

This booklet is an illustration of the design guidelines Sheryl Bishop and Sandra Häuplik-Meusburger highlighted in their book *Space Habitats and Habitability Designing for Isolated Confined Extreme Environments on Earth and in Space*, 2021.

The Social psychologist and Space architect collaborated to define and promote habitability concepts to design «living spaces» instead of «surviving places».

The aim is for individuals to thrive in a medium to long-term environment that is to be their **home** in a compact settlement. It may be shared between functions, people and away from one's native region.

The design recommendations are showcased and detailed through the redesign process of the communal space onboard an icebreaker.



DESIGN FOR ICE HABITATS

ILLUSTRATED GUIDELINES

Margot Landry




DESIGN FOR ICE HABITATS

The project and booklet aim to showcase visually how to devise **a habitat where humans thrive** based on the research of Social psychologist Sheryl Bishop and Space architect Sandra Häuplik-Meusburger. They studied previous experiences of humans in Space or on Earth and concluded design guidelines for Isolated Confined Extreme environments (ICE).

It is intended for designers but also engineers, architects, planners and any professional working on a project where people will live.

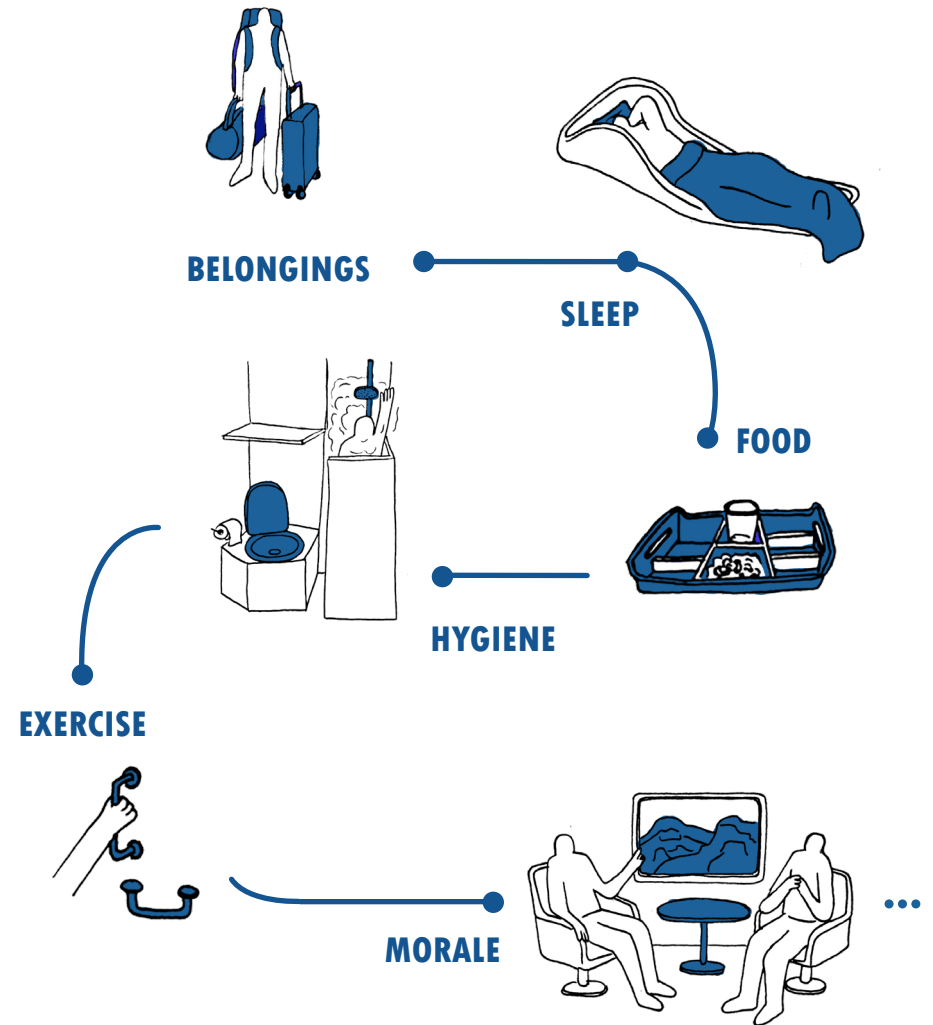
This booklet was made in 2024, anyone is welcome to update it in the future.

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BASIC NEEDS FOR

ISOLATED
CONFINED
EXTREME
ENVIRONMENTS

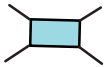


KEY SUCCESS FACTORS

FOR DESIGNING ICE HABITATS

According to Sheryl Bishop and Sandra Häuplik-Meusburger's guidelines in *Space Habitats and Habitability Designing for Isolated Confined Extreme Environments on Earth and in Space*, 2021.

In this booklet, the following guidelines were applied to the communal space onboard Nathaniel B. Palmer icebreaker.



SPACE PERCEPTION

Opening the space, play with perspective



GROUP INTERACTION

Encouraging communities to collaborate, fostering collective intelligence



HETEROTOPIA

Space with different levels of meaning, multi-use, redefinable purpose



SPACE APPROPRIATION

Humans are resourceful to customise the room as they wish to settle and feel well



STORAGE

No visual clutter, no crowdedness feeling



PATHING

Designing route alternatives for variety or to avoid people when we don't wish to

Icon credit: Ulcons, Ultimatearm, Freepik, smashingstocks, Ultimatearm, Freepik, Freepik, DinosoftLabs, Freepik, mnaulady, Hajicon, Freepik, Abbasi



LEISURE AND CREATIVITY

Staying busy to fight boredom and negative thoughts



GREENERY

Showcasing fractal elements -patterns found in nature- to improve human well-being and performance



VISUAL DEPTH

Providing distance vision, a view, a window to the outside



RETREAT

Giving opportunities for a person to take some time isolated from the group



COMMUNICATION SUPPORTS

To promote community events



KINESTHESIC SENSES

Stimulating with lights, colours, textures



PERCEPTUAL REFRESHMENT

Variety and new stimulations are vital for cognition and mental well-being



INTRAGROUP GATHERINGS

Meeting in small groups without involving everyone around



The following pages present the process of redesigning the communal space of an icebreaker. This ship travels to the Polar Region carrying scientists who live onboard for several months. This is just one way of illustrating the recommendations for creating a living space in an extreme environment.

THANK YOU TO

the experts who participated in the icebreaker project and shared their insight to address the socio-spatial and psychological challenges onboard:

Tuomas Ruomu

Senior Naval Architect employed at Aker Arctic

Niklas Nihlén

Architect Lecturer specialised in Lights and Colours at Lund University

Per Liljeqvist and Pia Jablonsky

Design Lecturers at Lund University

Larry Toups

Space Architect and Lecturer at University of Houston

Wiktoria Dziduta

PhD Student in architecture with ICE habitats as primary focus

STUDY TRIP

JOURNEYS AND TRANSPORTS



HABITAT ONBOARD MEANS OF TRANSPORT

Travelling a distance in others ways than plane imply **longer journeys** and associated discomfort. A study trip in the United States took place during the icebreaker project. Travelling between San Francisco and Houston by bus and train took 48 hours. This time highlighted challenges, smart designs, pain points, and pleasant features. What would it take today to have a good experience of crossing the Atlantic by ship?



