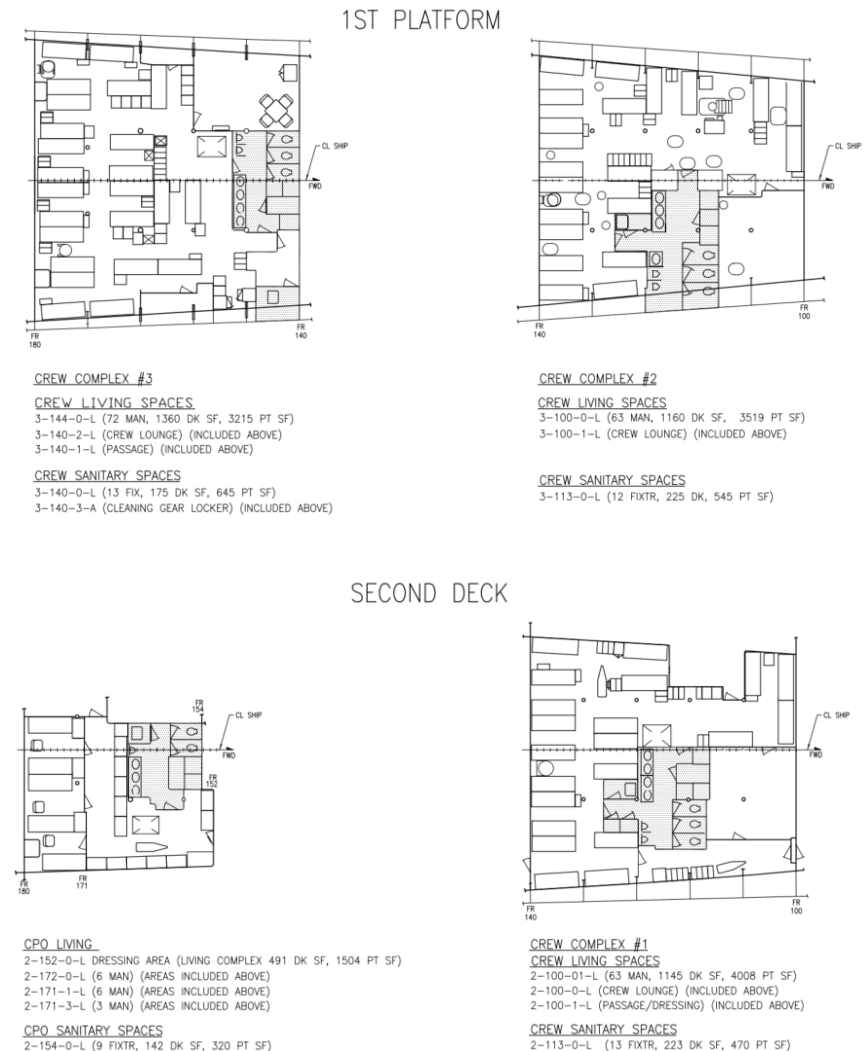
(t) Individual name tag plate to be provided on each bunk.

Habitability Drawings

DDG 51 Class Key Plan (Destroyer)

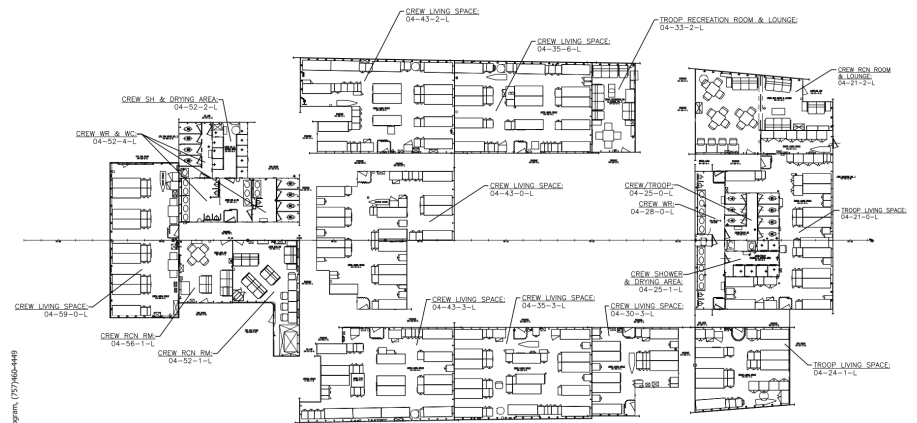


FFG Class Key Plan (Multi-role Frigate)



Program, (757)460-4449

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CPD LIVING SPACE (FEMALE)
05-49-4-L

CPD WR. WC & SH (FEMALE)
05-51-2-L

CREW WR. & WC (FEMALE)
05-52-2-L

CREW SH (FEMALE)
05-54-2-L

CPD LIVING SPACE (FEM)
05-57-4-L

CPD STNCO WR. & SH
05-57-2-L

SENR. TROOP LIVING SPACE (FEM)
05-56-2-L

CREW LIVING SPACE
05-43-0-L

CREW RECREATION RM & LOUNGE
05-38-1-L

CREW RECREATION RM & LOUNGE
05-48-3-L

CPD & STNCO WR. & WC
05-33-5-L

CPD & TROOP SH & DRYING AREA
05-34-1-L

STNCO LIVING SPACE & SURGE BERTHING
05-29-1-L

Articles and Research Papers

LIFE IN THE SEAS

How all work and little sleep have left the Indian navy fatigued and stressed

It is time to acknowledge that personnel on our ships and submarines need time for rest and recuperation.

Capt KP Sanjeev Kumar
Dec 13, 2016 · 06:30 pm

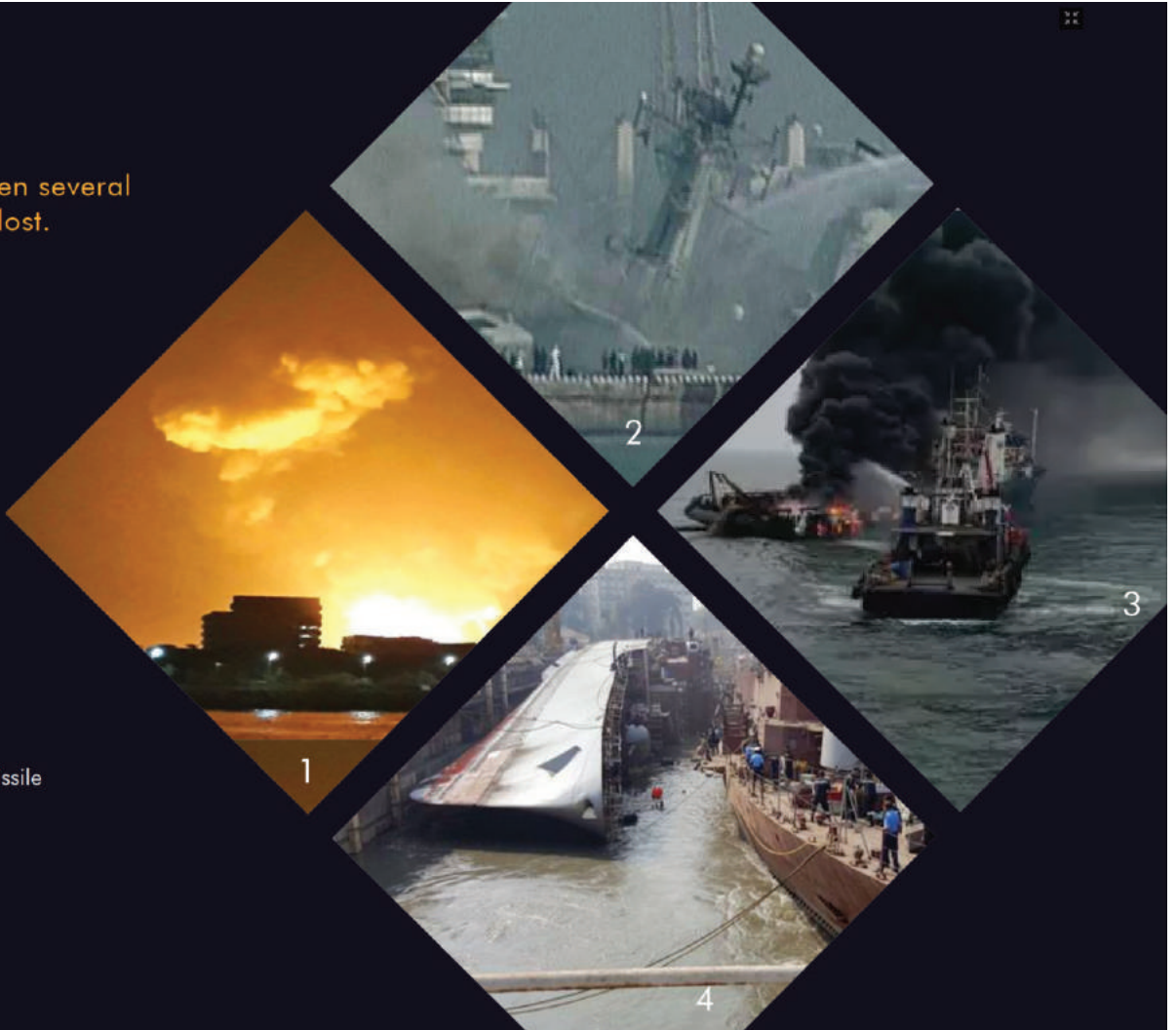


“The best bridge between despair and hope is a good night’s sleep”

High Profile Accidents

In the last decade, Indian Navy has seen several high-profile accidents with many lives lost.

- 1 August 13/14, 2013, INS Sindhurakshak, a Kilo-class submarine exploded into a huge fireball, killing 18 personnel.
- 2 INS Vindhyagiri, a Leander-class frigate sank in Mumbai harbor on Monday, Jan 31, 2011 by hitting a Merchant Vessel.
- 3 On Jan 2022 Three sailors died and eleven others were injured when an explosion took place aboard the INS Ranvir while it was docked in Mumbai.
- 4 On Dec 5, 2016, INS Betwa, a 3850-ton guided missile frigate keeled over during undocking post refit at Mumbai with loss of two lives.



Tired & Fatigued

- Inquiry reports on naval accidents often blame aging platforms, technological obsolescence, and human error, but fatigue is often ignored or downplayed as a contributing factor.
- Unfortunately, in our culture, safety and comfort become easy casualties in the 24/7 operational tempo.
- As a Commanding Officer or operations staff at Headquarters, it is taboo to even acknowledge that people on our ships and submarines may be way too tired.
- Working over weekends and holidays, sailing out on Fridays and returning to port on Mondays, disproportionate balance of work between afloat and shore agencies, poor habitability on ships – the list goes on.

NO Rest Recreation

- Ships undergoing maintenance refits have a different bag of woes. Refits are mostly dockyard responsibility only on paper at least.
- Ships in dockyards work under immense stress caused due to extremely poor habitability conditions, extraneous secondary duties, poaching of manpower by higher formations, and finally "inherited" tasks which are actually the responsibility of dockyard.
- The hierarchical structure and "yes boss" culture doesn't allow for rest and recreation in the true sense that our predecessors ordained while framing the rules.
- "One-year syndrome" and "zero-error syndrome" have contrived to ensure that personnel on our ships are often fatigued and sleep deprived to insane levels.

