WFP World Food Programme

World Health Organization

INITIATE²

Technical report
Infectious Disease Treatment Module

Not just an isolation module but a safe care environment centered around patients, families and community

WFP UNHRD Humanitarian Response Depot

téchne

INITIATE². Technical report. Infectious disease treatment center.

Suggested citation. INITIATE². Technical report. Infectious disease treatment centerGeneva: World Health Organization; 2022 Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Index

Acknowledgments

INITIATE² is made possible by the engagement of:

Alima, Bring Hope Foundation, Doctors with Africa (CUAMM), Directorate-General for European Civil Protection and Humanitarian Aid Operations at the European Commission (DG ECHO), Food and Agriculture Organization (FAO), The Federal Department of Foreign Affairs of Switzerland of Switzerland (FDFA), GOAL, International Committee of the Red Cross (ICRC), represented by the Norwegian Red Cross, International Federation of the Red Cross (IFRC) , International Medical Corps (IMC), International Rescue Committee (IRC), International Organization for Migration (IOM), Medair, Medical Aid Films, Médecins Sans Frontières (MSF), Save the Children (SCI), Samaritan's Purse, United Nations International Children's Emergency Fund (UNICEF), United States Agency for International Development (USAID), World Vision International (WVI), World Food Programme (WFP), and World Health Organization (WHO).

The core INITIATE² team behind the development of the Infectious Disease Treatment Module (IDTM) is composed by:

Alima, International Medical Corps (IMC), Doctors with Africa (CUAMM), Médecins Sans Froontières (MSF), Ministry of Health of Malawi, Ministry of Health of Guinea, Samaritan's Purse, World Food Programme (WFP), and World Health Organization (WHO).

Téchne, in close collaboration with its members Politecnico di Torino, University of Toronto, Carleton University and the International Federation of Healthcare Engineering (IFHE), and UNHRD Lab, as well as the Emergency Medical Team (EMT) for the water and sanitation components, were behind the proposed solution of the IDTM.

In April 2020 the World Health Organization established Téchne, the Technical Science for Health Network (www.who.int/groups/techne).

Téchne's members are recognized technical universities and institutions that, seeing the critical phase the world was facing, decided to support WHO to implement its mandate through a direct collaboration with the Health & Technical Logistics Team within the Operation, Supply and Logistic Unit. Technical and academic backgrounds vary from architecture, civil engineer, mechanical engineer, industrial design often with specialization on healthcare facilities. Téchne's members cooperate with WHO on a diverse range of activities such as sharing specific technical knowhow, supporting State Members on ad-hoc requests and developing technical innovation to better respond to infectious diseases outbreaks, complex emergencies and related needs and gaps.

Abbreviations

CRI - Italian Red Cross

CUAMM - Doctors with Africa

DG ECHO - Directorate-General for European Civil Protection
and Humanitarian Aid Operations at the European Commission

EMT - Emergency Medical Team

EOI - Expression of Interest

FAO - Food and Agriculture Organization

FDFA - The Federal Department of Foreign Affairs of Switzerland of Switzerland

HDU - High Dependency Care

ICRC - International Committee of the Red Cross

IDTM - Infectious Disease Treatment Module

IFHE - International Federation of Healthcare Engineering

IFRC - International Federation of the Red Cross

IMC - International Medical Corps

IOM - International Organization for Migration

IPC - Infection Prevention and Control

RFP - Request for Proposal

SCI - Save the Children International

UNICEF - United Nations International Children's Emergency Fund

USAID - United States Agency for International Development

WFP - World Food Program

WHO - World Health Organization

WVI - World Vision International

Background

In June 2021, the World Food Programme (WFP) and the World Health Organization (WHO) launched INITIATE² (www.who.int/initiatives/initiate2), a five-year initiative which brings together emergency response actors, as well as research and academic institutions, to develop innovative and standardized solutions and the related training in support of readiness and response capabilities in health emergencies.

These solutions include medical facilities, temporary medical installations, laboratory and disease-specific facilities and other innovative products to support readiness and response capabilities in health emergencies involving infectious diseases.

INITIATE² is based on two interconnected workstreams: technical innovation for the design and development of standardized technical solutions; and training and simulation for the development of standardized procedures and response capacity.

As the convenors of the initiative, WFP and WHO have developed the project governance structures, methodologies, the project plan, engaged key partners and made available the resources for implementation and are responsible for the overall management of the initiative.
Virtual and in-person sessions were organized to determine partner engagement and assess the first solution to be prioritized, which is an Infectious Disease Treatment Module (IDTM).

Scope of the document

The document aims to convey the voices of experts, lessons learned, and technical knowledge shared during the hearing phase into technical and design requirements through the creation phase to support the delivery phase of the infectious disease treatment module.

Problem Statement / Need for the product

Epidemics of infectious diseases are occurring more frequently and are spreading faster and further than ever before in different regions of the world. Climate change, high population pressure expanding to previously uninhabited areas, unplanned urbanization and growing global interconnectedness has led to increased occurrences of emerging and re-emerging infectious diseases including zoonoses with the potential to rapidly spread across the globe.

Infectious disease treatment centre designs have improved considerably within the last few years where units have evolved from being pure isolation facilities to proper treatment centres designed around patients, staff and community to improve the quality of medical care provided, infection prevention and control (IPC), patient's comfort and community acceptance. During the last Ebola outbreaks, several innovations have been developed in the field while the SARS-CoV-2 pandemic and the airborne risk pushed the development of engineering capacity to a new level.

However, the construction and installation of such facilities may require several weeks, while the first phase of the emergency is still improperly managed with simple structures which do not allow for providing adequate levels of medical care. With this in mind, INITIATE² is a promising solution for a rapidly deployable, easily transportable, extendable, self-contained and self-sufficient treatment module for infectious diseases

irrespective of the mode of transmission. Such a solution, built on field experiences, will not replace current facilities but rather integrate them by enabling responders to safely provide the high quality of care needed with dignity, respect and compassion towards affected communities from the very onset of the emergency while more permanent and complex structures are being set up.

Programmatic relevance for the INITIATE^2 partners

Besides providing a tool to strengthen preparedness and response capability, this innovation will enable a certain degree of standardization across emergency responders and humanitarian organisations involved in an outbreak response. Moreover, the simulation and drill exercise around the innovation will foster communication and coordination across the different institutions involved while enabling a multidisciplinary collaboration.

Current approaches used by the INITIATE2 partners

INITIATE2 partners use different approaches to cope with the above needs:

1. Set up temporary structures built with local materials

@ REUTERS/James Giahyue

2. Deploy temporary structures such as tents or containerized prefabricated solutions

@ picture alliance, ASSOCIATED PRESS, Hajarah Nalwadda

3. Deploy temporary add-on solutions

@ Baz Ratner / Reuters

4. Adapt and use existing facilities

@ REUTERS/Jean Robert N'Kengo

5. Set up hybrid solutions

@ Léa Ledru / ALIMA

IDTM development cycle

The IDTM was developed using interdisciplinarity co-design approach, relying on mix-methods, both qualitative and quantitative, to ensure knowledge synthesis and integration with the aim of delivering a design and a prototype able to embed the complexity of variables of multiple disciplines, such as medicine, nursing, energy and building engineering, architecture, product design, and social studies. Interdisciplinarity is crucial to analyze, study and find solutions to real-world problems, rather than problems framed in the core of a specific discipline (Repko, 2016). Interdisciplinarity rather than multidisciplinary requires knowledge integration (Repko 2016; MacLeod and Nagatsu 2018) and a comprehensive and holistic perspective understanding of a set phenomenon (Frickel and Jacons 2009). This approach allowas for setting a common language among fields, developing integrated knowledge and crossing discipline boundaries to ensure innovation.

The development of the IDTM relies on the Key Driver Framework that helps obtain the system requirements in a systematic way and to provide a structured overview.

The key driver framework is divided into four steps:

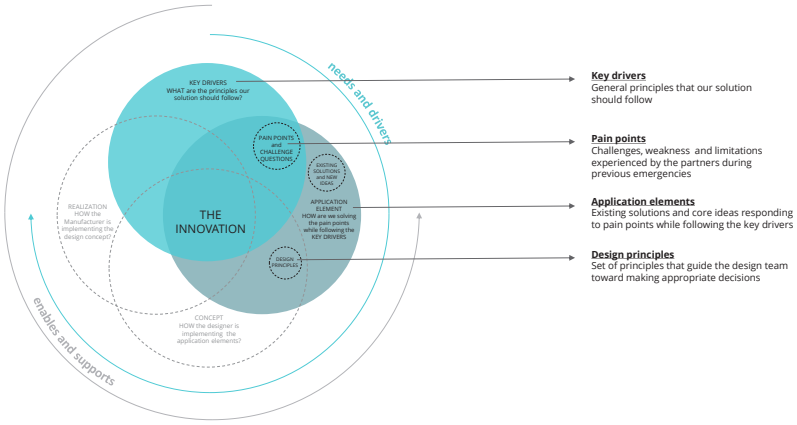
- **Development of the key drivers** (general principles that the solution should follow) through the definition of the pain points and challenge questions (challenges, weakness and limitation experienced by the partners during previous emergencies)

- **Development of the application elements** (existing solutions and core ideas responding to pain points and challenge questions while following the key drivers) through the definition of the design principles (set of

principles that guide the design team toward making appropriate decision)

- **Concept** (how the designer is implementing the application elements)

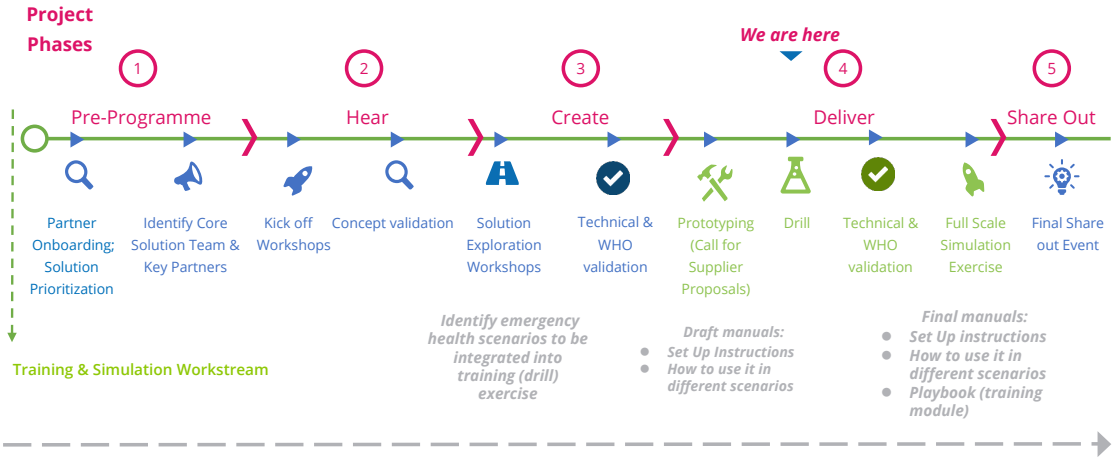
- **Realization** (how the manufacturer is implementing the design concept)



Each phase is characterized by several steps informed by both qualitative and quantitative methods, with the involvement of professionals and academics with different expertise and high international profiles. A regular feedback loop system was put in place to ensure the quality of the work and the respect of the specificity of each discipline in place. These loops occurred both at milestones with deliverables and in the middle of each project phase. Reviews are carried out by all the partners involved in the initiative of INITIATE².

INITIATE² methodology

The development of the IDTM is underpinned within an overall project methodology that guides INITIATE². The INITIATE² methodology, developed with the support of the WFP Innovation Accelerator, is structured around five project phases, as shown in the image below.



The five main project phases are as follows:

1. **Pre-programme**
Identify priority solution to move forward for further stages of development
2. **Hear**
The 'Hear' phase is aimed at setting a common language across disciplines, gaining in depth understanding and alignment on the challenges, visions, target users, and to envision an initial design concept.
To achieve this aim, this phase is organized around innovation workshops, desk research, and empirical experience reports analysis. The milestones of this phase involve developing the definition of key drivers and design principles, comparative analysis, innovation from the field analysis, and key components.
The deliverable of the 'Hear' phase is the design brief (Annex 3), a document in which the voices of experts

are translated into a technical language to inform the following 'Create' phase and the design process.

3. **Create**
The objective of the 'Create' phase is to deliver a design proposal that addresses all the requirements and needs explained in the brief, including technical specifications as well as test and simulation results, leveraging WHO's frameworks for review and approval. This phase started with the set-up of a design team composed by architects, engineers and designers specialized in health infrastructure. Based on the design brief developed at the end of the hear phase, the design team developed a full set of drawings with technical specifications through a process of weekly design advancements and reviews.As part of the create phase two mock-up exercises were developed to inform the design development.

4. **Deliver**
The 'Deliver' phase is aimed at completing and testing a full-scale prototype. The milestone involves building a minimum viable product that is replicable, scalable, reliable and impactful. The process is as follows:

1. Issue an Expression of Interest (EOI) – this is a high-level exercise that will be published and that intends to short list bidders for the tender.
2. Issue a request for proposal (RFP)
3. Hold a bidders' conference
4. Conduct a technical evaluation of the received proposals through a technical evaluation panel
6. Conduct a financial evaluation of the received proposals through a technical evaluation panel
7. Make a recommendation for award and authorization to engage for prototype development
8. Review first prototype development
9. Drill exercise in Brindisi at the UNHRD base
10. Test the module performance to validate the design decisionsFollowing the testing phase, the prototype may need design adjustments.
11. Conduct final prototype development
12. Conduct full-scale simulation in Brindisi at the UNHRD base

The deliverable of this phase is the prototype itself, as well as the technical reports refined after the testing phase.

5. Share out
Organize the final share out event.
Each phase is characterized by milestones with specific deliverables, which allows consolidation of knowledge and informs the next phase.

Project phases methodology, milestones and deliverables

The following sections will explain for each phase the methods utilized, milestones and deliverables (to be found as an Annex to this document).

Hear phase

Methodology

The hearing phase included the first two steps of the method to develop key drivers in which involved four working sessions (two online and two face-to-face workshops).

The output of the hear phase was the design brief, a document that translate the voices of experts, lessons learned, and technical knowledge shared during the hear phase into technical and design requirements to support the creation phase of the

infectious disease treatment module.
In the first two online working sessions, partners worked on the identification of pain points and corresponding challenge questions. During the two face-to-face workshops at the UNHRD Training Centre in Brindisi (Italy), the focus was on the macro journey behind a pandemic preparedness and response process and defining the micro journey of a patient from Day 3 of illness (admission within the treatment centre and diagnostic confirmation), clinical evolution (new symptoms, monitoring, use of specific therapeutics), until the end of the patient's journey (either death or discharge).

After the identification of the pain points and corresponding challenge questions, through the Key Drivers framework, the INITIATE² partners identified:

- key drivers
- design principles
- key components through a comparative product and field solutions analysis

Milestones

A. Key drivers

The key drivers identified by the INITIATE² Core Team to be considered while developing the infectious disease treatment module are the following:

1. **Humanised care**: rapid accessibility, visibility, constant monitoring, privacy, and ensuring that the proposed structure targets an individual's well-being

2. **Environmental sustainability**: making more environmentally responsible choices with our energy, waste, and water, and quantifying our carbon impact as well as holding groups responsible

3. **Disaster resilience**: ensuring that the proposed structure is resilient to natural hazards

4. **Accessibility and inclusiveness**: ensuring that the proposed structure is accessible to an older adult, a child, or a person with a disability

5. **Cultural adaptation**: ensuring that the proposed structure fits into different local contexts

6. **Deployment and installation rapidity**: ensuring that the proposed structure can be installed within the first days of an epidemic outbreak and be installed by unskilled workers

7. **Circularity**: ensuring that the proposed structure minimizes resource flows and waste generation, and can be easily reutilized

8. **Sustainable maintenance**: ensuring that the proposed structure can be repaired easily

9. **Health system integration**: ensuring that the proposed structure fits the local health systems

10. **Usability**: ensuring that the proposed structure is easy to use

B. Design principles

The design principles to be considered while developing the design of the infectious disease treatment module are the following:

1. **Contact-enabling design:** The design should enable contact via different mediums in relation to the type of disease transmission modalities. This could be achieved by focusing on the relation between visibility and privacy (through transparency, geometrical layout solutions, technological characteristics, or other), or safe tactile and visual interaction between patient/HCW and patient/visitors.

2. **Climatic responsive and energy responsible:** the design should rely on hybrid/passive design and low energy consumption where possible. This could be achieved by offering technological alternatives based on macro climatic areas differentiation (cold, hot, humid, et cetera) and, through add-on system design, microclimatic conditions site-analysis (wind conditions, presence of natural shade such trees, presence of water, such as lakes, rivers, et cetera). The IDTM design should be energy responsible by ensuring that energy consumption is optimized according to space use and requirements.

3. **Resiliency to disruptive phenomena:** the design should take into account whereverpossible natural hazards and other disruptive phenomena that could impinge on the correct functioning of the IDTM.

4. **Accessibility and inclusiveness:** should be achieved through a spatial design that can provide minimum dimension requirements and adequate space and characteristics for all people including patients with particular ergonomic considerations (i.e. children, older adults, people who are pregnant, persons with disabilities and others).

5. **Cultural adaptability and participation:** The design should provide opportunities to ensure, respect, and enhance the engagement and understanding of local culture(s).

6. **Modularity:** The design should rely on the principles of modularity in order to provide flexible layout organisation and surge capacity.

7. **Constructability:** The design should allow for ease of set-up through intuitive construction.

8. **Cradle to cradle and reuse design-based:** The design should take into account life-cycle assessment, as well as rely on reuse where possible (packaging, materials, and end-life material/components).

9. **Minimum and local maintenance:** The design should ensure low maintenance requirements, which can be carried out by the local workforce.

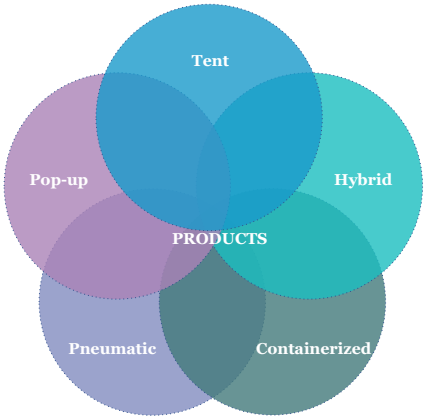
10. **Adaptability and Infection Prevention and Control (IPC):** The design should rely on an add-on system approach, in order to provide customizability and adaptability to the different needs (climate, local context, use, acuity, severity and infectious status). Moreover, the spatial design should provide interaction with existing health facilities in order to enhance health system integration.

11. **Usability:** The design should be intuitive and facilitate wayfinding.

12. **Transportability:** The design should allow for easy transport, on small size local transport, such as tricycles with flat beds, carts or tuk-tuks, carried by hand, on large and small boats, by donkey or other pack animals.

C. Comparative analysis

A group of technical experts from WHO, WFP-UNHRD Lab and the Téchne members Politecnico di Torino and the University of Toronto analysed existing solutions available on the market and categorised them per product typology, product performances and compliance with agreed upon design principles as technical requirements. Products were divided into five product categories:

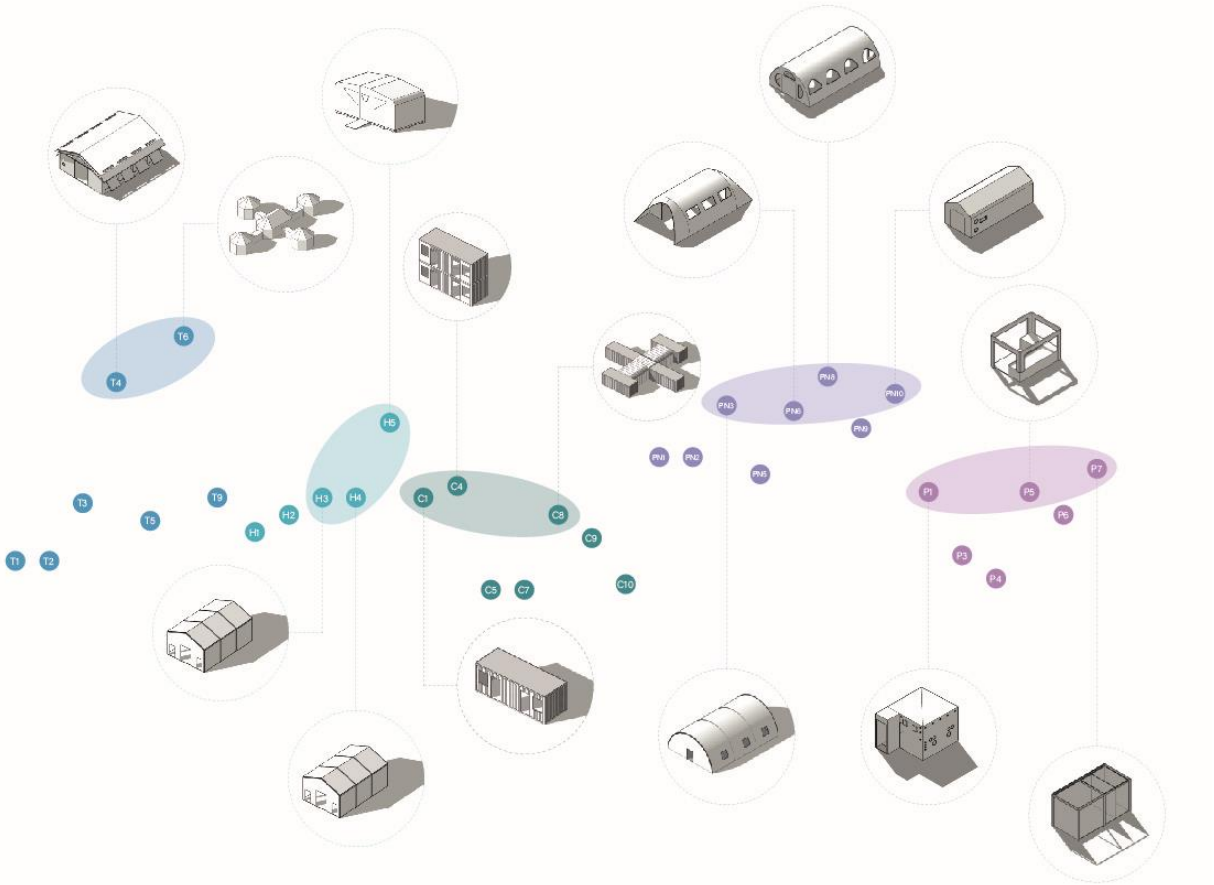


1. Tent
2. Hybrid
3. Containerized
4. Pneumatic
5. Pop-up

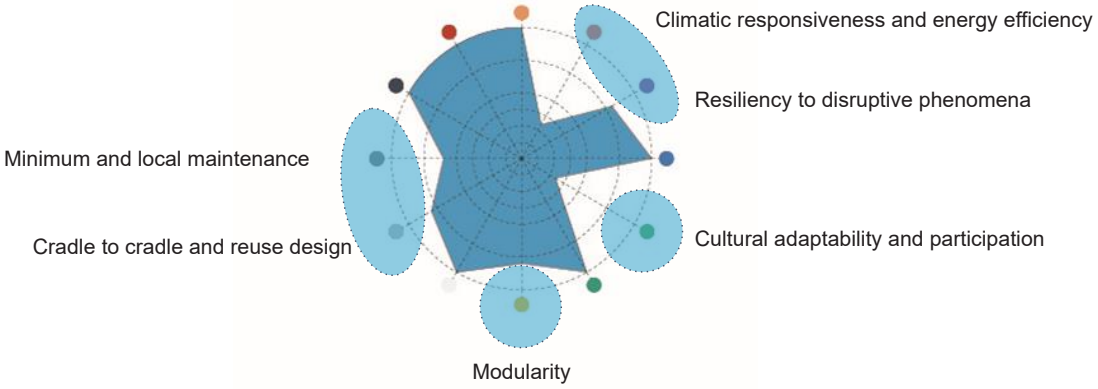
The 50 solutions analized by the technical experts were afterward assessed against the design principles with a scale of 0 to 2, where:

- 0 is a product not addressing a design principle
- 1 is a product partially addressing a design principle
- 2 is a product completely addressing a design principle

After the assessment, the team selected the 15 products that scored highest and studied their technical performance in depth.



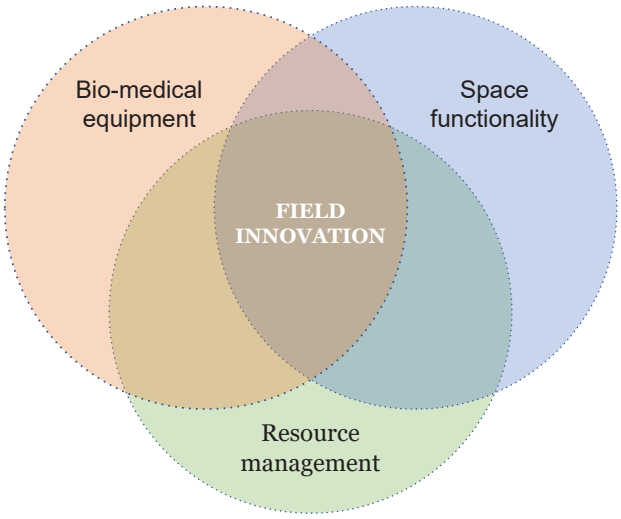
The results of the analysis on the 15 products demonstrated a need to improve the following design principles, for the successful development of an efficient and effective treatment module.



The market assessment enabled the team to understand whether the key components were already met by existing solutions. Additionally, it provided interesting inspiration points for the conceptualization of the IDTM.

D. Innovations from the field

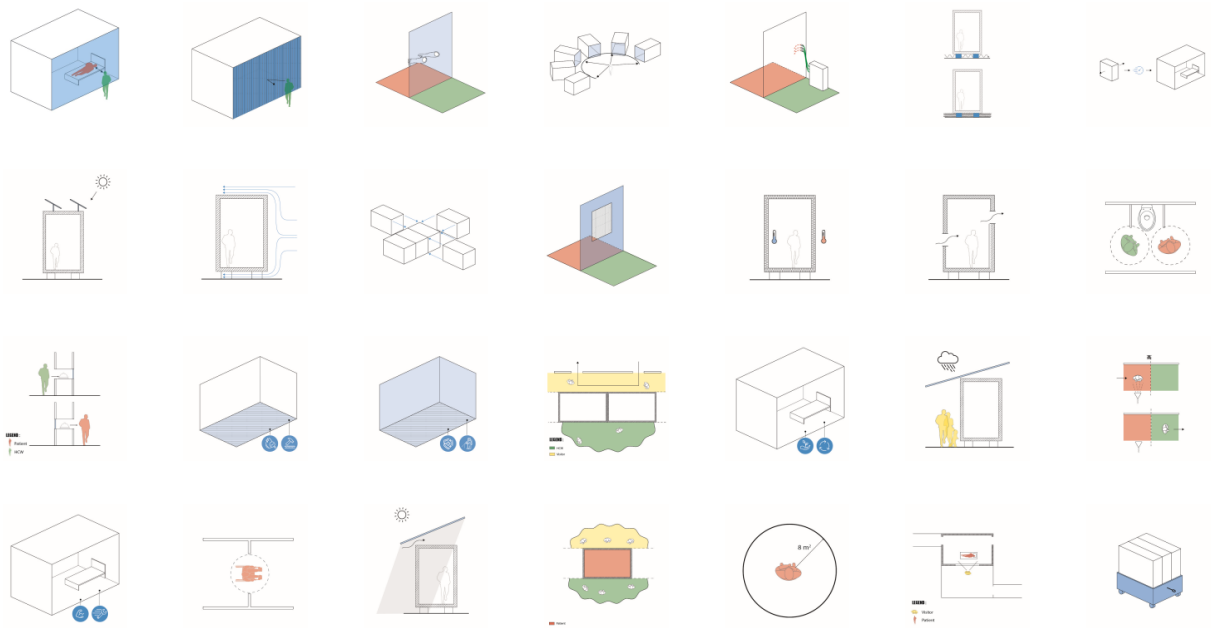
A group of technical experts from WHO, WFP-UNHRD Lab and the Téchne members Politecnico di Torino and Toronto University analyzed the field innovations developed by the core INITIATE² team and divided them into three categories: bio-medical equipment, spatial functionality, and resource innovation.



After the analysis, the team decided to focus on the space functionality and resource management categories and selected the following:

1. **Nursing/medical areas inside the patient's area** (to ensure patients' surveillance)
2. **Installation of a private viewing area in the morgue** (to ensure body visibility and cultural acceptance)
3. **Bio-secure space** (to rationalize the use of PPE and reduce the risk of contamination)
4. **Creation of sliding furniture to transfer food or water from low-risk to high-risk zones** (to allow transfer of items from low-risk to high-risk zones while rationalizing the use of PPE and reducing the risk of contamination)
5. **Plexiglass and transparent surfaces** (to allow maximum visibility of the patient from green areas to red areas)
6. **Hard flooring** (to ensure resistance to multiple forms of use)

E. Key components



The key components were extracted, during a core INITIATE² team workshop, through the analysis of the existing products available on the market, thefield innovation analysis and the pain points exercise looking at the challenges, weakness and limitation experienced by the partners during previous emergencies. The selected 49 key components to be considered while developing the design of the infectious disease treatment module are the following innovations:

No.	Key components
1	Modularity through connection system/extendibility
2	Easy to disinfect materials
3	Excreta and wastewater management
4	Drainage management
5	Controlled building ventilation
6	Smooth hard flooring
7	Separated access and flow for staff and visitor
8	Central staff area
9	Ready to use within minutes
10	Ease of transport
11	Easy access to different water sources and treatment
12	Access and exit routes must be integrated
13	Transparent screen to view patients
14	Visitors' area
15	Integrated indoor/outdoor distribution
16	Communication between staff, patients, and visitors
17	System for items transfer
18	Shutter system
19	Minimum 8m2
20	Integrated water storage
21	Reliable energy supply

22	Morgue with family space
23	Access for patients with reduced mobility
24	Connectivity of water system
25	Easy oral communication
26	Security
27	Double roof/shade net
28	Visitor area protected with cover
29	Solar panel/photovoltaic
30	IPC + module dedicated to clinical care first
31	Accessibility for any kind of transportation and beds
32	Ad-hoc space for biomedical devices within the green area
33	Vector control
34	Insulated material
35	Durable and easy-to-fix parts
36	Doffing
37	Use of sustainable and repurposable materials
38	Turnaround time/reusability
39	Elevated structure
40	Indoor and outdoor use
41	Screening area/triage
42	Outside access for patients
43	Wind resistance
44	Short/culturally acceptable fencing
45	Permanent temperature control
46	Indoor latrines/showers, large enough for 2 people
47	Intuitive layout and set up
48	Wall integrated manipulation gloves
49	Alarm system for patients

E. Expected solution: the IDTM

The Infectious Disease Treatment Module (IDTM) is a rapidly deployable, easily transportable, extendable, self-contained and self-sufficient treatment module for infectious diseases irrespective of the mode of transmission. The IDTM is adaptable to different climates, use, dimensions and patients' clinical needs (acuity, severity and infectious status) through an add-on system approach.

Each IDTM is for two patients and allocates space for the following procedures: treatment (including HDU - High Dependency Care, minor surgery and delivery), resuscitation, isolation, patient toilet and shower, and nursing area. Some of the above-mentioned procedures can be done within the same space.