REFRESHMENT & VARIETY

San Francisco, urban landscape surrounded by **nature** and special for its steep relief rich in point of views



«WINDOW ON SOMETHING LIVING»

In the train from Los Angeles to Houston, passengers become spectators of a great **scenery** changing throughout the States



GROUP INTERACTION

Amtrak trains feature a «sightseer car» with large windows, it turns out to be the «**social space**» onboard where people who are strangers to one another chat about their lives

INTERIORS

CURRENT TRANSPORTS



LIGHT, LAYOUT & VISUAL DEPTH

Onboard SAS aircraft between Europe and the United States, Amtrack 'Sunset Limited' from Los Angeles to New Orleans; lights hidden and embedded in the ceiling

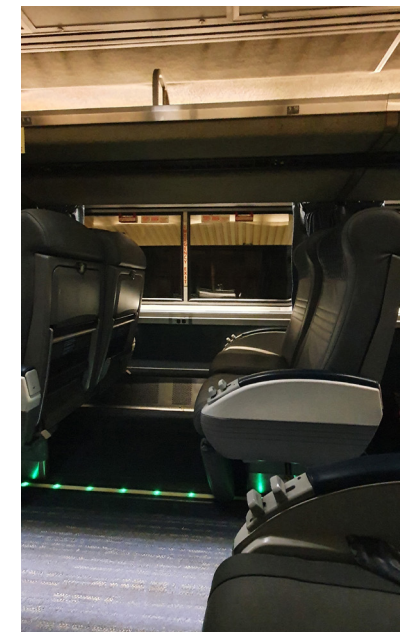
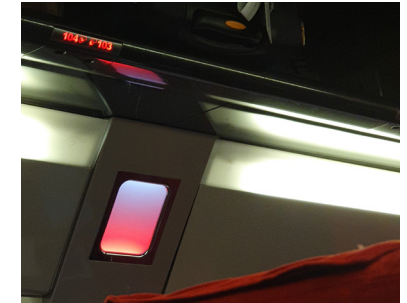


STORAGE, CLUTTER, CLEANLINESS

Bathroom study onboard Amtrack train, AirFrance aircraft, Dutch train, smart storage, user interactions, variety of material finishes

SPACE PERCEPTION

Lights changing along the day altering the indoor view with natural/artificial light, day/night





NATHANIEL B. PALMER

U.S. ICEBREAKER

Managed by the United States National Science Foundation, it is used for scientific missions in the Polar region.

Crew capacity **22**
 Scientists and staff **39**
 Total number of passengers **35-60+**
 Scientific cruises a year **10**

Length **94.0 m**
 Breadth **18.3 m**
 Depth **9.1 m**

MESS HALL

(marine term for dining room)

Limitations for the size and number of porholes on the Main deck

2.1 m ceiling height

Direct light + reflective surfaces = not enhancing the room's narrowness

Visually heavy and non mobile furniture



BERTHING

(bedroom)

For some, even the bedroom is shared



LOUNGE ROOM

Only room with home-like decoration, TV and couches



THE «GALLEY» (KITCHEN IN MILITARY TERMS)

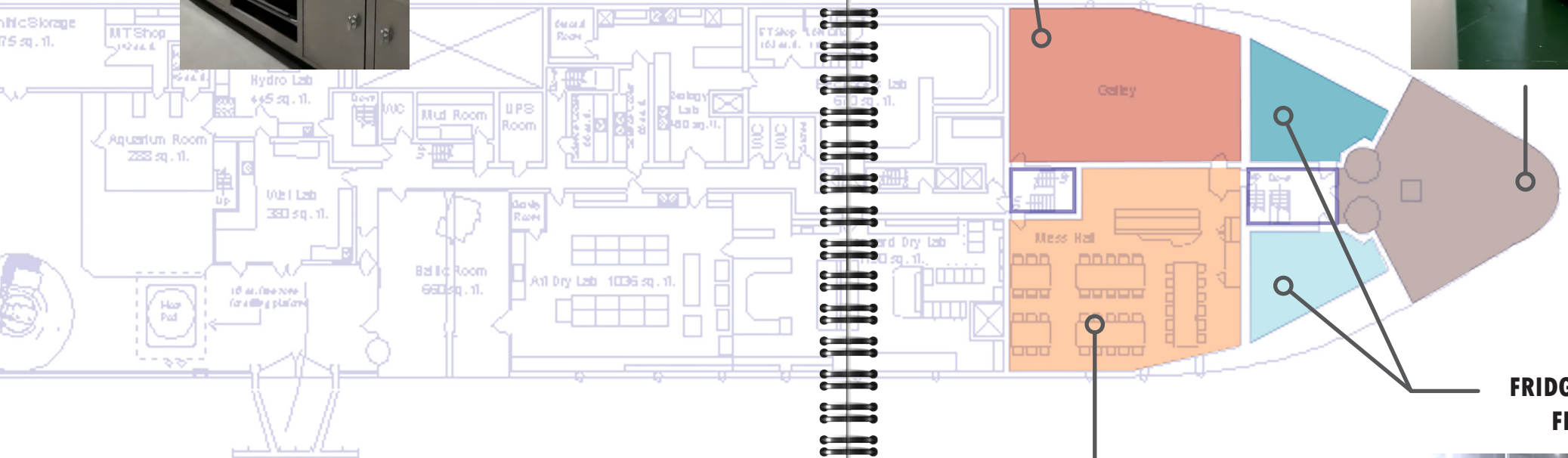
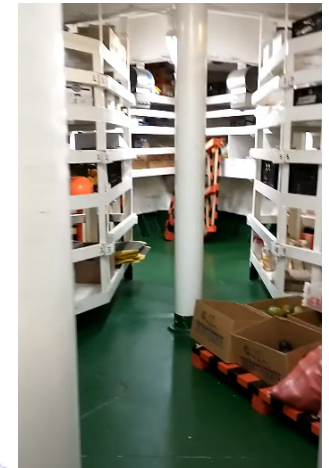
The «warm heart» of the house yet only the kitchen personnel is authorised in for sanitary reasons

HOW TO ENGAGE THE CREW IN COMMUNAL MEALS ?

STORAGE

Only one purpose for this room

COULD IT BE A SITTING ROOM?



Main Deck

In order to best illustrate the challenges from a group and individual perspective, the focus is on the «common spaces». It hosts more scenarios and therefore covers the guidelines in a more comprehensive way. By contrast, the berthing space is best suited to address the privacy topic.

THE «MESS HALL» (DINING ROOM)

THE common space
Every one comes here to eat



FRIDGE AND FREEZER



fostering community
GROUP INTERACTION

VISUAL DEPTH
providing an open view

allowing to isolate
RETREAT

GREENERY
introducing plants



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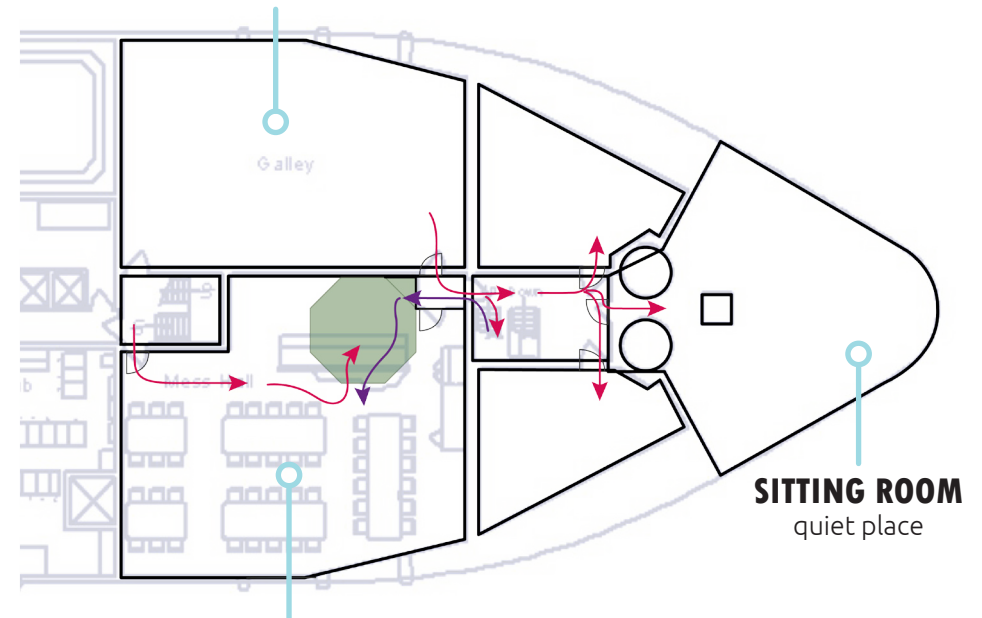
9 m² Wardroom (dining, storage, gathering) in
Skykab 2 training module, Raymond Loewy 1972
Cupola, ISS
Amundsen-Scott Greenhouse, South Pole Station

CREATING A CONNECTING ROOM BETWEEN THE COMMON SPACES

Designing '**living spaces**' focusing on the 'communal space' for long missions in Isolated Confined Extreme habitat onboard an icebreaker, addressing well-being and function at individual and group level, friendly to personality or cultural diversity.