Habitability in Berthing Compartments and Well-Being of Sailors Working on U.S. Navy Surface Ships

Panagiotis Matsangas¹ and Nita Lewis Shattuck, Naval Postgraduate School, Monterey, CA, USA

The study aimed to assess sleep-related habitability concerns in the berthing compartments of U.S. Navy surface ships and determine their impact on the sleep and well-being of crew members. Little is known about the association between habitability factors in sleeping/berthing compartments and sailor well-being in operational conditions. Fit-for-duty sailors from six ships (N = 1,269) participated in the naturalistic and longitudinal study. They reported habitability factors affecting their sleep and completed standardized questionnaires on daytime sleepiness, insomnia, sleep quality, and mood. Sleep was assessed using wrist-worn actigraphy and activity logs. The most frequently reported concerns were noise, ambient temperature, poor bedding conditions, and ambient light.

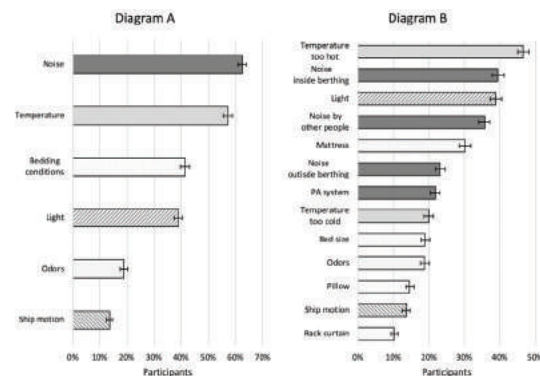


Figure 1. Habitability-related factors affecting sailor sleep (horizontal lines denote the standard error of the mean). PA = public announcement.

Sailors with more habitability-related complaints were more likely to experience elevated daytime sleepiness, insomnia symptoms, lower sleep quality, and longer sleep duration. They also reported worse mood. The study concludes that habitability-related complaints are associated with sailor well-being and sleep. Ship designers should consider these findings and explore cost-effective methods to mitigate the identified problems, as habitability in berthing compartments of surface ships is linked to sailors' daytime sleepiness, insomnia severity, mood, and sleep attributes.

TABLE 2: Habitability Factors Affecting Sailor Sleep

Noise	557 (62.4%)
Noise inside berthing	352 (39.5%)
Noise by other people	318 (35.7%)
Noise outside berthing	207 (23.2%)
Public announcement system (1MC)	194 (21.8%)
Temperature	511 (57.3%)
Temperature too hot	416 (46.6%)
Temperature too cold	178 (20.0%)
Poor bedding conditions	370 (41.5%)
Mattress	269 (30.2%)
Bed size	169 (19.0%)
Pillow	130 (14.6%)
Rack curtain	91 (10.2%)
Light	347 (38.9%)
Odors	168 (18.8%)
Ship motion	121 (13.6%)



64%

Sailors felt lack of desire to stay in navy after their first enlistment



81%

Enlisted planned to leave navy at their next decision point were dissatisfied



60%

Officers planning to leave were dissatisfied, while only 32%, planning to stay felt that way.



56%



51%

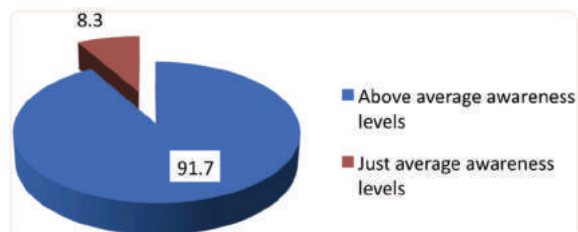
Believed that living conditions decreased their desire to stay in the Navy.

Crew awareness as key to optimizing habitability standards onboard naval platforms: A 'back-to-basics' approach

Anand Neelakantan, Surg Cdr,^{a,*} Mookkiah Ilankumaran, Surg Capt,^b and Sougat Ray, Surg Capt^c

Study Population and Awareness Levels:

The study population consisted of naval personnel onboard warships in Mumbai, with a mean age of 29.4 ± 4.2 years. More than half of the participants were junior sailors. Analysis of awareness levels showed that 91.7% of crew members had above-average knowledge of habitability guidelines and norms, while 8.3% had average levels of knowledge.



Different Ranks and Awareness:

Among the junior sailors, 92.6% reported above-average levels of awareness, compared to 93.6% among senior sailors and 82.2% among officers.

Rank

Officer	47	8.5
Senior sailor	207	37.6
Junior sailor	298	53.9

Awareness of Habitability Components:

Participants showed maximum awareness on accommodation (85.6%), followed by water systems (82.3%), noise (76.9%), lighting (71.0%), and indoor climate (70.4%). Regarding pest control, 67.6% had very good awareness levels, while 65.8% had very good awareness of waste management onboard.

Relationship between crew awareness levels and habitability guidelines.

Awareness levels	Habitability standards		
	As per guidelines	Below specifications	Total
Above average	488	47	535
Up to average	10	7	17
Total	498	54	552

Odds ratio: 7.27, 95% CI = 2.64–19.98. Chi-square value: 19.58, $p = 0.0001$.

Association between Awareness and Habitability Standards:

There was a strong association between crew awareness levels and maintenance of habitability onboard warships in line with guidelines. The habitability standard was 7.27 times more likely to be in accordance with guidelines when crew awareness levels were above average.

Table 1

Age and rank-wise (demographic) distribution of study population.

Characteristic	Numbers	Percentage
Age (years)		
<25	98	17.8
26–50	421	76.3
>50	33	5.9

Overall, the study highlights the importance of crew awareness in achieving and maintaining optimal habitability standards onboard warships.

Shipboard Habitability in the U.S. Navy

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The introduction of the report highlights the significance of studying shipboard life and its impact on sailor quality of life (QOL) and retention plans. It emphasizes that the research on factors affecting satisfaction with shipboard life is lacking in exploration, with most studies on shipboard habitability being conducted 25 years ago. The study aims to analyze data from the 2002 Navy QOL Survey to identify the most and least satisfying facets of shipboard habitability, create habitability subscales, and utilize them in multiple regression to better understand satisfaction with shipboard life. The concept of shipboard habitability is defined as the conditions that determine the sailors' physical well-being, comfort, and adequacy of personal services, while quality of life encompasses broader factors like leadership, job satisfaction, and professional development. The literature review addresses shipboard life and retention, key issues and outcomes of shipboard habitability, and the implications of habitability for ship design.

This table presents the most dissatisfying aspects of shipboard life for both enlisted sailors and officers, arranged in descending order. For enlisted sailors, "dissatisfied" percentages ranged from 69% to 51%. The top four aspects that generated the highest dissatisfaction were personal storage space, room in the berthing area, space in the rack, and privacy. These findings indicate that enlisted sailors were primarily dissatisfied with personal space and privacy issues. On the other hand, a lower percentage of officers (ranging from 43% to 31%) expressed dissatisfaction with shipboard life, and their concerns were often different from those of enlisted sailors. Officers raised issues such as noise levels in their surroundings, unlike the enlisted personnel.

Aspect	Satisfied (%)	Neutral (%)	Dis
Enlisted perceptions ^a			
Personal storage space	21	10	
Room in berthing area	23	11	
Space in your rack	25	10	
Privacy	25	12	
Shower/head spaces	28	13	
Number of showers and heads	31	14	
Mattresses	33	13	
Berthing area	36	12	
Laundry	33	16	
Lounges in berthing area	33	16	
Officer perceptions ^b			
Shower/head spaces	45	12	
Noise	41	17	
Mattresses	45	13	
Shower and head fixtures	50	13	
Room in working area	53	10	
Internet access	54	9	
Laundry	55	12	
Ventilation	56	12	
Pillows and bed linens	52	15	
Quality of port calls	61	8	

TABLE 5
Aspect Scales: Differences in Enlisted and Officer Means Evaluated With
t-Test and Effect Size

Scales	Enlisted			Officers			t-Value ^a
	Mean	S.D.	SE _M	Mean	S.D.	SE _M	
Privacy	3.0	1.6	.05	4.6	1.5	.05	21.50
Berthing	3.4	1.4	.04	4.3	1.3	.04	15.40
Onboard Social Needs	4.9	1.3	.04	5.5	1.0	.03	12.24
Services	4.3	1.3	.04	4.8	1.1	.04	7.77
Recreation	4.2	1.2	.04	4.6	1.1	.04	7.62
Computers	4.3	1.4	.05	4.7	1.4	.05	6.42
Environment	4.5	1.2	.04	4.8	1.0	.03	6.06
Port Calls	3.9	1.8	.06	4.3	1.8	.06	4.60

Note. Sailors responded to items using this response scale: 1 = completely dissatisfied, 2 = dissatisfied, 3 = somewhat dissatisfied, 4 = neutral, 5 = somewhat satisfied, 6 = satisfied, 7 = completely satisfied.

Exploring Sleep-related Habitability Issues in Berthing Spaces on U.S. Navy Ships

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Habitability encompasses all the factors that contribute to the living and working environment of a ship's crew, promoting crew morale, quality of life, safety, health, and comfort. It is an important aspect of human systems integration and plays a crucial role in optimizing human and system performance. Better habitability has historically been associated with improved crew morale, increased retention, and enhanced effectiveness of the ship's company.

Ship designers face the challenge of balancing the demands of wartime conditions and peacetime operations when designing warships. The objective is to provide maximum comfort to the crew during peacetime without compromising the primary task of combat. However, the need for well-designed sleeping spaces is essential in both peacetime and wartime, as sleep is a biological necessity for humans. Research has shown that sleep problems are prevalent in the military operational environment, with chronically sleep-deprived crewmembers on Navy ships due to long work hours and operational commitments. The 24/7 nature of military missions often leads to sleep opportunities occurring during circadian-misaligned time periods, exacerbating the problem of chronic sleep debt. Additionally, the sleeping conditions in the military are often suboptimal.

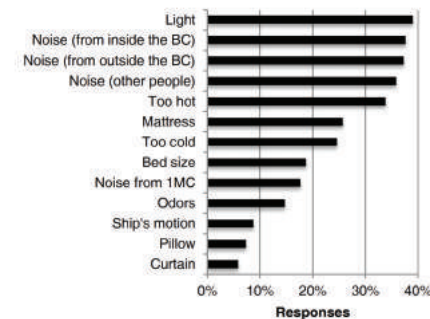


Figure 2. Factors affecting sleep (USS NIMITZ)

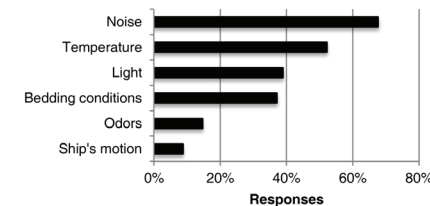


Figure 1. Groups of factors affecting sleep (USS NIMITZ)

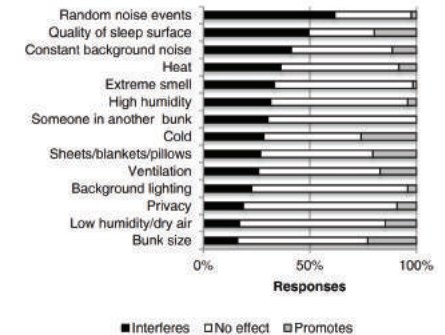


Figure 4. Factors affecting sleep (HSV-2, LCS)