The IDTM is expected to be divided in three pods: a central staff area to allow for constant observation of patients without wearing PPE and two individual patient rooms. Moreover the IDTM is enabling responders to safely provide the high quality of care needed with dignity, respect and compassion towards affected communities from the very first days of the outbreak.

IDMT operator: The IDMT is operated by the INITIATE² partners, their implementing partners that run emergency response programs in the context or government institutions that do the same, qualified in the management, support and provision of services in the health sector.
IDMT user: The IDMT is used by the IDMT operator and the people the IDMT operator provides services

to, which includes all age groups, men, women and children, from all different cultural, religious and ethnic backgrounds, people suffering from illnesses or living with disabilities across all impairment groups.

F. Volume and potential impact

Every year, disasters and emergencies affect the health and wellbeing of millions of people.
The WHO Health Emergency Dashboard is a platform which aims to share information about public health events and emergencies. The data on the dashboard is refreshed every fifteen minutes and data is accurate as at time of refreshing. https://extranet.who.int/publicemergency
The WHO Health Emergency Dashboard is not a comprehensive representation of all the events and emergencies that WHO is aware of and responding to. The events displayed are a subset of those reported through official channels as mandated by the International Health Regulations (IHR 2005). The content of the WHO Health Emergency Dashboard is for general information only.

G. Target unit cost

The purchase cost of the IDTM has to be kept as low as possible to enable reaching to the widest extent possible, the affected population.

Deliverables

A. Please see the design brief document attached as an Annex.

Create phase

The Infectious Disease Treatment Module (IDTM) was designed following the key drivers, design principles and key components developed by the INITIATE² partners.
The IDTM was designed following a "human-centred approach" ensuring its usability and usefulness by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance.

Methodology

Following the two face-to-face workshops in Brindisi where the hear phase was completed, the INITIATE² Core Team, in close collaboration with Téchne, brought together a design team composed by Politecnico di Torino, University of Toronto, Carleton University and the International Federation of Healthcare Engineering (IFHE), that together with the WFP-UNHRD Lab, the Emergency Medical Team (EMT) for the water and sanitation development, and WHO were behind the proposed solution of the IDTM. The team was selected on the basis of their experience, international profile and high level of knowledge on the specific challenges to address in the design.

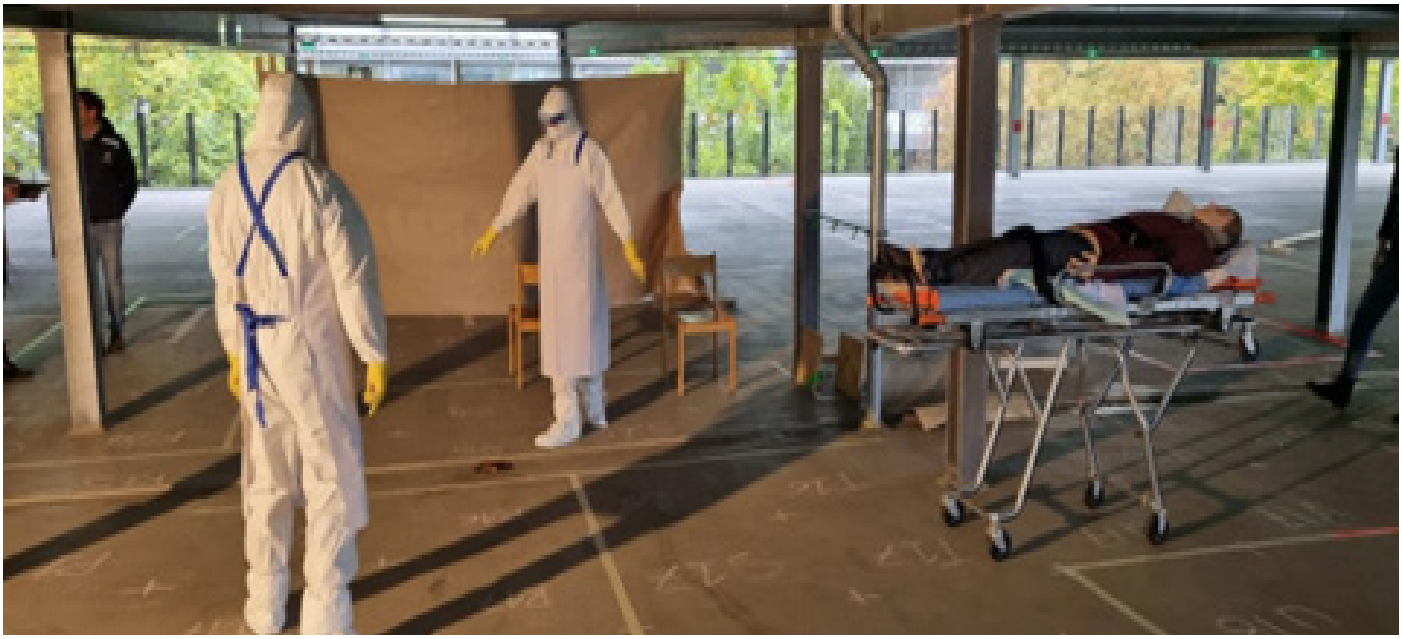
The team was composed by architects, engineers and designers specialized in health infrastructure. Yet, to ensure the adequate flows of information, knowledge exchange and interdisciplinarity, a system of verification with rapid prototyping through the use of mockups was put in place. Rapid prototyping is a crucial method to achieve interdisciplinarity because it allows all the stakeholders involved in projecting and testing the compliance with their own values on a shared product (MacLeod and Nagatsu 2018).

Mockups were therefore used to verify at crucial steps of the design process, the satisfaction of different requirements from partners and experts involved in the initiative.
The design process in place was organized around weekly meetings, during which the design team participated by proposing design solutions, verifying those through multi-nature verification processes (both virtual and real-life simulations), and reiterating the process to verify or implement design solutions. Virtual simulations were carried out to test building physics, such as natural ventilation and thermal control to ensure conditions of comfort inside ITDM. Real life simulations were conducted through the use of mock-ups, with the aim of testing: spatial requirements, users circulation flows, visibility, accessibility, and technical characteristics of transparent and equipped internal partitions.

Mock-up IDTM - Tübingen

The University Clinic at the University of Tübingen, in collaboration with the WHO, Téchne and WFP has been overseeing the organisation of the mock-up for the testing of the IDTM. In preparation for the drill exercise and to finalise the design of the IDTM, a mock-up exercise took place on 29 September 2022 with the overall objective of evaluating the space configuration according to the indicators defined by the INITIATE² Core Team during the in-person meeting in Brindisi in July 2022. The main intended outputs to be delivered by the University of Tübingen were:
- assess space configuration according to clinical activities, patient's position, and visibility features.
- provide measurable indicators for a design that enables contact and accessibility

Some pictures of this exercise have been included below.



@WHO

@WHO

The methodology adopted was based on performing two simulations of medical procedures to assess the design's fitness for purpose of: scenario 1) adult anaphylaxis; and scenario 2) pediatric shock (Annex 4).

The mock-up exercise allowed the INITIATE² Core Team to obtain first impressions on the dimensional aspect of the structure, as well as the patients-staff flow within the structure. The testing served the design team to propose final adjustments. The exercise was filmed, and the video can be watched through this link: RackStation - Synology NAS (klinische-anatomie.de), along with a mock-up manual and building instructions (Annex 5).

Mock-up equipped transparent screen – Turin

The Téchne member Politecnico di Torino, in collaboration with the University Clinic at the University of Tübingen and the WHO, has been overseeing the organisation of the mock-up for the testing of the transparent screen.

One of the outcomes of the first mock-ups in Tübingen was the clear need to further develop the design of the transparent screen placed between the red zone (high-risk area) and the green zone (low-risk area). The scope of the second mock-up in Turin was to verify the technical characteristics of the equipped transparent screen enabling medical procedures from the green area.

Some pictures of this exercise have been included below.

@WHO

The methodology adopted is based on performing three simulations of medical procedures to assess the design's fitness for purpose of:

1. adult anaphylaxis scenario
2. pediatric shock scenario
3. standard patient monitoring scenario

The simulations were performed by five people from Politecnico di Torino, University Clinic at the University of Tübingen, the Italian Red Cross (CRI) and the WHO conducting fitting trials of different heights (185 cm, 182 cm, 155 cm, 172 cm, 168 cm, 163 cm); with different professions, namely two doctors, one nurse and three architects.

During the simulation, the following medical equipment was used: bag valve mask (BVM) ambu bag in a bag inside the room (within 3 min); laryngoscope/intubation (within 3 min) set/kit; nasal canula; suction hose; venturi mask; ventilator circuit; vital sensor monitor; IV lines (intra venal); defibrillator; attachable pads for

defibrillator; consumables; emergency ;medications pad; sharps container; syringes; glucometer; pupil light; thermometer; tape; and physiological solution.

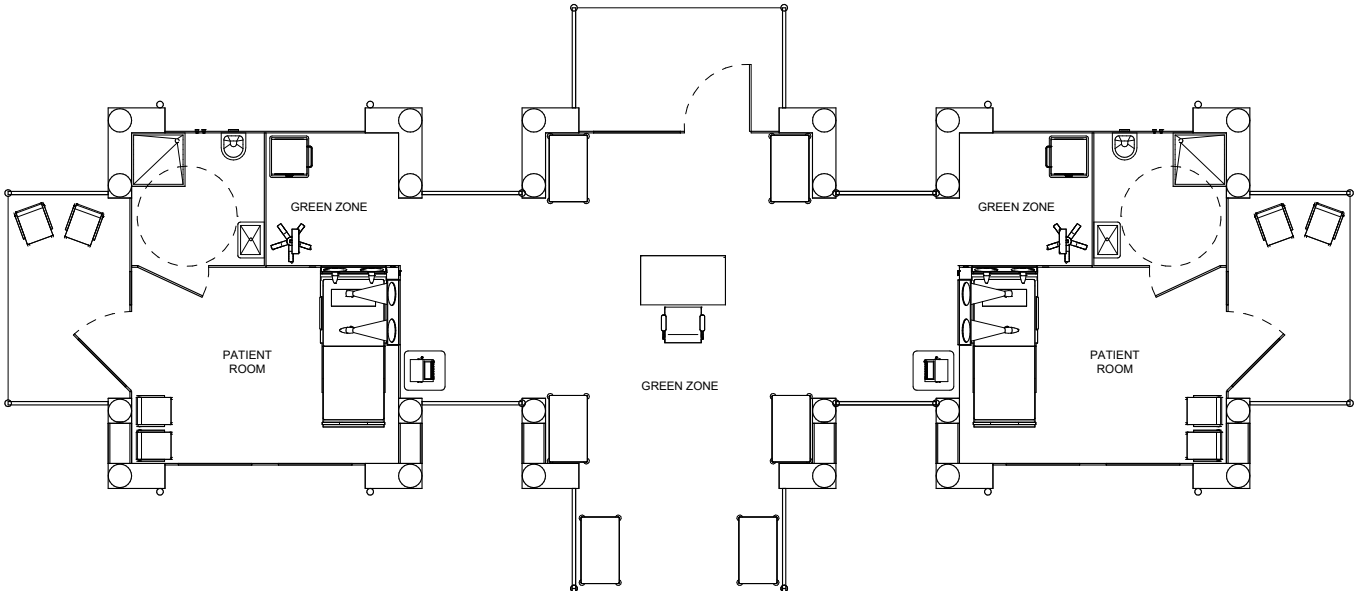
Milestones

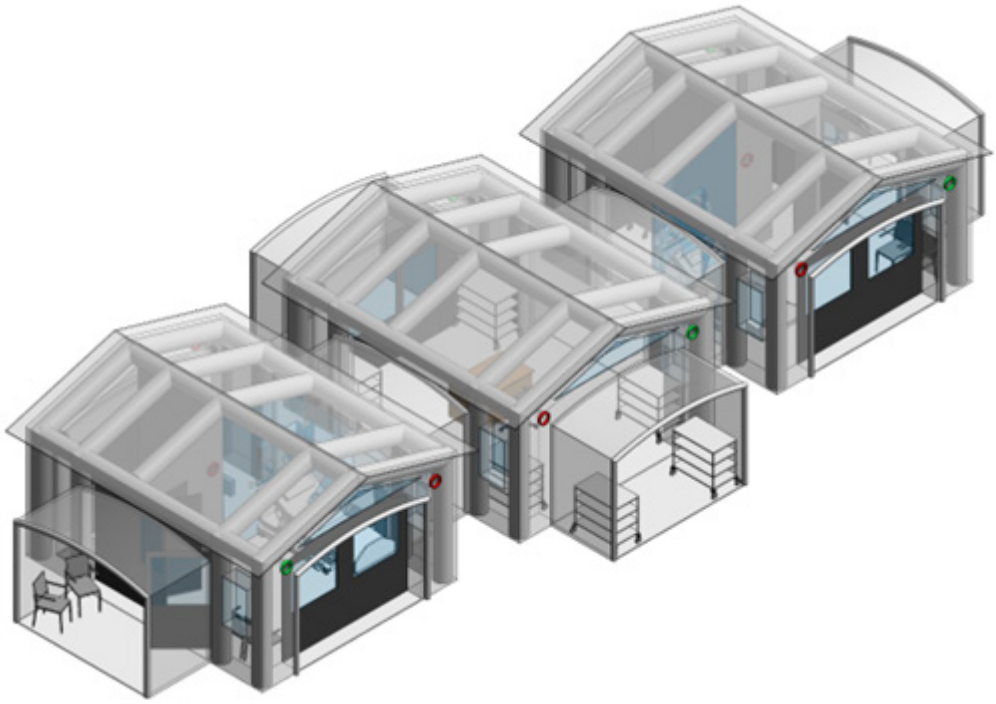
A. Design of the IDTM

On the basis of the process described above, the design team has developed a proposal for IDTM (Annex 6) that address all the design principles and is in line with the key drivers defined by the partner during the 'hearing phase' of the INITIATE² initiative.

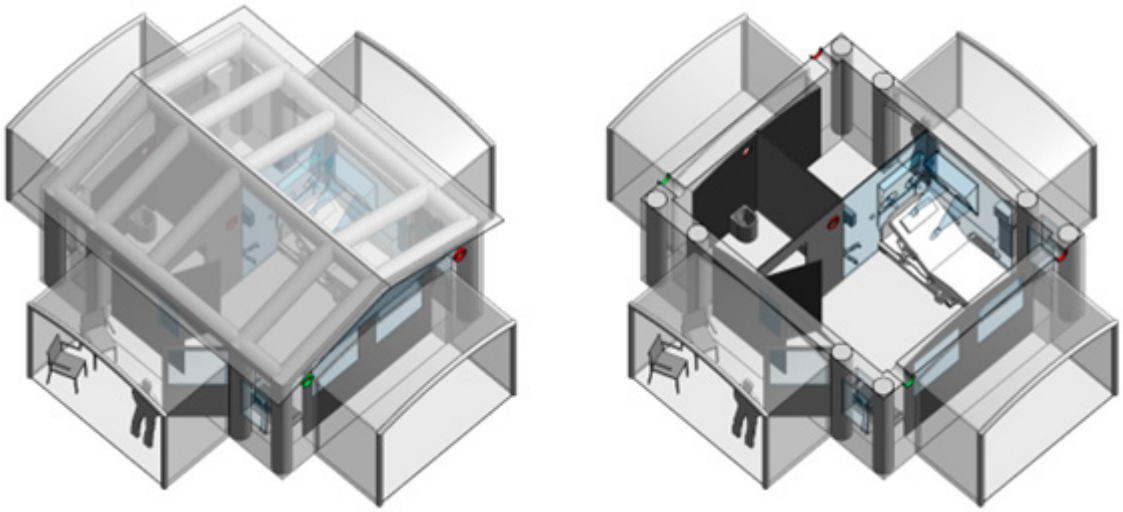
The module is designed with straight walls to increase space capacity and enable an improved interior usability. Each IDTM is divided in three pods:

- a central staff area of 20 m² (5X4m) to allow for constant observation of patients without wearing PPE, and in the first days of the emergency, can be used also as a donning area, office and/or pharmacy; and
- two individual patient rooms of 20 m² (5x4m).

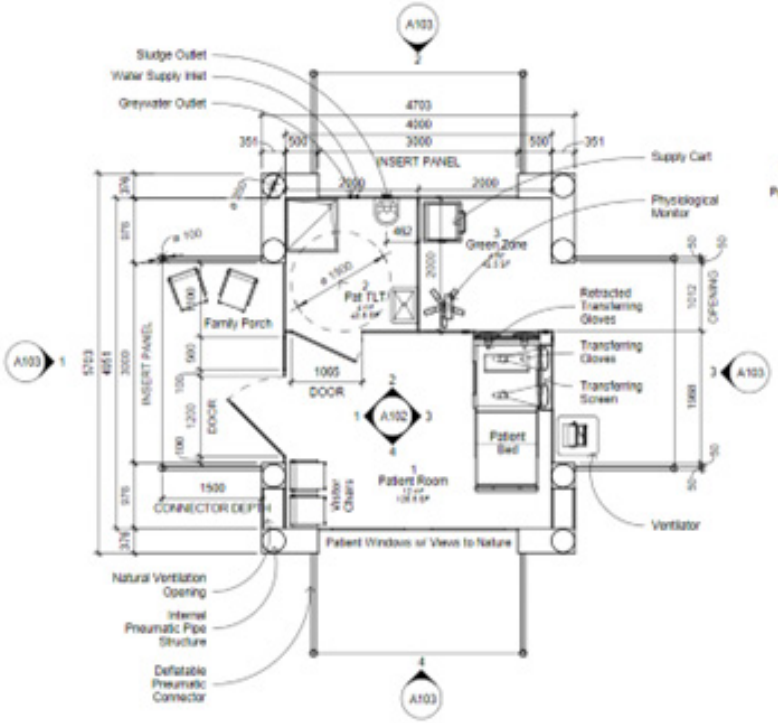


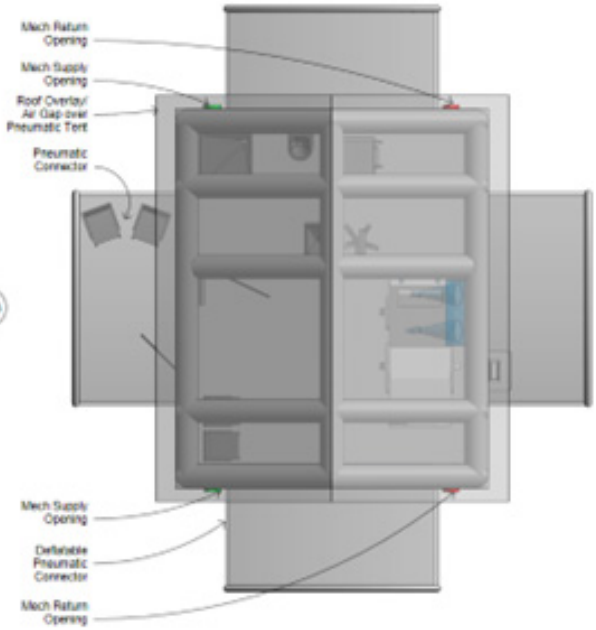


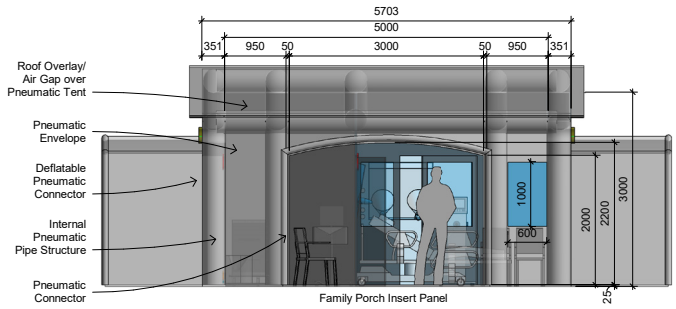
The module proposed is envisioned as a low-pressure inflatable structure, that can both be set up as a self-standing structure outdoors, and as an indoor temporary space within existing buildings. This module ensures the design principles of transportability and ease of construction. This 20 m² pod is designed to be carried on a pick-up truck (due to its weight of about 200 kg divided in smaller carry-on bags), and as it is inflatable, it can be easily and quickly set up in a few minutes.

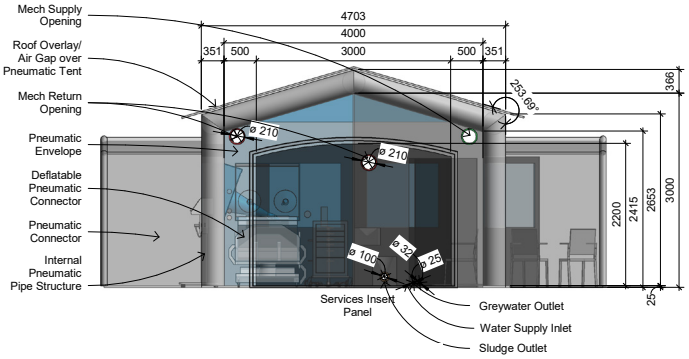


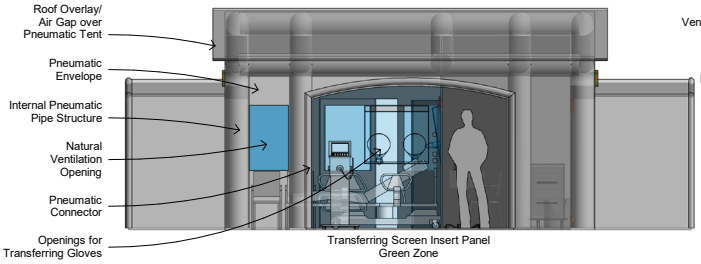
The inflatable structure is compartmentalized and organized according to red and green areas, to ensure ease of flow, infection prevention control, and ease of set up. Each patient room (red area) is divided in: an individual room of 12 m² that can be used for two patients in the event this is required; a toilet of 4 m² with a sink, a shower and a pour-flush toilet that allows easy access for a patient and an assistant; and a green staff area of 4 m² allowing adequate space for bio-medical devices.

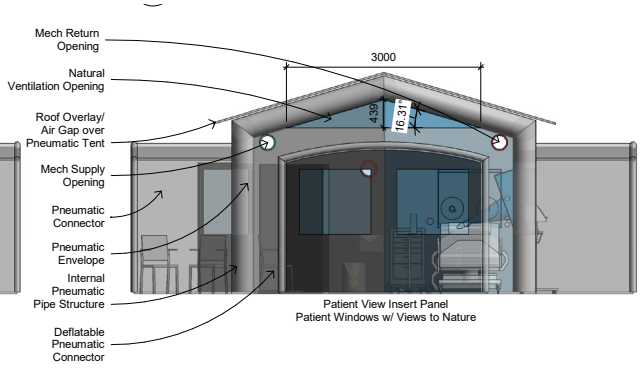






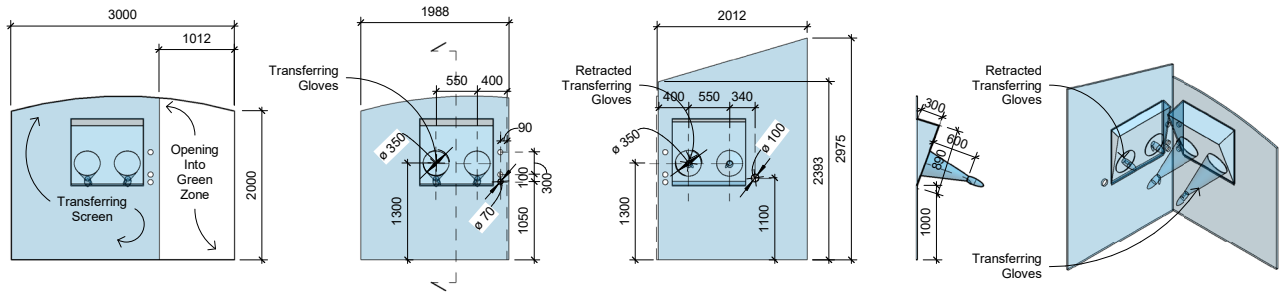




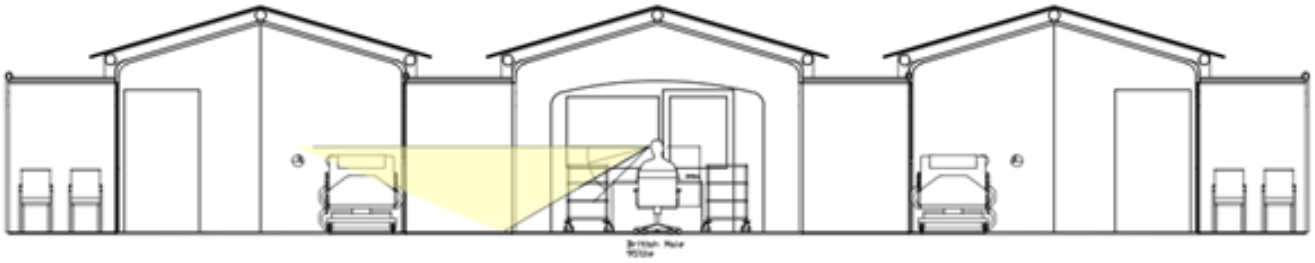


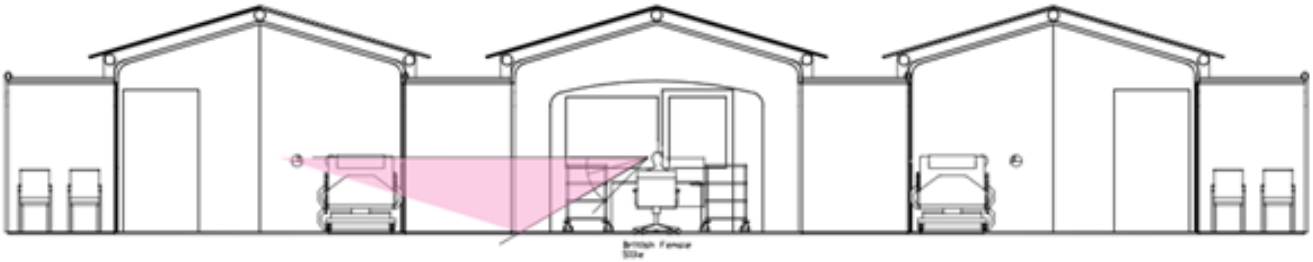
The placement of the bio-medical devices in the green area allows for staff to respond to alarms and interact with equipment without having to don full PPE. A morgue with a dedicated family space can be built in with locally purchased materials using the standard module as a base.

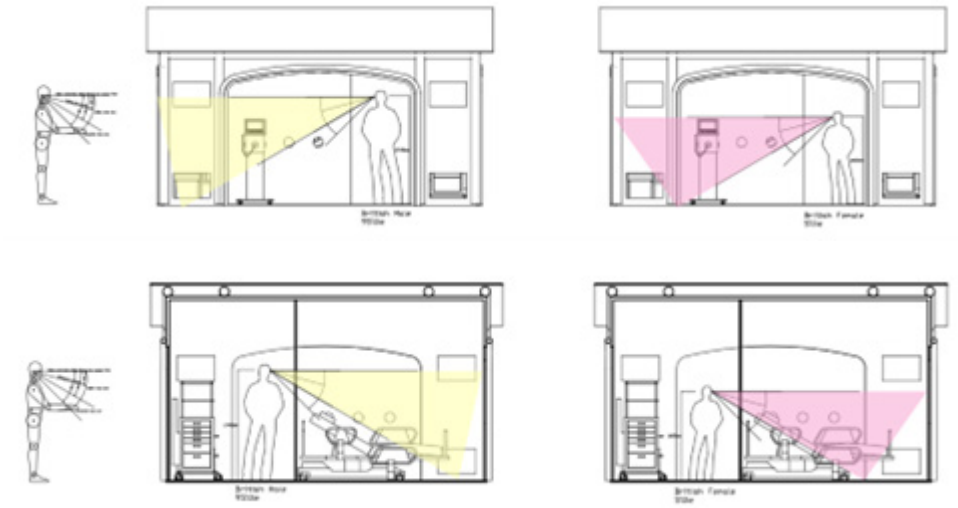
The visibility and manipulation of the patient is guaranteed and enhanced with the provision in each room of a large transparent screen, both on the side and on the head of the patient's bed. These screens house integrated manipulation gloves – wearable from the green area – and sealed technical holes to allow for the passage of medical equipment and cabling systems.



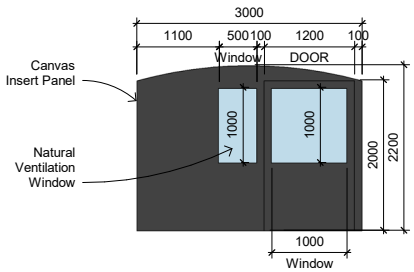
To ensure the adequate visibility from the green central area to the patient room through the transparent screen were performed several visibility studies as shown below.