KITCHEN

«the warm heart of the home»



LIVING ROOM
communal space

SITTING ROOM
quiet place

KITCHEN

SELF-SERVICE

TO THE
SITTING ROOM

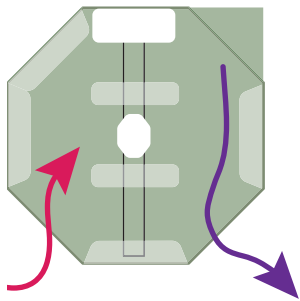
LIVING ROOM

PATHING

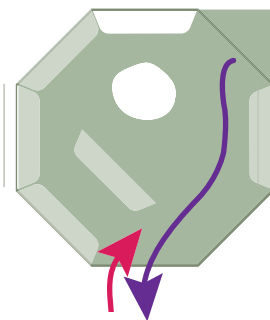
FLOW AND TRACKS

TESTS

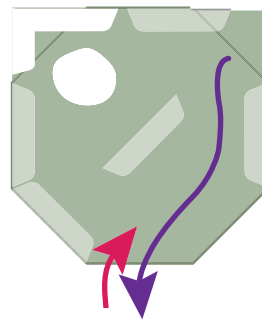
- + more entrances, pathing and variety



- single entrance
More planters



- including the
back-left corner



- risk of being a crossroad were one cannot rest quietly

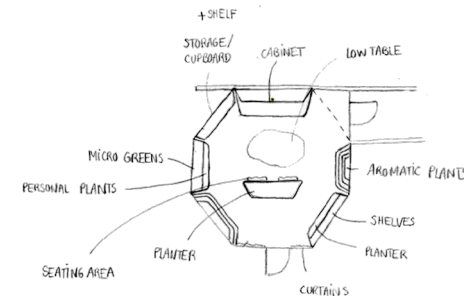
better to use it instead as a coffee corner next to the self-service counter outside



HETEROTOPIA

SPACE WITH MULTI-USES

Compact spaces need to keep some **flexibility** in the layout to accommodate different uses.



One room is rarely used for its designed purpose. Tuomas Ruomo, Senior naval architect and close advisor on this project summarises: «I also know crews tend to be quite **resourceful** and will over time modify the original layout (anything short of moving bulkheads) according to their needs and preferences.» (2023).

OCTAGONAL LAYOUT

regular shape allowing to swap items from one wall section to another

Picture:
Greenhouse on board Vaygach icebreaker (URSS)



SPROUTS
in a dark environment



MICROGREENS AND AROMATIC PLANTS
with 12-16H artificial light/ day



Plants impact the human cognition and well-being positively. It provides an added value to the concept by being relatable to any nationality or culture. Besides benefiting on the individual level it also fosters group interaction. Gardening can become a collective activity between crew members with different backgrounds.

GREENERY

BENEFITS ON HUMAN HEALTH



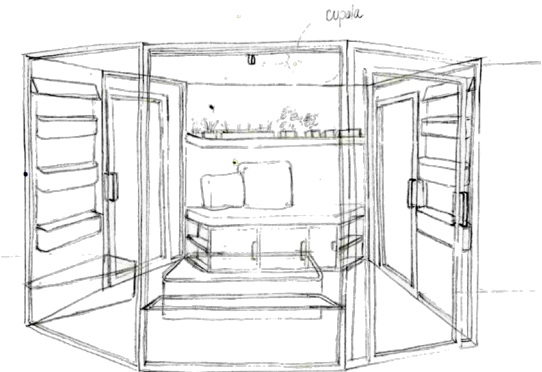
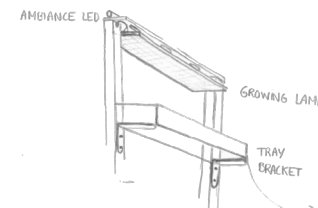
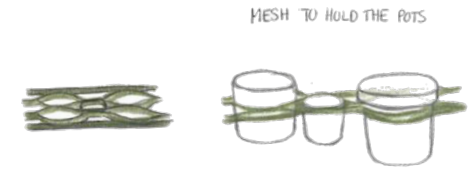
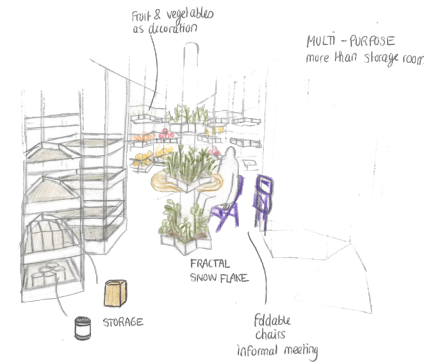
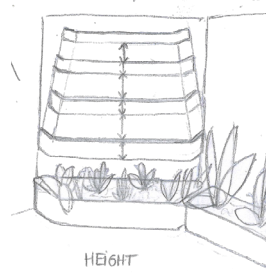
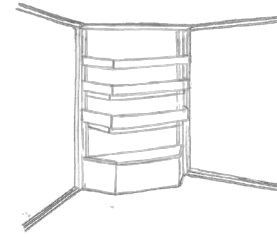
PLEASANT FOOD
to eat fresh greens, to grow and taste the result



RECREATION
against boredom as a group or alone activity



RELAXING VIEW
stress relief and fascinating to see evolve



WINTER GARDEN
thinking the multi-uses inside, designing the layout, the view from and towards, and the flow around

THE GREENHOUSE

1. CREW'S KITCHEN

- personal storage
- cold dishes counter during mealtimes

2. WINDOW ON THE GALLEY (KITCHEN)

- warm dishes counter
- to provide the staff with fresh herbs

3. DRINKING STATION

- all-day drinks and snacks
- for crew's to take a break outside mealtimes

4. SHELVES

- decreasing depth and colour shading for perspective effect
- for plant pots, sprouting trays or jars
- fixed with brackets to the metallic beams, adjustable height