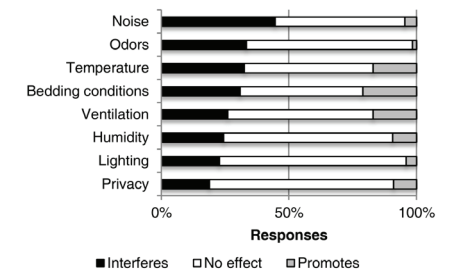
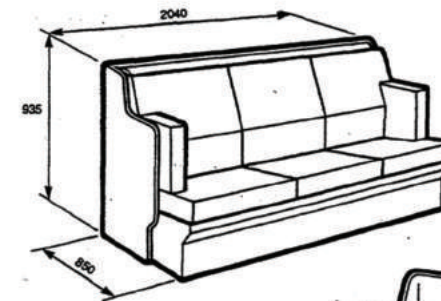
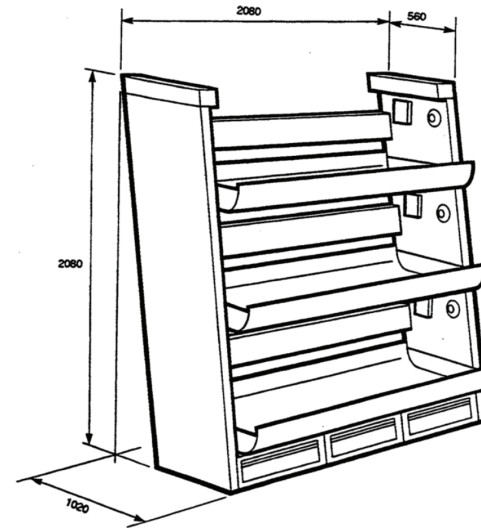
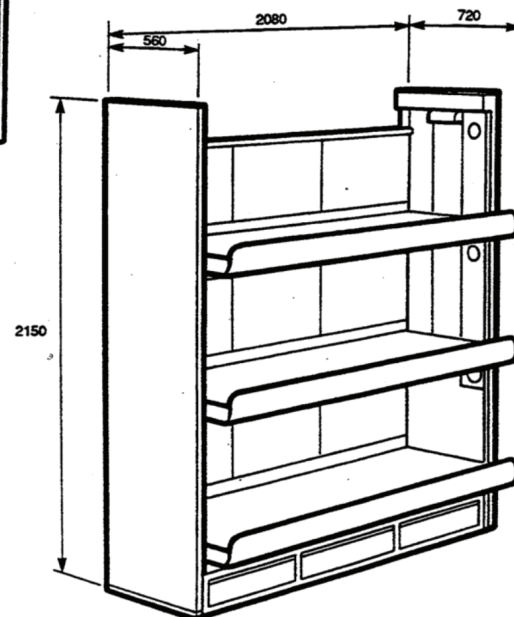
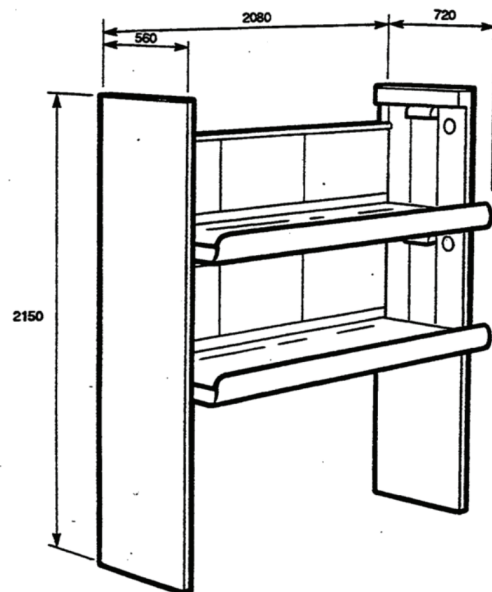


Figure 3. Groups of factors affecting sleep (HSV-2, LCS)

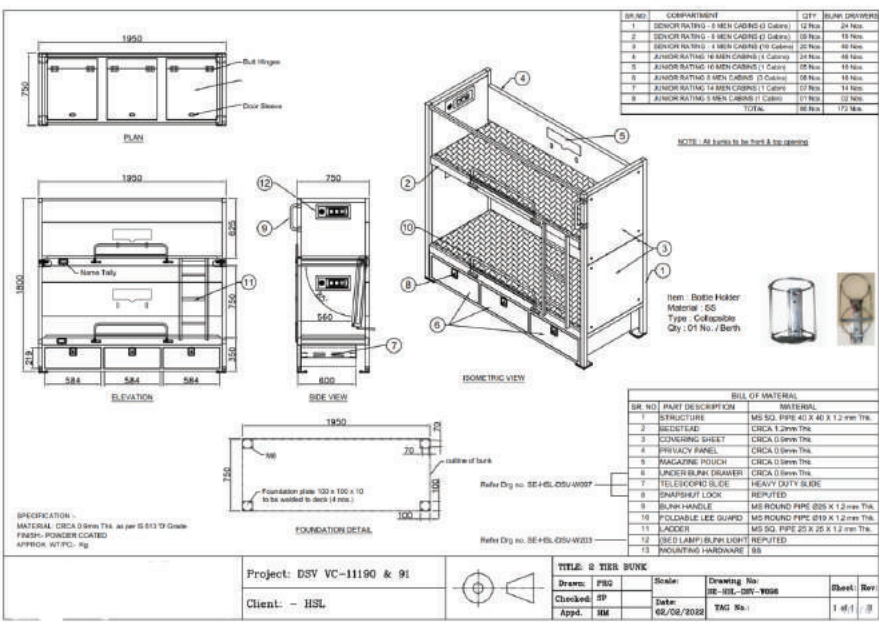
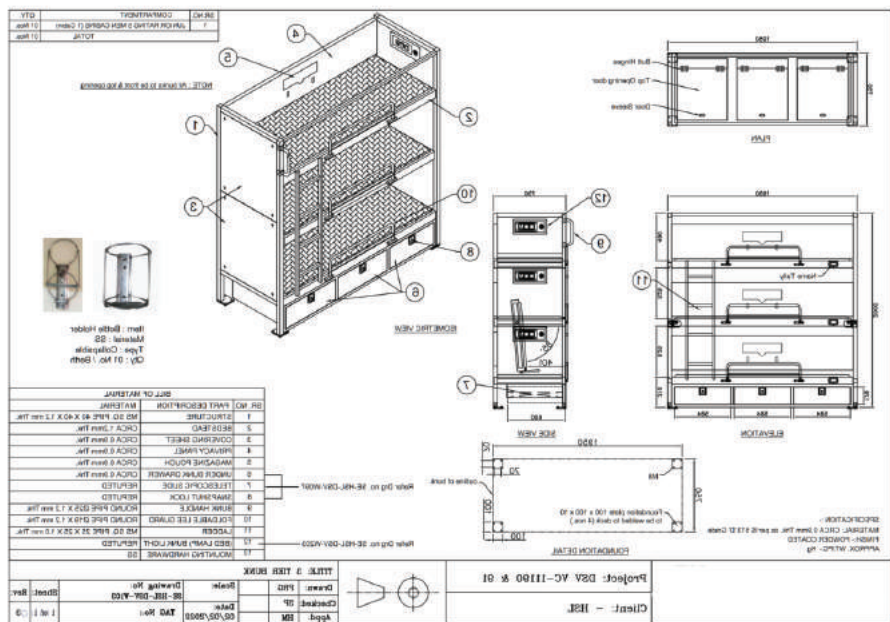
This study focuses on habitability issues in the berthing compartments of surface ships, which are the areas where the crew sleeps. The study aims to assess the existing standards associated with habitability in these areas and evaluate the impact of habitability factors on the sleep of crewmembers in U.S. Navy ships. The berthing compartments, also known as staterooms or accommodation areas, are of particular interest in understanding and improving sleep conditions for the crew.

Furniture Catalogue

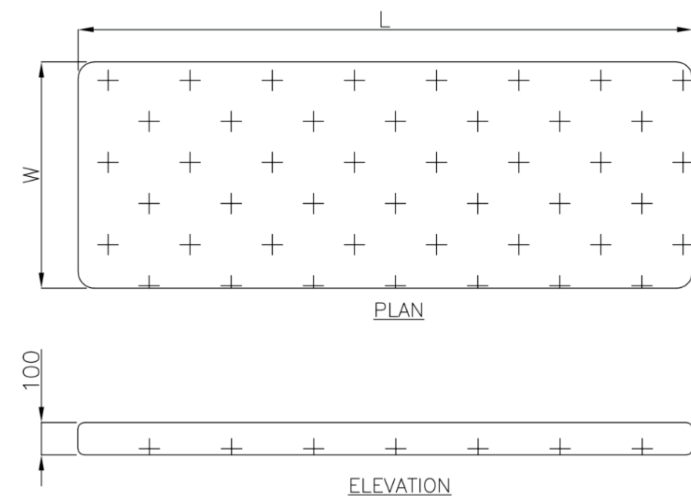
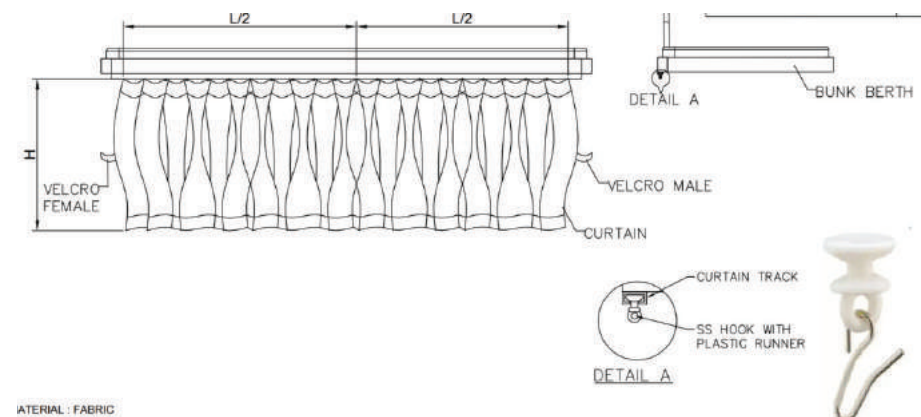
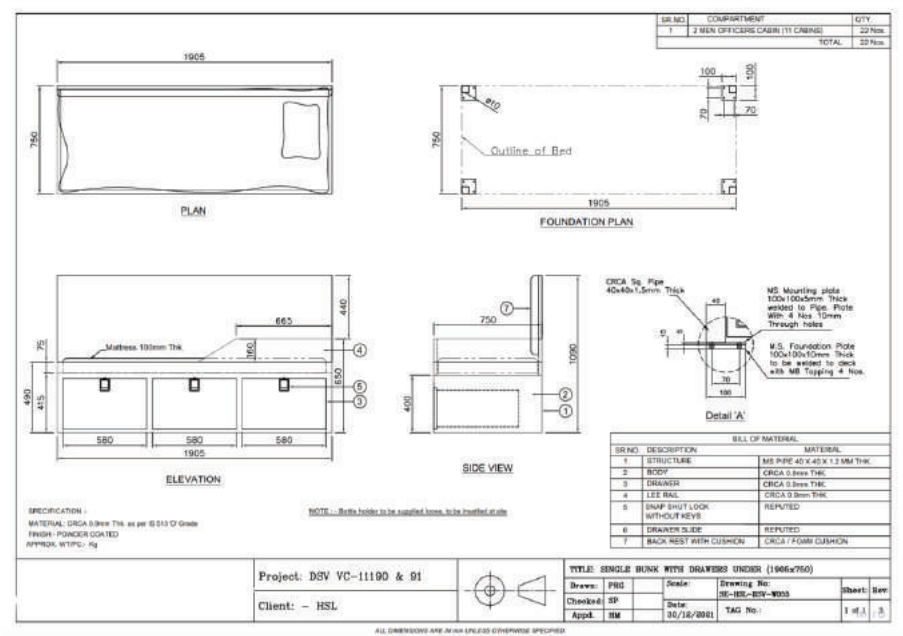
UK Navy Furniture