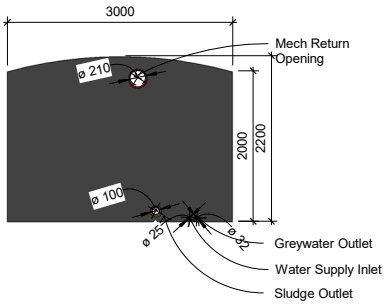


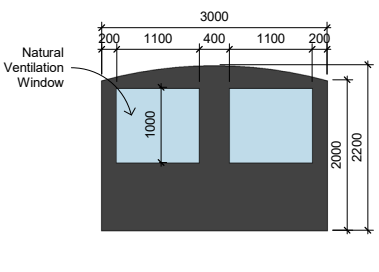


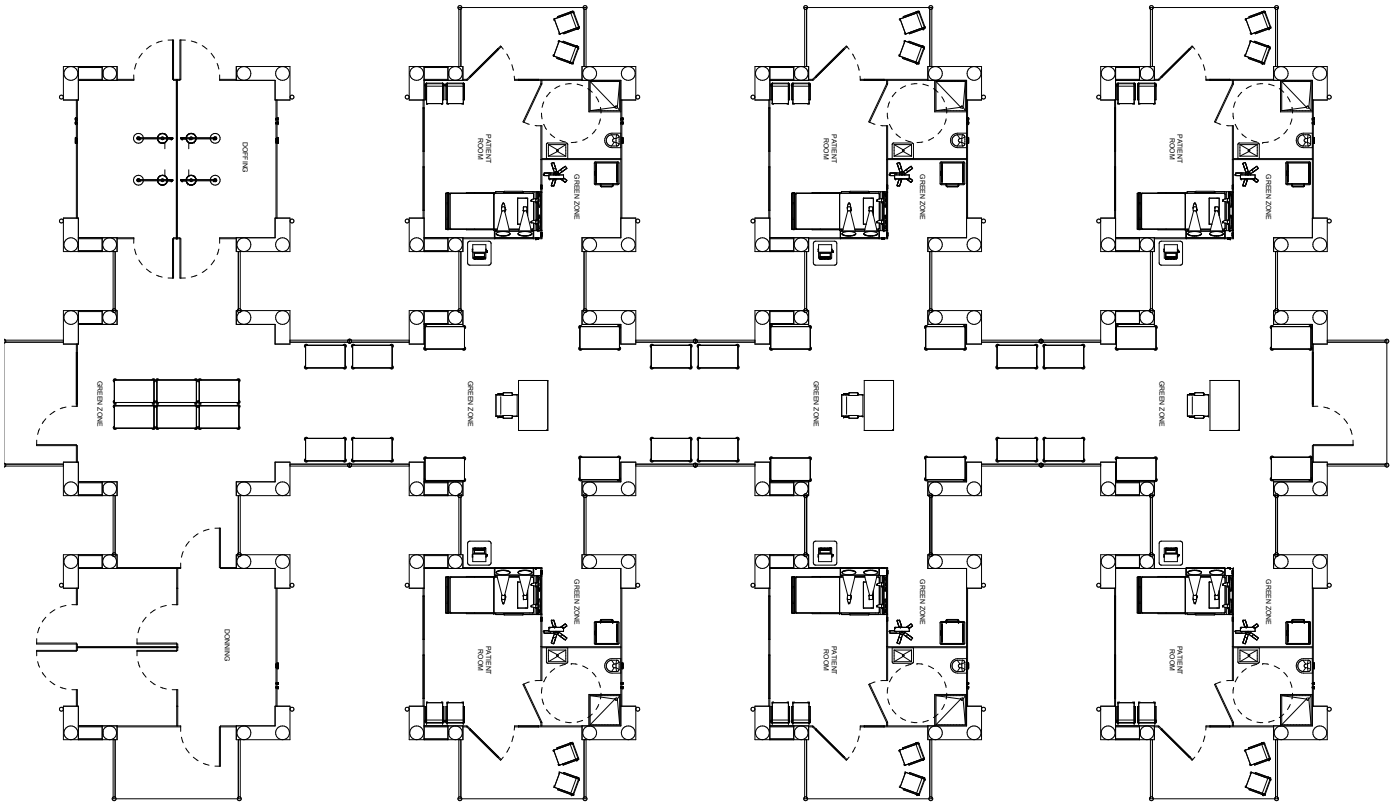


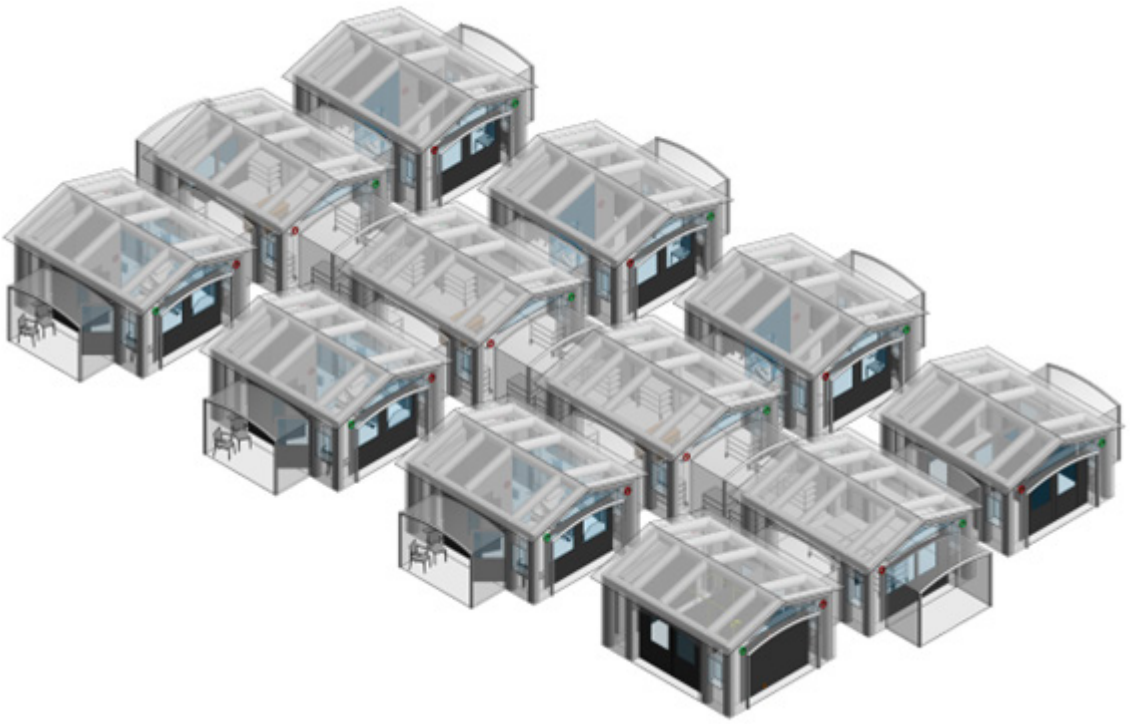
The design proposed also includes a large window on the red area to address a number of critical design principles identified in the hear phase, namely: the need for natural ventilation, natural light, and community engagement. The modularity of the IDTM is ensured by four large identical interchangeable openings which enable easy connection on both axes.








DOFFING
DONNING
PATIENT ROOM
GREEN ZONE



The inflatable structure is resistant to wind gust due to its 6/8 bar Teflon tubular elements, as well as providing at least 80 km/h wind resistance on every surface. The inflatable structure will be thermos-sealed to prevent the use of episodic glue and to ensure the use of long-lasting materials. The proposed IDTM can be adapted with replacement parts included in the package that extend the lifetime of the structure.

The structural component of the module was moved to the exterior with the aim of guaranteeing and enhancing ease of disinfection of the patient room. The flooring system shall be durable and easy to install due to the modular interlocking of hard panels offering a firm surface. Moreover, this system will also support the ability to be disinfected due to a PVC roll that will be laid on top of the modular hard flooring.

The IDTM design has been studied to enable improved natural ventilation. However, the application of the appropriate ventilation and heating/cooling solution will be situation dependent based on:

- Mode of transmission of the pathogen considered – airborne (e.g., SARS-CoV-2), contact (e.g., Ebolavirus) and others.

- Local conditions – can the location and prevailing winds support the minimum recommended ventilation based on the type of illness?

- Climate – is cooling or heating required to maintain comfortable conditions? Include acceptable temperature ranges.

To ensure adaptability to the context, the module will be provided with reinforced non-perforated closable openings to install ventilation, cooling, and heating where required. Refer to the Mechanical Ventilation and Space Conditioning section below for details.

The structure will present another reinforced non-perforated closable opening on the opposite side to eventually install an air exhausting fan. The structure shall rely on controlled-building ventilation technology based on a computational fluid dynamic analysis as carried out by the designers. Each window will have three layers: a fixed mosquito net to ensure vector control, an openable, transparent sheet and a full cover to ensure privacy. The design team estimates a treatment center with a 2-bed capacity will have an estimated electrical power need of 6 KW/h.

B. Transparent screen

The transparent screen is a crucial key component highlighted during the hear phase and therefore needed special attention during the creation phase.

Following the mock-up developed in Turin where 3 scenarios were tested (adult anaphylaxis, pediatric shock, standard patient monitoring), the design team developed the design for the transparent screen following the anthropometric data from Bodyspace 3rd Edition (Pheasant & Haslegrave, 2006). The placement of the manipulation glove apertures (both height and breadth) are designed to cover 90% of a representative population (based on existing anthropometric data tables, Table 10.1 Pheasant & Haslegrave, 2006). In this case, the specifications accommodate the shoulder height and shoulder breadth of 5th percentile female to 95th percentile male adults from the United Kingdom, aged 19-65 years of age (precise dimensions will vary based on the anthropometrics of specific populations). These considerations are intended to reduce the risk of workers adopting awkward postures which accelerate fatigue and present risks related to musculoskeletal injury, while increasing a healthcare worker's ability to perform their roles accurately and safely.

Moreover, the design team assumed that the following equipment will be located in the green area:

- suction, oxygen
- ventilator, monitoring devices
- IV lines (dripping), medications, nutrition;

and that the following will be located in the red area

- glucometer
- pupil light
- thermometer

and, that if required, dialysis, Extracorporeal Membrane Oxygenation (ECMO) or any surgical operations will be performed in the red area.

Through the mock-up developed in Turin, the following key components were highlighted:

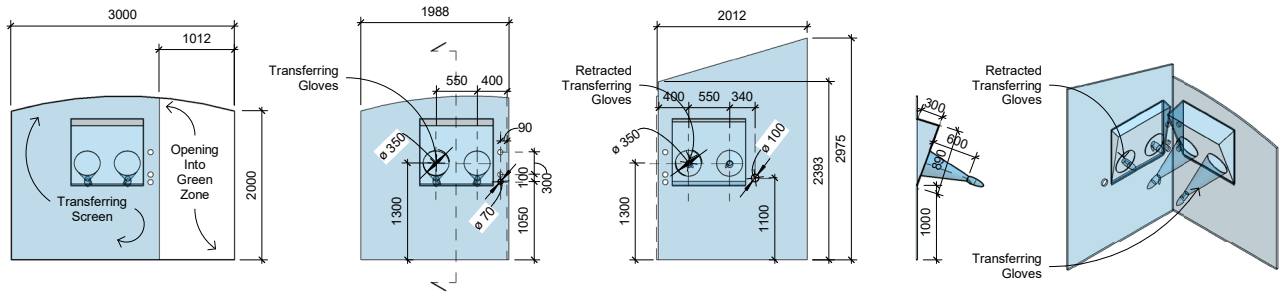
- screen
- manipulation gloves
- adequate space for staff face and feet
- equipment holes
- shelve
- adequate visibility
- lighting system
- communication between red and green area
- cables/pipes

Key components considered	Scenario 1: ADULT EMERGENCY	Scenario 2: PEDIATRIC EMERGENCY	Scenario 3: PATIENT MONITORING
SCREEN			
Transparency	Need to ensure transparency	Need to ensure transparency	Need to ensure transparency
Material Flexibility	Need to enhance ability to move	Need to enhance ability to move	Need to enhance ability to move

Zip extension system	Avoid breaking the transparent screen by pinching it with zip	Avoid breaking the transparent screen by pinching it with zip	Avoid breaking the transparent screen by pinching it with zip
Easy to clean	Need to ensure transparency	Need to ensure transparency	Need to ensure transparency
Strength of screen	Need to ensure strength	Need to ensure strength	Need to ensure strength
Backup system	Add a backup system, 150 cm from the screen	Add a backup system, 150 cm from the screen	Add a backup system, 150 cm from the screen
GLOVES			
Dimension	Diameter of 30 cm	Diameter of 30 cm	Diameter of 30 cm
Materials	Need to allow precision movements	Need to allow precision movements	Need to allow precision movements
Position	Need to be variable according to staff height	Need to be variable according to staff height	Need to be variable according to staff height
Number	2 on the long side and 2 on the short side	2 on the long side and 2 on the short side	2 on the long side and 2 on the short side
ADEQUATE SPACE FOR STAFF FACE AND FEET			
Space for face	Acceptable with the zip extension system	Acceptable with the zip extension system	Acceptable with the zip extension system
Space for feet	Might require some extra space	Might require some extra space	Might require some extra space
EQUIPMENT HOLES			
Equipment position (inside or outside)	Monitor outside but cables and pipes need to pass from green to red area	Monitor outside but cables and pipes need to pass from green to red area	Monitor outside but cables and pipes need to pass from green to red area
Dimension 7 cm diameter for pipes and cables	10 cm diameter for material transfer	10 cm diameter for material transfer	10 cm diameter for material transfer
Materials	Need an ‘airtight connection system’ to reduce leakage between holes and pipes	Need an ‘airtightconnec-tion system’ to reduce leakage between holes and pipes	Need an ‘airtight connection system’ to reduce leakage between holes and pipes
Position	110 cm from the ground and 10 cm from the corner	110 cm from the ground and 10 cm from the corner	110 cm from the ground and 10 cm from the corner
Number of holes	Long side: 3 holes (7 cm diame-ter) according to A,B,C (ATLS Coding) Short side: 3 back up holes (7 cm diameter) + 1 hole for material transfer (10 cm diameter)	Long side: 3 holes (7 cm diame-ter) according to A,B,C (ATLS Coding) Short side: 3 back up holes (7 cm diameter) + 1 hole for material transfer (10 cm diameter)	Long side: 3 holes (7 cm diame-ter) according to A,B,C (ATLS Coding) Short side: 3 back up holes (7 cm diameter) + 1 hole for material transfer (10 cm diameter)

Hole for material transfer from green to red area	Ensuring unidirectional flow from green to red area. Ensure air tightness to avoid leakage. Avoid objects falling. Ensuring the ability to grab objects from the red area, while avoiding potential contamination	Ensuring unidirectional flow from green to red area. Ensure air tightness to avoid leakage. Avoid objects falling. Ensuring the ability to grab objects from the red area, while avoiding potential contamination	Ensuring unidirectional flow from green to red area. Ensure air tightness to avoid leakage. Avoid objects falling. Ensuring the ability to grab objects from the red area, while avoiding potential contamination
SHELVES			
Shelving system (inside or outside)	At least 1 triangular corner shelf inside the patient room	At least 1 triangular corner shelf inside the patient room	At least 1 triangular corner shelf inside the patient room
Hooks	All hooks (not more than 5) should be on the fixed side of the zip extension of the transparent screen	All hooks (not more than 5) should be on the fixed side of the zip extension of the transparent screen	All hooks (not more than 5) should be on the fixed side of the zip extension of the transparent screen
Over side bed trolley	Objects are likely to fall	Objects are likely to fall	Objects are likely to fall
Space in the green zone near the corner for monitors	50 cm space	50 cm space	50 cm space
Waste system (bag inside the patient room)	The bag can be hung onthe side bed trolley	The bag can be hung onthe side bed trolley	The bag can be hung onthe side bed trolley
ADEQUATE VISIBILITY			
Transparent surface dimension	Maximise transparency	Maximise transparency	Maximise transparency
Patient visibility	Ensure full visibility	Ensure full visibility	Ensure full visibility
LIGHTING SYSTEM			
Light on the patient bed	Required	Required	Required
COMMUNICATION BETWEEN RED AND GREEN AREA			
System to communicate between patient and staff	It needs to be controlled from outside and the patient needs to have the possibility to call the doctor	It needs to be controlled from outside and the patient needs to have the possibility to call the doctor	It needs to be controlled from outside and the patient needs to have the possibility to call the doctor
CABLES/PIPES			
Position of cables and pipes	It needs to be outside the range of movement of staff during a medical intervention	It needs to be outside the range of movement of staff during a medical intervention	It needs to be outside the range of movement of staff during a medical intervention

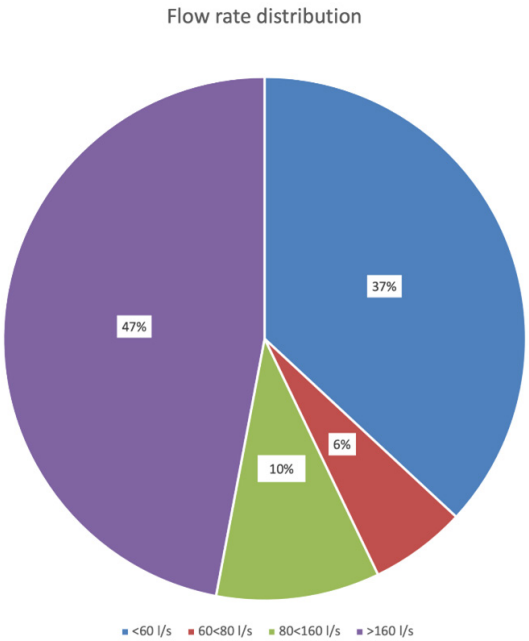
The elements analyzed in the table above were the basis for the design of the transparent screen below. The drawings can be found also within the Annex 6.

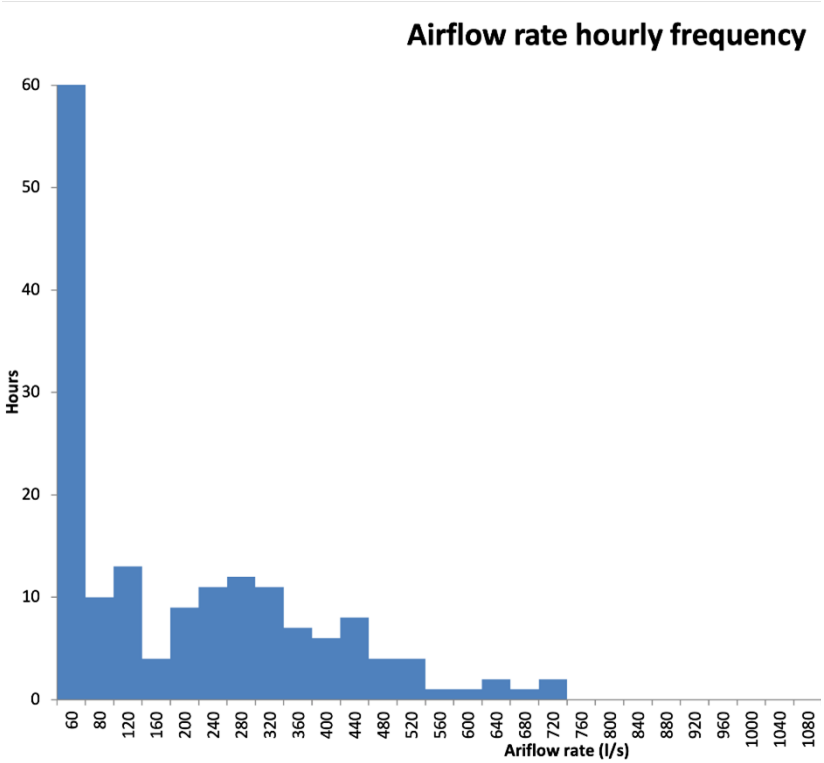


C. Natural ventilation

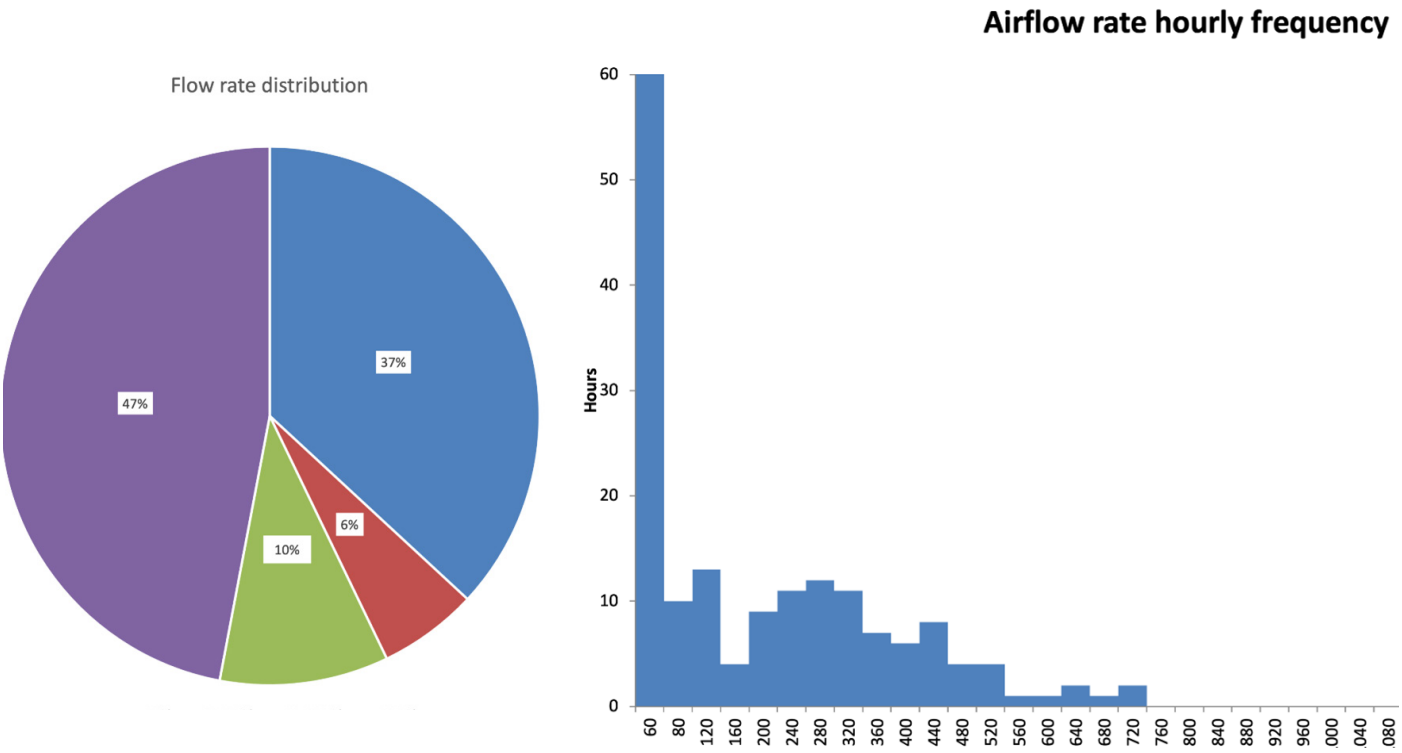
This section looks at the natural ventilation strategy developed by the Téchne member Politecnico di Torino. The natural ventilation strategy envisioned for IDTM is characterised by independent ventilation systems for each space inside the module, with the aim of avoiding cross contamination between the red and green areas and between the different patient rooms. To ensure this approach, a re-iterative process with double feedback loop and computational simulations were put in place. The simulations were set to verify the compliance of the IDTM with the WHO requirement for an airflow rate of 160 l/s, as well to analyze the dispersion of contaminant patterns between modules in the multiple IDTM configuration setting.

The natural ventilation strategy has been simulated and verified by analysing a module against disadvantageous microclimatic conditions, to test its behavior in a challenging context. The context that was selected for the analysis was the city Bangui (368 a.s.l.), in the Central African Republic. The climate is tropical with a temperature range between 40.2°C and 12°C, with local winds at an average speed of 1.3-1.4 m/s. The simulations have been run to analyse natural ventilation and thermal conditions during the weeks 1-7 September and 20-26 April, considering the windows may always be open anytime the temperature is above 18°Celsius, and with a presence of a mosquito net for the patient room.
The results for the analysis concerning the period from 1-7 September show that 47% of the time that was simulated, the 160 l/s was achieved, 10% of the time the airflow rate was between 80 and 160 l/s, 6% was between 60 and 80 l/s and the remaining 37% was below 60 l/s.





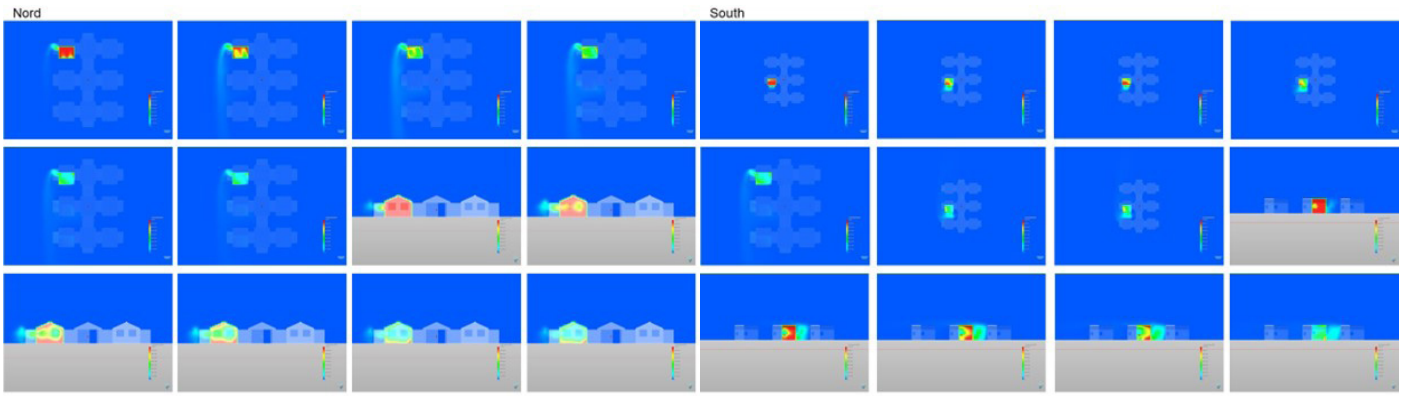
The results for the analysis concerning the period 20-26 April show that 47% of the time that was simulated, the 160 l/s was achieved, 10% of the time the airflow rate was between 80 and 160 l/s, 6% was between 60 and 80 l/s and the remaining 37% was below 60 l/s.

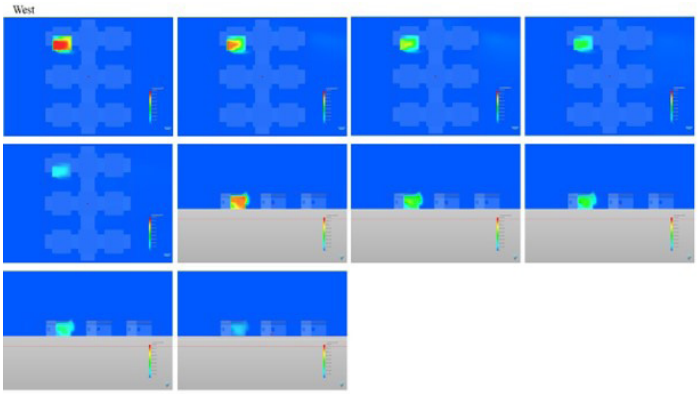


Overall, the results showed that in disadvantageous microclimatic conditions, the required 160 l/s of airflow rate could be achieved on an average 50% of the days over an entire week with the most extreme microclimatic conditions of the year. Yet, the remaining 50% can be achieved with the introduction of low energy consumption fans to assist the air flow movement and extraction.

The results of the analysis of contaminant dispersion patterns of the multiple IDTM configuration setting shows that no significant contamination seems to occur between pods. The analysis has been run by analyzing north, south and west wind direction. Due to the symmetry, an east direction wind would provide the same results than west direction. The images below show, for each wind direction, the pattern of contaminant from inside the red zone to the outdoors, within a 200 second time step, within the simulation conditions mentioned above.

More information on the natural ventilation analysis can be found in Annex 7.





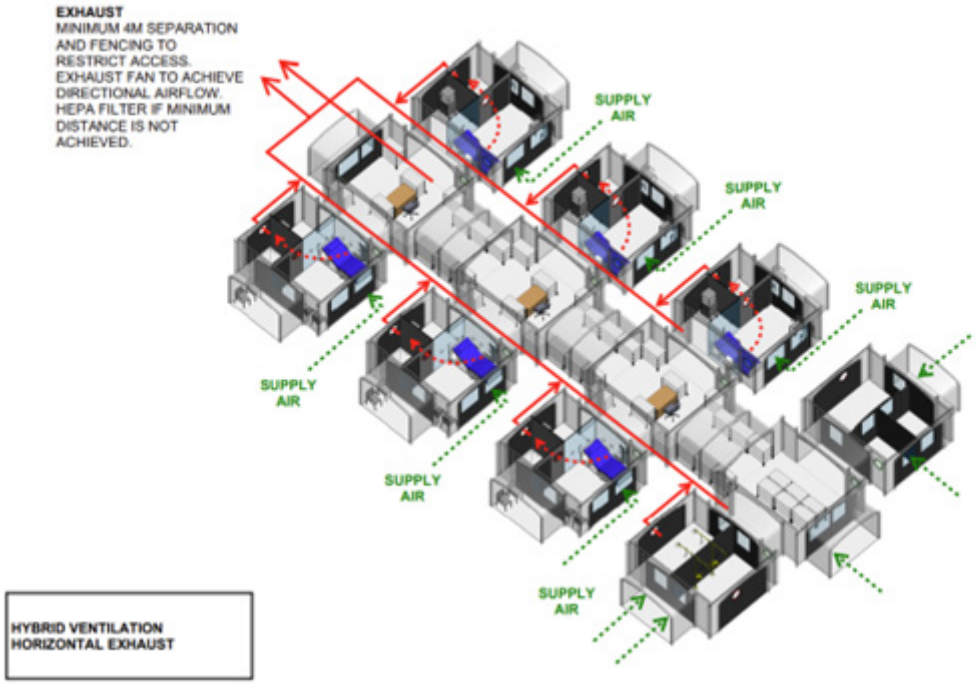
D. Mechanical Ventilation and Space Conditioning

This section looks at the mechanical ventilation and space conditioning strategy developed by the Téchne member International Federation of Healthcare Engineering. Each tent module includes four mechanical ventilation openings that can be used as required. In general, the airflow direction should always be from clean to less clean areas. Adding a fan for exhaust from the modules promotes airflow through the modules and exhaust away from the patients and green zones and exhausted at a safe distance.

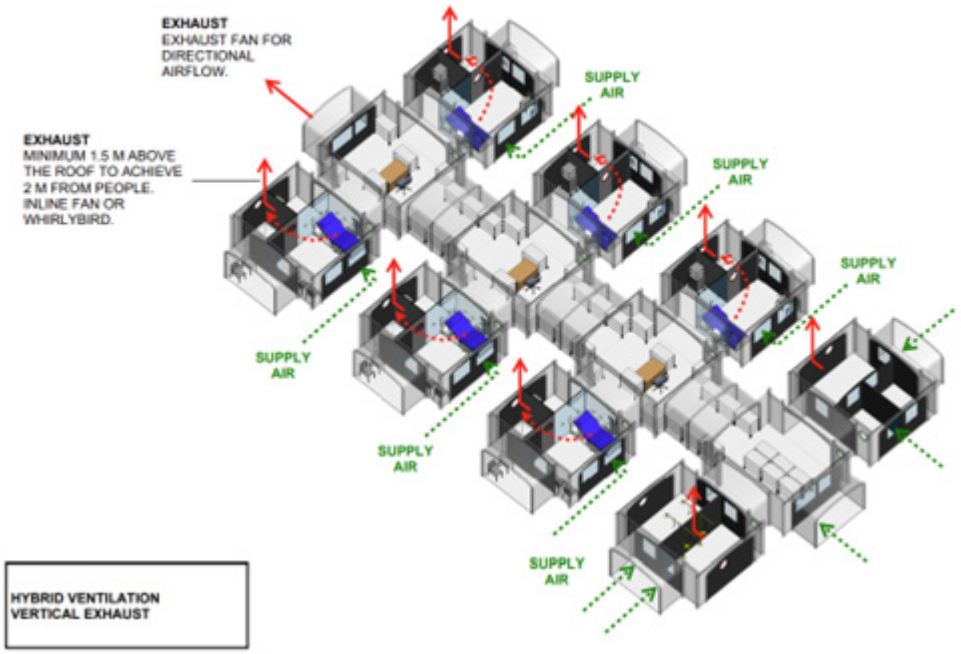
Mechanical exhaust to be used where required due to:

1. The mode of transmission of the pathogen
2. The set-up does not achieve the minimum ventilation rates with natural ventilation alone
   · 160 L/s/patient or 12 air changes per hour where aerosol generating procedures are performed
   · 60 L/s/patient or 6 air changes per hour for other
3. Achieving the appropriate directional airflow

Refer to Annex 8 for hybrid ventilation configuration options.