5. PLANTERS

- for vegetables and bigger plants growing

6. STORAGE

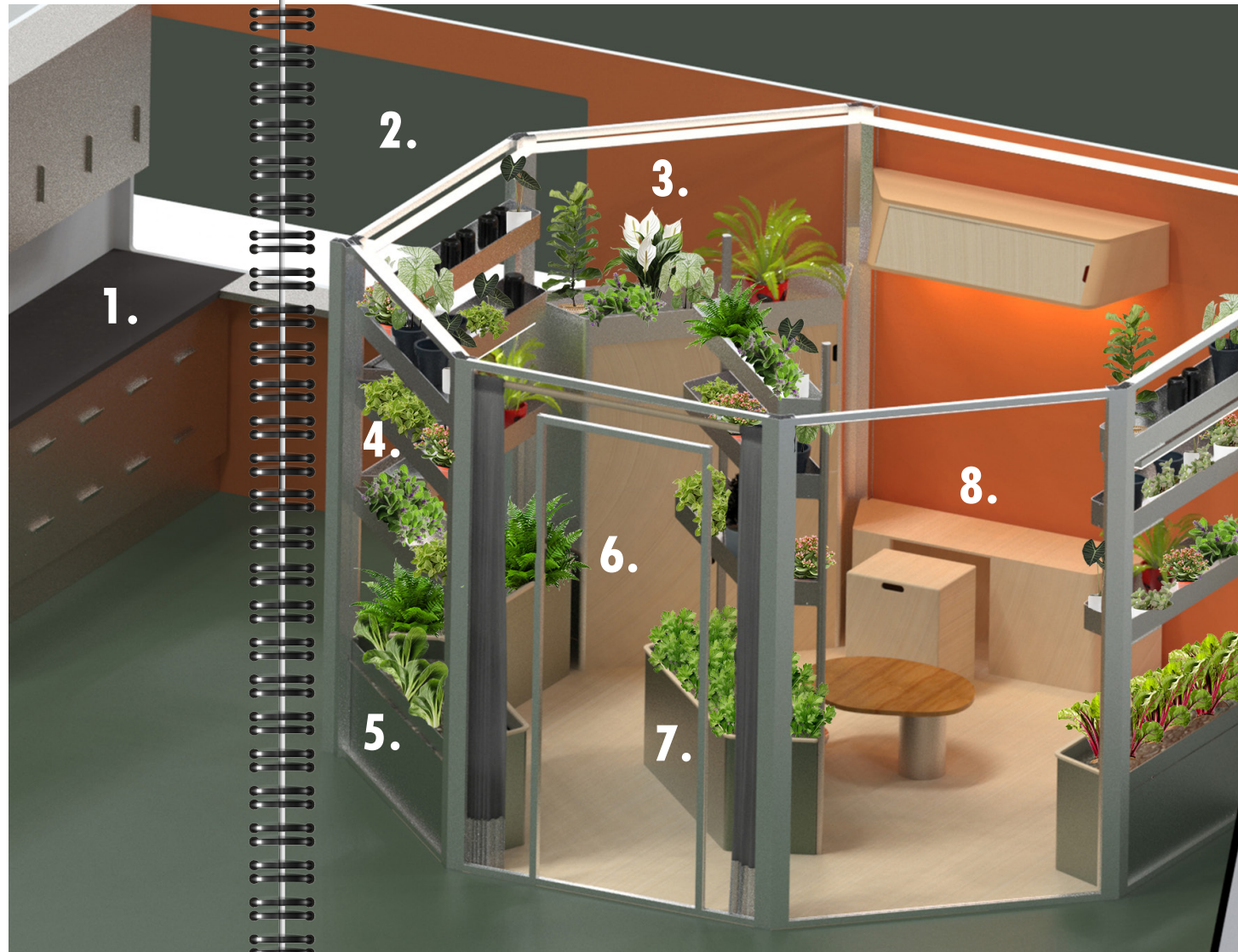
- for gardening gear and unused shelves
- foldable desk station

7. MIDDLE PARTITION

- screen between the sitting area and the open view on the living room

8. SITTING AREA

- bench and hidden storage + independent stool
- rotative coffee table
- upper storage and reading lights



Strap and non slip mat
to keep the pots in place

Growing lights

LED ribbon
(ambience light)



TIDY

NO VISUAL CLUTTER, SPACE MADE

Increasing depth and colour
intensity towards the bottom for
perspective effect

Storage with doors

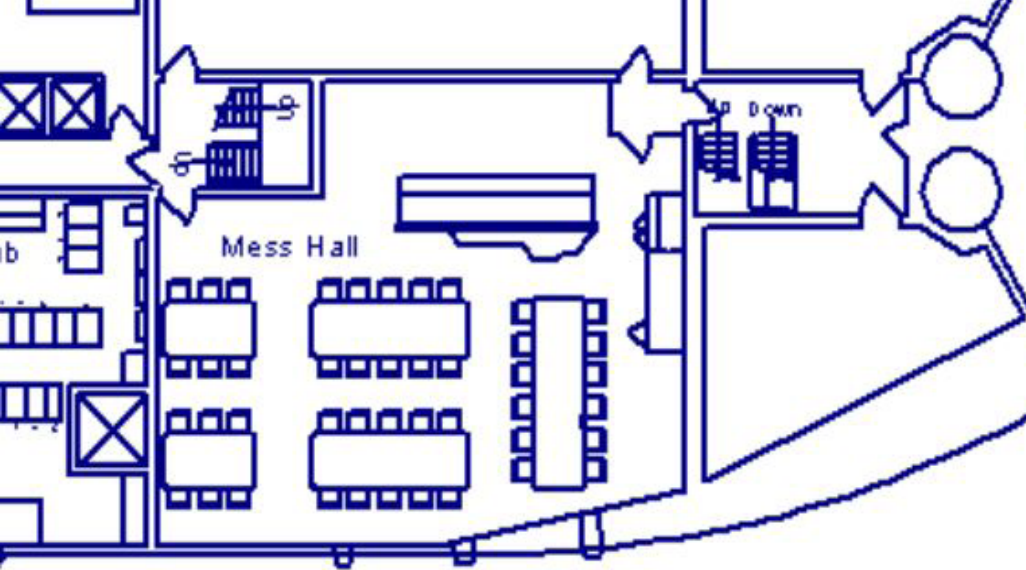
Foldable desk

Bench and
storage



FLEXIBLE

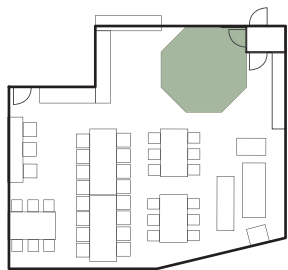
GARDENING, READING BOOKS, CHATTING, PLAYING GAMES
RETREATING FROM THE BIGGER GROUP
CHANGING THE LAYOUT: WALL SECTIONS ARE THE SAME



LIVING ROOM

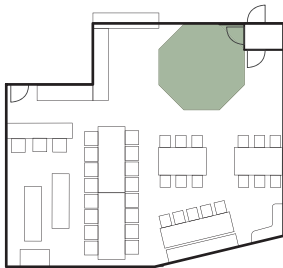
IMPLEMENTING THE GREENHOUSE IN A VERSATILE COMMUNAL SPACE

TESTS +



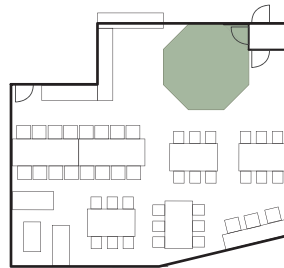
- The couch area is next to a porthole, the daylight might disturb a film projection

The couch area is in a quiet corner



The communal table stand as a fence in front of the entrance door

Better integration of the communal table and couch in the layout

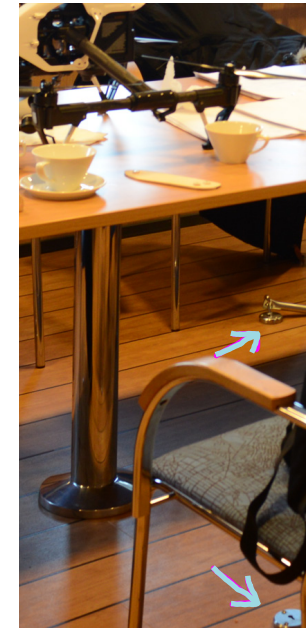


Narrow space between tables (only the 700 mm safety requirement)



PORTHOLES

Limited in number and size, daylight is either absent or omnipresent



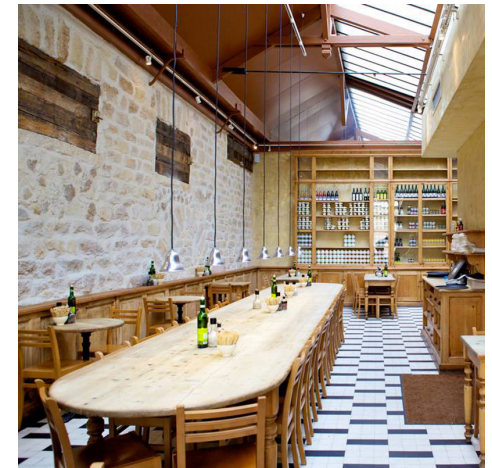
HOOKS

Allows lighter furniture choices because it can be fasten to deck if stormy



EXPERIMENTATION 1:1 SCALE

Testing out the 2D drawings layouts
Space saved with benches along the walls instead of chairs with perimeter



COMMUNAL TABLE

Inspired from Le Pain Quotidien, Belgian restaurant chain featuring a long table in all its restaurants

PSYCHOLOGY OF SPACE

Insight from Niklas Nihlén, Architect Lecturer at Lund University specialising in Light and Colour



1.