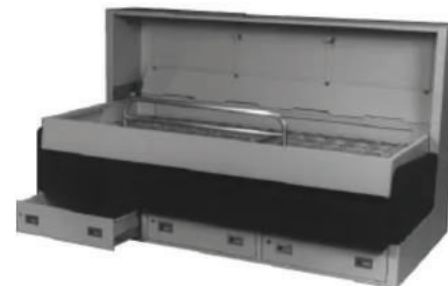
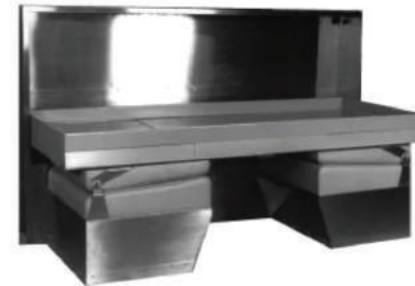
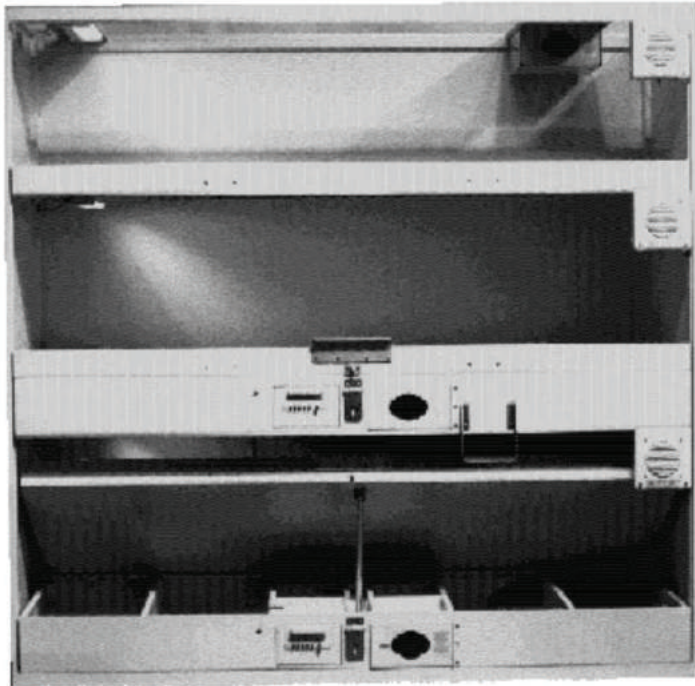
Indian Navy Furniture



Indian Navy Furniture



US Navy Furniture



OPEN



CLOSED

US Navy Furniture



Design Opportunity

Narrowing Down Focus

Given the limitations of time and available resources, a deliberate decision was made to delineate the scope of the furniture project for the Navy. Acknowledging its multifaceted nature and vast potential, which necessitate substantial research endeavors and an extended timeline for completion, a focused approach was adopted. The necessity to narrow down the project's ambit was imperative, enabling a pragmatic allocation of limited resource constraints. By streamlining the project's objectives, the opportunity to concentrate efforts on a specific facet emerged, facilitating efficient utilization of time and resources, ultimately ensuring a scholarly and satisfactory culmination within the designated time-frame.

Focus

20% officer : 80% sailor

Dimensions of destroy, frigate and corvette class are more or less similar

- 11 destroyer X 300 men = 3300
- 13 frigate X 200 men = 2600
- 23 corvette X 130 men = 2990
- 10 Offshore petrol vessel X 120 men = 1200
- Total 7120 men served

Destroyer, frigate and corvettes along with other vessels have longer endurance than petrol vessel and oil tanker vessel and merchant vessels



Aircraft Carrier

- 7,500 nautical miles (13,900 km; 8,600 mi)
- 2,300 compartments manned by 1700 seamen
- 45,000 tonnes
- 196 officers, 1,449 sailors



Destroyer

- 7,400 Tons
- 4,000 nautical miles (7,400 km; 4,600 mi)
- 45 days
- 300 (50 officers + 250 sailors)



Frigates

- 6200 Tons
- 4,000 mi (6,400 km)
- 30 days
- 200 (18 officers)



Corvettes

- 3,300 tons
- 3,450 nautical miles (6,390 km; 3,970 mi)
- 28 days
- 130 (incl. 17 officers)

IN Ship Interior Study

Visakhapatnam Class Destroyer



fixed ladder use up bed length
so not many people can sit in the
lower bed

has to sit in the bed for wearing
show

only one chair



no play of colour

long unusable locker for
customization



3 tier bunk has very less bunk to bunk height



the jumping bar is adjustable but also ladder is given

Vikrant Class Aircraft carrier



Non adjustable lee rail

climbing bunks are very difficult

little space for coat hanging



The jumping bar is very thin



Hospital Type colour

Layout in 3 tier bed uses more length

no proper place given for the chair to keep



very low quality pillow

Vikramaditya class aircraft carrier



bed understructure is economic but uncomfortable



very narrow horizontal space between two bunks



only one light and a magazine rack is given

bolted lee rail



wrong placement of tv

thin pillow given
mattress are tied with band

at least has wood grain

Khukri Class Frigate/Corvette



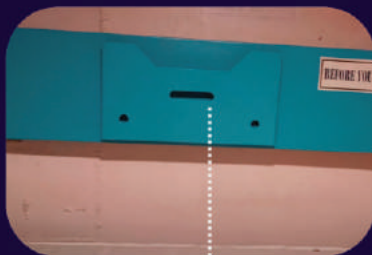
adjustable lee rail
but no handle



one coat and cap
hanger attached

cramped place-
ment of bunks

lack of clearance,
difficult to maintain



Sharp metal magazine holder



very short lee rail height,
no use



handles are
given far from
lee rail

no privacy lack of panaling

Tarangini Class Training Ship



Jugad for hanging
cloths and towels

Angular arrangement
of bunks



Strapped up mattress

Extremely sharp
corners



No space for
sleeping

Cramped up
with excess
luggage



Lee rails are often
seen tilted

Ironing towel over
bed

Design Objective

To design a new age sleeping solution of three tier bunk/ berth cubicle for a 6 men sailor living quarter with better safety, more functionality, better sleeping environment and enhanced storage and recreation facility.

Design Brief

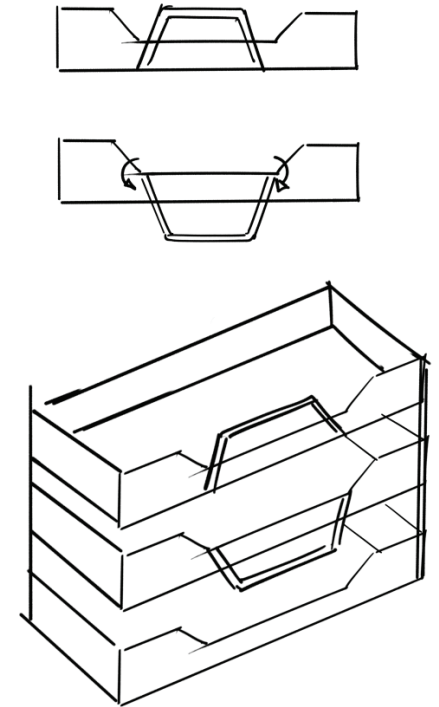
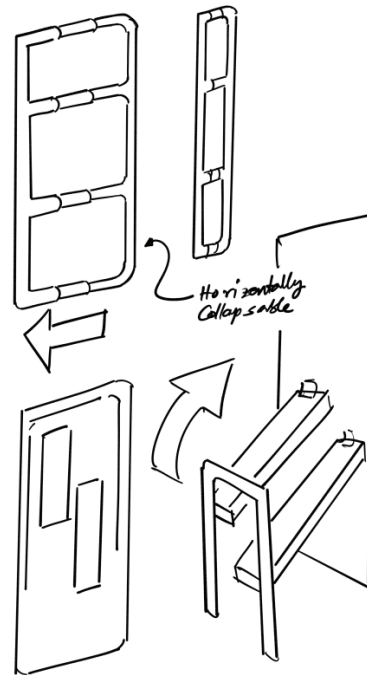
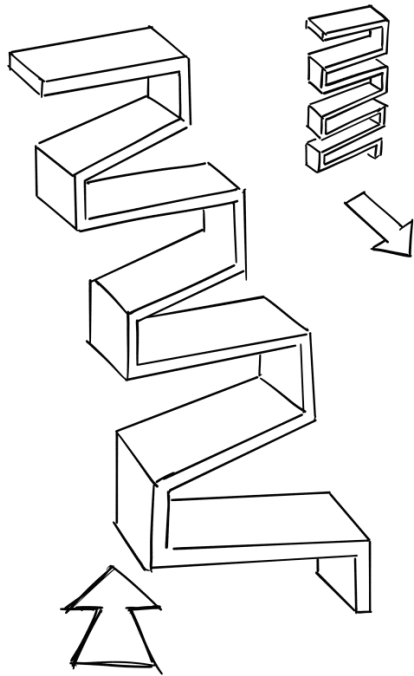
Design Brief

Design a three tier bunk/ berth cubicle for accommodating at least 6 personnel

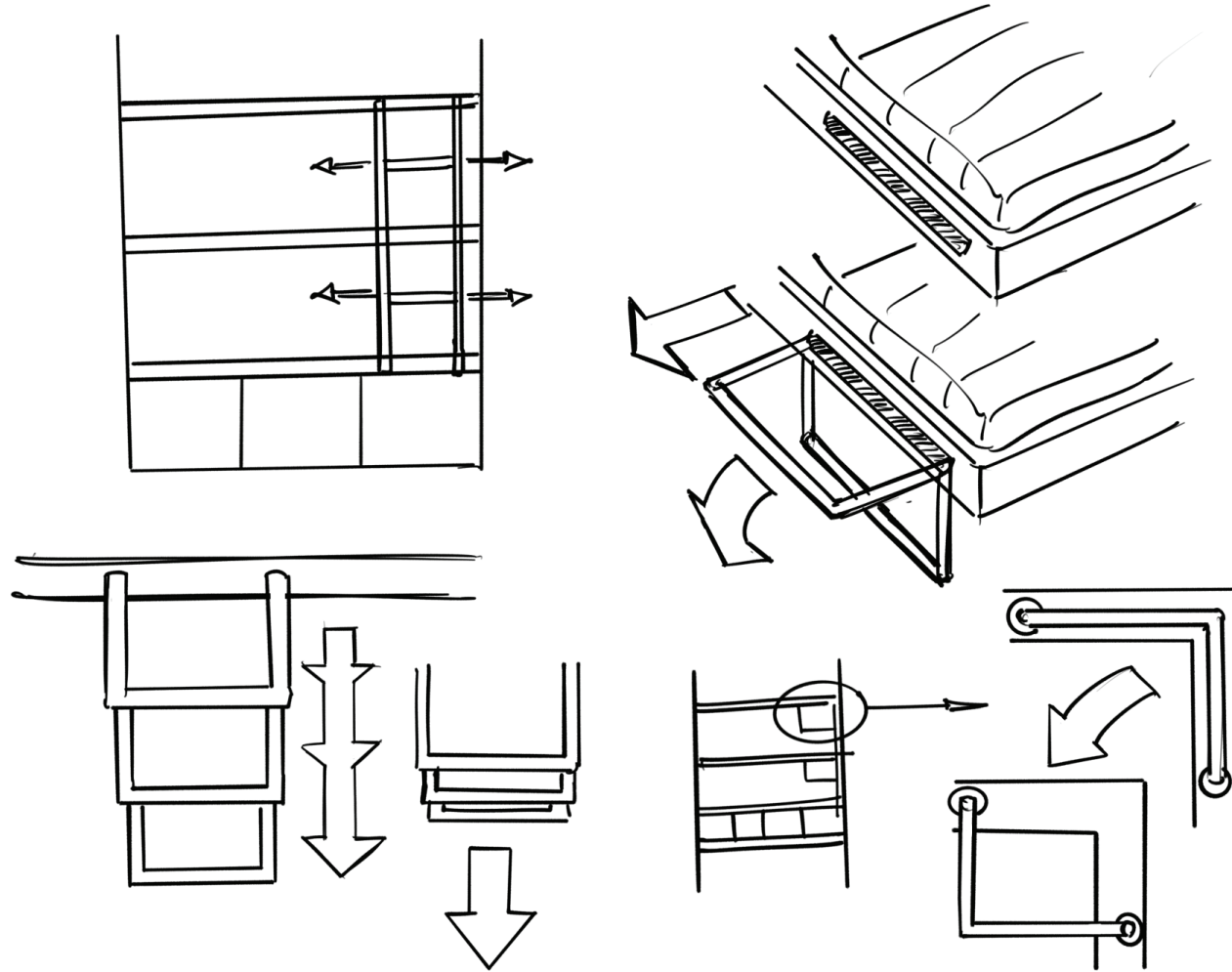
- Multi-functional bunk bed with foldable usability
- Multi-functional storage space
- Better storage and accessibility
- Provide better privacy
- Better noise reduction
- Better vibration reduction
- Better sleeping surface
- Foldable multipurpose ladder