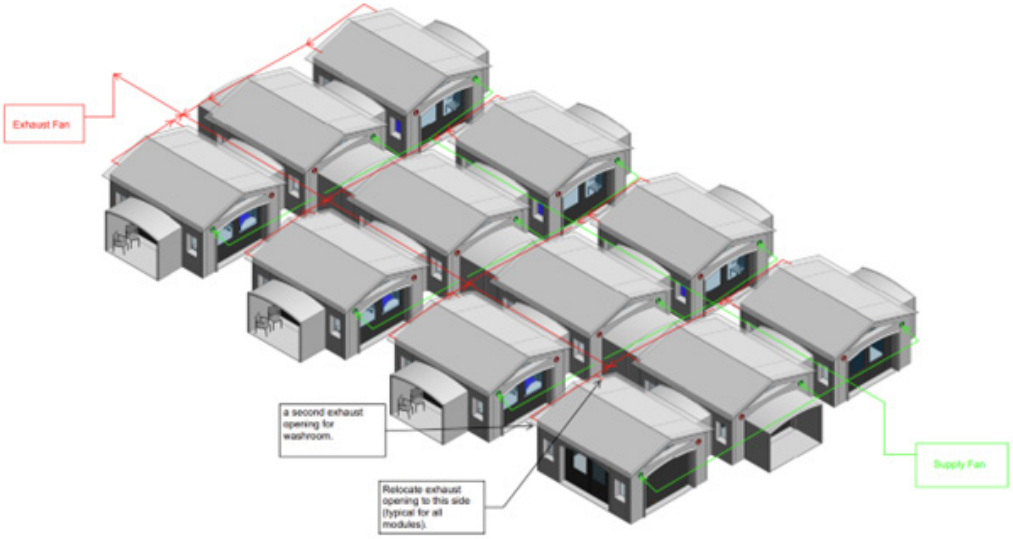


Following WHO guidelines and healthcare design requirements, air is to be exhausted directly to the outside away from any air intakes or people. In the hybrid ventilation configuration options, separation of the exhaust is being achieved by vertical exhaust at a minimum of 2m higher than people circulating around the exhaust or by installing a fenced area to keep people and animals away by a minimum of 4m.



Where the ambient conditions do not allow for a comfortable patient and staff environment with natural ventilation alone, mechanical ventilation with cooling or heating will be required.

Refer to Annex 9 for the heating and cooling ventilation configuration.



Compact air source heat pumps with water as the working fluid are the recommended source of heating and cooling equipment. The quantity and size of the heat pumps will depend on the number of modules, ambient condition, and power available. For larger set-ups, it is recommended that multiple smaller units are installed. The air source heat pumps with water as the working fluid have an operating temperature range of -20 °C to 42 °C.

Below the cooling load table can be used to determine the appropriate cooling required based on the outdoor temperature and desired indoor temperature for a three-pod (1 module) set-up of two patient rooms and one central staff area.

Indoor Air Temperature[2] [DB] [C]	Outdoor Air Temperature [DB][1] [C]																					
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
	Cooling Load[3] [Tons]																				
22	0.4	1.2	1.5	2.1	2.7	3.3	3.9	4.7	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6	10.5	11.1	11.7	12.3
23	-	0.6	1.2	1.5	2.1	2.7	3.3	3.9	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.3	9.9	10.5	11.1	12.0
24		-	0.6	0.9	1.5	2.1	2.7	3.3	3.9	4.5	4.8	5.4	6.0	6.6	7.2	8.1	8.7	9.3	9.9	10.5	11.4
25	-	-	-	0.6	0.9	1.5	2.1	2.7	3.3	3.9	4.5	4.8	5.4	6.0	6.9	7.5	8.1	8.7	9.3	9.9	10.8
26	-	-	-	-	0.3	0.9	1.5	2.1	2.7	3.3	3.9	4.5	5.1	5.7	6.3	6.9	7.5	8.1	8.7	9.3	10.2
27	-	-	-	-	-	0.3	0.9	1.5	2.1	2.7	3.3	3.9	4.5	5.1	5.7	6.3	6.9	7.5	8.1	8.7	9.6
28	-	-	-	-	-	-	0.3	0.9	1.5	2.1	2.7	3.0	3.6	4.5	5.1	5.7	6.3	6.9	7.5	8.1	9.0

Notes:
1 - Outdoor air dry bulb temperature is based on a constant outdoor air relative humidity of 36.1%.
2 - Indoor air dry bulb temperature is based on a constant indoor air relative humidity of 60%.
3 - Cooling load is for a 3-module setup (two patient rooms and one central clean core).

Below the heating load table can be used to determine the appropriate heating required based on the outdoor temperature and desired indoor temperature for a three-pod (1 IDTM) set-up of two patient rooms and one central staff area.

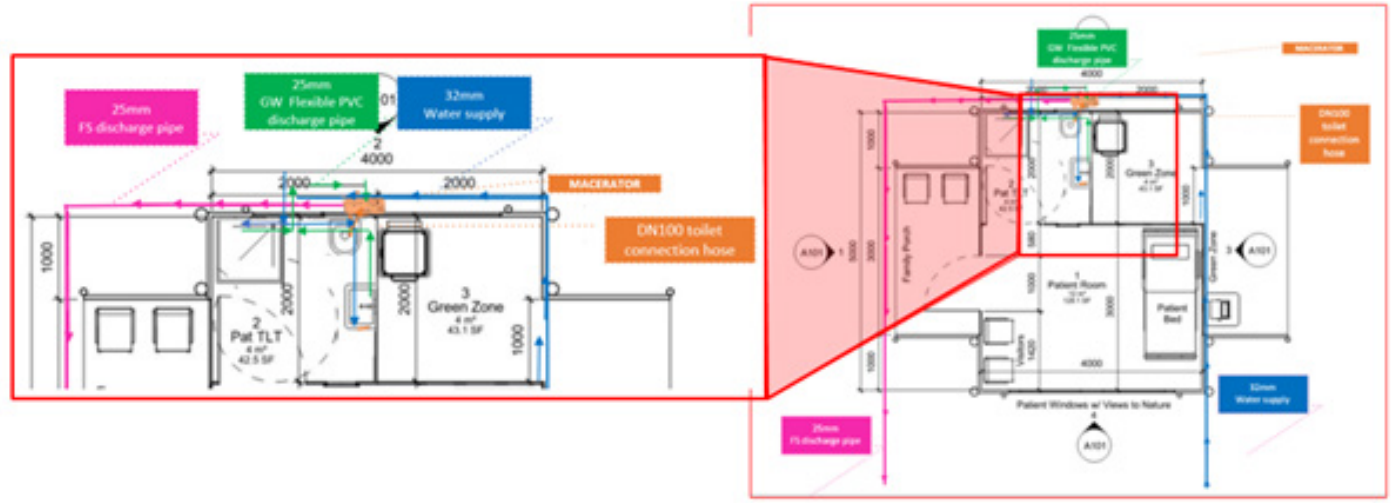
Indoor Air Temperature [DB] [C]	Outdoor Air Temperature [DB] [C]																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Heating Load[1] [kW]																		
15	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9	3.3	2.7	-	-	-	-
16	7.8	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9	3.3	2.7	-	-	-
17	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9	3.3	2.7	-	-
18	12.9	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9	3.3	2.7	-
19	13.5	12.9	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9	3.3	2.7
20	14.1	13.5	12.9	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9	3.3
21	14.7	14.1	13.5	12.9	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5	3.9
22	15.3	14.7	14.1	13.5	12.9	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5	6.9	6.3	5.7	5.1	4.5

Notes:
1 - Heating load is for a 3-module setup (two patient rooms and one central clean core).

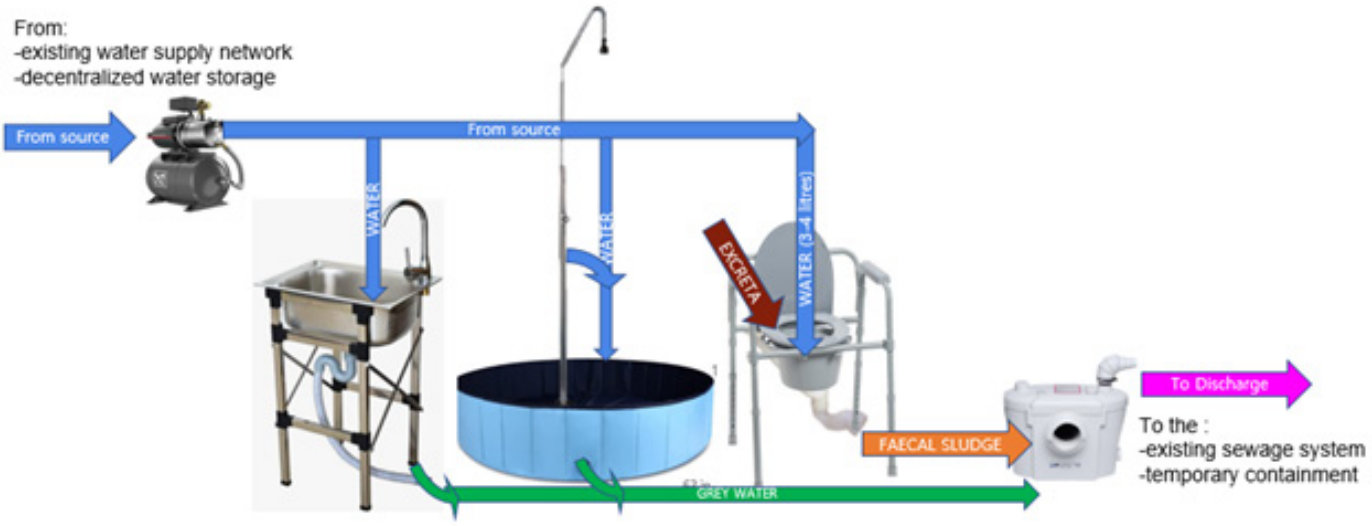
A modular fan box module will be used for supply ventilation as well as distribution of cooling and heating where required. This fan box module consists of fan(s), a heating/cooling coil, and filters. A fan box module is to be flat packed for ease of transportation and should be able to be assembled using standard tools only.

E. Water and Sanitation

The proposed technical solution is in line with key drivers such as humanized care by proposing a solution that enables individual well-being, environmental sustainability as the pour-water system requires low water volume, while enabling adequate transport and safe management of human excreta and potentially infectious grey waters. Accessibility and inclusiveness are addressed by providing a user interface that is accessible to an older adult, child or person with a disability. The pour-flush / macerator solution is also ideal to ensure that all cultural considerations and adaptation to different environments are potentially met. The proposed system enables rapid deployment and installation and offers sustainable operation and maintenance options.
The proposed system allows a sequential build up. See below how the system would be set-up on each module:



Water and sanitation services will be provided in the 4m2 as follows:



Water

A water supply for a sink, pour-flush system and shower will be facilitated by a looped network sourced by a booster pump connected to the existing water network or to a decentralized water treatment system. The interchangeable panel close to the toilet will include a water supply inlet to allow connection, a sludge outlet and a greywater outlet. Service to each module could be interrupted via a gate valve located outside the module prior to the water supply inlet to ensure better repartition of water yield and the continuity of services in case part of the network is closed off (maintenance, etc.).

Item	Quantity		Technical specifications
Booster pump	1	Unit per facility	• Self-priming pump • Max. Flow rate 4 m3/h • Max. Head 50 m • Power 750 W • corrosion-free materials
Pressure switch	1	Unit per facility	• Polypropylene pressure regulator
Pressure tank	1	Unit per facility	• Hydraulic tank capacity 20 l
32 mm HDPE pipe	20	Meters per 2 modules	• HDPE

1” “T”	3	Unit per module	• HDPE
1” “Elbow”	2	Unit per module	• HDPE
1” to ½” reduction	3	Units per toilet unit (shower, toilet hose , sink)	• HDPE
1” Gate valve	1	Unit per module	• HDPE

Sanitation

Sanitation will be addressed via a pressurised fecal sludge network. Pressure sewer systems are a safe and environmentally appropriate way to collect and transport infectious fecal sludge through the facility. A pressure sewer system consists of a network of fully sealed pipes fed by pumping units at each macerator, which acts as a collector container and grinding pumping station. The macerator unit processes the fecal sludge from the toilet and transfers it to the pressure sewer through a small pipe in the facility. For disposal, this technology enables several options for an existing wastewater system, a septic tank or temporary containment such as flexible storage tanks that could be considered as part of the kit.

Item	Quantity		Technical specifications
Commode toilet	Unit per module	1	• Height adjustable • Foldable
Bucket	Unit per module	1	• Plastic handle • Measure marks
Toilet wash Bidet Faucet Spray Gun	Unit per module	1	• ABS plastic
Macerator	Unit per module	1	• Consumption Max. 620 W • Net weight 7.3 kg • Rated current 3.0 A • Flow rate Max. 149 l/min. • Pump head Max. 8.5 m • Inlet pipes 32/36/40mm diameter • Discharge pipes 22/25/28/32/36/40 mm diameter • Easy Access for repairs
Toilet connection hose	Meters per modules	4	DN100
PVC 32” flexible Pipe	Meters per 2 modules	10	• Flexible PVC • Heavy duty
Fecal sludge management Containment	Unit per facility	1	• Waste input 280 l/day • 10.000 liters capacity • Approx. weight 135 kg • Packed dimensions120 x 80 x 47 cm

Hygiene

A shower and a sink with an elbow or foot valve opening will facilitate hand and personal hygiene needs. Discharge will be collected and directed towards the macerator via gravity.

Item	Quantity		Technical specifications
Portable Sink with stand	1	Unit per module	• portable standing free light weight sink • ½" water inlet pipe • No sharp edges • Stand size 42*35*74 cm • Bowl size 47*35*17cm
Tap	1	Unit per module	• Elbow opening
Shower base plate	1	Unit per module	• Non slippery • 100 cm x 80 cm. • Resin or HDPE based
Free standing Shower Faucets Set	1	Unit per module	• Shower with 1 hand-held shower head and 1 foot wash tap. Height of shower head bracket: 1.05 meters

Deliverables

A. Design proposal

Please see the full set of drawings attached as Annex 6.

B. Technical specifications

Please see the technical specification attached as Annex 10

Next steps

The next steps will focus on finalizing the delivery phase and will look at both the INITIATE² workstreams:

- technical innovation and
- testing and training

As part of the technical innovation workstream the next steps will be to focus on the prototype development and the performance testing.

Regarding the testing and training workstream, partners will test the IDTM in real-life scenarios through the drill exercise and therefore will develop training exercises for installation, management and use to ensure a standardized and integrated approach to emergency response through the full-scale simulation exercise.

Deliver phase

Methodology

After issuing the EOI and consequently a RFP, the technical evaluation panel formed by 3 voting members will evaluate the technical and financial proposals with the support of an advisory panel including the design team and the INITIATE² core members for this project.

The chosen suppliers will then be authorized to develop the first prototype that will be tested through the drill exercise and a series of tests on the module performance. Following the drill and test phase the prototype will be adjusted and tested again through a full-scale simulation before being launched in the market.

Milestones

A. First prototype

The first prototype will be developed by the chosen suppliers according to the technical drawings and specifications developed during the creation phase. The prototype will then be tested during the drill and its performance will be tested as explained in the section below.

B. Drill

The objectives of the 2-3 day drill exercise in Brindisi, UNHRD base, are:

- to test and evaluate the first protype according to the indicators defined by the INITIATE² partners during the hear phase

- to test the feasibility of critical interventions in the prototype for the best staff and patient safety

- train stakeholders and users with the new developed prototype / innovation

- strengthen the multidisciplinary collaboration towards the use of the new developed prototype / innovation needed to run the IDTM

Before the drill, to better test the feasibility of critical interventions and evaluate the space configuration of the first prototype, it is important to identify the medical equipment listneeded for the IDTM. A draft of the list can be already found in Annex 11.

C. Testing phase

Testing the module performance is a key process to validate the design decisions before fine tuning the prototype, extensive production and launch on the market. Following the testing phase, the prototype may need design adjustments.

Logistic tests:

Test	Objective	Duration	Equipment	People
Transportation	Ease of transportation Ease to lift	1 day During the full-scale simulation	IDTM	Logistic team involved in the full-scale simulation
Set up	Type and ease to set up	1 day During the full-scale simulation	IDTM	Logistic team involved in the full-scale simulation
Disinfection	Material resistance to cleaning and disinfection products	Everyday constant monitoring over 4 months starting from the drill	IDTM	Logistic team involved in the full-scale simulation

Dismantling	Ease to dismantle and repack	1 day During the full-scale simulation	IDTM	Logistic team involved in the full-scale simulation

Use of space and space configuration:

Test	Objective	Duration	Equipment	People
Transparent screen	Visibility Fitness for purpose	During the drill and the full-scale simulation	IDTM	Teams involved during simulation
Space circulation	Fitness for purpose	During the drill and the full-scale simulation	IDTM	Teams involved during simulation
Space Dimension	Fitness for purpose	During the drill and the full-scale simulation	IDTM	Teams involved during simulation
Visibility	Indoor visibility (from staff area to patient room) Outdoor visibility (from visitor area to patient room)	During the drill and the full-scale simulation	IDTM	Teams involved during simulation

Structural soundness:

Test	Objective	Duration	Equipment	People
Wind resistance	Verify prototype performance	Everyday constant monitoring over 4 months starting from the drill	IDTM	
Waterproof	Verify prototype performance	Everyday constant monitoring over 4 months starting from the drill	IDTM	
Structural soundness	Structural weight and structural loads resistance	Everyday constant monitoring over 4 months starting from the drill	IDTM	
Mechanical stress	People movements and IDTM use	1 day During the full-scale simulation	IDTM	

Building Physic tests:

Test	Objective	Duration	Equipment	People
Solar Radiation	Indoor environmental comfort and safety Color Air Chamber Aging material	Everyday constant monitoring over 4 months starting from the drill	2 Data logger 2 Solar radiation sensor UV Aging sensor	Technical team (Politecnico di Torino) Onsite for start/end of the test
Radiant Temperature	Indoor environmental comfort and safety	Everyday constant monitoring over 4 months starting from the drill	Globe thermometer	Technical team (Politecnico di Torino) Onsite for start/end of the test
Humidity	Indoor environmental comfort and safety Transparent screen visibility and performance	Everyday constant monitoring over 4 months starting from the drill	Condensation sensor	Technical team (Politecnico di Torino) Onsite for start/end of the test
Airflow rate	Comply with WHO airborne requirements	Once a month for the 4 months of the test	Gas tracer Gas sensor (SF6)	Technical team (Politecnico di Torino) Onsite for start/end of the test
Airflow direction	Comply with WHO airborne requirements Airborne contaminant removal over time	Once a month for the 4 months of the test	Smoke generator 2 Camera	Technical team (Politecnico di Torino) Onsite for start/end of the test
Airborne Contaminant leakages	Airborne contaminant leakage over time	Once a month for the 4 months of the test	Smoke generator 2 Camera	Technical team (Politecnico di Torino) Onsite for start/end of the test

Annex 1: Hear phase, Workshop 29-31 March 2022

INITIATE² - Infectious Disease Treatment Module

Brindisi, 29-31 March 2022 - Workshop Report

Table of Contents

Participants

Organisation	Name
ALIMA	Eric Barte de Sainte Fare
	Hans-Joerg Lang
CUAMM	Vanessa Valentim
Malawi MoH	Jones Masiye
	Sanderson Kuyeli
MSF	Armand Sprecher
	Francois Chatelain
	Olaf Pots
Polytechnic of Turin	Marianna Nigra
Samaritan's Purse	Cindy Albertson
WFP	Andrea Tornese
	Bart Provoost
	Emma-Lee Knape
	Julian Civiero
	Marta Laurienzo
	Michelle Joseph
	Nadia Desai
	Roberto Marazzani
	Silvia Rossi
	Stefan Bruni
	Stefano Guagliardo
WHO	Dan Youkee
	Luca Fontana
	Janet Diaz
	Kamal Ait-Ikhlef
	Marta Lado Castro-Rial
	Michele Di Marco
	Paul Molinaro
	Veronica Rovegno

Agenda


DAY 1
29/03/22
Challenge Framing
DAY 2
30/03/22
Ideation & Prioritization
Day 3
31/03/22
Prototype and Validation Plan
User Journey Mapping
Detail how clinicians respond to the different steps (daily journey) in a localised transmission phase during a suspected case . Land on pain points
Ideation
Ideate around prioritized challenge questions to identify new and existing opportunities to solve them
Future State Journey Mapping
Decide and map how your solution will work
Detailing and Visualizing Ideas
Deep dive into each step of the solution: visualise & explain how it would work from the user's perspective
Design Brief and Validation Plan
Describe the problem we are solving, the solution, and value we aim to create. Validate critical assumptions through user research - talking to key stakeholders, users, patients, caretakers, etc.
How Might We Challenge Questions
Craft HMW Challenge Questions to to guide ideation and ensure we are solving the right problems
Idea Prioritization
Prioritize ideas based on feasibility, viability, desirability, and impact
Training Workstream Introduction
Introduction and overview of the training workstream

Day 1 – Challenge Framing

Activity	Time
Welcome & Agenda (zoom link open)	9:00am
Recap of the programme previous sessions and Key Driver Framework (zoom link open)	9:30am
Icebreaker game	10:00am
Coffee Break	10:30am
Patient Journey Map Exercise (small groups)	10:45am
Patient Journey Rotation & Prioritization (small groups)	12:15pm
Lunch	1:00pm
Pain Points Prioritization	2:00pm
Break	3:00pm
How Might We Challenge Questions Exercise (small groups)	3:15pm
Check out and Plan for Day 2	4:45pm

Recap of the programme previous sessions and Key Driver Framework

The purpose of this workshop was to identify more specific pain points and opportunities to inform the design of the infectious disease treatment module.

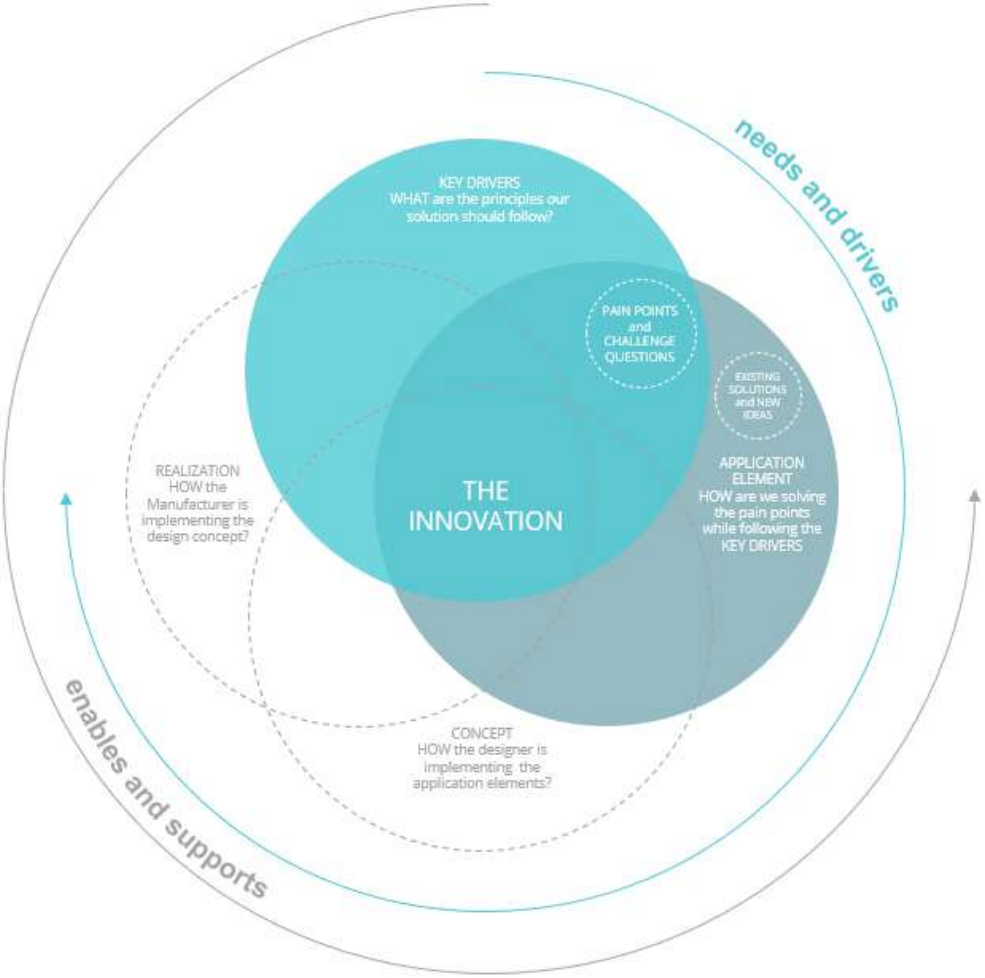
The expected outcome of this workshop was to come up with a design brief that details the problem partners are solving, visualises how the solution will work, and articulates the value it will create.

The methodology of this workshop relies on a Key Driver Framework:

In the previous online working sessions, partners worked on identification of pain points and corresponding challenge questions. Challenge questions can be addressed by existing solutions or responded to with new ideas. Key drivers address principles that our solutions should follow in that regard. Application elements show how partners solve the identified pain points while following the key drivers.

During the current workshop, partners will build on the key drivers, pain points, challenge questions, and application elements to come up with a design brief. On the basis of the design brief, in the next phases of the INITIATE² project partners will come up with a solution concept which shall show how the designer implements the application elements, and partners will enter the realisation phase where they will look at how the manufacturer implements the design concept.

The key drivers identified by the INITIATE² Core Team to be considered while developing the infectious disease treatment module pilot solution are the following:



1. *Humanised care (accessibility, privacy, and ensuring that the proposed structure targets individual's well-being)*
2. *Environmental sustainability (making more environmentally responsible choices with our energy, waste, and water, and quantifying our carbon impact as well as holding groups responsible)*
3. *Disaster resilience (ensuring that the proposed structure is resilient to climatic shocks)*
4. *Accessibility and inclusiveness (ensuring that the proposed structure is accessible to an old person, a child, or a disabled person)*
5. *Cultural adaptation (ensuring that the proposed structure fits into different local contexts)*
6. *Deployment and installation rapidity (ensuring that the proposed structure can be installed within the first hours of an epidemic outbreak and be installed by unskilled workers)*
7. *Circularity (ensuring that the proposed structure minimises resource flows, avoids waste creation, and can be reutilised)*

8. *Sustainable maintenance (ensuring that the proposed structure can be repaired easily)*
9. *Health system integration (ensuring that the proposed structure fits the local health systems)*
10. *Usability (ensuring that the proposed structure is easy to use)*

Important considerations for the interactive work sessions were defined as follows:

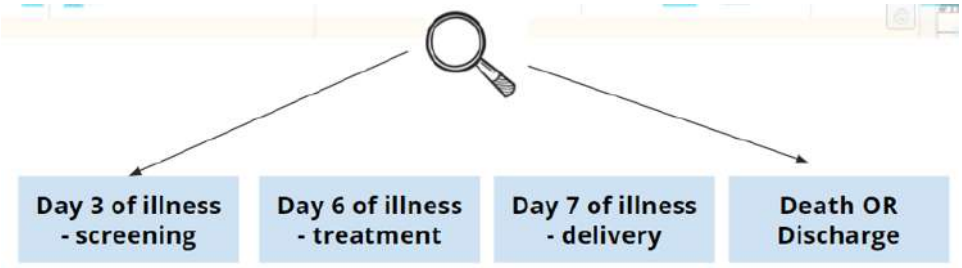
- Agreeing on terminology is of essence to come up with a design brief. Pain points are the problems, ideas are the solutions already identified in the field, key drivers are principles, application elements shape our wish list for future innovative solutions.
- Defining the level of care of the referred pathway informs the type of design brief partners come up with. Different tools might be required which focus on preparation of local health facilities on one hand, provision of mobile medical support in mobile units on the other hand, and which target different phases of a pandemic outbreak. It is important to agree on what outbreak scenarios partners define in this regard. Moreover, the temptation of delivering different standards of care which a local hospital usually does not provide might be disruptive and this is important from a health systems integration perspective.
- Defining the scope boundaries for health system integration is important. A rapidly deployable solution can be considered of short-term use among developers, but as an opportunity to leave something semi-permanent in the country of application. The proposed structure should be able to support in the first four weeks of an intervention, with possibility of integrating the solution under the form of a surge plan.
- Deciding which pathogen will be considered informs the level of care needed for the proposed structure.
- In order to provide rapid efficient response during a pandemic outbreak, the proposed structure should be small and agile and should be fit for the worst-case scenario.

Patient Journey Mapping and Pain Points Prioritisation

On Day 1 of the workshop, an interactive patient journey mapping exercise was carried out to assess the main pain points and point out challenge questions throughout different phases of a patient journey at the outset of an outbreak.

Part of the exercise was to assess the main pain points faced by Fatou, an imaginary 35-year-old local storekeeper who has been 34 weeks pregnant, was vaccinated with rVSV-ZEBOV and which has been experiencing 3 days of fever with 2 episodes of vomiting,

abdominal pain and diarrhoea. After discussing with staff at her health clinic, she decided to go to the Ebola treatment centre.



Below is an overview of the outputs of the exercises completed by our participants:

Day 3 of illness – suspect Ebola patient admission

Prioritised and Voted Pain Points:

- Correct screening and triaging and improper management of severe cases upon arrival

- Need for quick diagnostics

- Need for temperature-controlled treatment centre

- Language barriers

- Unstable provision of medical supplies

- Inconsistent data collection procedures

Day 6 of illness – confirmed stable Ebola patient

Prioritised and Voted Pain Points:

- Timely treatment of Ebola Virus Disease (EVD)

- Lack of safe and differentiated treatment spaces

- Visibility, constant monitoring, and rapid access

- Meeting patients' needs and privacy during pregnancy and delivery while ensuring constant observation capability

- Counselling and contact with the family

Day 7 of illness – confirmed critical Ebola patient

Prioritised and Voted Pain Points:

- *Insufficient staff training*
- *Diagnostic tools used on patient cannot be used again*
- *Physical space insufficient and not adjustable*
- *Moving ill patients according to degree of severity and risk status*

Death of the identified patient

Prioritised and Voted Pain Points:

- Ensuring correct dead body management while respecting local funeral rituals
- Lack of plan B when full capacity within the treatment centre has been reached
- Appropriate communication to the family about patient's death
- Lengthy decontamination process which delays room availability
- Community acceptance of safe burial
- Disposal of dead body in a safe manner

Discharge of the identified patient

Prioritised and Voted Pain Points:

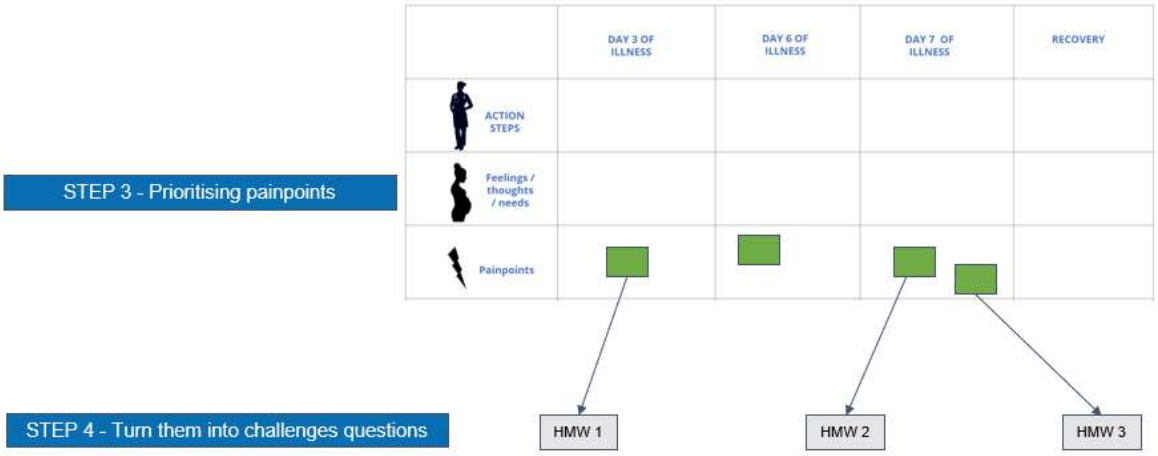
- Appropriate communication to the family about discharge and continuity of care

- Area for family conversations

- Challenging coordination and communication across different departments involved in the discharge process

"How might we" (HMWs) challenge questions exercise

Following the prioritisation of pain points, a second exercise was carried out which looked at turning pain points into challenge questions. Defining clear scenarios of intervention at multiple stages of a patient journey allows to consider different key drivers at different steps of a medical intervention.