3.



2.

REFERENCES

websites: Cate St Hill, Cliccdesign, Benjamin Moore, LEDMyPlace



4.

1. MAXIMISING THE FEELING OF SPACE

- Dimming the glare coming from lights
- Choosing mat colours and surfaces (furniture, floor) that will not reflect boundaries like with a glossy finish
- Playing with paint, some blue shades give the illusion to go backwards, other yellows, towards the eye

2. ENHANCING THE DAYLIGHT

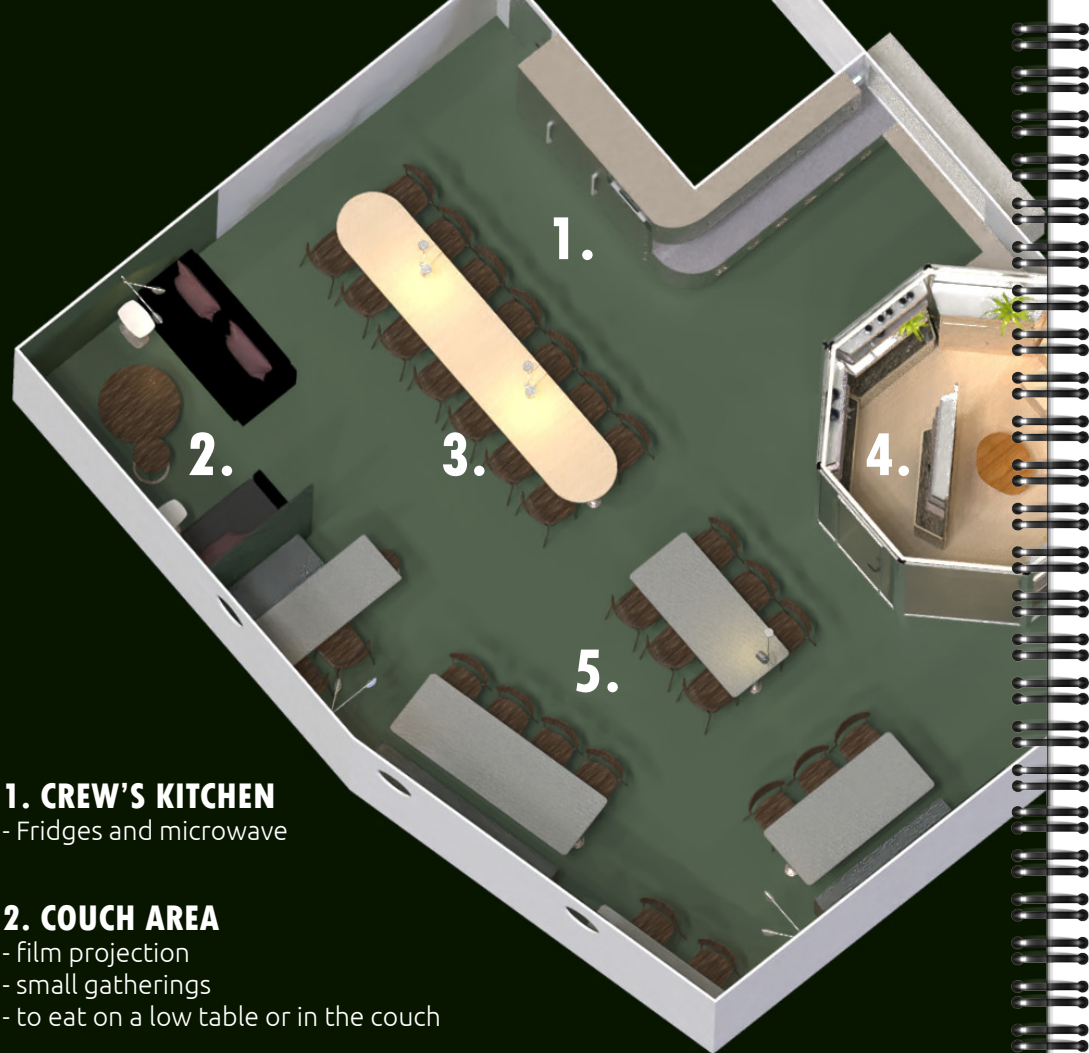
- Adding a darker colour around the window will create contrast and reveal a stronger light
- Adding a silk or transparent curtain will distribute the light inside the room

3. CHOOSING THE RIGHT CHROMATIC COLOUR

- Using NCS system® to choose according to how the eye perceives the colour depending on the material it is applied on
- Taking into account the blackness, chromaticness, the nuance and hue will provide a different experience e.g. a light blue with maximum 10% blackness can give the impression that the walls move back

4. CHOOSING THE RIGHT LIGHT

- Choosing consciously in the colour temperature range between cold and warm
- Considering the purpose it will light e.g. 3000K is common for Swedish interiors looking for warm hues in contrast with the cold daylight and darkness during winter months
- Considering the context e.g. a cold light is recommended for a clearer view on food



1. CREW'S KITCHEN

- Fridges and microwave

2. COUCH AREA

- film projection
- small gatherings
- to eat on a low table or in the couch

3. COMMUNAL TABLE

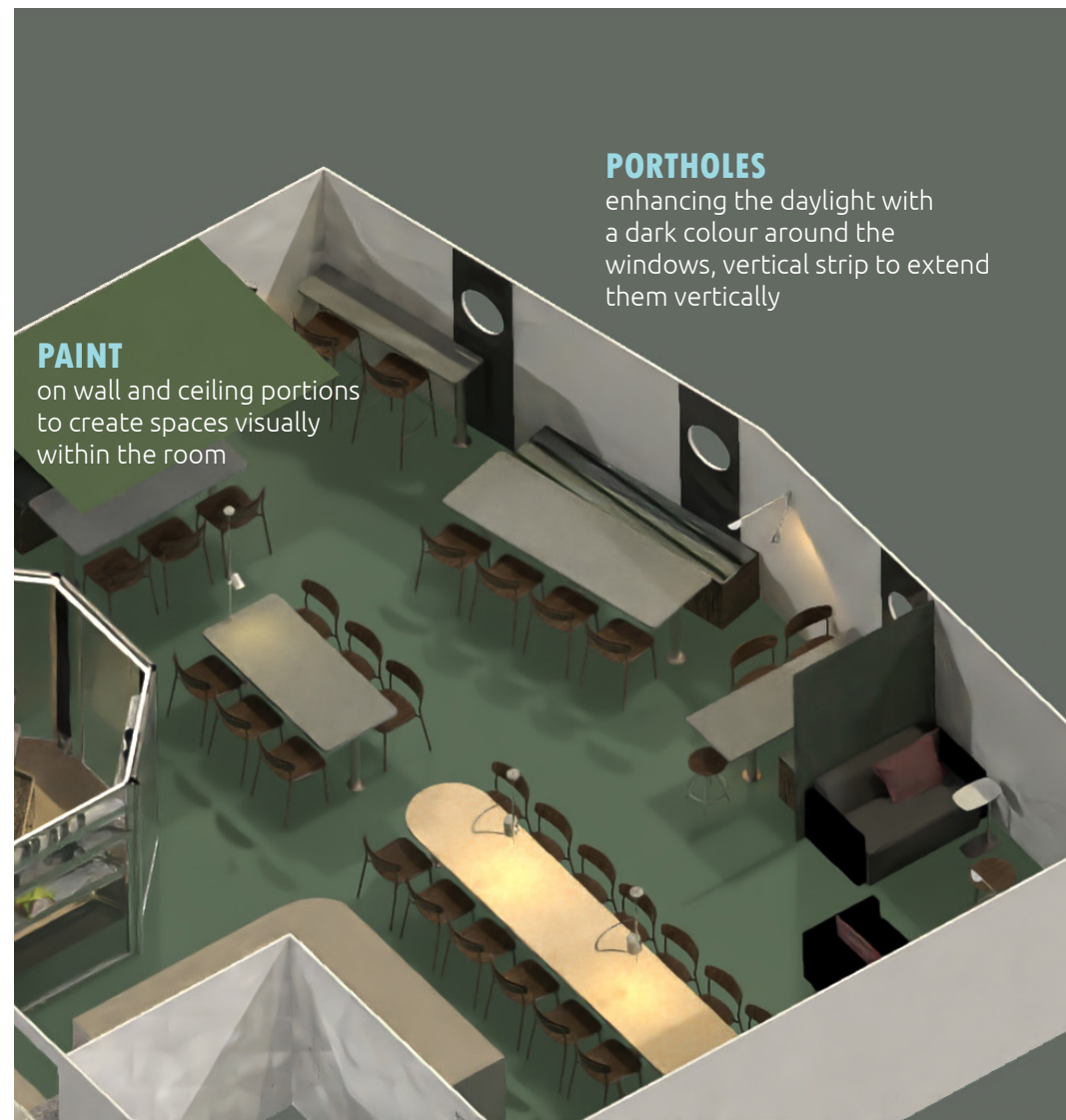
- 14 seatings
- community dinners fostering interactions