Idea Generation

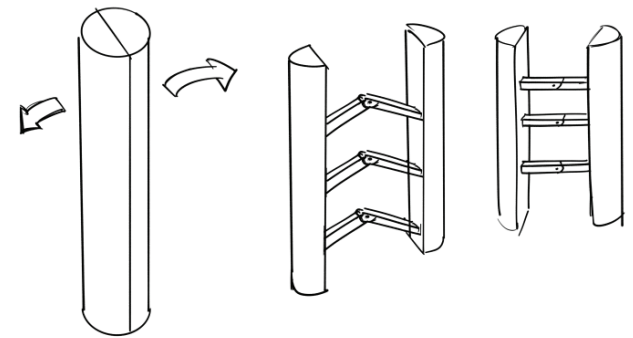
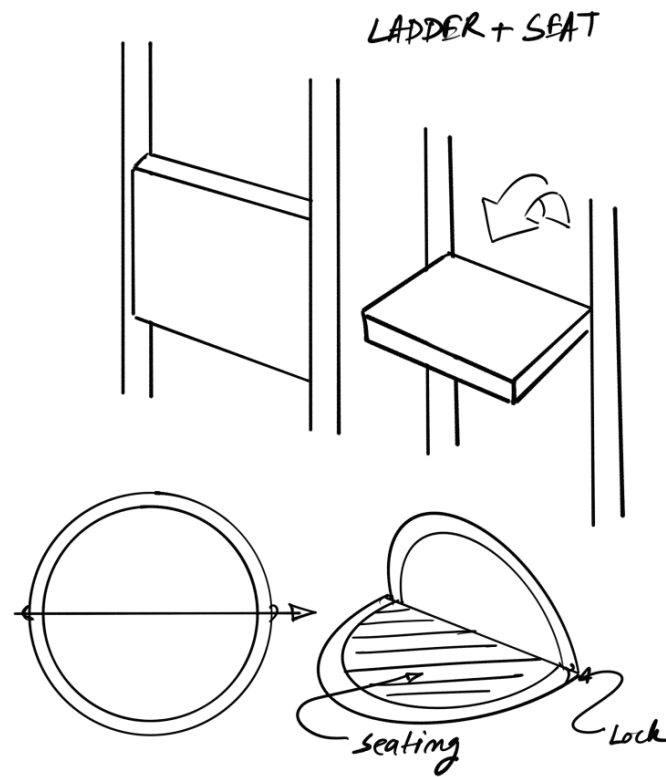
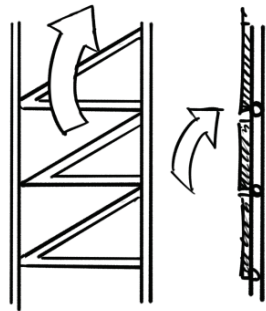
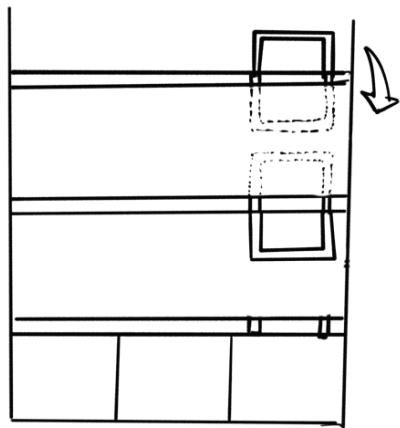
Ladders and Lee Rail



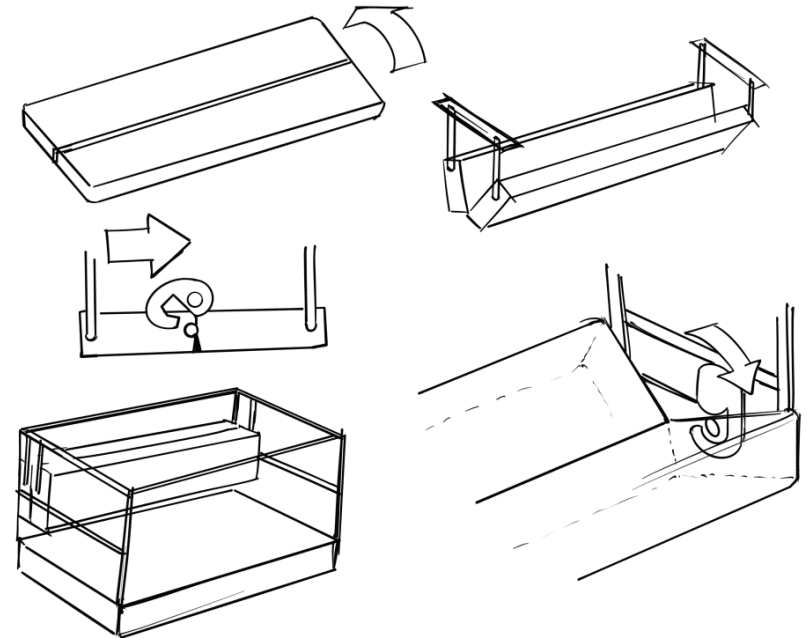
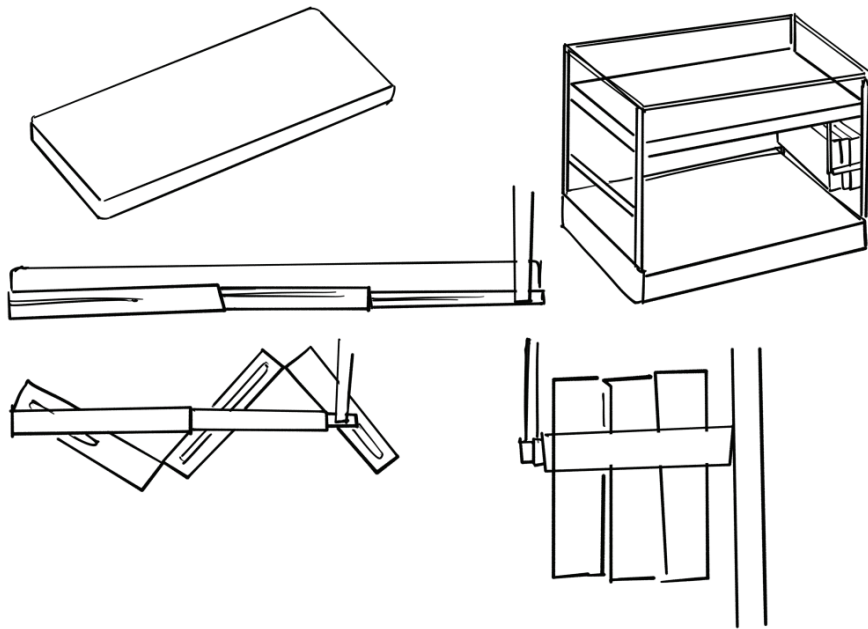
Collapsible Ladder