Below is an overview of the most voted HMWs by our group of participants:

HMW 1	*How can we ensure our staff is knowledgeable about the core design principles of treatment centre construction, and how can we develop core design principles of the facility in such a way that working in it requires a minimum amount of training?*
HMW 2	*How might we care for patients of undetermined severity/infection risk?*
HMW 3	*How might we reduce exposure to contamination of diagnostic tools?*
HMW 4	*How might we make both healthcare workers and patients more comfortable, and how can we design a solution that would ensure visibility while keeping privacy of the patients?*
HMW 5	*How can we design an adjustable space that allows as much care to be delivered at the lowest risk of staff and patients?*
HMW 6	*How can we design a solution that allows a rapid access for the clinicians from green to red zone to respond to emergencies?*

Key take-aways of day 1

Day 1 allowed partners and participants from multiple backgrounds to collaboratively work together on the identification of pain points for patient journey mapping during the outbreak of a pandemic. Most importantly, bringing different practitioners in the health sphere together at UNHRD premises gave INITIATE² physical space for brainstorming around medical innovation in emergency response.

Pain points identification is a vital element of the "Human-Centred Design" methodology which implies that each solution falls within an already existing complex system around the people you aim to help, while their life will not revolve around your solution. Turning them into "How might we?" questions allows partners to engage in reverse thinking and identifying possible intervention scenarios.

Integrating such a human-centres design methodology in design-thinking for medical innovation towards health emergency response permits partners to take key drivers into account which, at a first glance, might not be directly related to the core solution but which, in fact, do have strong repercussions on the relevance, useability and effectiveness of a proposed structure.

Day 2 – Ideation and Prioritisation

Activity	Time
Field visit to the base	9:00am
Break	10:30am
Agenda & Recap of of Day 1 and review of shortlisted How Mights We's (zoom link open)	10:45am
Ice-breaker	11:00am
Ideation Exercise (small groups)	11:10am
Ideation Prioritization and Discussion	12:10pm
Lunch	1:00pm
Detailing and visualising ideas (small groups)	2:00 pm
Gallery walk of visualised ideas & forming assessing groups	3:00pm
Break	3:30pm
Assessing ideas against Key Drivers, Feasibility, and Viability (small groups)	3:45pm
Checkout and Plan for Day 3	4:45pm

Day 2 focused on ideation departing from the "how might we?" questions identified during day 1. Different ideas for medical intervention were assessed against Key Drivers, as well as feasibility and viability of such possible scenarios.

Conceptualisation of the design brief

The 6 HMWs as laid out above were translated and categorised under different core ideas. This was done to ensure key problem areas are addressed properly, before moving more in detail towards the proposal of design concepts.

HMW 1: *How can we ensure our staff is knowledgeable about the core design principles of treatment centre construction, and how can we develop core design principles of the facility in such a way that working in it requires a minimum amount of training?*	**Idea 1: Intuitive Design Concept**
HMW 2: *How might we care for patients of undetermined severity/infection risk?*	**Idea 2: Triage Criteria**
HMW 3: *How might we reduce exposure to contamination of diagnostic tools?*	**Idea 3: Visibility and Separation**
HMW 4: *How might we make both healthcare workers and patients more comfortable, and how can we design a solution that would ensure visibility while keeping privacy of the patients?*	**Idea 4: Community Engagement; Ventilation and Temperature**
HMW 5: *How can we design an adjustable space that allows as much care to be delivered at the lowest risk of staff and patients?*	**Idea 5: One-Size-Fits-All; Modularity**
HMW 6: *How can we design a solution that allows a rapid access for the clinicians from green to red zone to respond to emergencies?*	**Idea 6: Visibility and Separation**

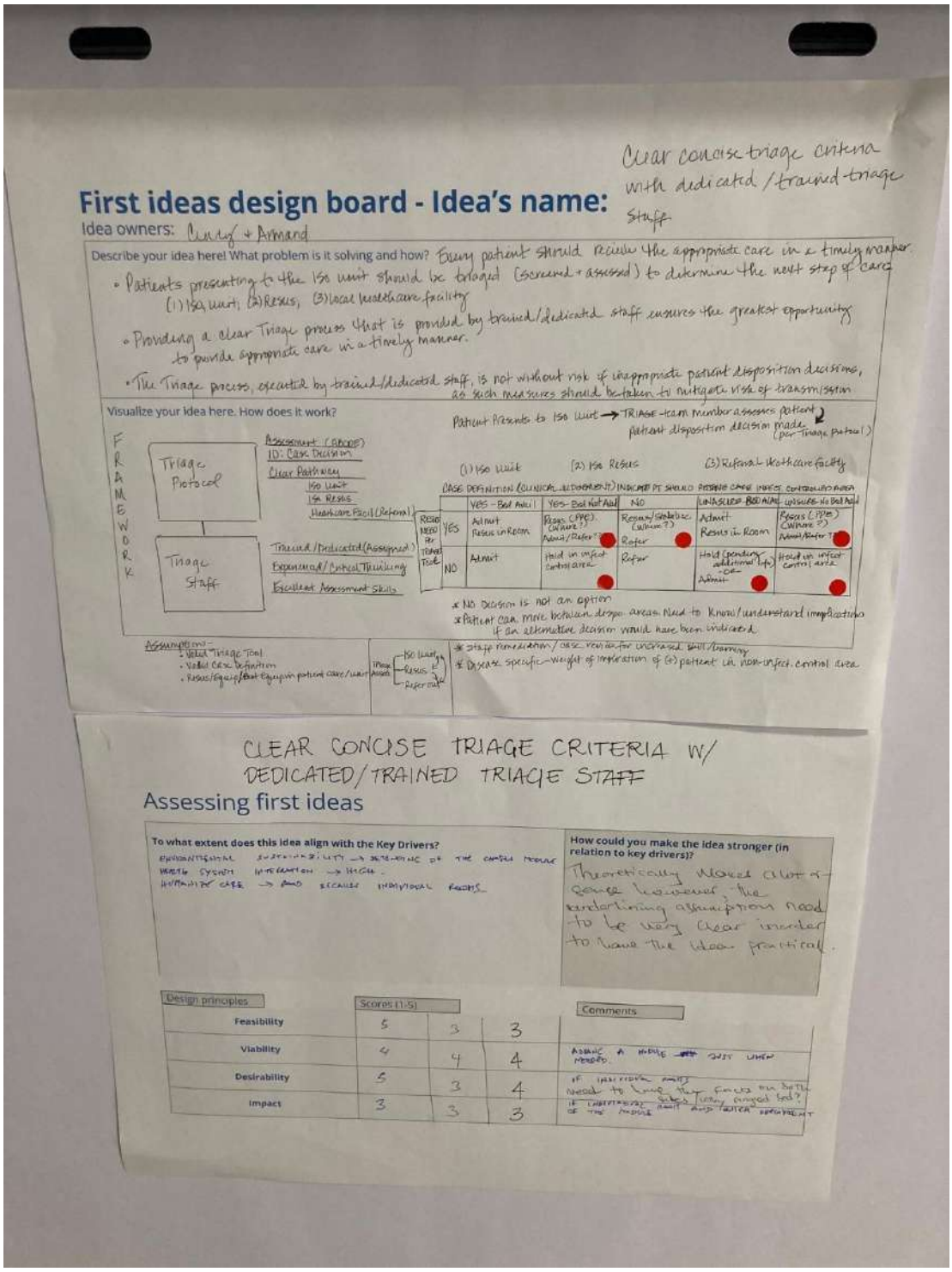
Partners were subsequently asked to collaborate together in order to evaluate what key features the proposed infectious disease treatment module should include in order to respond to those key ideas.

Design brief

Idea	Triage criteria	Visibility & separation	Ventilation & Temperature	Modularity	One size fits all 1 unit module	Community engagement	Intuitive design concept
Focus? Y/N							
What to include?							
How to include it?							
Solution Constraints?					Key Drivers?		

Below is a representation of each of the exercises completed and assessed by our partners.

Idea 1 – Triage Criteria



This idea addresses the issue of how to take care of patients of undetermined severity/infection risk, including the definition of clear and concise triage criteria assessing whether a person coming into the treatment centre needs care in an infectious disease treatment environment, and whether they do need medical care immediately.

Patients reaching the treatment unit should be triaged (screened and assessed) to determine the next step of care. A clear triage process is to be provided by trained/dedicated staff to ensure the opportunity to provide appropriate care in a timely manner is guaranteed. The triage process is not without risk of inappropriate patient disposition decisions, as such measures should be taken to mitigate risk of transmission.

The partners defined a triage framework* composed of triage protocol and triage staff, as well as a case resuscitation mechanism laid out as follows:

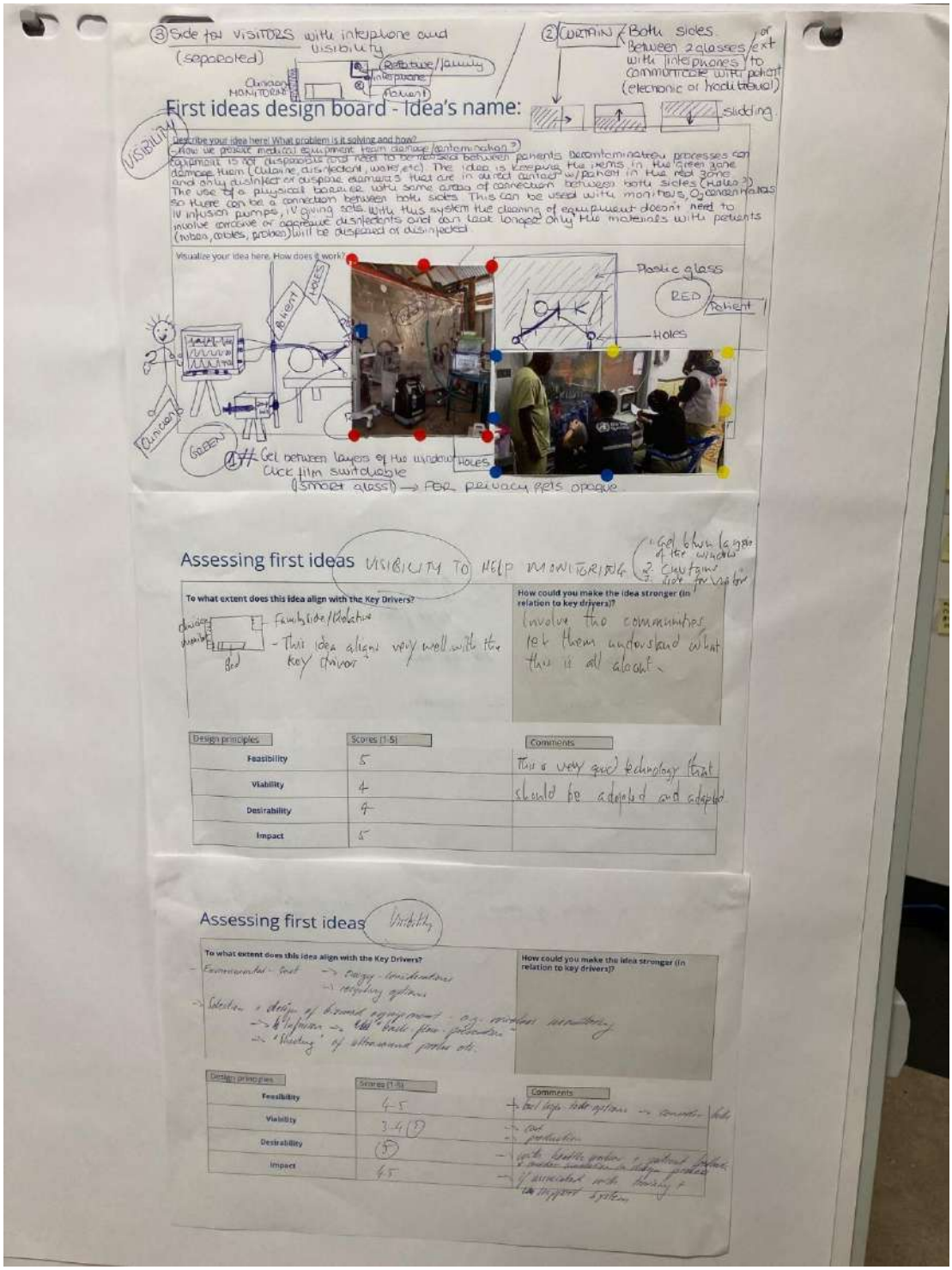
		Assessment: Care needed and bed available	*Assessment: Care needed and bed unavailable*	*Assessment: No care needed*	*Assessment: Unsure and bed available*	*Assessment: Unsure and bed unavailable*
Do I need immediate resuscitation ?	*Yes*	Admit for resuscitation	Resuscitate (PPE) but where? Admit/refer?	Resuscitate / stabilise but where? Refer?	Admit for resuscitation	Resuscitate (PPE) but where? Admit/refer?
	No	Admit	Hold in infection control area	Refer	Hold in infection control area or admit	Hold in infection control area

**Assumptions: (I) valid triage tool in place; (II) valid case definition in place; (III) best equipment patient care and unit; (IV) no decision is not an option; (V) patient can move between disposable areas. Treatment personnel must understand implications of what alternative decisions if taken.*

The thought process above does have implications for the design process in a way that it defines proxies for existing health facilities and demonstrates that the development of a treatment procedure cannot be separated from design treatment strategy. WHO defined triage classification criteria including definition of disease severity which is directly linked to action and resuscitation. It is important that the tool we develop is aligned to internationally recognised triage criteria and can be deployed in peripheral settings as well as existing regular health structures for efficient treatment.

Having a one-size-fits-all unit module in place does not necessarily mean that acuity and severity is not being considered. The modular approach of such a module means it can be adapted to different functions and can contain critical patients and/or suspect cases at the same time.

Idea 2 – Visibility and Separation



This idea was developed by two teams of partners and looked at, on one hand, preservation of diagnostic tools for reusability purposes and, on the other hand, visibility principles to preserve patient privacy. The teams used the ALIMA Cube and Plexiglas solutions as prime examples to discuss how treatment operators can place material in an

uncontaminated area which is simultaneously close to the patient for the provision of humanised care.

The partners reckon that it is important to separate key treatment equipment in green zones from disposable and disinfected equipment (in direct contact with the patient) in red zones. Holes in the treatment unit (for both the ALIMA Cuba or Plexiglas solutions) allow for these two forms of equipment to be connected and guarantees equipment cleaning without use of corrosive or aggressive disinfectants. Under such a treatment modality, only the materials in direct contact with patients will be disposed of.

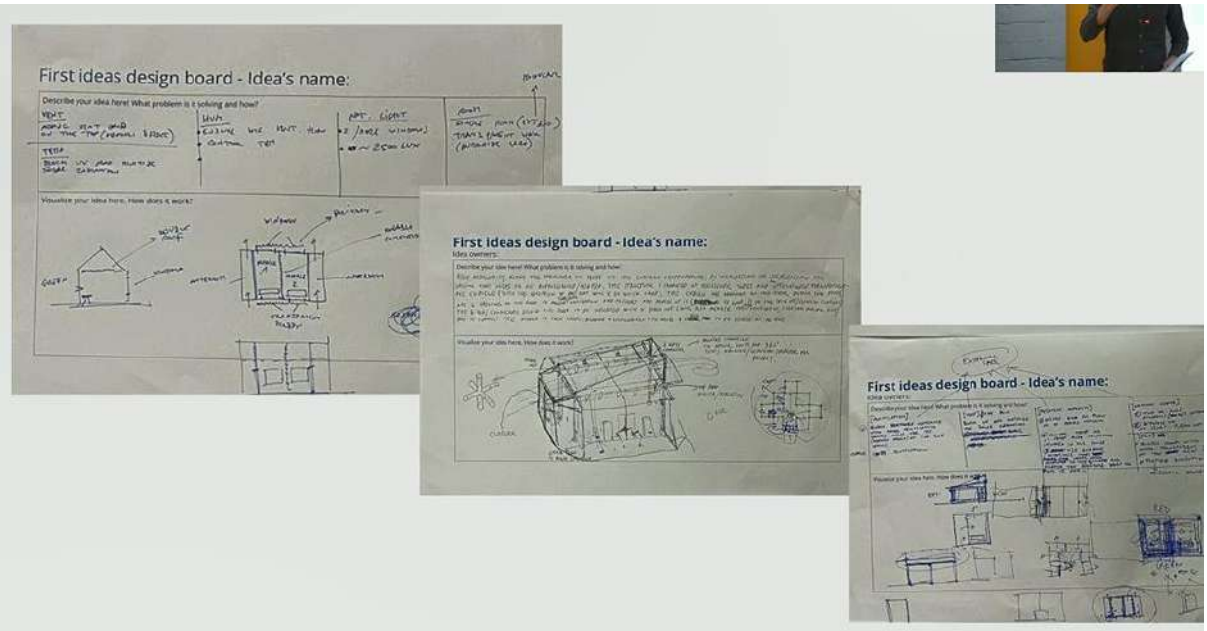
Transparent walls allow for increased patient visibility when in critical conditions but can impact negatively patient privacy when in stable conditions. Curtains can be introduced to enhance patient privacy, which can be removed when needed. An alternative is to introduce opaque glass technology in the healthcare structure to adapt visibility according to medical conditions.

In certain situations, family will be present in the singe patient treatment centre and will want to communicate with the patient without presence of medical personnel. Curtain or Plexiglas technology should allow for modularity, by ensuring that the patient's family can be separated from the presence of doctors. The possibility of introducing interphones could be considered.

Such solutions allow for reduction of PPE use, since you do not need to use equipment every time you visit the patient. Secondly, infection prevention is assured. From a cultural perspective, the patient is in touch with the family and what happens around him/her. Essential equipment can be used on different patients and does not need to be decontaminated after use.

Important considerations on this topic refer to the selection of monitor type and whether to apply Bluetooth technology, ensuring that for blood infusions there is no reflux from the patient to the outside of the red zone, and preparation of versatile kits for different types of interventions (e.g. introduction of an intravenous (IV) line, resuscitation of a newborn, etc).

Idea 3 – Ventilation and Temperature

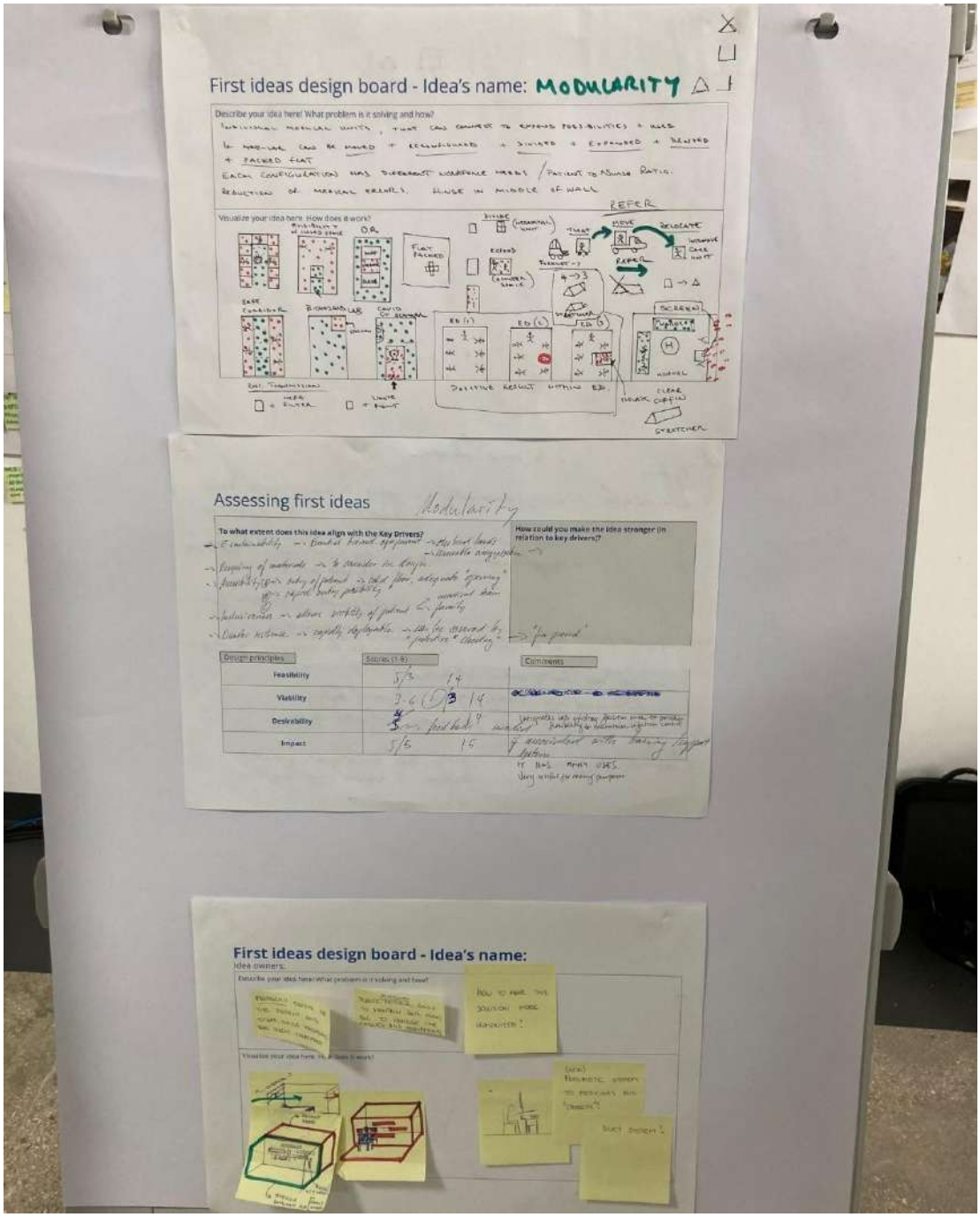


This exercise addresses the issues of ventilation and temperature. In our design-thinking, considerations on temperature-controlled and humidity-controlled treatment will enhance effectiveness of our proposed structure.

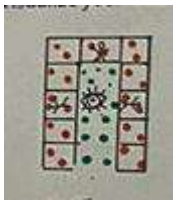
If we aim to integrate average temperature in our treatment centre, we could consider the introduction double roofing technology which reflects UV rays. In terms of regulating humidity levels, we could aim to increase the airflow which is useful for airborne disease circulation reduction. Cross-ventilation can be achieved in different ways. For example, the introduction of a "Venturi effect" ensures that air is channelled naturally towards the top of the treatment module.

Important considerations related to this topic refer to providing clear instructions on window positioning, roof positioning, and double roofing systems given that these allow module users to benefit from the natural environment in which the solution is located. Secondly, not all epidemic outbreaks take place in hot climatic environments, and versatility of use in colder environments should be considered in our design-thinking. Thirdly, in our design-thinking a decision has to be made to rely on active negative pressure or on passive natural airflow systems, and the geographical area in which our intervention will take place plays a role in such a decision. Allowing for different add-ons depending on the climatic environment might provide a solution in this respect. Last but not least, it is important to consider international and local norms in terms of airflow dissemination when developing our structure.

Idea 4 – Modularity



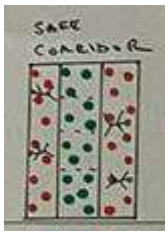
The idea of <u>modularity was defined as a system having a core function, but which can be broken down across different components for reconfiguration for the integration of other core functions</u>. The ALIMA Cube was used as a reference structure for exploring the possibility of moving, dividing, expanding, dropping, and packing different parts of the Cube's configuration. Each configuration identified by our partners has different workforce needs and patient to nurse rations. Overall, modality should reduce medical errors.



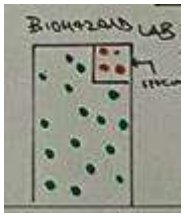
Module 1: connection of several available Cubes in a C-shape for single patient treatment centres with a low-risk zone at the centre and high risk zones around the centre.

Module 2: availability of up to two Cubes with many patients. In this case, patients would be pooled in a tent with the Cubes serving as low-risk zones at the entrance for staff walking inside the treatment centre. Staff would not need PPE to view different patients.

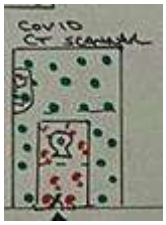
Module 3: the possibility of dropping the Cube over your operating table to convert your treatment theatre would allow for safe treatment under different scenarios.



Module 4: in case of need of passing through a high-risk area, the Cubes could be aligned in such a way as to create a safe corridor through the creation of a daisy-chain.



Module 5: the possibility of dropping the Cube over your laboratory to have a higher-level biohazard laboratory integrated within your existing laboratory.

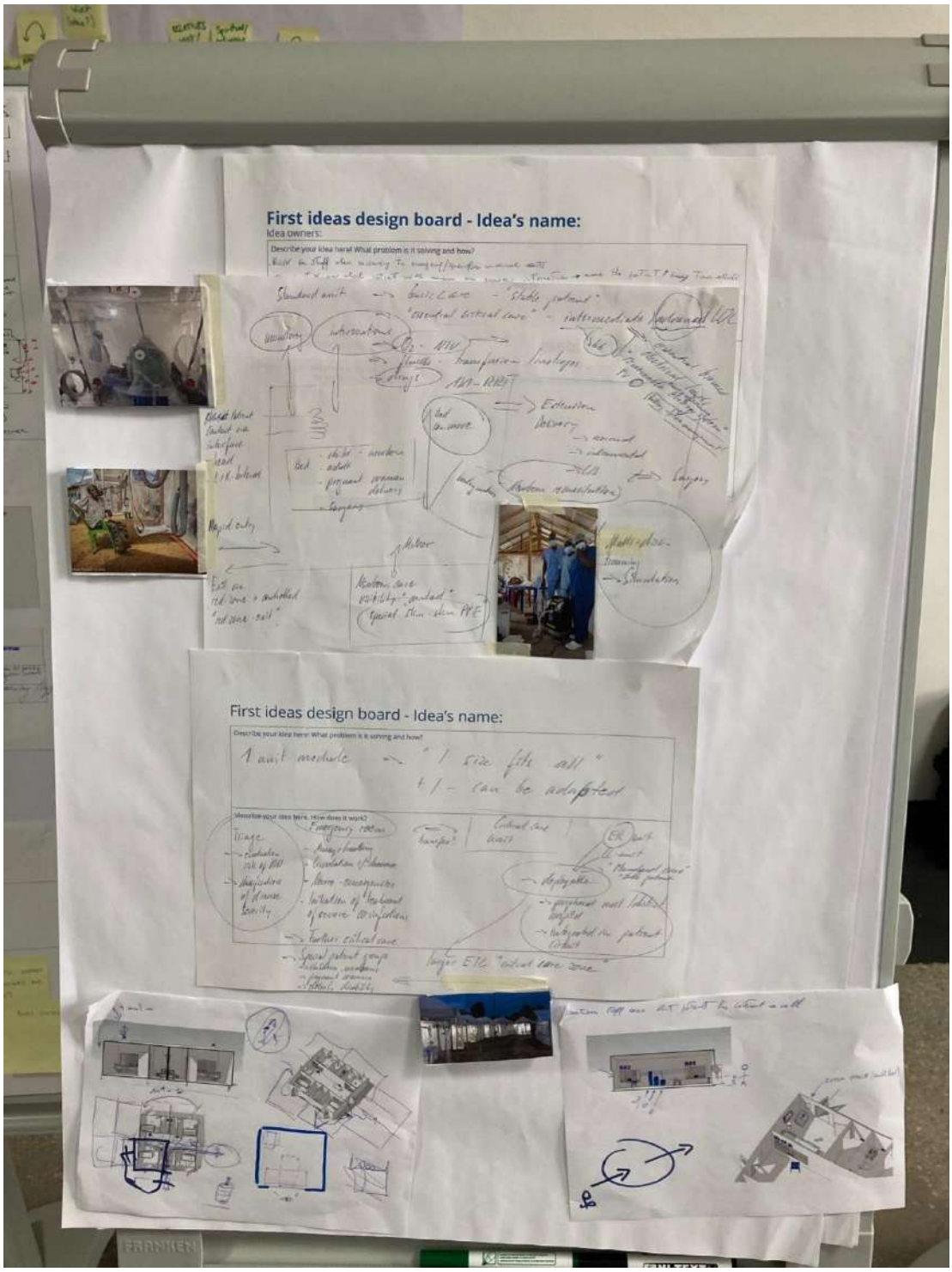


Module 6: the possibility of dropping the Cube over your COVID-19 computed tomography (CT) scanner or imaging device to have access to safe imaging.

A second consideration entails moveability of the proposed structure. The proposed solution should guarantee that a treated patient can be moved with a forklift and be relocated to an intensive care unit (ICU). For facilitated transport, a possibility could be to reconfigure the cube into a triangular shape.

A modular approach allows to be as close as possible to the affected population and allows for quick integration in existing health systems. The possibility of pooling smaller structure together for the construction of a bigger ICU is useful as well.