4. GREENHOUSE

- gardening
- small gathering
- leisure activities and retreat from the group

5. TABLES AND SITTING AREA

- accommodating various sitting configurations
 - 2-seat high table
 - 4 to 8-seat standard tables



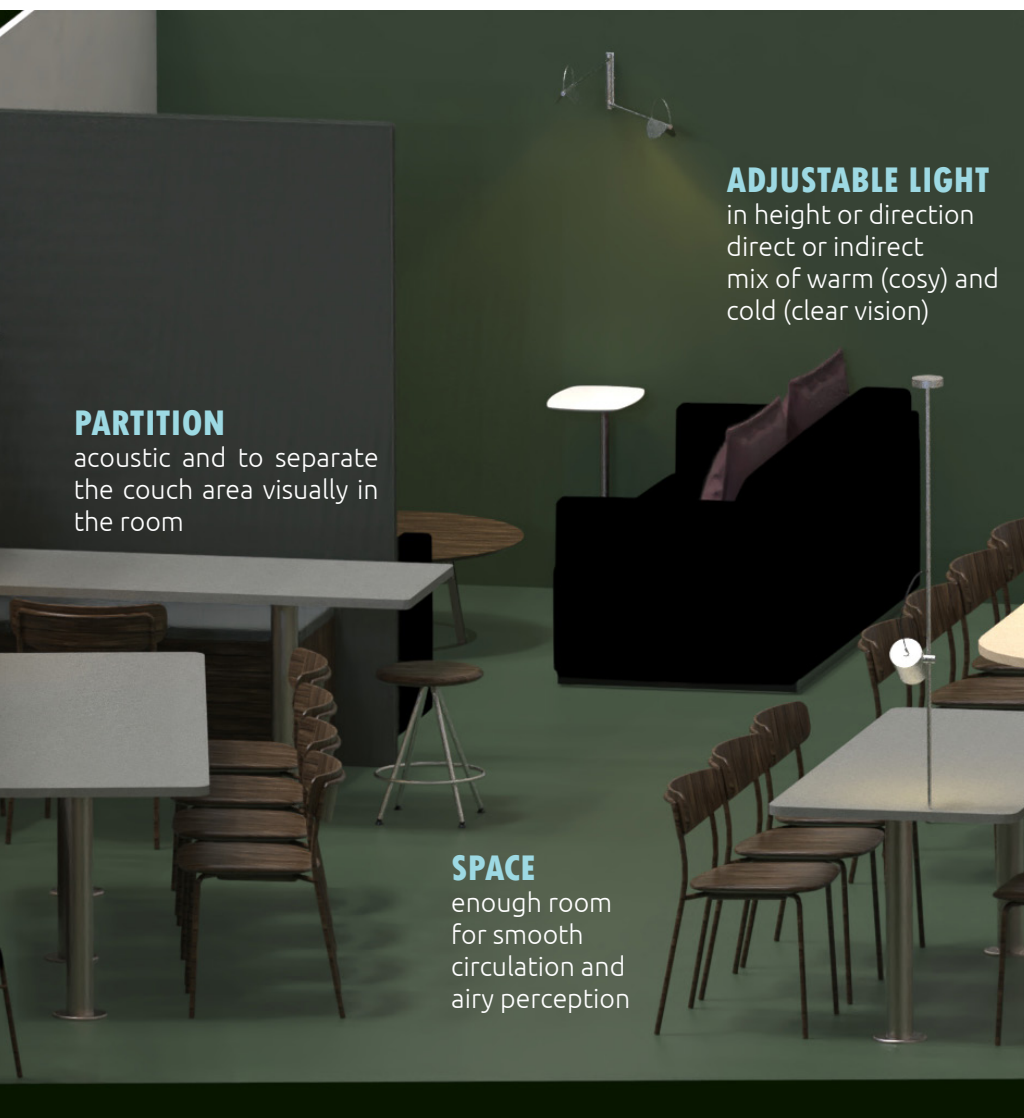
PORTHOLES

enhancing the daylight with a dark colour around the windows, vertical strip to extend them vertically

PAINT

on wall and ceiling portions to create spaces visually within the room

FLOOR in its original green colour connecting the greenhouse to the living room
SHAKKEI (China) «Capturing alive»
IKEDORI (Japan) «Borrowed scene» } Integrating a distant view in the design



PARTITION

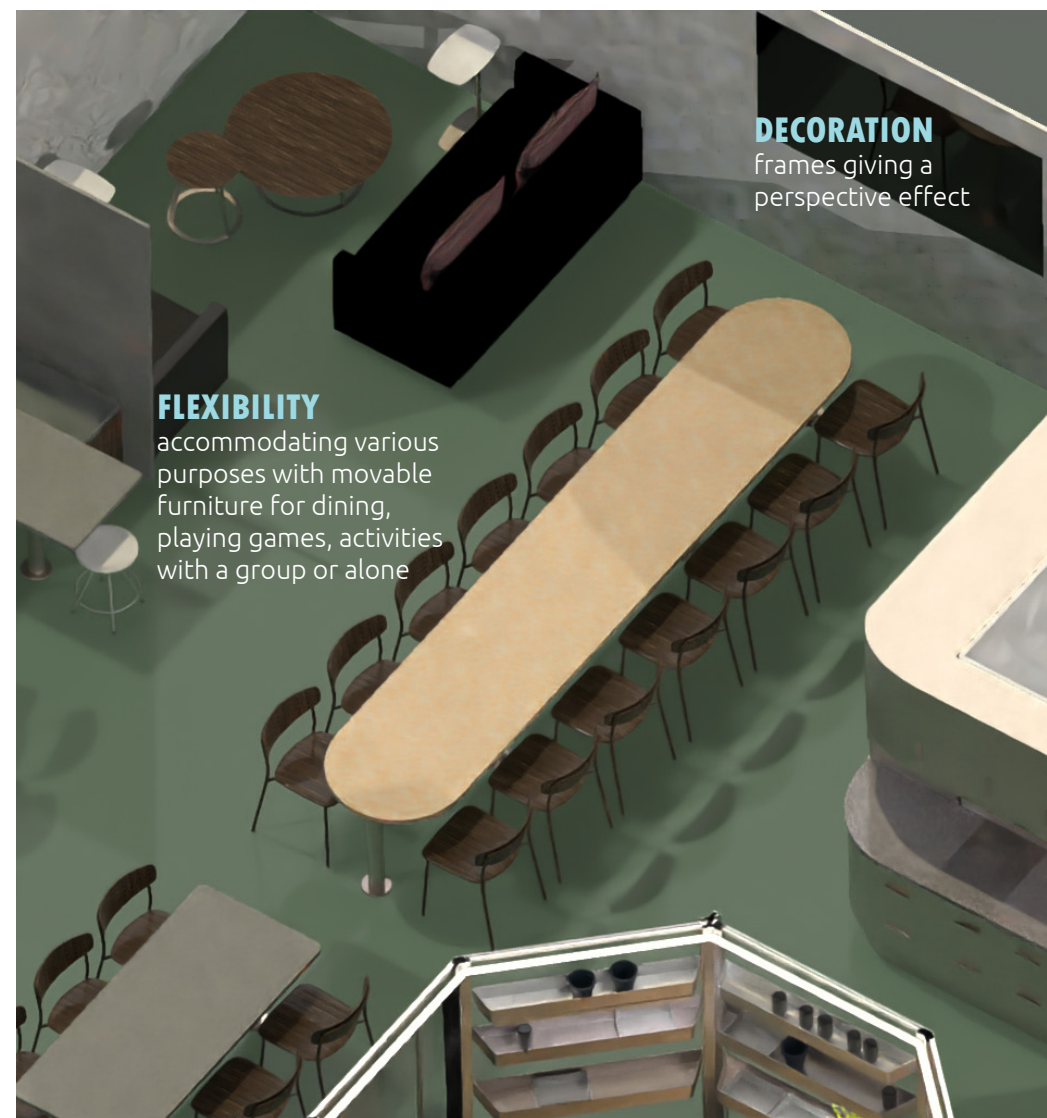
acoustic and to separate the couch area visually in the room