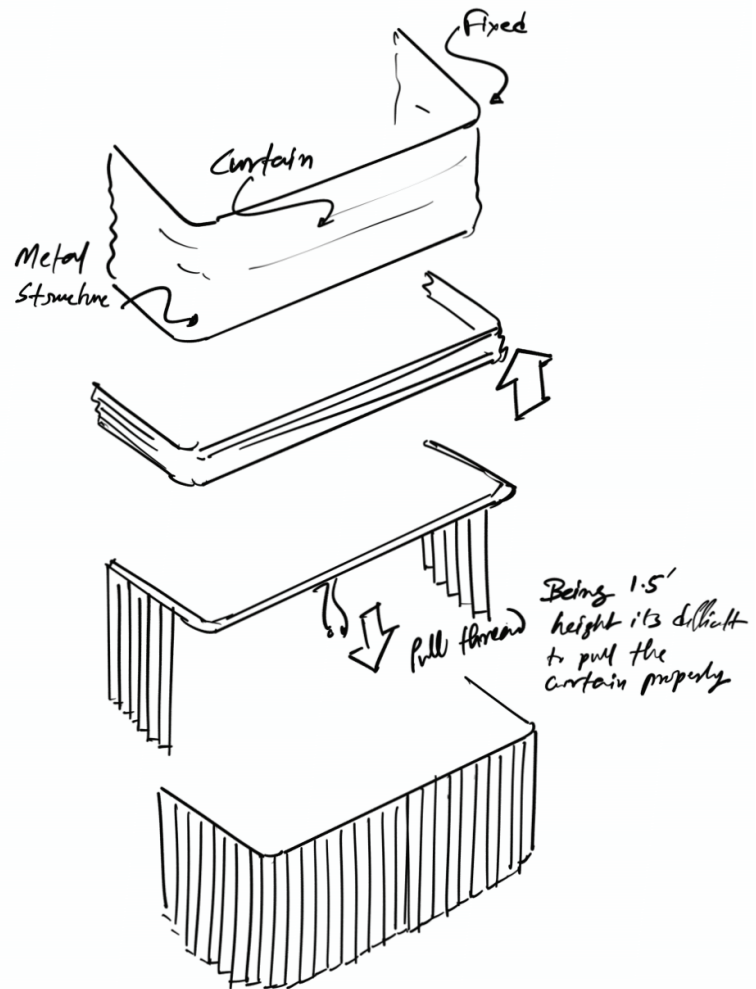
Collapsible Ladder and Seating



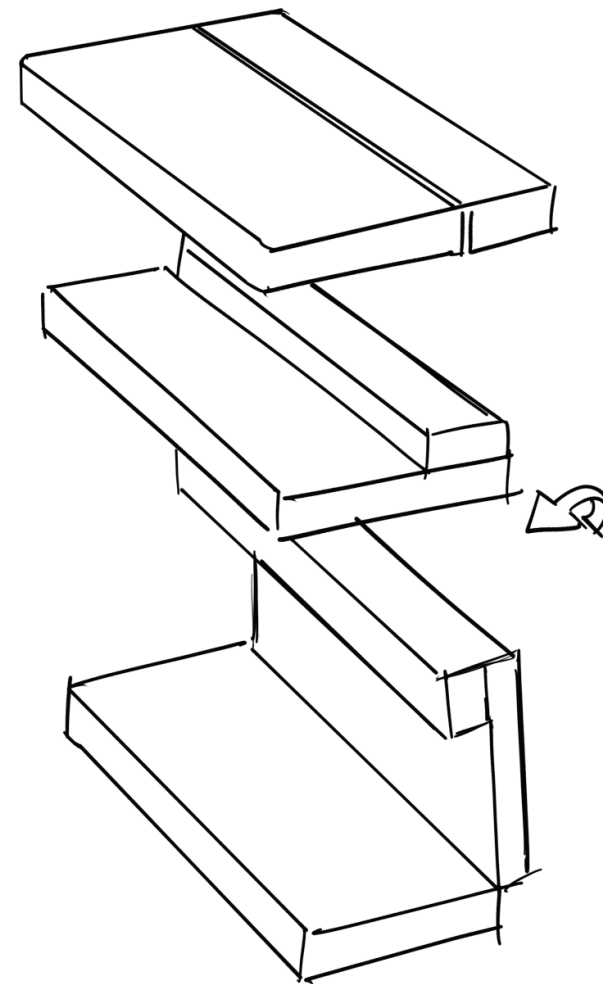
Bunk Bed Folding



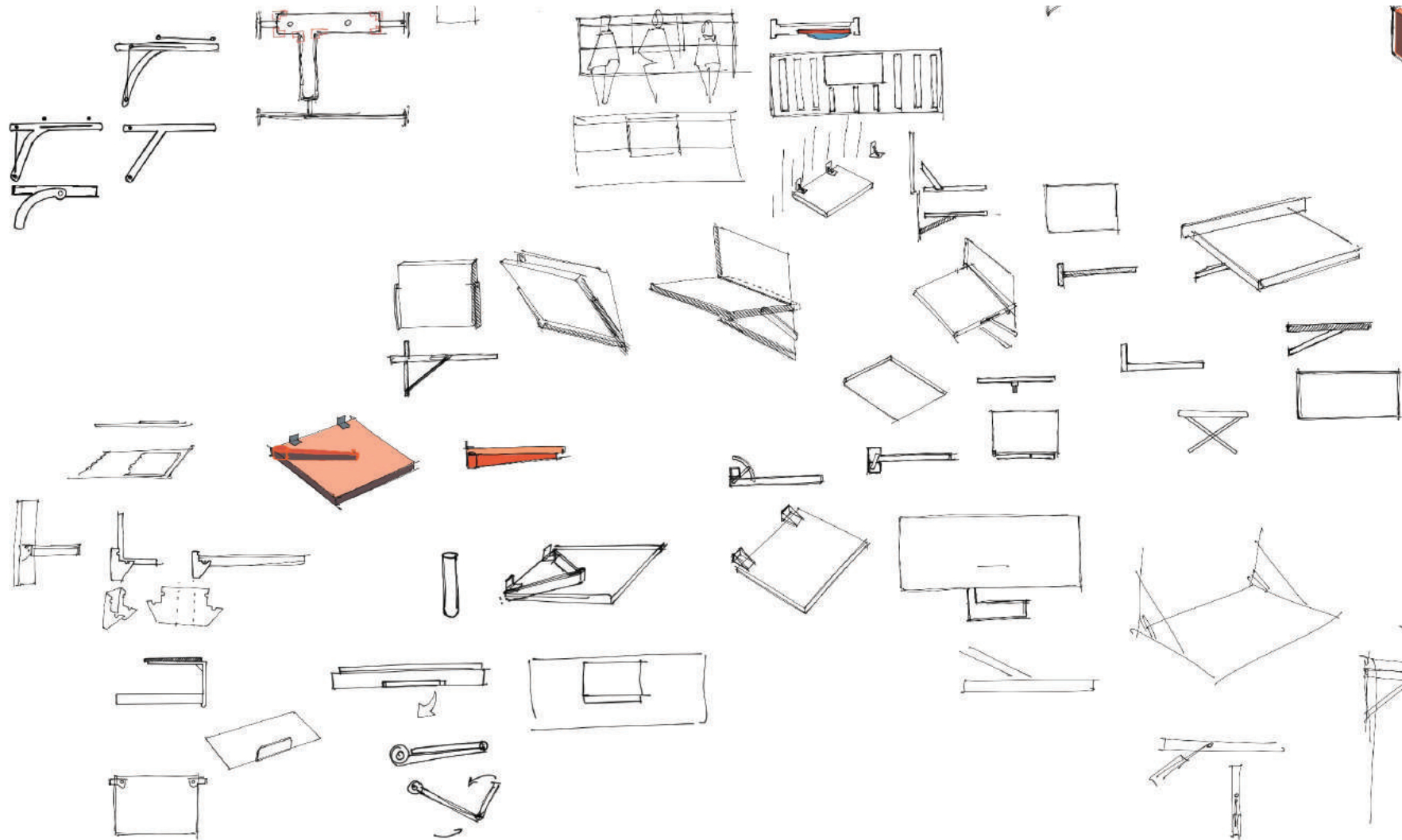
Privacy Curtain



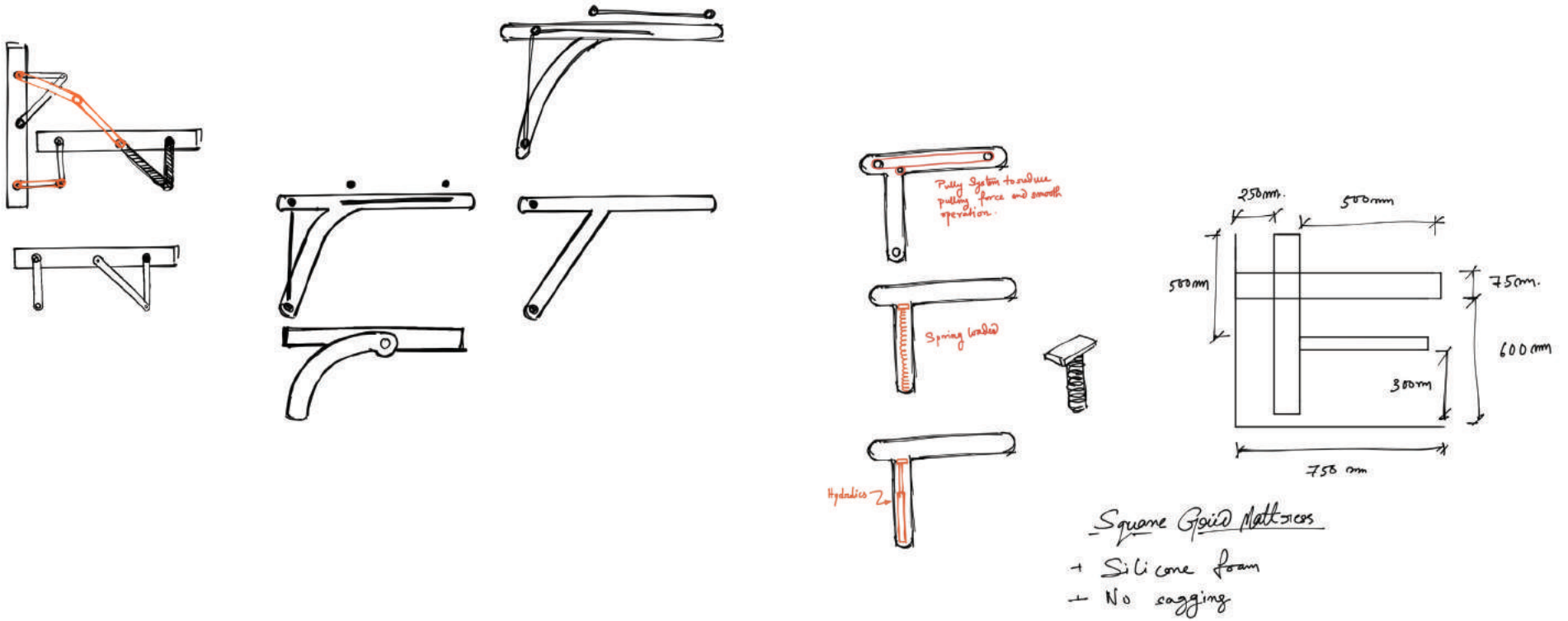
Bunk Bed Folding



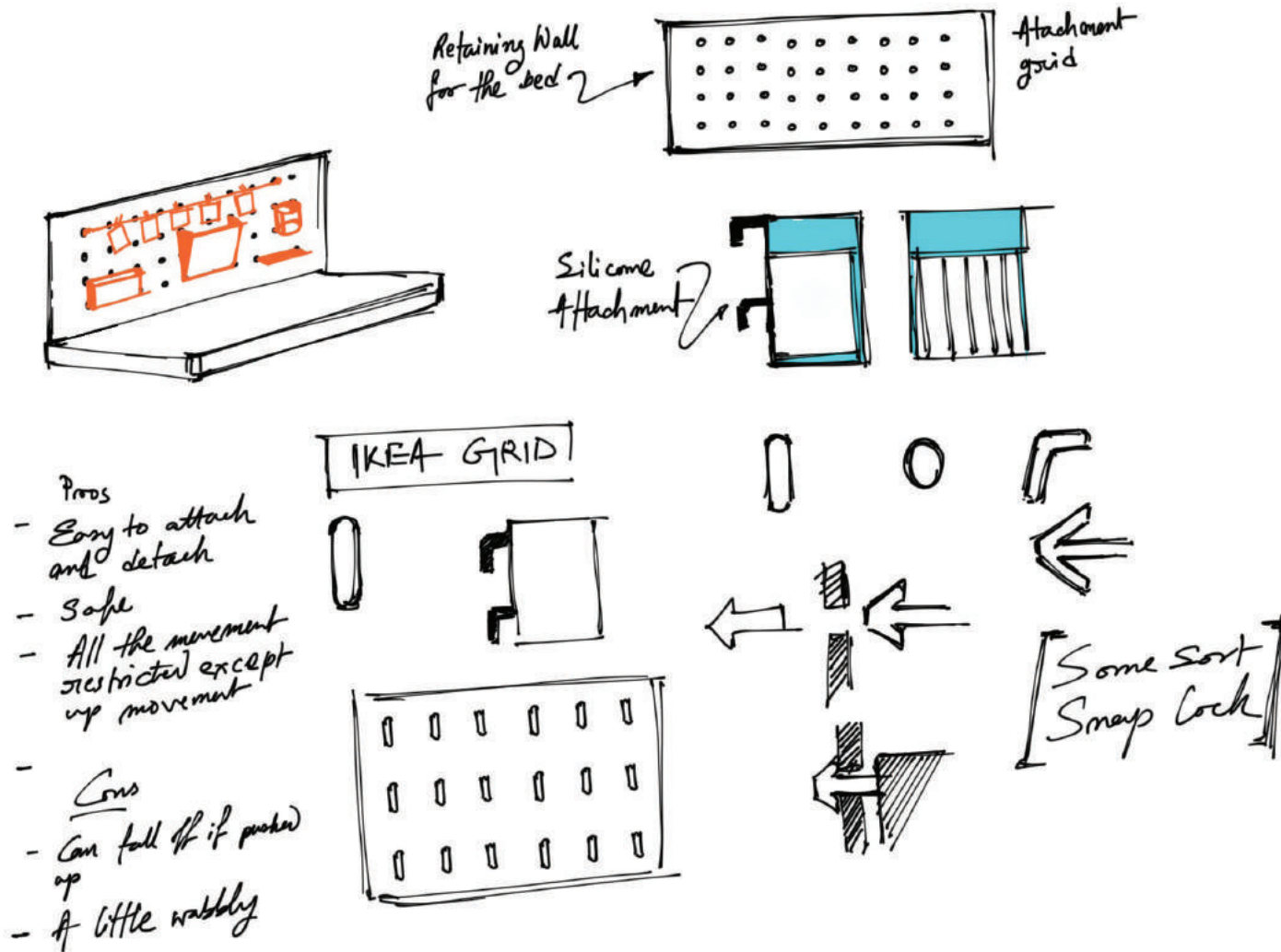
Folding Table Under Bed



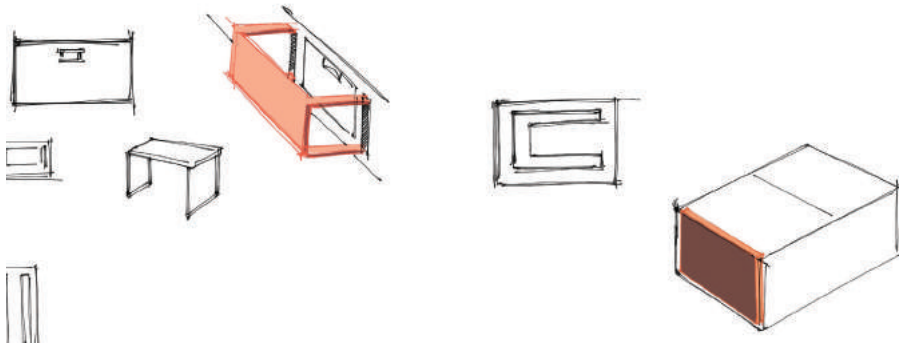
Bed Folding Mechanism



Additional Storage Ideation

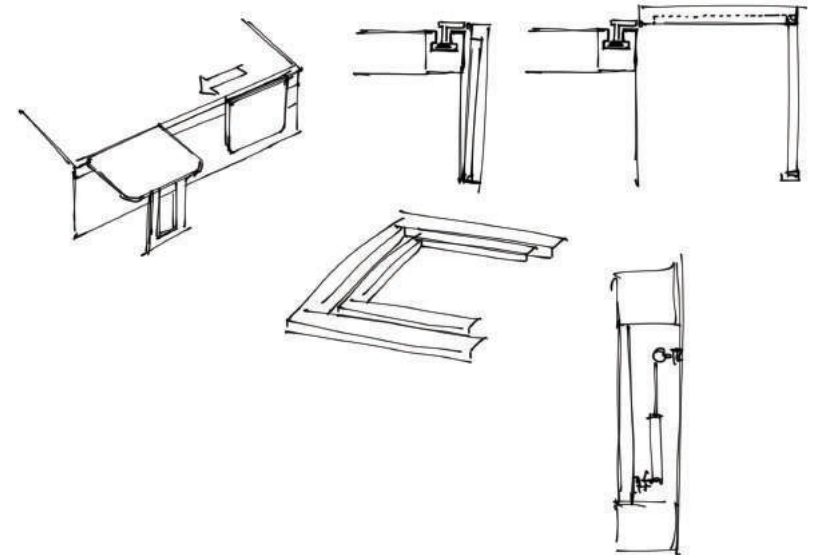
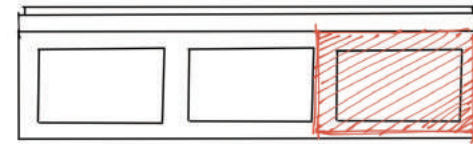


Sliding Chair Ideation



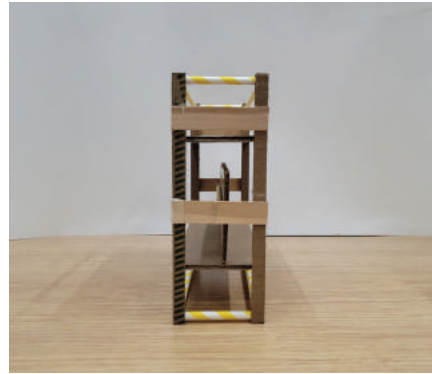
A pulling chair can be given at the front of the bottom storage unit to efficiently store the chair.

Here a sliding chair can be given over the bottom bed rail so that it can unfold and personnel can sit anywhere he wants.



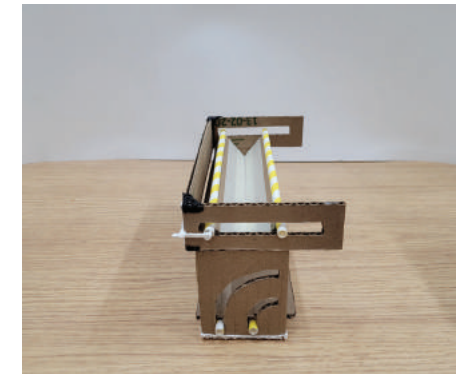
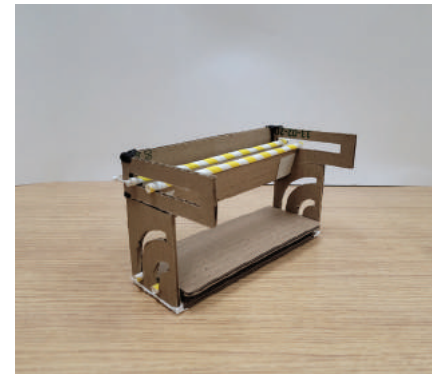
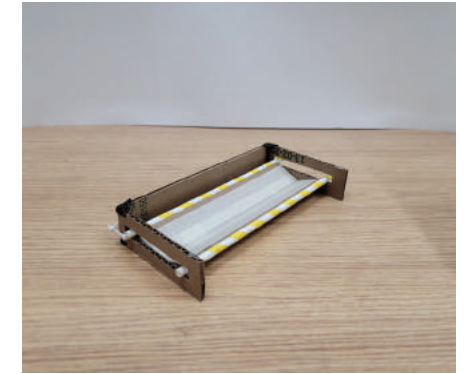
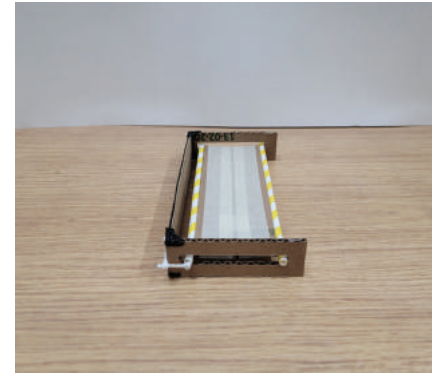
Mock Up Making

Mock-Up 1



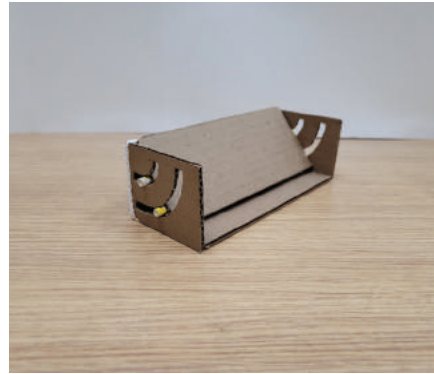
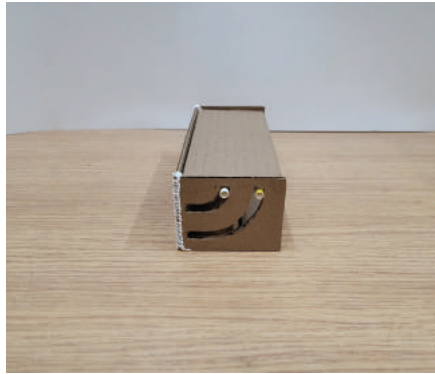
To start with I made this model with existing dimension to understand the problems in real 3d environment. As the width of the middle berth is more than the height from the lower bed, the bed folding pivot has to be given at a distance instead of end. But by doing this a lot of space is being wasted at the back of the bed. Also the mattress side of the beds is on the front which might make the personnel uncomfortable to share.