Idea 5 – One-Size-Fits-All Unit Module



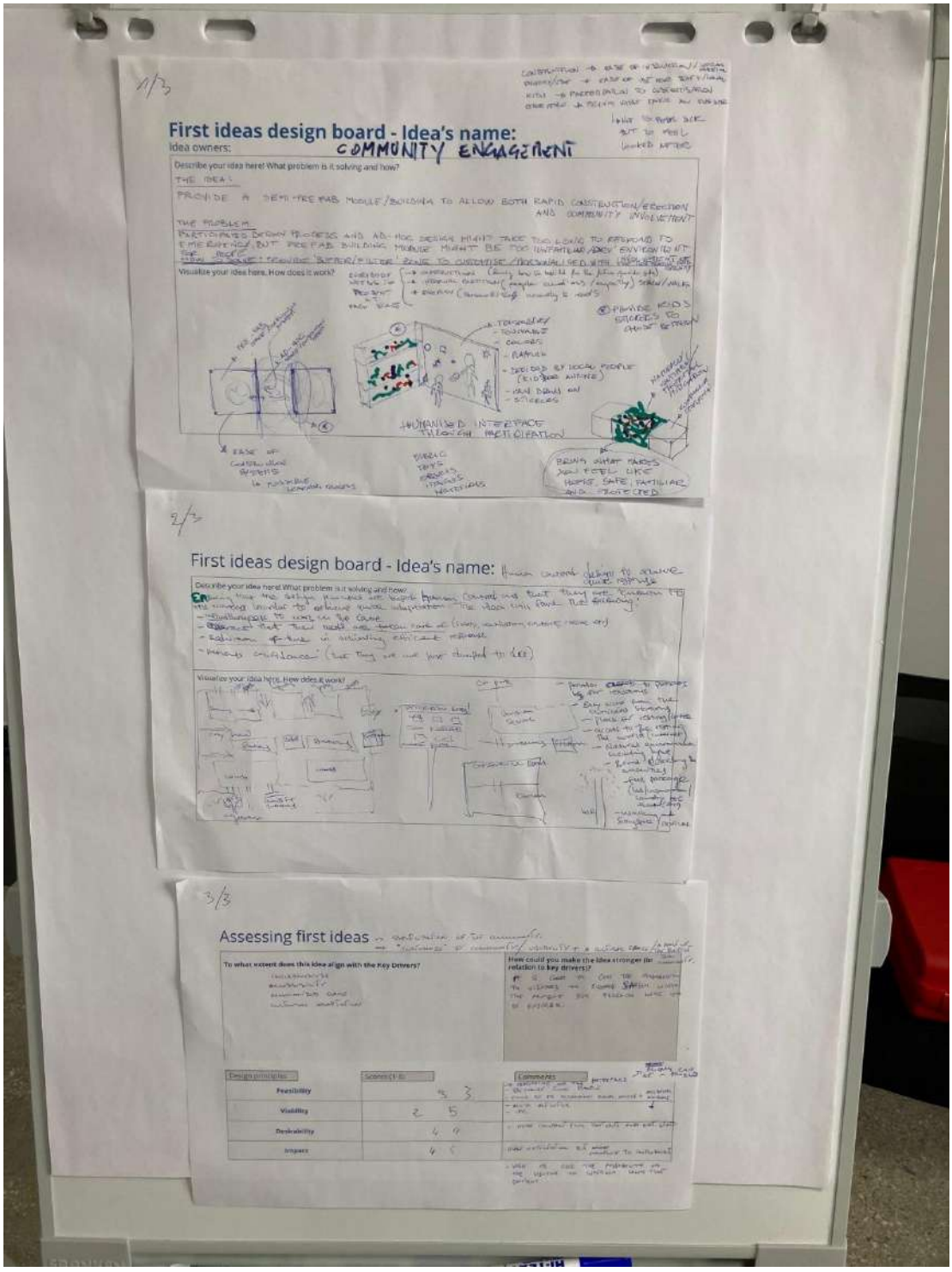
The partners conceptualised a one-size-fits-all unit module which guarantees different type of medical care interventions, and which can be set up within 24 hours anywhere and at any time for the provision of best standards of care. As part of this module, partners defined the need for a big ICU bed (bigger than a regular hospital bed) that can be rotated to enhance visibility and clinicians to move around easily. The module should

allow for integration of a second bed to host new-borns or mothers coming in with their children and should include sufficient space for biomedical devices for treatment.

The one-size-fits-all unit module should allow for replication as well as integrate safe space for staff. Ventilation is a vital element and air flow control should ideally be maintained naturally. Transparency of the module was considered for visibility purposes. Last but not least, partners thought about the possibility of developing the one-size-fits-all unit module in such a way that it can also be used for screening and triage purposes. In fact, since screening and triage is a process, our partners assumed that such a procedure could be integrated in the treatment module itself.

Important considerations refer to energy implications of such a module in order to run this with the correct biomedical equipment (e.g., oxygen production systems, oxygen concentrators, non-invasive respiratory support systems, infusion pumps, monitors, hyper filters, lighting). In that regard, it is important to define the level of care we aim to address to design the correct energy system needed for the running of such a module. If instead this is conceptualised as a standalone module, solar panels and biogas technology could be integrated but integration of the module into existing health systems should be guaranteed where applicable.

Idea 6 – Community Engagement



Our partners addressed the design of a <u>semi-prefabricated module that can allow for both rapid construction and community involvement</u>. They emphasized the risk of stigma that health facilities are sometimes recognised by the local population as places where to go and die. They also highlighted the fact that some of the local clinicians might not want to work in certain mobile health facilities given that they do not deem them as

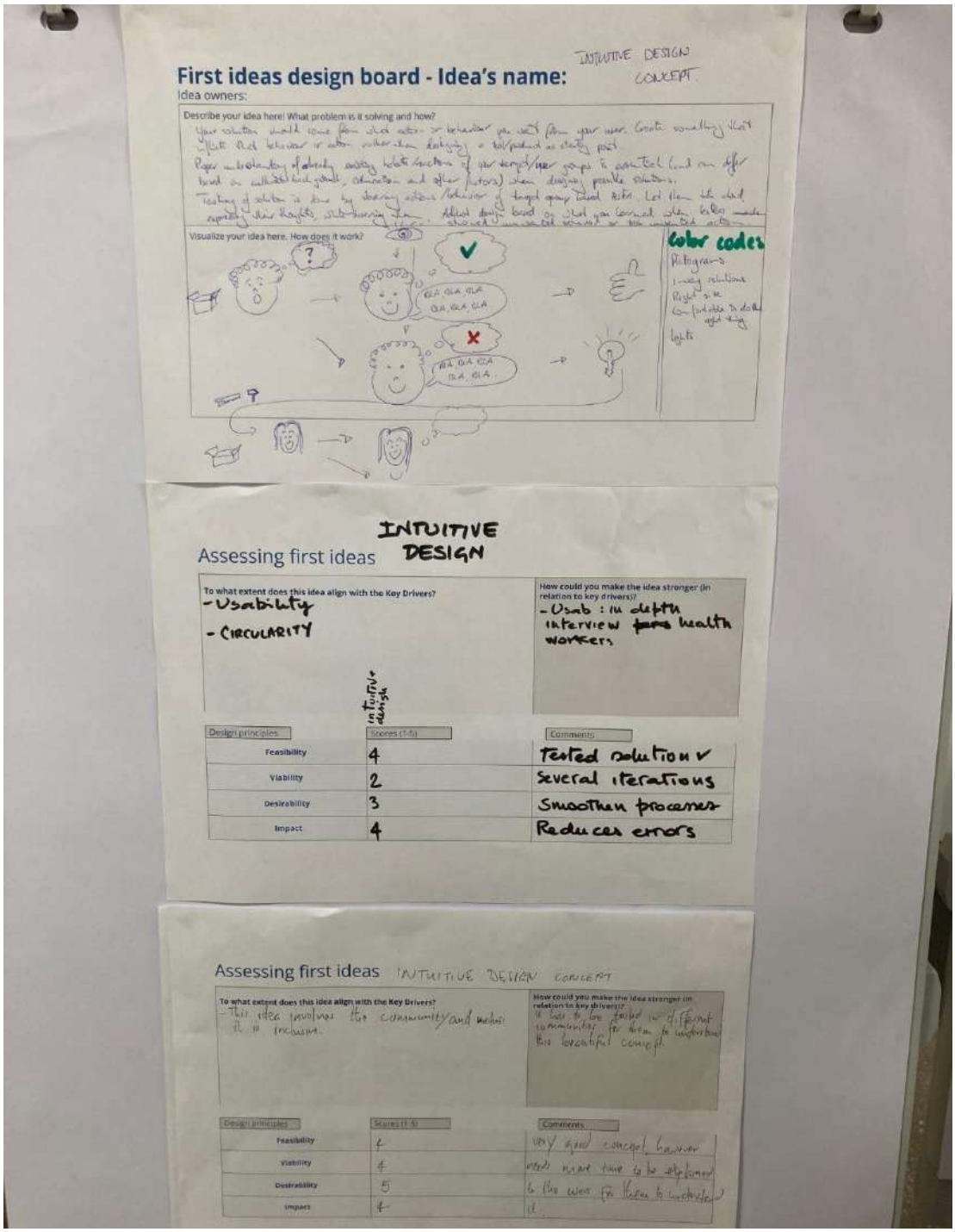
efficient or comfortable enough. Conversely, when local clinicians find themselves comfortable in working in a certain health centre, there is a higher perceived satisfaction rate of the local community in receiving treatment in these centres. Thirdly, they stressed the importance of ensuring that the treatment centres look comfortable for children, who often do not wish to feel like they are in a hospital.

Our partners have therefore identified the need for introducing a physical space for the local community to be present when we advance in our design-thinking. This involves not only the introduction of a humanised interface through community participation, but also the introduction of customisable spaces for loved ones to be present across all stages of care. In terms of privacy, it is important to consider the customisation of privacy to allow for family members to be able to interact with each other even when the patient wishes to remain alone.

During an epidemic outbreak, there is insufficient time to engage in participatory processes to define a space which is entirely in line with the expectations of the local community. By introducing a homely approach in our design-thinking, we can only wish that community engagement increases and that the treatment centre is being considered as a place where you are being looked after.

Important considerations are to be made in terms of the location of treatment centre installation. The structure should be installed in a location which allows for easy access for relatives and clinicians, in a location where it is possible to rest and to have coffee with loved ones, in a location close to other areas of activity, and possible in green environments. Unknowingly, it regularly occurs that infectious disease treatment centres are placed close to a morgue, close to emotion. When integrating human elements in our design-thinking, it is important to bear in mind that location please an important role in how the community perceives the role of a treatment centre.

Idea 7 – Intuitive Design Concept



In responding to this HMW, the partners developed a methodology for intuitive design-thinking. Intuitive design implies that the user guidelines of your structure are easily readable by different stakeholders. When working in your treatment centre, it should be clear for clinicians how IPC will be maintained and how intensive care will be organised. Staff should be able to clearly understand how to engage with the patient and the local community.

Important considerations are to be made in terms of introducing an "IKEA-approach" when developing user manuals. Our proposed structure should be readily understandable by those users who do not necessarily have the technical skills to engage in detail with the different functionalities of the treatment module. Moreover, the proposed structure should account for the functional needs of all users, including the patient itself.

Key take-aways of day 2

Day 2 allowed participants to collectively brainstorm about the design-thinking implications of an initial idea for responding to existing gaps in the area of health emergency response. Visualising how an initial idea responds to key drivers, how it works, which design principles it embodies, and which solutions it aims to provide has allowed partners to get a tangible feel for an innovative infectious disease treatment module can indeed address existing loopholes for efficient and effective pandemic treatment in an emergency context.

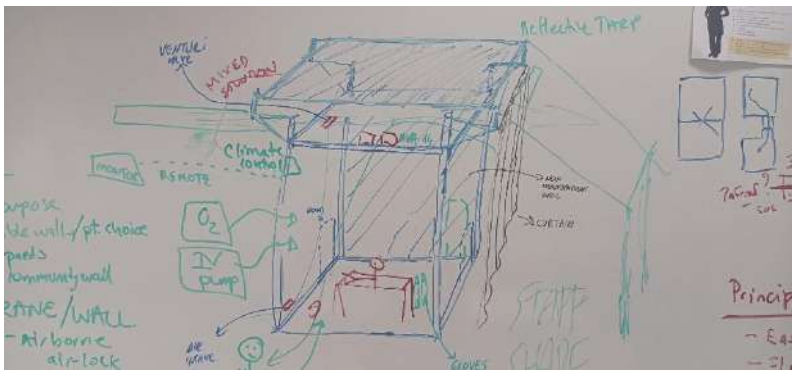
Day 3 – Design Brief Presentations

Activity	Time
Welcome, Agenda, Icebreaker	9:00am
Recap of Day 2 and review of ideas	9:30am
Combining ideas into one solution	9:50am
Break	11:15am
Solution design presentations, discussion and voting	11:30am
Lunch	12:30pm
Design Brief	1:30pm
Research Plan	2:15 pm
Break	3:15pm
Training	3:30pm
Next Steps, Closing	4:30pm

Day 3 focused on combining ideas into one solution and coming up with a broad solution design. The final outcome of this exercise entailed the provision of two concrete design briefs which have been summarised below, and which will be considered as main points of departure for the co-creation workshops launched in the near future.

Design Brief 1 – The Cube

The Cube as proposed by our partners is presented as a revised version of the ALIMA Cube, and includes swappable and movable walls, including sun shading technology for the patient and the introduction of a passive ventilation system.



The Cube proposed to address considerations related to visibility versus privacy, ventilation and temperature, modularity, community engagement, intuitive design and the offering of a one-size-fits-all unit module.

The base module will have an optimal size (3m x 3m x 2.1m) and include collapsible materials (PVC, polyurethane) that can be easily transported. The ICU wall allows for clinician penetration, entry points for biomedical equipment, includes a glovebox and

allows for easy entry/exit to ensure patient flow and IPC. The basic module allows ICU care with remote monitoring of patient vital signs, entry of tubes/lines via the wall maintaining large biomedical equipment outside and consumables inside, and entry point for exchange of medicines.

The proposed innovation looks at addressing community engagement, ventilation and temperature, and add-ons for customisability and adaptability via the integration of a "transformable wall". The transformable wall can improve patient comfort and aesthetics. Moreover, wall functionality can change, based on whether a paediatric wall, family wall or community wall is to be integrated. The transformable wall can be a set up as a "penetrating wall "that allows families to visit the room while maintaining patient privacy and safety for staff and the community.

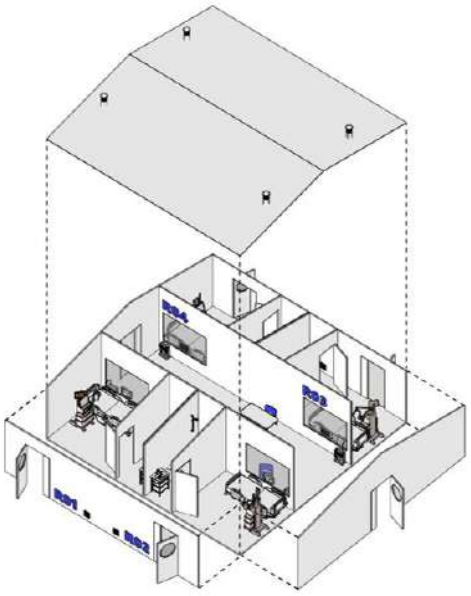
The transformable wall can be set up as an "expanding wall" that allows for extra space for screening and triage procedures, and which can accommodate biomedical equipment and patient movement. Ventilation and temperature control can be maintained by air conditioning and/or natural ventilation and sun shading which will optimize energy efficiency and can be adapted to local conditions. IPC for contact precautions is integrated in the module, but add-ons for airborne precautions can be included with the use of negative pressure with pressure gradients at entry and exit points. This solution is modular and can be deployed quickly and function in an energy-efficient manner.

Main constraints of this proposed design are the fact that it is expensive and that it does not come up with a seal that does not leak too much in order to guarantee differential pressure technology. Main benefits entail portability, deployment to remote locations, customizability allowing for community and patient acceptance, and family engagement through the introduction of a movable wall.

Key drivers have been taken into account: the module can be repurposed, is reusable and passive ventilation is possible (environmental sustainability); the module can be used for all patients (accessibility); the module is customizable to all needs (inclusiveness); the module is rugged and robust (disaster resilience); the module allows for privacy and family access (humanized care); the module is lightweight and low volume (deployment and installation rapidity); the module can be deployed anywhere, including inside health facilities (health system integration); the module is easy to use (usability).

Design Brief 2 – Modular Unit

The second proposed solution consists of a self-contained modular unit which can be integrated into local infrastructure. Such a modular unit has been designed to enable the provision of care regardless of pathogen, patient' risk, severity status and typology of users. Most importantly, the modular unit guarantees the necessary flexibility to meet the evolving operational needs throughout an outbreak and beyond.



The unit is equipped with transparent surfaces between staff and patient areas to enable constant monitoring of the admitted patients while ensuring their privacy, and to promote community access and acceptancy. The unit takes airborne precautions and temperature into account, as well as Relative Humidity (RH) control through hybrid ventilation and appropriate selection of material.

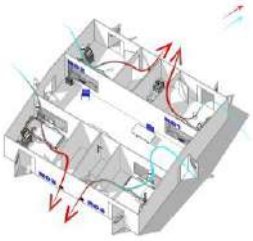
The unit is fully customizable as follows:

Unit

Model

Expansion

Ventilation and RH Control



The modular unit aims to address the following problems:

- ✓ *Enable provision of care regardless of patient' risk and severity status*
- ✓ *Enable constant monitoring of the admitted patients while ensuring their privacy*
- ✓ *Enable implementation of airborne precautions*
- ✓ *Ensuring a comfortable environment for patients and staffs*
- ✓ *Enable to make the clinical needs of the patients regardless of their acuity, severity, and infectious status*
- ✓ *Enable the facility to adapt to the outbreak evolution regardless of the pathogen*
- ✓ *Enable and promote transparency toward the community*
- ✓ *Enable usability regardless of context and users*

Main constraints refer to cost and difficulty in customising the unit to specific geographical locations and pathogens. Similar to the proposed "The Cube" design brief, all key drivers have been addressed.

Key take-aways of day 3

Day 3 has allowed partners to collectively come up with two proposed innovative infectious disease treatment structures which respond to the main problems identified at the beginning of the workshop as well as the key driver framework that guides the human-centred approach in design-thinking within INITIATE². On this basis, INITIATE²'s project management team, in coordination with its partners, will further work towards the definition of a single design brief with a focus on defining the technical specifications of the INITIATE² infectious disease treatment centre. Once technical specifications have been agreed upon, the proposed structure will be circulated across the INITIATE²'s broader partner network for provision of feedback. More information will be shared with partners in the weeks to come.

Annex 2: Hear phase, Workshop 05-08 July 2022

INITIATE² - Infectious Disease Treatment Module

Brindisi, 5-8 July 2022 - Workshop Report

Table of Contents

Participants

Organisation	Name
ALIMA (Alliance for International Medical Action)	Eric Barte de Sainte Fare
	Hans-Joerg Lang
Agence Nationale de Sécurité sanitaire (ANNS) - Guinea	Thiany Camara
IMC (International Medical Corps)	Syed Yasir Ahmad
Istituto Superiore di Sanità	Marco Simonelli
MSF (Médecins Sans Frontières)	Francois Cathelain
	Hilde De Clerck
	Armand Sprecher
Ministry of Health - Malawi	Sanderson Kuyeli
Samaritan's Purse	Sasha They
University of Tübingen	Alexander Muench
	Robert Wunderlich
WFP (World Food Programme)	Nadia Desai
	Stefano Guagliardo
	Emma Kettle
	Emma-Lee Knape
	Andrea Kobor
	Carlos Paniagua Ferrari
	Bart Provoost
WHO (World Health Organisation)	Kamal Ait-Ikhlef
	Janet Diaz
	Michele Di Marco
	Luca Fontana
	Marta Lado Castro-Rial
	Paul Molinaro
	Awa Ndir
	Veronica Rovegno

Agenda – Day 1 – Recap on Progress, Design Brief, and Presentation of the Comparative Analysis of Field Innovations in Health Emergency Response

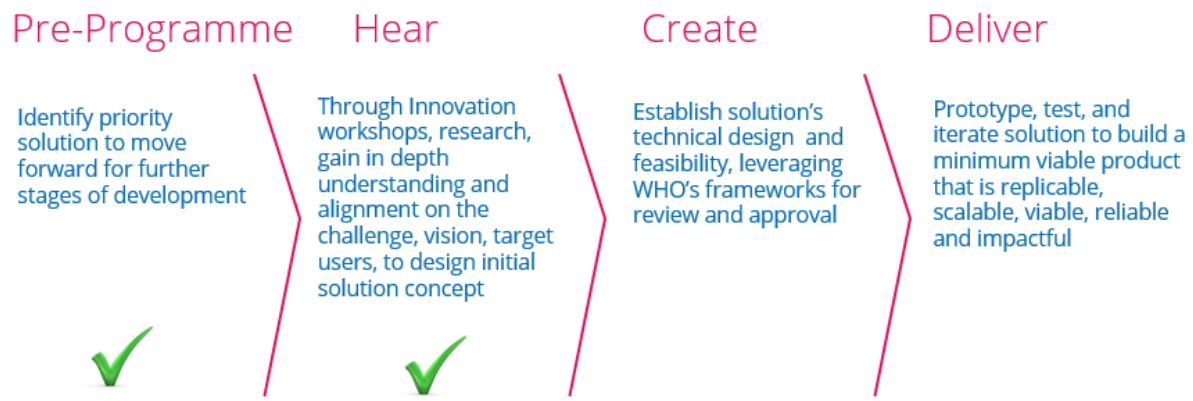
Activity	Time
Welcome & Agenda	1:30pm
Programme Overview and Recap	2:10pm
Energiser and Introductions	2:30pm
Recap on Progress, Design Brief and Q&A	2:45pm
Coffee Break	3:30pm
Presentation of comparative analysis, field innovations and Q&A	3:45pm
Check out and Plan for Day 2	4:55pm

Programme Overview and Recap

INITIATE² brings together emergency actors, research, and academic institutions to design and develop innovative standardised solutions such as medical installations, laboratories, and disease-specific facilities. The project also trains logistics and health responders on their installation and use, contributing to their capacity to respond to health and infectious disease emergencies. Virtual and in-person sessions were organised with partners to discuss and assess the first innovative solution to be prioritised: an infectious disease treatment centre.

The infectious disease treatment centre design development is structured across four separate phases. We currently find ourselves in the Create phase, where we are collectively engaged in furthering the technical design of our first solution.

Fig.1: the four phases of the INITIATE² infectious disease treatment centre development cycle



INITIATE² is based on two interconnected workstreams, a technical innovation workstream and a training workstream. To date, the February and March 2022 workshops have exclusively focused on the technical innovation workstream, while the current workshop will see the launch of the training workstream as well.

Throughout February 2022, we looked at the macro journey behind a pandemic preparedness and response process, and focused on conceptualising paint points, opportunities, existing solutions across different phases, and key drivers which define our thinking.

In the March 2022 workshop, we focused on defining the micro journey of a patient from Day 3 of illness (admission within the treatment centre and diagnostic confirmation), clinical evolution (new symptoms, monitoring, use of specific therapeutics) until the end of patient's journey (either death or discharge). We further distilled pain points and key drivers towards the ultimate development of a Key Driver Framework, consisting of general principles that our solution should follow:

Table 1: Key Driver Framework

Key Driver Framework	
1. *Environmental sustainability*	***2.*** *Health system integration*
3. *Accessibility*	***4.*** *Usability*
5. *Inclusiveness*	***6.*** *Cultural adaptation*
7. *Disaster resilience*	***8.*** *Sustainable maintenance*
9. *Humanized care*	***10.*** *Circularity*
11. *Deployment and installation rapidity*	

Towards the end of the March 2022 workshop, challenge questions that our proposed solution should respond to were defined by our participants, and broad ideas that our solution should address were defined to commence the design brief exercise:

Fig.2: the key ideas for the conceptualisation of the Design Brief

Idea	Triage criteria	Visibility & separation	Ventilation & Temperature	Modularity	One size fits all 1 unit module	Community engagement	Intuitive design concept
Focus? Y/N							
What to include?							
How to include it?							
Solution Constraints?					Key Drivers?		

After the March 2022 workshop, the INITIATE² Core Team , leveraging onthese outputs,developed the Design Brief of the infectious disease treatment module.

Recap on Progress and Design Brief

Based on the ideation process carried out in the March 2022 workshop, INITIATE²'s aim is to develop a solution or a rapidly deployable, easily transportable, extendable, self-contained, and self-sufficient treatment module for infectious diseases irrespective of the mode of transmission.

Such a solution, built on field experiences, will not replace current facilities but integrate them by enabling responders to safely provide the high quality of care needed with dignity, respect, and compassion towards affected communities from the very onset of the emergency while more permanent and complex structures are being set up.

The design brief developed by the INITIATE² Core Team transforms the voices of experts, lessons learned, and technical knowledge shared during the Hear phase into technical and design requirements to support the Create phase of the infectious disease treatment module. The first draft was then shared with the Core Team as well as with the broader INITIATE² community to gather feedbacks and inputs. Moreover, to further capitalise previous field experiences, partners were invited to share the field-based developed innovations.

Lesson learned from the field: https://docs.google.com/spreadsheets/d/1KKbM3-VIx0ETlb_I2RV9Lm8D-Q-wBHhx4ttKW3wPA_8/edit?usp=sharing

Translation of the Key Driver Framework into design principles

the Key Driver Framework (consisting of general principles that our solution should follow) was translated into design principles, consisting of a set of principles guiding the INITIATE² design team towards making the appropriate design decisions:

Table 2: Design Principles

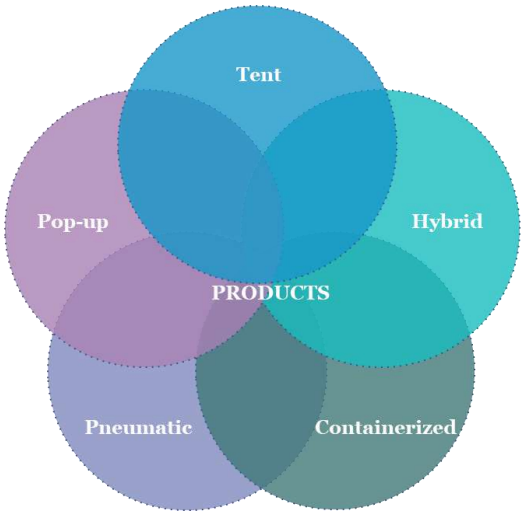
Design Principles	
1. Contact enabling design	*The design should enable contacts via diverse ways considering the typology of disease transmission. Contact-enabling design can be achieved by focusing on the relationship between visibility and privacy, or on safe tactile and visual interaction between patients and healthcare workers (HCWs) or patients and visitors*
2. Climatic responsiveness and energy efficiency	*The design should rely on hybrid or passive design and consider low energy consumption where possible. This could be achieved by offering technological alternatives based on climatic differentiation. Energy consumption should be optimised according to space use and requirements.*
3. Resiliency to disruptive phenomena	*The design should consider possible natural hazards and other disruptive phenomena that could influence the correct functioning of the solution*
4. Accessibility and inclusiveness	*Spatial design should consider minimum dimension requirements and guarantee adequate space for everyone, including patients with special needs (i.e. children, elderly, pregnant women, persons with disabilities, etc.)*

5. Cultural adaptability and participation	*The design should provide opportunities to ensure, respect, and enhance the engagement and understanding of local culture*
6. Adaptability and IPC (Infection Prevention and Control)	*The design should rely on an add-on system approach, to provide customizability and adaptability to the diverse needs (climate, local context, use, acuity, severity, and infectious status).*
7. Modularity	*The design should rely on the principles of modularity to provide flexible layout organization and surge*
8. Constructability	*The design should allow for ease set-up through intuitive construction*
9. Cradle to cradle and reuse design-based	*The design should consider lifecycle assessments, as well as rely on reusability where possible*
10. Minimum and local maintenance	*The design should ensure minimal maintenance requirements, which can be carried out by the local workforce*
11. Usability	*The design should be intuitive and facilitate wayfinding*
12. Transportability	*The design should allow easy transport also on small size local transport*

Comparative product analysis and field solutions

As part of the design brief development, the INITIATE² Core Team analysed existing solutions on the market and categorised them per product typology, product performances and compliance with agreed design principles as technical requirements. In this regard, the INITIATE² Core Team produced a comparative product analysis allowing it to pool different solutions into five product categories.

Fig. 3: Comparative Product Analysis

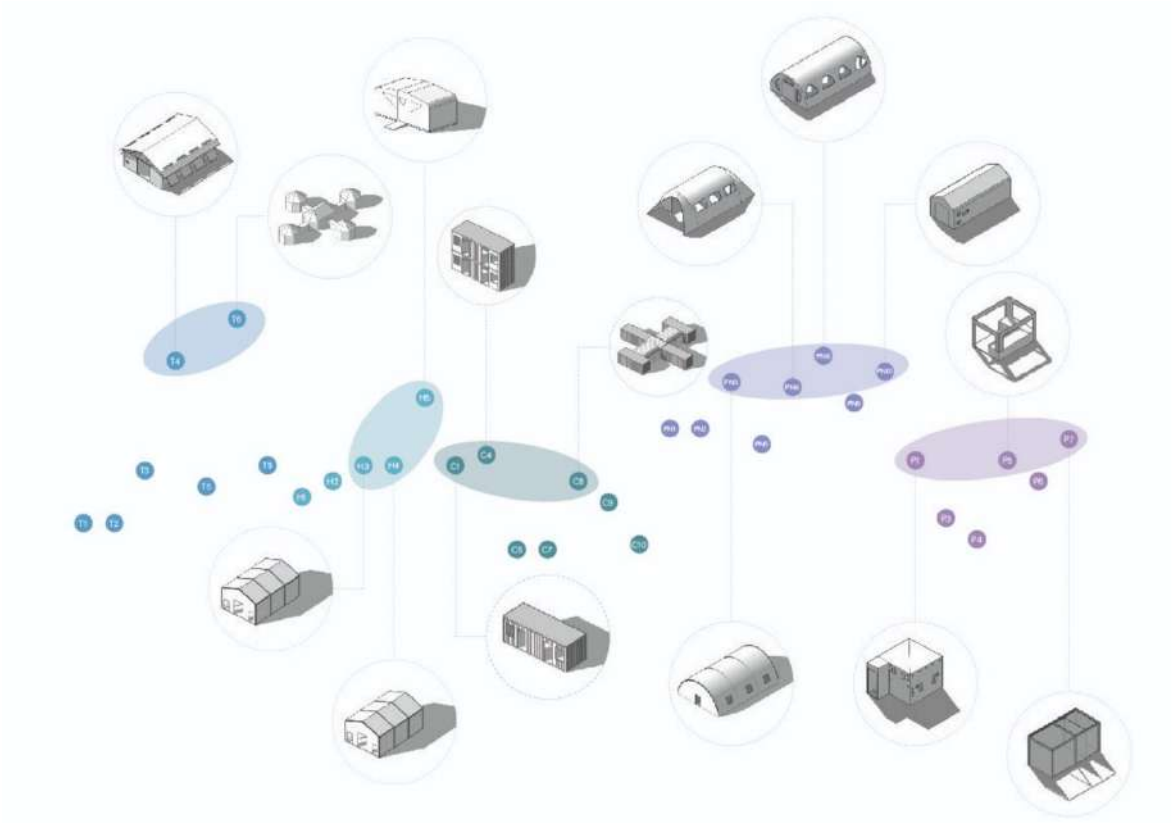


Following feedback on the design brief from partners, the INITIATE² Core Team identified approximately 50 solutions currently on the market and classified them by product category.

The INITIATE² Team assessed the relevance of each solution against the design principles with a scale of 0 to 2, where:

- 0 is a product not answering a design principle
- 1 is a product partially answering a design principle
- 2 is a product completely answering a design principle

Even though the evaluation of existing solutions was not carried out by outside partners, and even though the weighing criteria were unilaterally decided by the INITIATE² Team, it nevertheless allowed the INITIATE² Team to obtain a good understanding of which existing solutions could be drawn inspiration from for the conceptualisation of the infectious disease treatment module.



Product requirements and technical specifications

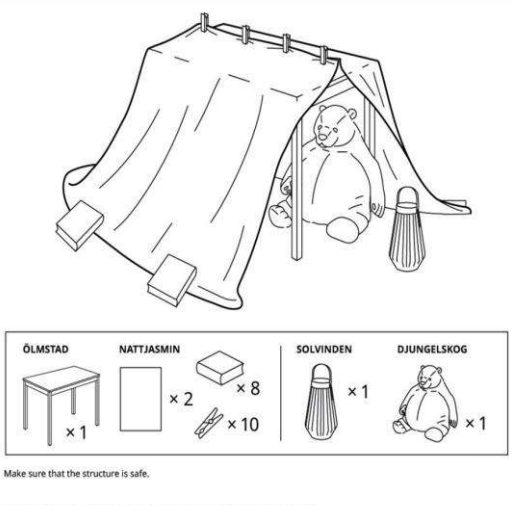
As an additional sub-chapter of the design brief, the INITIATE² Core Team also included information related to logistical, environmental, functional, and economic product requirements that must be considered during the conceptualisation phase and design process:

Table 3: Product requirements

Product Requirements	
1. *Supply Chain*	***2.*** *Climate*
3. *Hazards*	***4.*** *Flexibility*
5. *Functionality (operational & IPC compliance)*	***6.*** *Resource management (water, energy, waste)*
7. *Durability and maintenance*	***8.*** *Post-operational management*
9. *Cost*	***10.*** *Timeline*
11. *Testing and certification*	

Table 4: Technical specifications

Technical Specifications
1. *Supply chain specifications*
2. *Product specifications*
3. *Performance specifications*
4. *User specifications*
5. *Information specifications*



Key Components

Finally, to support the design phase, the INITIATE² Core Team proposed a series of essential components that must be included in the design for the development of a successful innovative product.