ADJUSTABLE LIGHT

in height or direction
direct or indirect
mix of warm (cosy) and cold (clear vision)

SPACE

enough room for smooth circulation and airy perception



DECORATION

frames giving a perspective effect

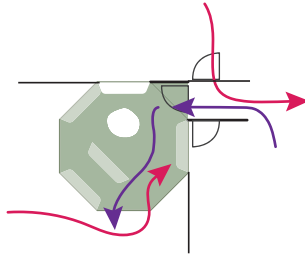
FLEXIBILITY

accommodating various purposes with movable furniture for dining, playing games, activities with a group or alone

GREENHOUSE

distant point of view to look at and from
like «a window to something living»
(Bishop, Häuplik-Meusburger, 2021)

THE GREENHOUSE



ILLUSTRATED SUCCESS FACTORS IN THIS PROJECT

GREENERY

spaciousness feeling
stress relief
hobby to recreate
mind refreshment
senses stimulation

GROUP INTERACTION

community activity

INTRAGROUP

small group meeting

RETREAT

privacy (time alone)

APPROPRIATION

flexible interior

VISUAL DEPTH

a window to nature

STORAGE

no visual clutter

PATHING

route variety

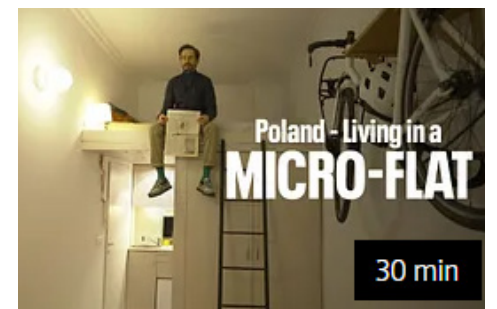
COMMUNICATION

writing on windows

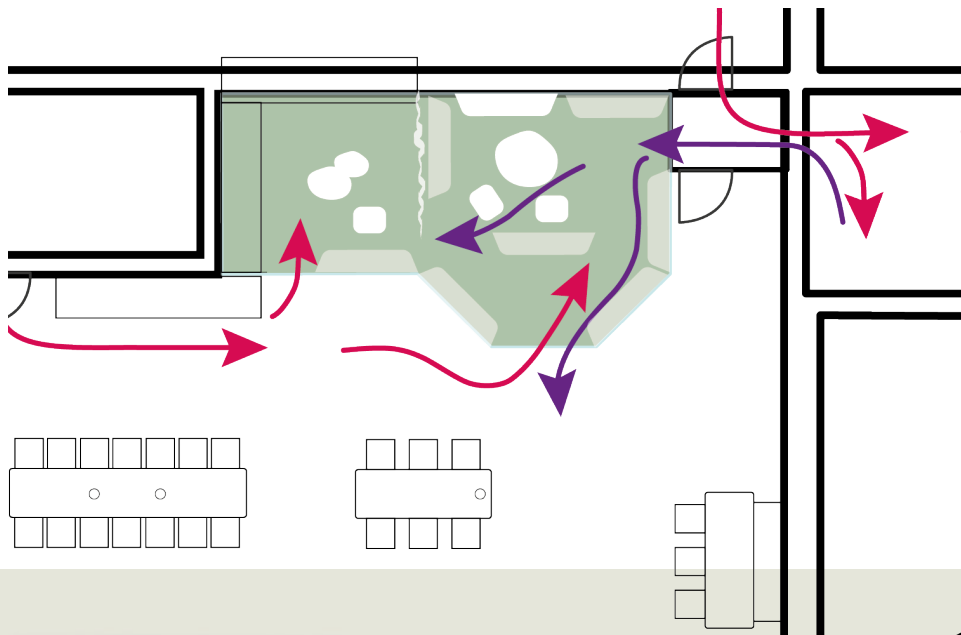
OPPORTUNITIES IN COMPACT LIVING SITUATIONS



Long-distance transport interior design



Small & shared accommodations

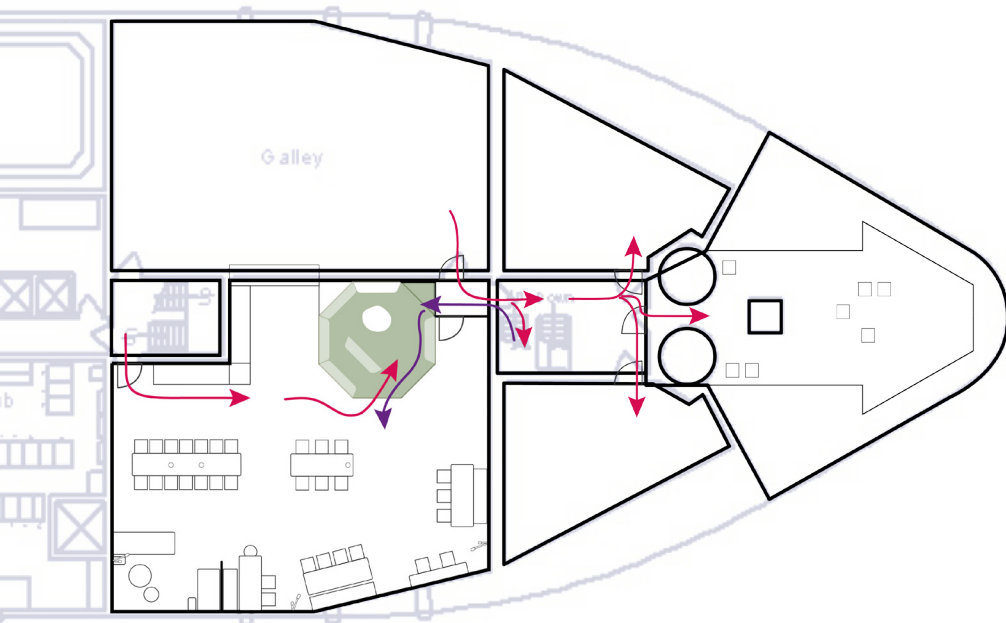
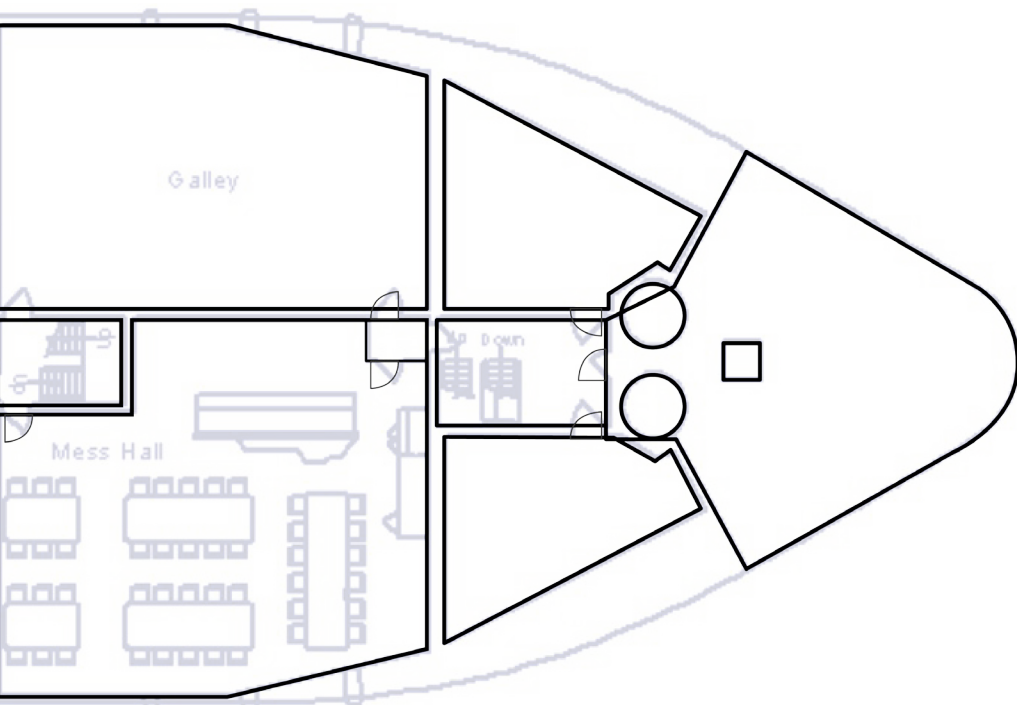