Mock-Up 2



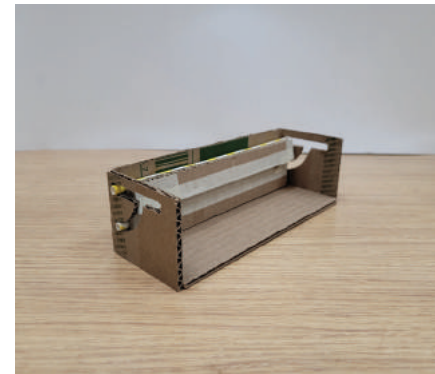
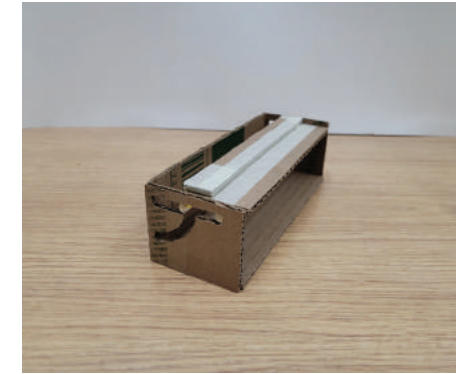
Here I explored a simple middle folding mechanism where you can fold the bed in half and can slide to the back for more room. The folded bed can be used as a head rest while sitting on the bed. The challenge will be here is to add multi functionality and also folding the mattress. Also the person sleeping may feel insecure. But is very easy operation.

Mock-Up 3



In this mock up model the middle berth has a pivot point a little ahead of the end of the bed. This design has two leading rail to guide the movement of the bed in an inverted curve manner. The beauty of this mechanism is, it is extremely easy for operation. Also the operation is an one swipe motion. But the biggest drawback of this design is its lack of safety. As the mechanism goes down the stability of this design depends on the locking mechanism. But that can fail badly if not secured well.

Mock-Up 4



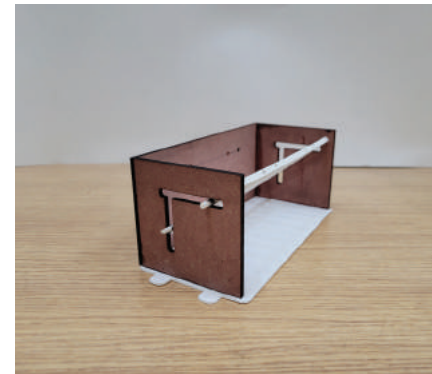
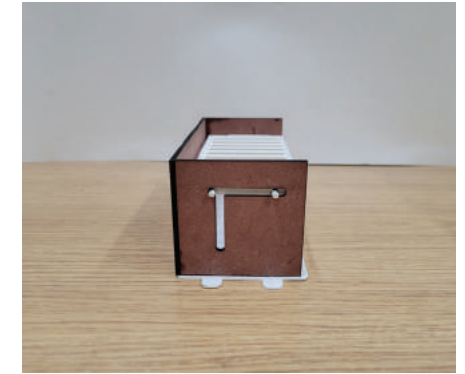
The above mechanism shows how we can fold the bed in half and can fold it back to make it vertical at the same time making a good headrest for personnel to sit. At the same time the increasing number of steps can create lack of desire to use more often. Also the cut out for the mechanism can create weak spot if not manufactured well. But the back rest can provide good ergonomically support for the sailors to sit and relax.

Mock-Up 5



This is among one of the better ideas where a lot of multi functionality has been added. The mechanism for folding here is a simple circular cutout through which a pin can move freely. A locking mechanism can be developed to restrict the movement. The folding table from the back of the bed can give the sailors added usability to use their bunk for recreational activity. The sliding chair can provide sitting for the third person.

Mock-Up 6



This is a modified version of the mechanism of the previous model. Here there are two pins for more stability and the inverted I cutout can act as a channel for the pins to run and fold the bed properly. Also the cut out can make the bed into a good back rest when fully pushed to the back. The only problem here is the friction that can be introduced due to the vertical channel. A nylon roller can fix this easily.

Mock-Up 7

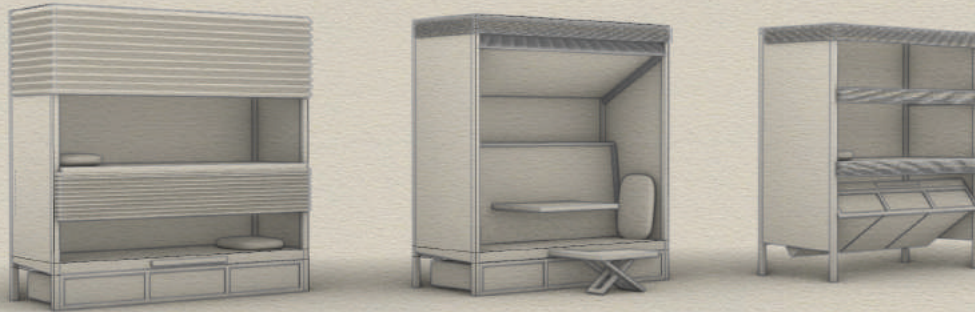


This is a 1:10 scale mockup that I made to fit all the features. The top and bottom beds also can be lifted to make more space and clean the floor properly. The sliding chair will be added into the bed system. This also has better ergonomics and easy operation.

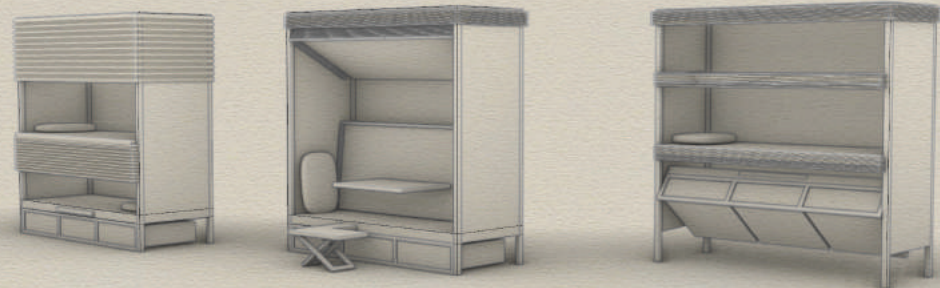
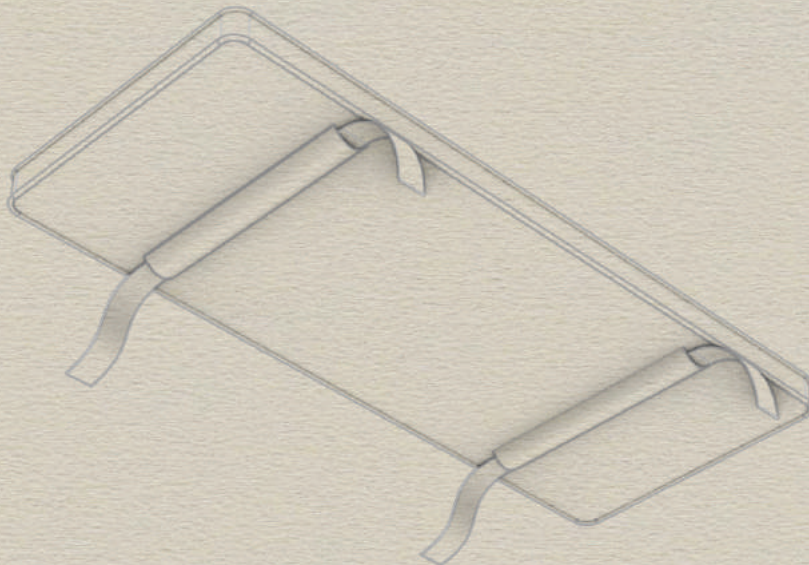
A folding ladder is also attached here for better climbing of the bed. The ladder can be folded back and tucked back in the side of the bed. This expandable ladder is excellent for comfortable save space at the same time full utility.

Concept Generation

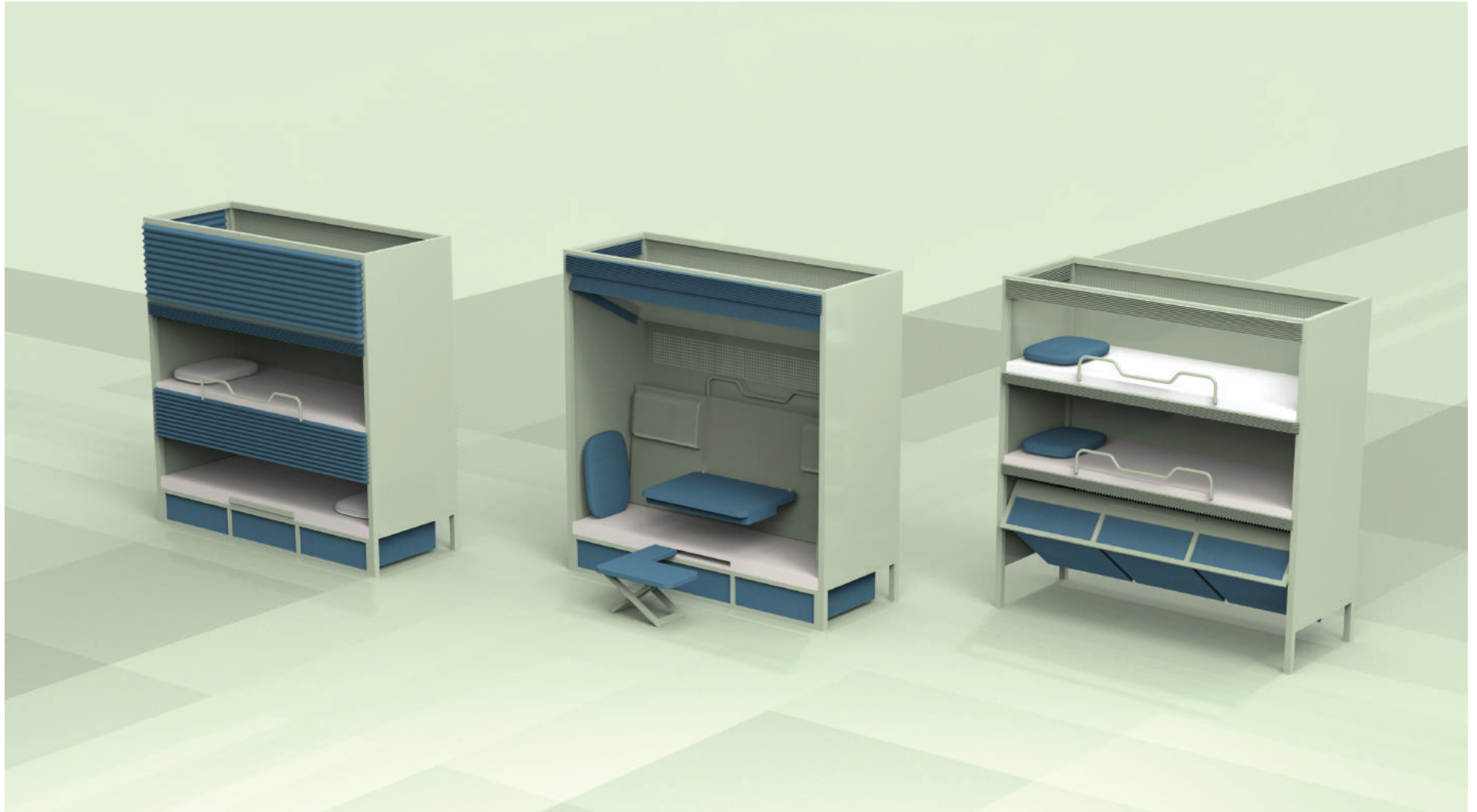




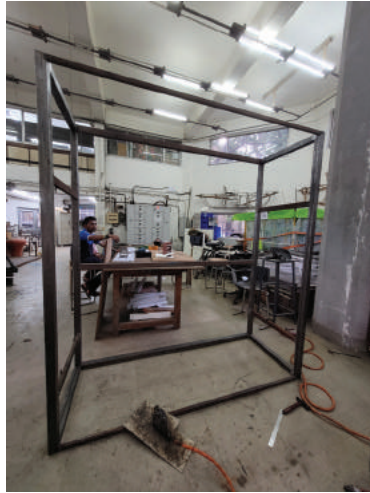
- Simple slide down privacy curtain
- Foldable Table and sliding chair for enhanced recreational opportunity
- Middle berth fold back completely,
- Upper berth folds up
- Bottom berth along with lockers can be tilted for better maintenance
- Straps go under the mattress



Concept Render



Prototype Making



Final Prototype



I'm thrilled to share that I've crafted a fantastic prototype of a bed that sailors will absolutely love! We've used top-notch materials like a sturdy metal frame and durable plywood for construction. This bed is a game-changer, let me tell you why.

First off, we've incorporated a folding middle bed that's equipped with a nifty table. Sailors can unfold it and use it for all sorts of tasks like reading, eating, and playing games - it's multitasking at its finest!

We've got three spacious drawers with super-strong castor wheels underneath. Not only do they support heavy loads, but they also serve as extra seating or even an additional sleeping spot with a third mattress on top.

We've paid close attention to comfort too. The advanced grid mattress keeps sweating at bay, allowing for better ventilation during those well-deserved naps. And don't worry about accessing the bed - our clever folding ladder saves space without compromising ease of use.

Our bed comes with a sleek metal structure that's both strong and lightweight, ensuring the mattresses stay securely in place even during the wildest sea adventures.

We've added personalized sideboards to give sailors extra storage space, so they can truly make the bed their own.

So, there you have it - a bed that's not only super space-saving and practical but also loaded with cool features and high-quality materials. Sailors will surely love this comfy, tech-savvy, and customizable addition to their ship quarters!





Sliding handle to prevent accident

Advanced curtain for one hand use

Peg board for keeping essential. Fully customizable

3 bed to accommodate 3 sailors with comfortable height of 550 mm



Folding ladder to further save space

Table, when folded can accommodate 3 person to sit.

Big drawer provides lot of storage and can be used as seat or bed



Dual folded lid for better user experience



Big table surface for multiple use by the sailor.



Ergonomic seating and
ideal for good social life

Please Visit for Video Demonstration



[https://www.behance.net/gallery/175261481/
Furniture-Design-\(Bunk-Bed\)-For-Indian-Navy](https://www.behance.net/gallery/175261481/Furniture-Design-(Bunk-Bed)-For-Indian-Navy)

Thank You