MORE ROOM FOR GREENERY

9 m² was the target to design the smallest space possible featuring the design recommendations presented by Sheryl Bishop and Sandra Häuplik-Meusburger. The idea is that what fits in the smallest area can be adapted to a larger dimension whenever the opportunity arises.

This is an illustration of how the greenhouse could extend to 16 m². The added value is to have a bigger space, to grow more plants notably. The risk is to leave the retreat bubble concept to become a busier crossroad with access to the kitchen's self-service.

The Greenhouse's aim is above all to illustrate the guidelines and promote **greenery** in all types of habitats. The emphasis is placed on introducing plants as a hobby to get fresh food occasionally rather than a hydroponic farm requiring assistance. It is nonetheless a major opportunity in contexts like ships. Scaling-up would be possible if the crew manifested interest.



FINAL WORD

When a project overlooks design expertise, it can result in delivering “surviving places” providing minimal requirements for people to live up to a certain point. However, **designing a “living space” is where an individual can thrive** even in temporary or harsh conditions. This is achieved by considering **socio-spatial relationships** and human **psychology**, which enhance performance and well-being.

Sheryl Bishop and Sandra Häuplik-Meusburger conducted thorough research and worded design guidelines. This project attempts to illustrate them visually so this booklet can be a user **manual**.

Is it possible to **feel at home** in 9 m²? At some point in life, we may find ourselves in unique living conditions, such as cramped spaces or unfamiliar surroundings. Although some people dream of Space, life on Earth is already quite eventful.

These design recommendations can be applied to **any scenario where people must reside away from their original home**. This can include very dense urban settings, shared accommodations such as co-living with a community, or areas experiencing extreme weather conditions. Design is also needed for unexpected yet challenging habitats like **transport** since choosing the least impactful often means embarking on a long journey onboard a bus, train, or boat.

That is the reason why I chose an icebreaker as an illustration. The intention was first to develop interior design suggestions for the two Swedish research ships to come. However, there is no reason to build more vessels considering the great amount already in service that can be redesigned from a different perspective.



TO THE NEW GREENHOUSE

AND ITS COMMUNITY

STORA RÅBY, SWEDEN

This shared housing is known to be isolated from the city centre where most of the students attending Lund University live. To counter the distance, a **community** spirit grew around activities organised by its tenants. No greenhouse but communal dinners where people meet, cook, and gather around a long table.

This community type is also an inspiration to design for groups of people sharing every day life in a compact and isolated habitat.

REFERENCE LIST

BASED ON

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IMAGE CREDITS

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p.4 Personal illustrations

p.5-6 Ulcons, Ultimatearm, Freepik, smashingstocks, Ultimatearm, Freepik, Freepik, DinosoftLabs, Freepik, mnauliady, Hajicon, Freepik, Abbasi

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p.9-12 Personal pictures

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p.17-18 NASA (Raymond Loewy), National Science Foundation, Personal drawings and sketch

p.19-20 Unknown photographer, greenhouse , on Vaygah icebreaker

p.21-22 Unknown photographer, on amazon.uk, Shilpa, Unknown photographer, Personal sketches

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p.27-28 United States Antarctic programme, Personal drawings, Linnah Neidel, Unknown photographer, Personal picture, Le Pain Quotidien

p.29-30 Unknown photographer, Unknown photographer, Benjamin Moore, LEDMyPlace

p.31-35 Personal renderings

p.36 VMF, Inversión, Arte

p.37-39 Personal drawings and renderings

p.41 Kungshällan

LECTURES AND LESSONS LEARNED

Sandén, U., 2023. **Life story and Camouflage**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

Feeling trapped in one's own brain because of a tumour can be related to the psychology of an individual stuck with other people in an extreme situation like a cramped space.

Toups, L., 2023. **Living in Space**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

Do, S., 2023. **Space design and architecture for Mars**, *IDEN25 Industrial Design Project III*. University of Houston, unpublished

NASA and all the research for Space exploration invested a lot in the technology so humans can survive a trip to Space. Aside from engineering, it seems that the psychological impact of living in Space for a long period has been left out. Accomplishing milestones on Earth is not necessarily as thrilling as being stuck in a spaceship for several months or maybe years.

Berggren, U., 2023. **From the Cold War to Space Tourism**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

Research has made groundbreaking breakthroughs to the point where the objective is now Space tourism. Is there a way to learn from the achievements and tackle challenges on Earth?

Christoforidou, D., Maya, N., 2023. **Four dimensions of Brain-O-flage**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

Every individual is concerned by a form of camouflage to hide things from one's own mind or to a group. The brain science and psychology dealing with uncertainty, solitude, identity crisis or boredom are essential components to consider in any project where the human factor is at risk.

Br. Björn, 2023. **Living as a Benedictin friar**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

Moving in with strangers and living as a community in a limited space that is isolated from relatives, can be challenging for the well-being. But the freedom to retreat from the group or even society is also essential for every individual to keep privacy and time on their own.

Vetti, V., 2023. **Virtual Reality, Mixed Reality, Augmented Reality, X.R. for Space Design**, *IDEN25 Industrial Design Project III*. University of Houston, unpublished

Technology has improved and presents opportunities to be used in the design process in addition to the implementation or communication of the project.

Vastrik, L., 2023. **Living in the AKA hunter gatherer community in the «Forest of the Dancing Spirits» in Congo**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

Integrating a community is about immersing oneself in an unknown environment that differs from prior experiences. It requires a lot of adaptation, awareness and openness, and therefore communication between the members. The challenge is to find a balance with and within the group, as an individual.

Axiom, 2023, **Goals and future projects in Space**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

The goal is now to make space more accessible and affordable to everyone but scenarios still overlook the human factors and psychology. It raises the question regarding the purpose of Space exploration nowadays and which is truly suited for a sustainable future: Earth or Space.

Dunér, D., 2023. **Interstellar communication, A view of the social and cultural context**, *IDEN25 Industrial Design Project III*. Lund University, unpublished

The quest to get in contact with extraterrestrial living beings reveals some of the most philosophical and unanswered questions humanity is still wondering about. What are we searching for? Who are we if we are not alone in this world? How long can a civilisation live? What is an intelligent life and would we be able to connect with it? What does our communication consist of, what is our culture? Are there concepts going beyond humanity's cognitive abilities impossible to grasp: the Infinite universe, the Creation, the Meaningless,...



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2024