Table 5: Key Components pre-identified by the INITIATE² Core Team

Key Components	
1. *Transparent screen*	***2.*** *Shutter system*
3. *Wall integrated manipulation gloves*	***4.*** *Central staff area*
5. *Ad hoc space for biomedical devices within the green area*	***6.*** *Elevated structure*
7. *Ready to use within minutes*	***8.*** *Ease of transport*
9. *Double roof/shade net*	***10.*** *Solar panel/photovoltaic*
11. *Wind resistance*	***12.*** *Modularity through connection system / extensibility*
13. *Vector control*	***14.*** *Insulated material*
15. *Controlled building ventilation*	***16.*** *Indoor latrines/showers, large enough for two people*
17. *Morgue with family space*	***18.*** *Visitors area*
19. *System for items transfer*	***20.*** *Smooth hard flooring*
21. *Easy to disinfect materials*	***22.*** *Separated access and flow for staff and visitors*
23. *Visitor area protected with cover*	***24.*** *Doffing*
25. *Minimum 8m²*	***26.*** *Access for patients with reduced mobility*
27. *Use of sustainable and repurposable materials*	***28.*** *Durable and easy-to-fix parts*

These components were addressed and fine-tuned more in detail throughout the workshop, during Day 2.

Agenda – Day 2 – Key Components

Activity	Time
Welcome & Agenda + Energiser	9:00am
Presentation on Key Components	9:15am
Missing Components Exercise (small groups)	10:00am
Coffee break	11:15am
Missing Components Exercise (small groups)	10:45am
Lunch	1:00pm
Presentation on Key Components, Discussion & Voting	2:00 pm
Base Structure Discussion	2:40 pm
Break	3:15pm
Cost Discussion	4:30pm
Check out and Plan for Day 3	4:55pm

Throughout Day 2, Key Components were further addressed in detail with the idea of further analysing which Components are missing and how to prioritise these different Key Components. These exercises are of essence for the designers in the INITIATE² Core Team to design and build the prototype.

Presentation on Key Components

The Key Components as briefly presented during Day 1 were extracted from the existing products analysis, from the field innovations analysis, and from the pain points exercise completed in the previous workshop. These were presented in detail during this session but, for the sake of simplicity, have been inserted into this meeting report under the form of an Annex I – Key Components Overview.

The Key Components presented here are those core elements that the INITIATE² Core Team would like to see in the infectious disease treatment module. Through this exercise, an attempt was made to move from broad principles to concrete items, to make the Create phase gradually more tangible.

The Key Components were identified based on our intent to design a mobile, rapidly deployable (24 hours), easily transportable, extendable (at least two beds, with the possibility of extending the module to four, six and more beds), self-contained and self-sufficient (water, electricity, waste management) treatment module for infectious epidemic diseases. The module is expected to

respond to the emerging needs in the first days of an epidemic crisis with the provision of the highest possible standard of care.

It is important to highlight that these Key Components have been proposed by the INITIATE² Core Team without incurring into partner consultations. This overview of Key Components was therefore fine-tuned in the Missing Components Exercise, whose outcomes have been listed in the next section.

In response to the Key Components overview presented by WHO, some observations were raised which have been summarised here below:

- *Hard flooring options*: to move patients from one place to another (for instance, from the ambulance arrival area to the triaging area), it could be useful to consider hard flooring options for trolley movements outside the infectious disease treatment module as well
- *Patient room area*: we might keep biomedical equipment in both the green and red areas of the treatment module. Food and care items should ideally be stored in a separate space.
- *Gloves*: the module must allow for hand entrance from the side but from the head as well. Fixed gloves make operations more difficult but minimise exposure to infections.
- *WASH (water, sanitation, and hygiene):* it might be worthwhile to dedicate additional time in factoring in WASH risk management aspects of the module
- *Thermo-control and insulated material*: conditioning and climatization technology needs to be considered in the design of the module, when it comes to medicine storage, laboratory analysis and the morgue.
- *Distinguishing between moderate and severe cases*: there is a difference in distinguishing between suspect and confirmed cases, and in distinguishing between patients' statuses. The medical intervention on a severe case is different from on a moderate case, and this consideration should be integrated into the design.
- *Modularity*: modularity should look at rationalising the use of space to optimise plug-and-play opportunities.
- *Cultural adaptability*: addressing adaptability in multiple contexts implies we need to be aware of the limitations of the proposed structure, to avoid that it cannot be used when brought to the field

Missing Components Exercise

The identified Key Components provided a solid starting point for partner organisations to collaborate in the identification of Missing Components not considered by the INITIATE² Core Team. The identified Missing Components were summarised here below, by group of participants.

Group 1 (led by Luca Fontana)

For Group 1, one of the priorities in terms of Missing Components is to guarantee access to safe water, analyse waste water, and water storage:

- It is important to have the capacity to stock water and to control water supply to cook, eat, drink, and operate.

- Piping technology should allow to have access to different water sources.
- Water could be stocked through a bladder to be installed on top of the facility to leverage gravity for water distribution purposes.
- Water is needed for excreta and waste water management: technology allowing operators to switch between showers and latrine would allow safe access to drinking water while also allowing for excrete analysis

Group 2 (led by Marta Lado Castro-Rial)

Group 1 identified water supply and intuitive lay-out as Missing Components, but its main priority is patient and staff safety:

- How can we guarantee the provision of humanised care during a militarised response?
- How can we mitigate concerns related to staff/patients security due to neurological confusion and agitation?

Group 3 (led by Hilde De Clerck)

Group 3 identified the following Missing Components:

- Communication between staff and patients, and between patients and visitors
- Outside access for patients (including rain/sun protection) for physical and mental health purposes
- Reliable energy supply (and backup systems) (transportable energy, solar/wind/battery/generator)
- Screening/triage areas (rain/sun protection and considerations for airborn transmission)
- Drainage management (storage of liquids)
- Fencing (balancing between transparency through glass windows, and avoiding handles to minimise transmission)

Group 4 (led by Armand Sprecher)

Group 4 identified the following Missing Components:

- Indoor and outdoor use
- Access and egress routes to be integrated in the structure (for water access, waste management, medical waste management)

Voting on Design Principles and Key Components

Day 2 ended with the gathering of initially identified Design Principles and Key Components by the INITIATE² Core Team, as well as the Missing Components identified by partners with the objective of prioritising Key Components and discussing potential base structures. In this regard, below we provide a visual overview of the results of the voting exercises. NOTE: the prioritization was not

aiming to exclude any key components but to establish an order (essential, preference) to facilitate the coming design development.

Main takeaways of these exercises are the following:

- Climate responsiveness, energy efficiency, and reusability were voted the least priority out of the design principles by the group s
- Transportability and Adaptability and IPC (Infection Prevention and Control) were rated highest as the design principles to consider
- In green, we highlight the top 21 Key Components voted on by the group, but given the complexity of the exercise a collective decision was made to still consider the other Key Components, although these will be weighed less heavily during the Create phase

Table 6: Design Principles voting exercise results:

Design Principle	Sum
Transportability	145
Adaptability & IPC	141
Accessibility and inclusiveness	139
Usability	133
Constructability	114
Modularity	114
Cultural adaptability and participation	110
Contact enabling design	91
Minimum and local maintenance	73
Resiliency to disruptive phenomena	69
Cradle to cradle and reuse design-based	63
Climatic responsiveness and energy efficiency	58

Table 7: Key Components voting exercise results:

NO.	Key Component	Total
1	Modularity through connection system/extensibility	31
2	Easy to disinfect materials	31
3	Excreta and wastewater management	31
4	Drainage management	31
5	Controlled building ventilation	30
6	Smooth hard flooring	30
7	Separated access and flow for staff and visitor	30
8	Central Staff Area	29
9	Ready to use within minutes	29
10	Ease of transport	29
11	Easy access to different water source and treatment	29
12	Access and exit routes must be integrated	29
13	Transparent Screen	28
14	Visitors area	28

15	Integrated indoor/outdoor distribution	27
16	Communication between staff, patients, and visitors	27
17	System for items transfer	26
18	Shutter System	25
19	Minimum 8m2	25
20	Integrated water storage	25
21	Reliable energy supply	25
22	Morgue with family space	24
23	Access for patients with reduced mobility	24
24	Connectivity of water system	24
25	Easy oral communication	24
26	Security	24
27	Double Roof/Shade Net	23
28	Visitor area protected with cover	23
29	Solar panel/photovoltaic	22
30	IPC + module dedicated to clinical care first	22
31	Accessibility for any kind of transportation and beds	21
32	Ad-hoc space for biomedical devices within the green area	20
33	Vector Control	20
34	Insulated material	20
35	Durable and easy-to-fix parts	20
36	Doffing	19
37	Use of sustainable and repurposable materials	19
38	Turnaround time/Reusability	18
39	Elevated Structure	16
40	Indoor and outdoor use	16
41	Screening area/Triage	16
42	Outside access for patients	16
43	Wind Resistance	15
44	Short/Culturally acceptable fencing	15
45	Permanent temperature control	14
46	Indoor latrines/showers, large enough for 2 pple	12
47	Intuitive layout and set up	11
48	Wall Integrated Manipulation Gloves	10
49	Alarm System for patients	7

Agenda – Day 3 – Training and Prototype Testing

Activity	Time
Welcome & Agenda + Energiser	9:00am
Overview of the Training Workstream	9:20am
Presentation on Prototype Testing Framework	9:50am
Break	10:20am
Prototype & Testing Exercise (Small Groups)	10:35am
Lunch	1:00pm
Prototype & Testing Exercise (Small Groups)	2:00pm
Prototype & Testing Exercise Team Rotation and Presentations (Round 1)	3:45pm
Break	3:30pm
Prototype & Testing Exercise Team Rotation and Presentations (Round 2)	3:45pm
Check out and Plan for Day 4	4:55pm

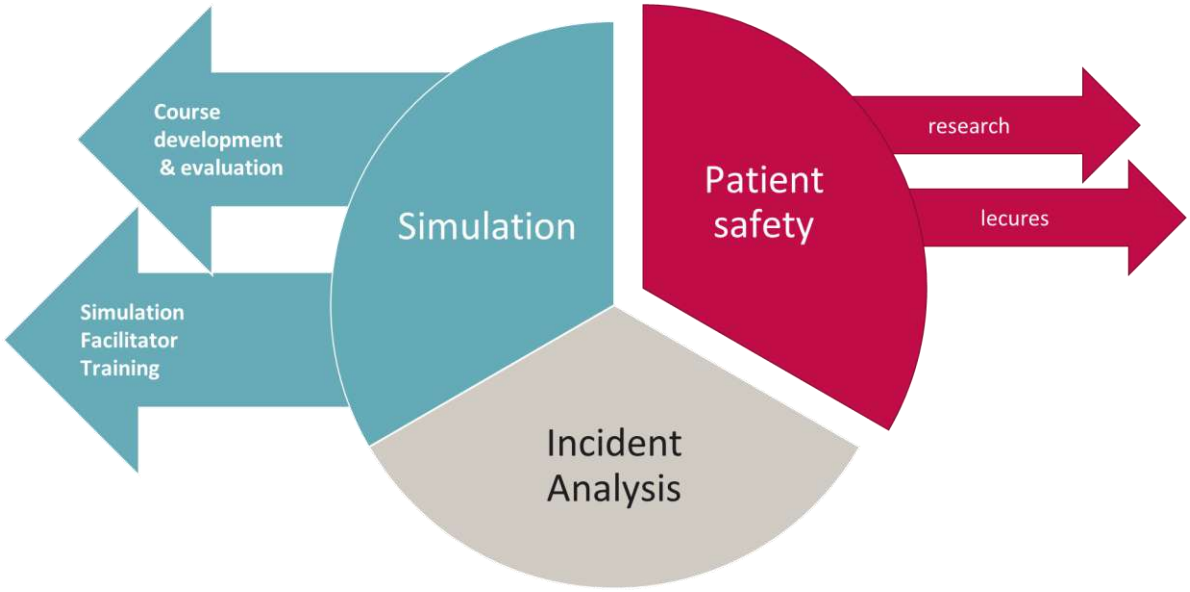
During Day 2, the pre-identified Key Components and Design Principles were reviewed by partners, and Missing Components were added by the partners. Prioritisation of Key Components exercises were carried out and potential base structures were discussed. We briefly touched upon the issue of acceptable costing, but a collective decision was taken to revisit this topic at a later stage of the Create phase. Day 3 looked at introducing the Training Workstream throughout the group, presenting the Prototype Testing Framework, and further delving into the Prototype and Testing Exercises. This implies planning for how to test the first prototype and designing of multiple testing scenarios.

Overview of the Training Workstream

INITIATE² is based on two interconnected workstreams, a technical innovation workstream and a training workstream. The INITIATE² training workstream focuses on organising prototype pilot simulations, developing standardised procedures, and identifying capacity strengthening needs for improved health emergency response capacities.

The INITIATE² Team has decided to collaborate with the University Clinic of the University of Tübingen (https://uni-tuebingen.de/en/), which is highly specialised in the provision of education in the sphere of disaster medicine, when it comes to simulations (course development, course evaluation, and facilitator/instructor trainings), patient safety (research projects, lectures, program development) and incident analysis. Colleagues from the University of Tübingen walked the participants through their activities.

Fig. 4: University of Tuebingen areas of activity:



As soon as the prototype has been finalised, the University of Tübingen will oversee organisation of the Drill and Simulations behind the infectious disease treatment module. This implies:

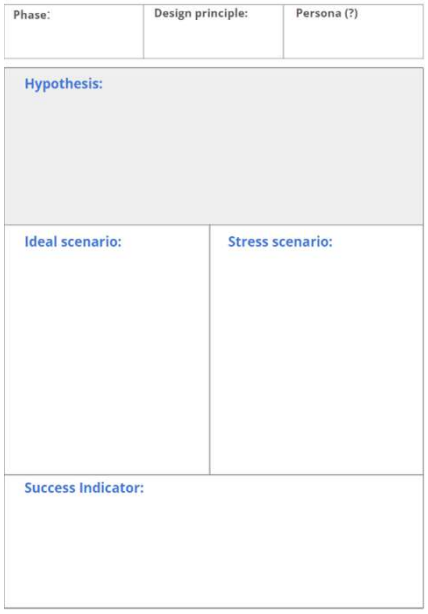
- Testing and evaluating the prototype according to the indicators defined by the INITIATE² Core Team under the form of a drill as first testing exercise
- Training of stakeholders and users in use of the newly developed prototype
- Strengthening multidisciplinary collaboration

The main intended outputs to be delivered by the University of Tübingen are:

- Development and adaptation of the innovation manual
- Drafting of the innovation playbook, based on the outcomes of the drill

Prototype Testing Framework

A drill is a coordinated, supervised exercise activity, normally used to test or train a single specific operation or function in a repeated fashion. The objective of this session was to engage in drill planning by identifying the main hypotheses to test during the drill, and design ideal and stress scenarios to test them.



Throughout this exercise, hypothesis testing exercises were carried out by different participant groups along distinct phases of the (technical) epidemic journey and (medical) patient journey. From transporting to dismantling the module, and from admitting and discharging the patient, it is of essence that the prototype ticks all the boxes during scenario and prototype testing.

Prototype Testing Exercise Presentations

To provide an exhaustive analysis for drill planning purposes, the groups were divided across five different technical and medical phases. Below, we list the topics that the groups addressed, and provide a brief overview of the different hypothesis testing exercises as conceptualised by the different participant groups. The outcomes of the prototype testing exercises were recorded in PowerPoint format and can be provided upon request.

Hypothesis Testing Exercises
Group 1: Transport and build
Group 2: Maintenance and operation, and cleaning and dismantling
Group 3: Admission, screening, and triage
Group 4: Suspect or confirmed cases
Group 5: Discharged or death

Group 1 – Transport and build

Hypotheses considered:

- The module can be transported in any type of road regardless of means of transportation
- The module can be transported without vehicle assistance as far as needed
- The module is well-packed and documented to pass customs
- Pathogens cannot be spread through transportation of the module
- The module can be easily repackaged for transportation to a new destination
- The module can resist to extreme weather events during transport
- Adjustments to the module can be made without full dismantling
- Broken components are easily replaceable with locally sourced material
- The module is composed of few and simple components

- The module can be easily built regardless of the instructions
- The module can be easily built regardless of the availability of tools
- The module can be set up quickly without compromising quality of IPC parts
- The module is accessible to all groups of the community

Group 2 – Maintenance and operation, and cleaning and dismantling

Hypotheses considered:

- The module supports the use of reusable energy and resources (this includes packaging and possibilities for multi-purpose uses
- The design allows for effective patient flows across a range of scenarios in collaboration with existing health stakeholders
- The module is appropriate to initiate essential care, and for the stabilisation of patients in critical conditions who need further care
- The design allows for high quality, context-adapted care
- The module can be used with different oxygen sources
- Biodata devices can be placed in the staff area
- Regular maintenance is done without affecting daily activities
- Packaging of the unit allows it to remain sterile once dismantled for immediate reusability
- The interior parts of the module can be rapidly cleaned while in use
- The module can be safely cleaned while a patient is being treated
- Standard cleaning operations will not affect material integrity
- Consumables can be managed from outside the treatment area
- Different forms of equipment can be cleaned rapidly and safely when preparing for arrival of a new patient
- Cleaning of the unit can be undertaken as per IPC standards without need for specialised training
- The module is set up in such a way that, when dismantled, the module's parts can be safely handled by two individuals weighing less than 100 kilograms
- The unit, including the patient interface, can be repaired with locally sourced materials
- The unit can operate during a range of expected (reasonable) environmental fluctuations (wind, rain, storms) without interrupting patient care

Group 3 – Admission, screening, and triage

Hypotheses considered:

- The module allows for emergency care in proximity to the triage area
- The screening/triage area enable safe, visual patient assessments
- The module can welcome an ambulance and receive a patient that is not ambulatory (when there is no clinical emergency)
- The screening area allows for easy staff access which need to move between green and red zones

- The screening and triage space enables staff to safely operate despite high occupancy rates
- The screening area is well-suited to accommodate wet/liquid-producing patients and allows consecutive patients to be screened safely
- Medical staff of the triage area is qualified and has the authority to receive a patient at any time of the day and night
- The local population is willing to go to the screening area when required
- Screening and triage space enables only unidirectional flows of items
- The module is easily accessibility for families with children
- The module enables caregivers to treat the patients correctly and safely
- The screening area is a space that permits staff to calmly interact with a patient
- The module has clear IPC protocols in place that are displayed and adhered to
- The module is accessible for the entire community with dignity
- The module can be easily accessed by people with disabilities by allowing for large openings and good spatial design
- The module abides to the necessary biosafety measures to accommodate patients with severe respiratory infectious
- The module's screening area allows for easily transmissible clinical data in respect of biosafety measures
- The WHO triage principles are used and adapted to high-infectious disease scenarios
- In-unit transfers are possible and safe
- Patients are safely admitted and fully informed on the treatment process

Group 4 – Suspect or confirmed cases

Hypotheses considered:

- Critical infrastructure is resilient to disruptive phenomena
- Agitated patients can be safely managed by staff
- The module is adaptable to all age groups, including people with disabilities
- The module can accommodate a small theatre as well as a neonatal resuscitation unit, if required
- The module allows for close monitoring and patient visibility day and night, and the layout can be modified whenever needed
- The patient is treated in real-time during critical incidents
- The module is designed, adapted, and used with full participation of community leaders and community health workers
- Language barriers do not impair treatment
- The module can be easily adapted to unexpected patient influx, and surge capacity can be easily increased
- The module is linked to an efficient transfer/ambulance system
- The module has an efficient patient circuit considering various levels of disease severity

Group 5 – Discharged or death

Hypotheses considered:

- The family can view the patient/body in the room from outside the treatment room
- The family is notified of death when possible
- In case of discharge, the patient and his/her family are provided with counselling support in a culturally acceptable manner
- The module can be set up and maintained in a rural area
- Shower exit areas have clear and safe pathways straight to low-risk zones upon discharge
- The module can be divided into multiple parcels to allow for easy transportation
- Natural light and passive cooling systems are available to limit energy consumption
- The module is resistant to chemicals used for decontamination, to its physical environment, and to multiple sessions of packing and repacking
- The medical and WASH teams collaborate on body preparation processes to avoid IPC breaches
- Differences in body preparation and burial procedures can be accounted for
- The module can be easily connected to water sources and drainage systems for decontamination and easy shower set up
- The module can be easily maintained by local staff and with local resources, and minimum maintenance is required
- Continuity of care for non-confirmed patients can be accounted for

Agenda – Day 4 – Prototype Testing Presentations

Activity	Time
Welcome & Agenda + Energiser	9:00am
Prototype & Testing Exercise Team Rotation and Presentations (Round 3)	9:15am
Prototype & Testing Exercise Team Rotation and Presentations (Round 4)	10:00am
Break	10:45am
Prioritisation Exercise	11:00am
Next Steps, Closing	11:45pm
Lunch	12:00pm

Presentations of the hypothesis testing frameworks continued during the morning of Day 4. These have already all been listed above.

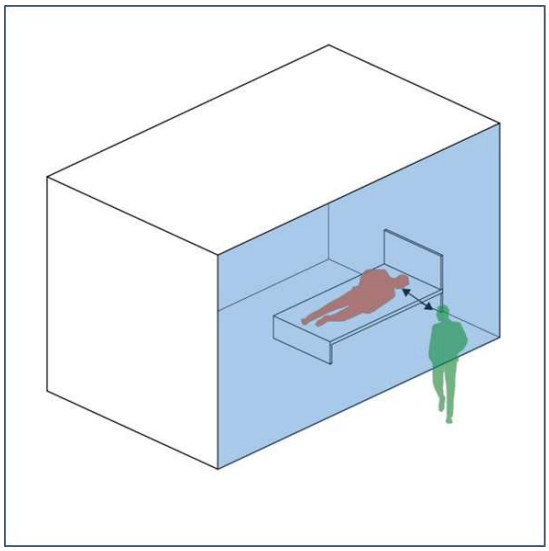
Next Steps

The next step for the training workstream is to review the suggested hypothesis and scenarios to test, and propose the top 15/20 scenarios for the drill taking into account existing WHO protocol on simulation testing. Regardless of the final design of the prototype, testing will have to be done. The drill shall allow us to engage in a measured testing exercise of different functionality aspects of the proposed structure. The drill provides the backbone of the training workstream in view of a broader simulation exercise where the scenario analysis as presented above shall be reproduced.

Immediate next steps consist of:

- Technical/design team will work on a draft preliminary design over the next few weeks. The outcome will be shared with the core team for discussion and iterations as needed.
- Once prelim design is agreed upon, we will initiate the mock set up of the structure – the manual/guidelines for this mock session will be developed over the next few weeks as well in parallel to the drafting of the prelim design.
- During a second stage, the design concept will be further fine-tuned, based on sketched technical drawings and the pooling of different Key Components. It is expected that the final design of the prototype of the infectious disease treatment module shall be ready by September/October 2022, with a drill planned for November 2022.

Annex I – Key Components Overview

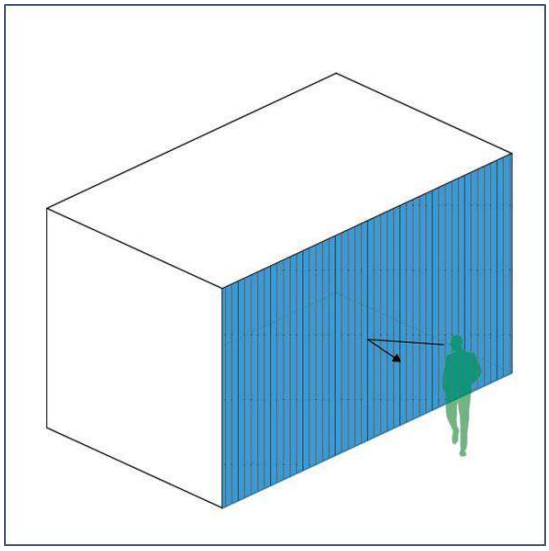


Transparent Screen

To allow maximum visibility of the patient from green area to red area

Design Principles:

- **Contact-enabling design**
- **Cultural adaptability and participation**

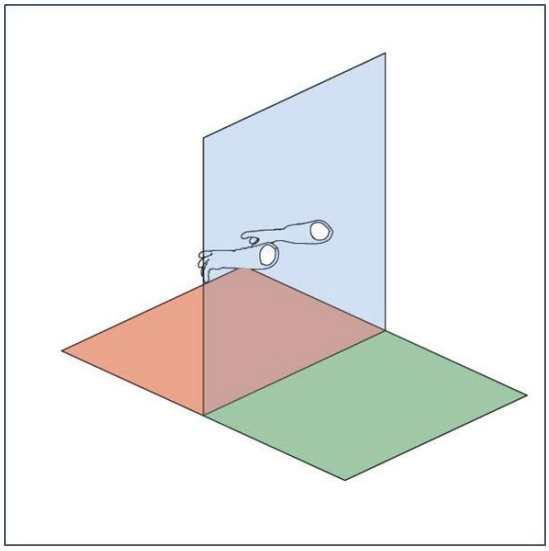


Shutter System

To ensure patient's privacy

Design Principles:

- **Cultural adaptability and participation**

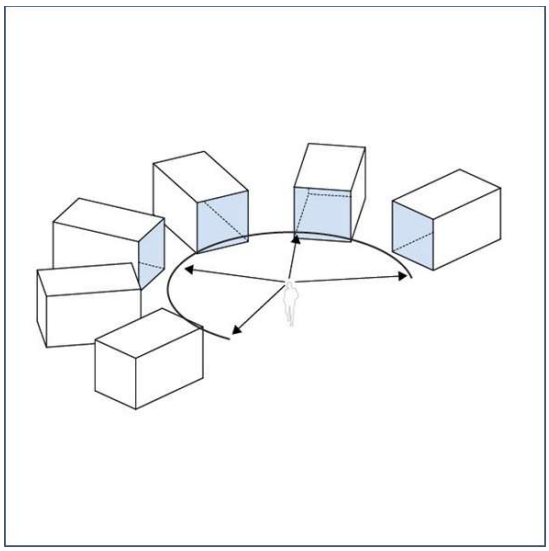


Wall Integrated Manipulation Gloves

To allow patient's manipulation avoiding contamination risk

Design Principles:

- **Contact-enabling design**
- **Adaptability and IPC**

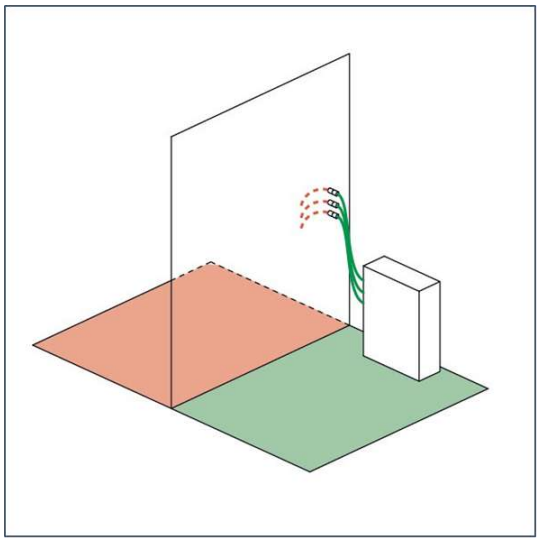


Central Staff Area

To ensure patients' surveillance

Design Principles:

- **Contact-enabling design**

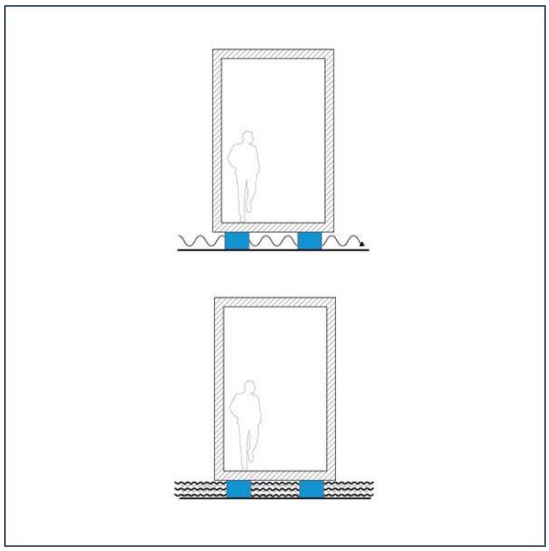


Ad-hoc space for biomedical devices within the green area

To avoid equipment disinfection and ensure a rationalized use of PPE

Design Principles:

- **Adaptability and IPC**

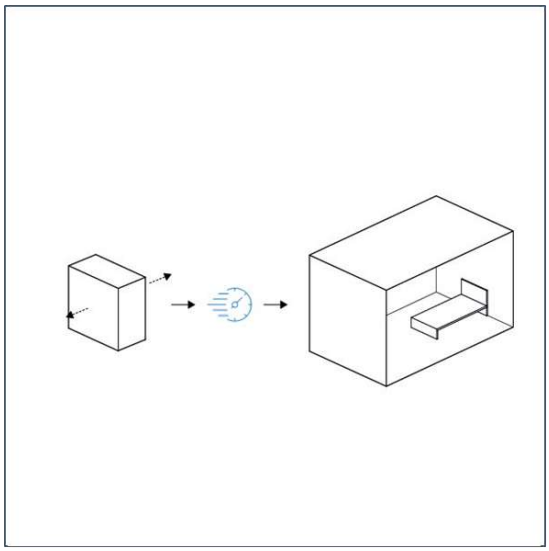


Elevated Structure

To ensure flooding resilience and passive cooling

Design Principles:

- **Resiliency to disruptive phenomena**

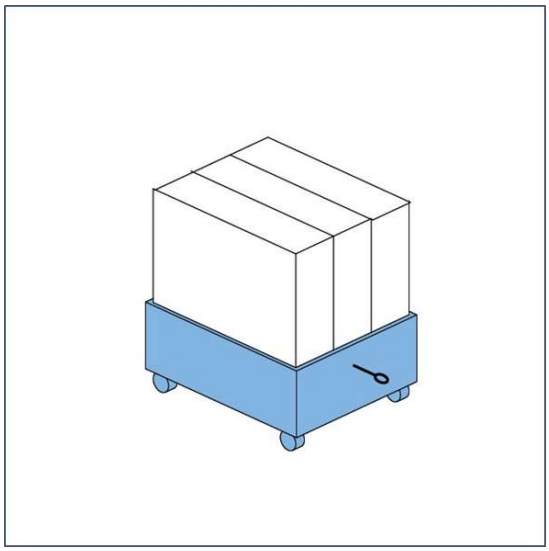


Ready to use within minutes

To ensure a quick set up

Design Principles:

- **Constructability**

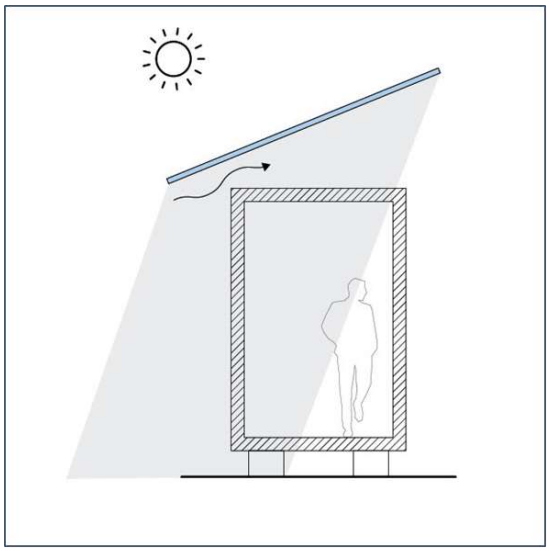


Ease of transport

To allow easy transport independently of the mode of transportation

Design Principles:

- **Transportability**

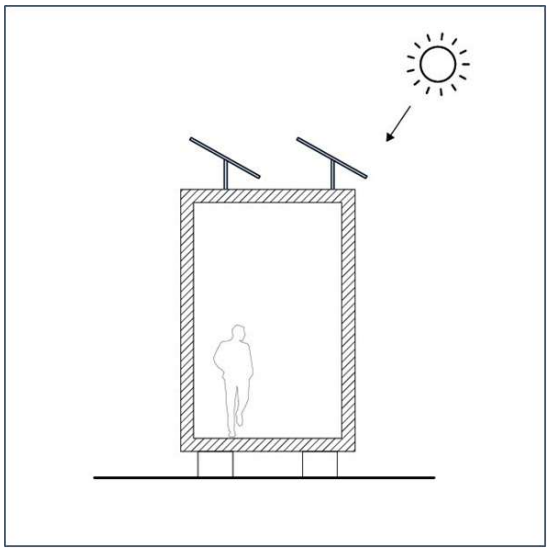


Double Roof/Shade Net

To allow adaptability to any geographical and climatic area

Design Principles:

- **Adaptability and IPC**

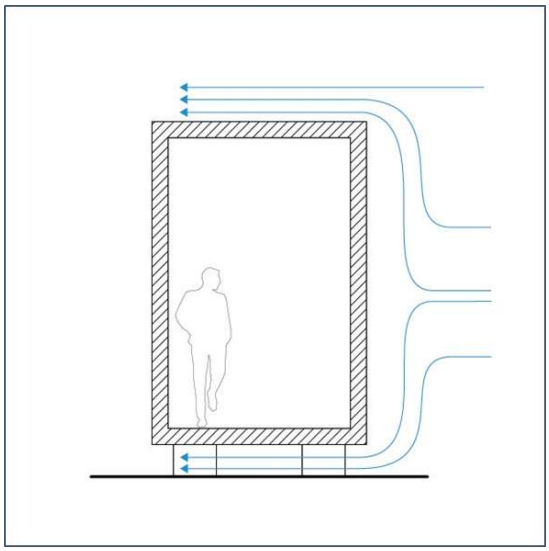


Solar panel/photovoltaic

To allow energy self-sufficiency and ensure low carbon footprint

Design Principles:

- **Climatic responsive and energy responsible**

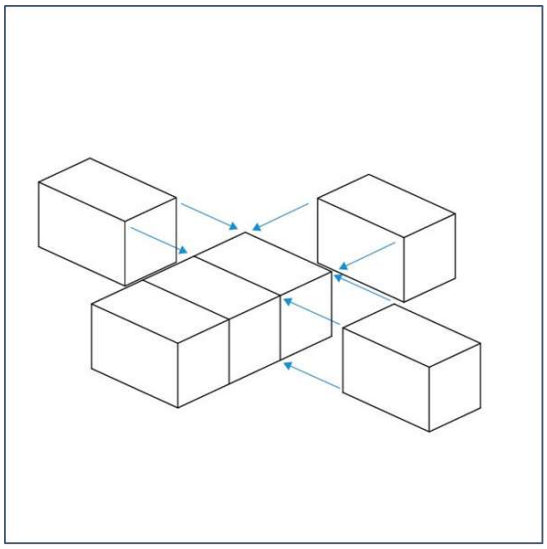


Wind Resistance

To ensure resistance to wind bursts up to 120 km/h

Design Principles:

- **Resiliency to disruptive phenomena**

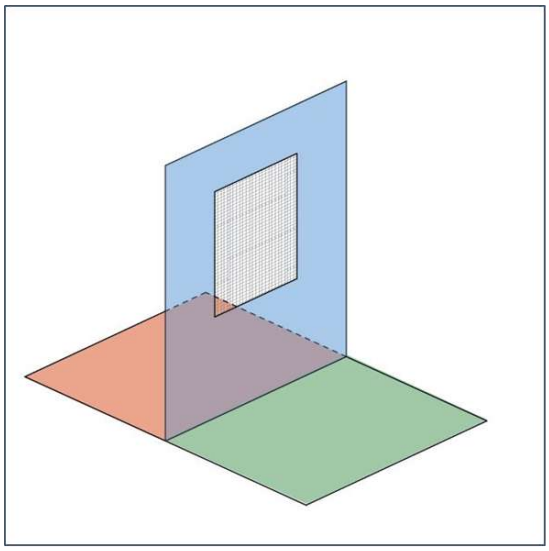


Modularity through connection system/extensibility

To maximize number of possible configurations and flexibility

Design Principles:

- **Modularity**

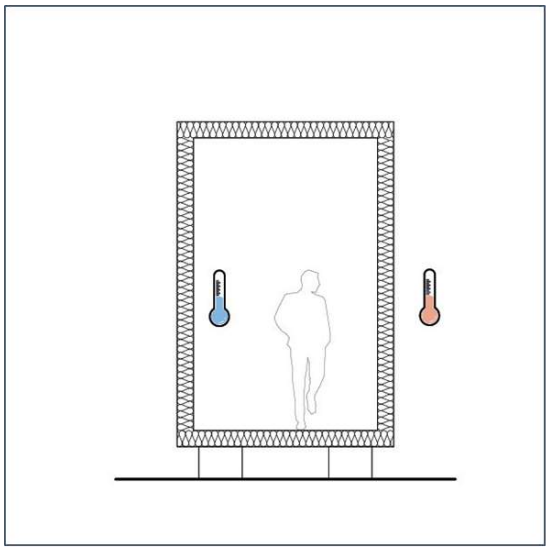


Vector control

To avoid any pest sneaking in the unit

Design Principles:

- **Adaptability and IPC**

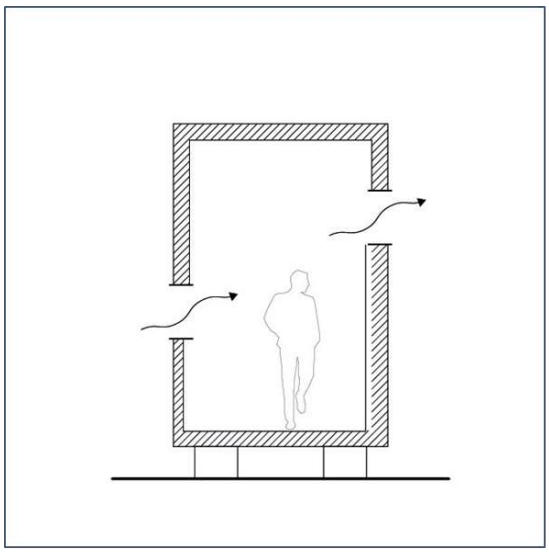


Insulated material

To ensure thermal control and reduce energy consumption

Design Principles:

- **Adaptability and IPC**
- **Climatic responsive and energy responsible**

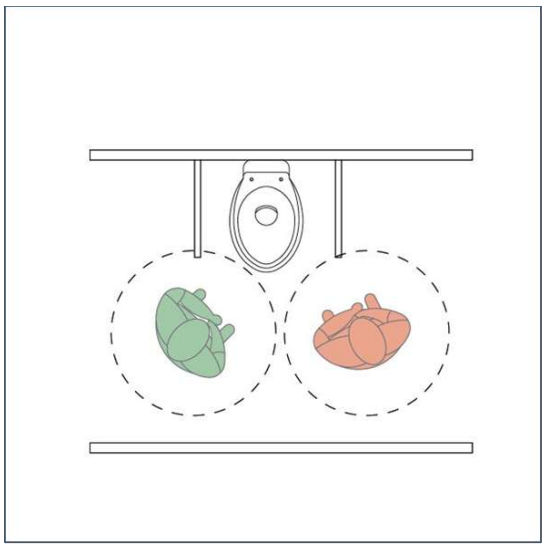


Controlled building ventilation

To reduce the risk of indoor health concerns

Design Principles:

- **Adaptability and IPC**

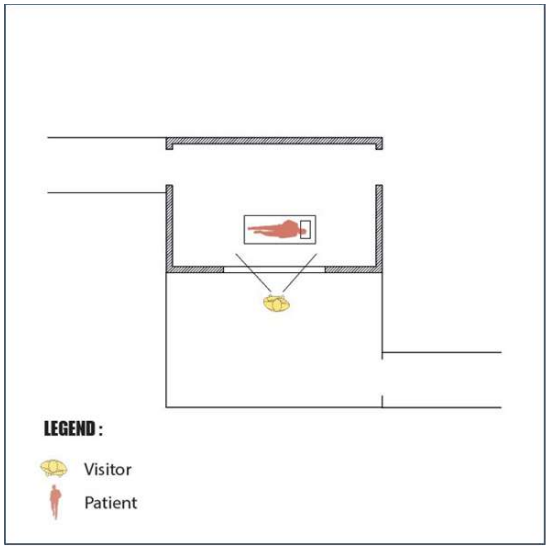


Indoor latrines/showers, large enough for 2 people

To ensure accessibility to latrine/shower for patient + assistant

Design Principles:

- **Accessibility and inclusiveness**

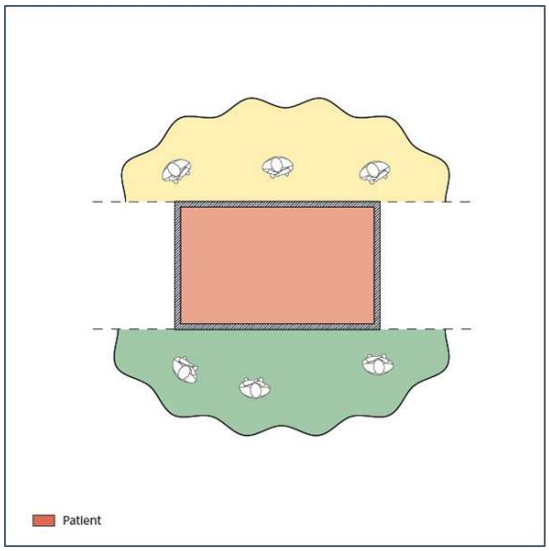


Morgue with family space

To ensure body visibility and cultural acceptance

Design Principles:

- **Cultural adaptability and participation**

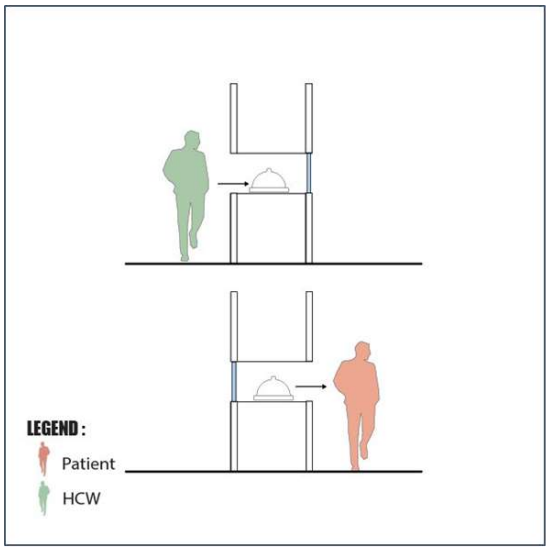


Visitors area

To ensure relatives visiting the patient while respecting IPC measures

Design Principles:

- **Cultural adaptability and participation**

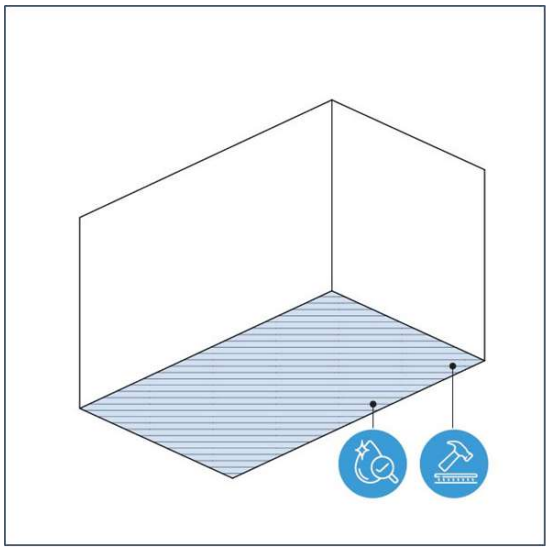


System for items transfer

To allow transfer of items from low risk to high risk zone while rationalizing the use of PPE and reduce the risk of contamination

Design Principles:

- **Contact-enabling design**
- **Adaptability and IPC**

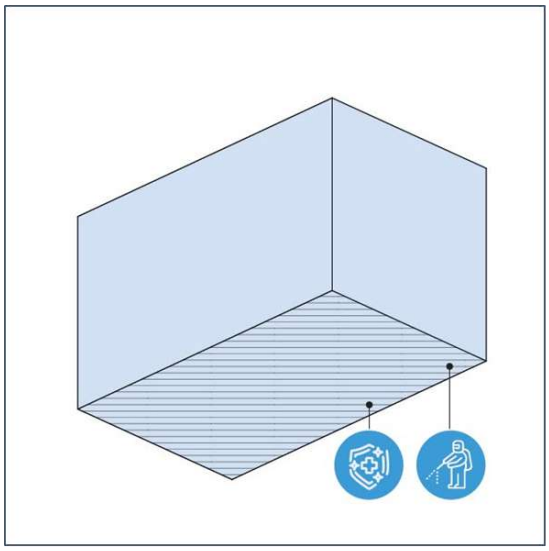


Smooth hard flooring

To ensure resistance to multiple use

Design Principles:

- **Adaptability and IPC**

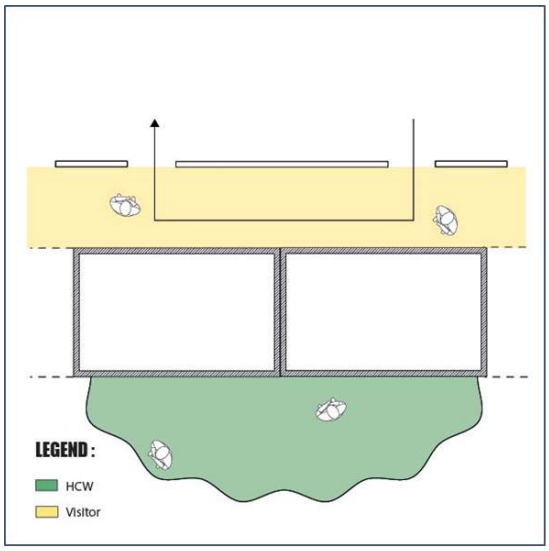


Easy to disinfect materials

To allow easy cleaning and disinfection

Design Principles:

- **Adaptability and IPC**

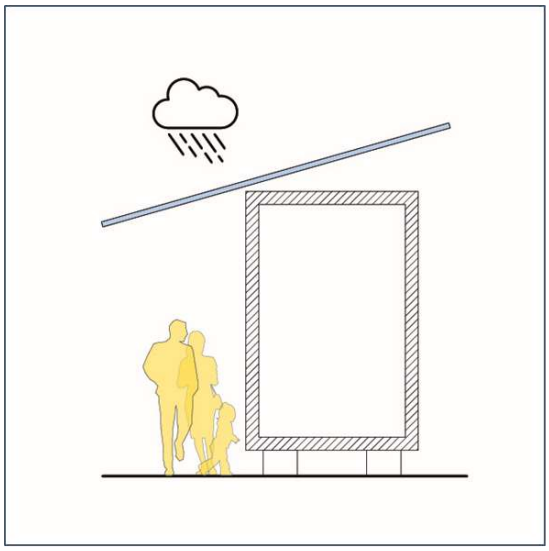


Separated access and flow for staff and visitor

To reduce the risk of contamination and ensure a rationalized use of the PPE

Design Principles:

- **Adaptability and IPC**

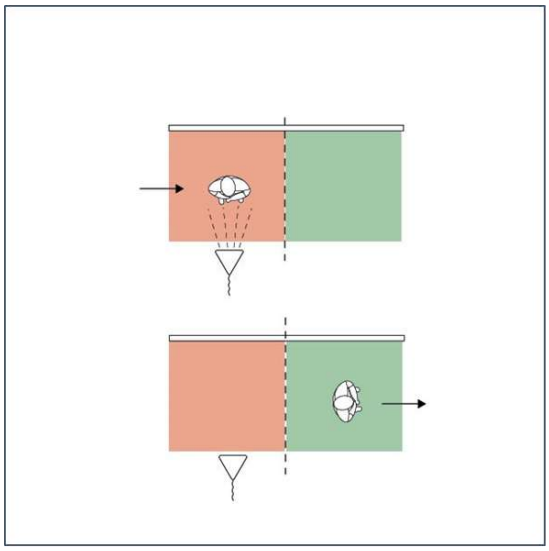


Visitor area protected with cover

To protect visitors from atmospheric agents while visiting the patient

Design Principles:

- **Cultural adaptability and participation**

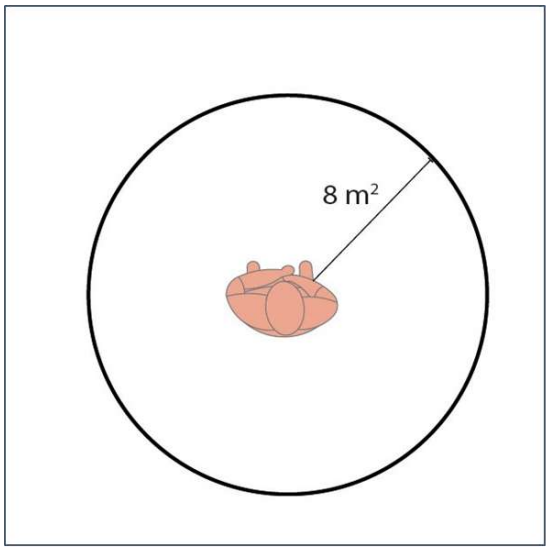


Doffing

To ensure a safe doffing area

Design Principles:

- **Adaptability and IPC**

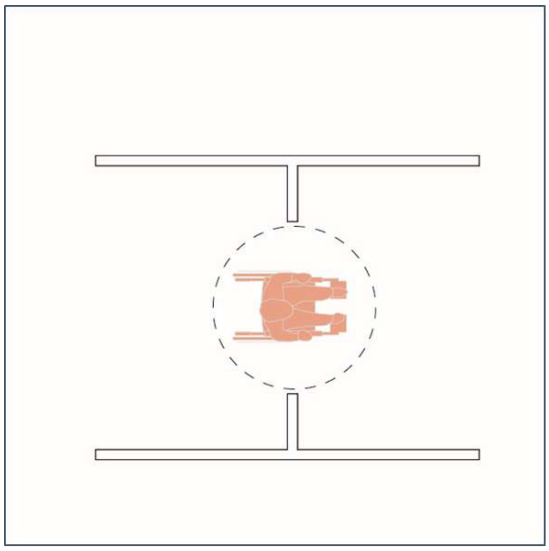


Minimum 8m2

To allow adequate space for patient treatment and comfort

Design Principles:

- **Usability**

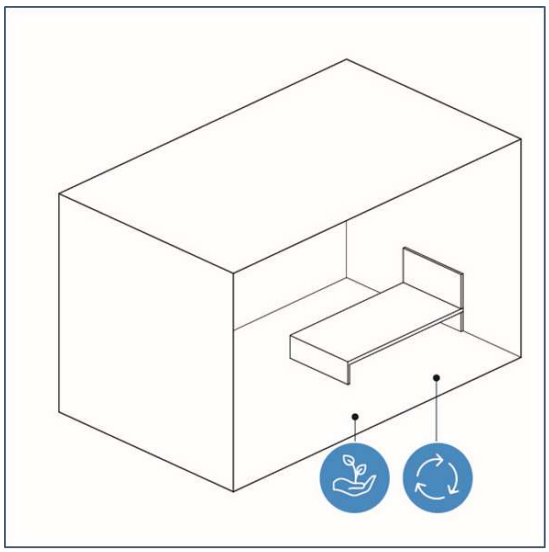


Access for patients with reduced mobility

To allow easy access to the modules to any patient

Design Principles:

- **Accessibility and inclusiveness**

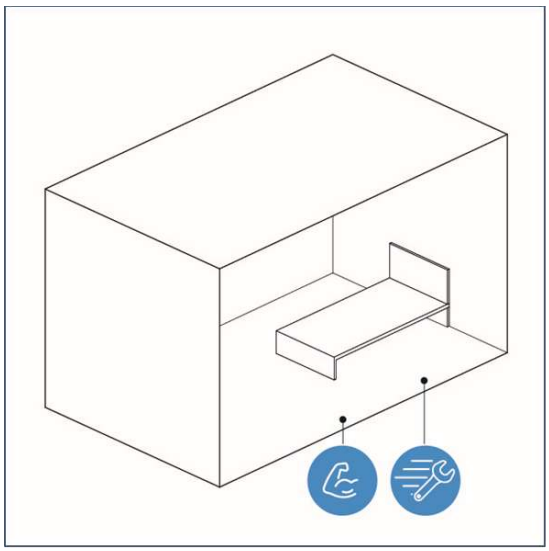


Use of sustainable and repurposable materials

To reduce environmental impact and prolong materials lifespan

Design Principles:

- **Cradle to cradle and reuse design-based**



Durable and easy-to-fix parts

To reduce maintenance frequency and cost

Design Principles:

- **Minimum Local Maintenance**

Annex 3: Hear phase, Design Brief

Table of Contents

Scope of the document

The ‘Hear’ phase is aimed at setting a common language across disciplines, gain in depth understanding and alignment on the challenges, visions, target users, and to envision design initial concept. To achieve this aim, this phase is organized around innovation workshops, desk research, and empirical experience reports analysis. The milestones of this phase are the definition of key drivers and design principles; comparative analysis, innovation from the fields analysis, and key components. The deliverable of the ‘Hear’ phase is the design brief. A design brief is a document in which the voices of experts, lessons learned, and technical knowledge shared during the hearing phase are translated into technical and design requirements to support the create phase.

Problem Statement / Need for the product

Epidemics of infectious diseases are occurring more frequently and are spreading faster and further than ever before in different regions of the world. Climate change, high population pressure expanding to previously uninhabited areas, unplanned urbanization and growing global interconnectedness has led to increased occurrences of emerging and re-emerging infectious diseases including zoonoses with the potential to rapidly spread across the globe.

Infectious disease treatment centre design has improved considerably within the last few years where units have evolved from being a pure isolation facility to a real treatment centre designed around patients, staff and community to improve the quality of medical care provided, infection prevention and control (IPC), patient’s comfort and community acceptance. During the last Ebola outbreaks, several innovations have been developed in the field while the current SARS-CoV-2 pandemic and the airborne risk pushed the development of engineering capacity to a new level.

However, the construction and installation of such facilities may require several weeks, while the first phase of the emergency is still improperly managed with simple structures which do not allow for providing adequate levels of medical care. With this in mind, INITIATE² plans to develop a solution for a rapidly deployable, easily transportable, extendable, self-contained and self-sufficient treatment module for infectious diseases irrespective of the mode of transmission. Such a solution, built on field experiences, will not replace current facilities but rather integrate them by enabling responders to safely provide the high quality of care needed with dignity, respect and compassion towards affected communities from the very onset of the emergency while more permanent and complex structures are being set up.

Programmatic relevance for the INITIATE^2 partners

Besides providing a tool to strengthen preparedness and response capability, this innovation will enable a certain degree of standardization across emergency responders and humanitarian organizations involved in outbreak response. Moreover, the simulation and drill exercise around the innovation will foster communication and coordination across the different institutions involved while enabling a multidisciplinary collaboration.

Expected solution: the IDTM

The Infectious Disease Treatment Module (IDTM) is a rapidly deployable, easily transportable, extendable, self-contained and self-sufficient treatment module for infectious diseases irrespective of the mode of transmission. The IDTM is adaptable to different climate, use, dimensions and patients' clinical needs (acuity, severity and infectious status) through an add-on system approach.

Each IDTM is for two patients and allocates space for the following procedures: treatment (including HDU - High Dependency Care, minor surgery and delivery), resuscitation, isolation, patient's toilets and showers and nursing area. Some of the above mentioned procedures can be done within the same space.

IDTM is enabling responders to safely provide the high quality of care needed with dignity, respect and compassion towards affected communities from the very first days of the outbreak.

IDMT operator: The IDMT is operated by the INITIATE² partners, their implementing partners that run emergency response programs in the context or Government institutions that do the same, qualified in the management, support and provision of services in the Health sector.

IDMT user: The IDMT is used by the IDMT operator and the people the IDMT operator provides services to, which includes all age groups, men, women and children, from all different cultural, religious and ethnic backgrounds, people suffering from illnesses or living with disabilities across all impairment groups.

Current approaches used by the INITIATE^2 partners

INITIATE^2 partners use different approaches to cope with the above needs:

1. Set up temporary structures built with local materials

2. Deploy temporary structures such as tents or containerized prefabricated solutions

3. Deploy temporary add-on solutions

4. Adapt and use existing facilities

5. Set up hybrid solutions

Volume and potential impact

Every year, disasters and emergencies affect the health and wellbeing of millions of people.

The World Health Organization (WHO) Health Emergency Dashboard is a platform which aims to share information about public health events and emergencies. The data on the dashboard is refreshed every fifteen (15) minutes and data is accurate as at time of refreshing. https://extranet.who.int/publicemergency

The WHO Health Emergency Dashboard is not a comprehensive representation of all the events and emergencies that WHO is aware of and responding to. The events displayed are a subset of those reported through official channels as mandated by the International Health Regulations (IHR 2005). The content of the WHO Health Emergency Dashboard is for general information only.

Target unit cost

The purchase cost of the IDTMs has to be kept as low as possible to enable reaching as large as possible portion of the affected population.

Methodology

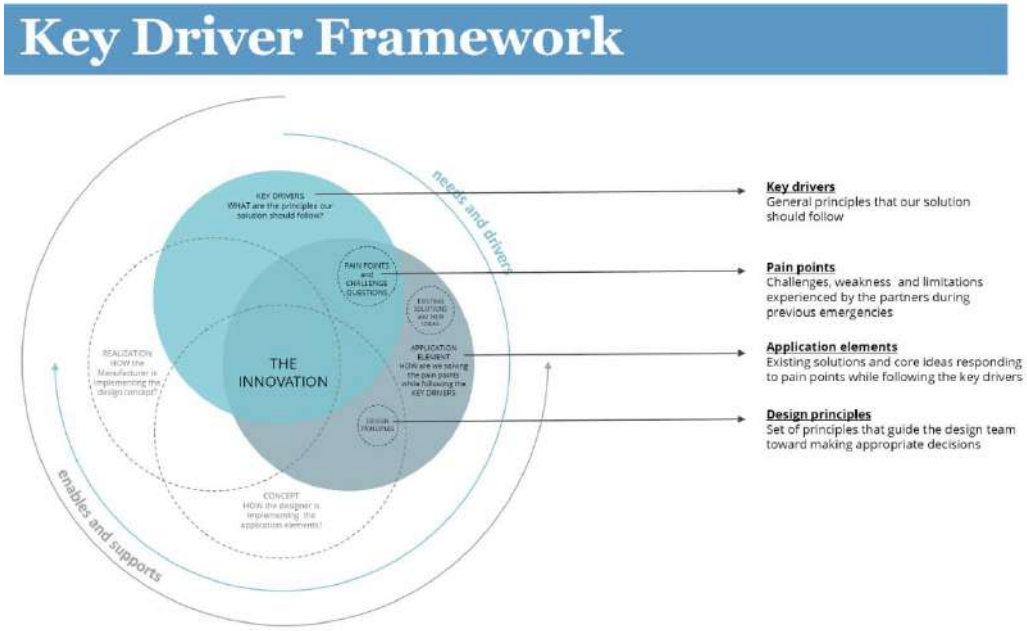
The methodology of the IDTM development relies on the Key Driver Framework that helps obtain the system requirements in a systematic way and to provide a structured overview. The key driver framework is divided in four steps:

- Development of the key drivers (general principles that the solution should follow) through the definition of the pain points and challenge questions (challenges, weakness and limitation experienced by the partners during previous emergencies)

- Development of the application elements (existing solutions and core ideas responding to pain points and challenge questions while following the key drivers) through the definition of the design principles (set of principles that guide the design team toward making appropriate decision)

- Concept (how the designer is implementing the application elements)

- Realization (how the manufacturer is implementing the design concept)



After the identification of the pain points and corresponding challenge questions, through the Key Drivers framework, the INITIATE² partners have identified:

- key drivers
- design principles
- key components through a comparative product and field solutions analysis

Key drivers

The key drivers identified by the INITIATE² Core Team to be considered while developing the infectious disease treatment module are the following:

1. **Humanised care** (rapid accessibility, visibility, constant monitoring, privacy, and ensuring that the proposed structure targets individual's well-being)

2. **Environmental sustainability** (making more environmentally responsible choices with our energy, waste, and water, and quantifying our carbon impact as well as holding groups responsible)

3. **Disaster resilience** (ensuring that the proposed structure is resilient to natural hazards)

4. **Accessibility and inclusiveness** (ensuring that the proposed structure is accessible to an old person, a child, or a disabled person)

5. **Cultural adaptation** (ensuring that the proposed structure fits into different local contexts)

6. **Deployment and installation rapidity** (ensuring that the proposed structure can be installed within the first days of an epidemic outbreak and be installed by unskilled workers)

7. **Circularity** (ensuring that the proposed structure minimizes resource flows and waste generation, and can be easily reutilised)

8. **Sustainable maintenance** (ensuring that the proposed structure can be repaired easily)

9. **Health system integration** (ensuring that the proposed structure fits the local health systems)

10. **Usability** (ensuring that the proposed structure is easy to use)

Design principles

The design principles to be considered while developing the design of the infectious disease treatment module are the following:

1. **Contact-enabling design:** Design should enable contact via different mediums in relation to type of disease transmission modalities. This could be achieved by focusing on the relation between visibility and privacy (through transparency, geometrical layout solutions, technological characteristics, or other), or safe tactile and visual interaction between patient/HCW and patient/visitors.

2. **Climatic responsive and energy responsible:** Design should rely on hybrid/passive design and low energy consumption where possible. This could be achieved by offering technological alternatives based on macro climatic areas differentiation (cold, hot, humid, et cetera) and, through add-on system design, microclimatic conditions site-analysis (wind conditions, presence of natural shades such trees, presence of water, such as lakes, river, et cetera). The IDTM design should be energy responsible by ensuring that energy consumption is optimized according to space use and requirements.

3. **Resiliency to disruptive phenomena:** Design should take into account possible natural hazards and other disruptive phenomena that could impinge on the correct functioning of the IDTM.

4. **Accessibility and inclusiveness** through a spatial design that can provide minimum dimension requirements and adequate space and characteristics for everyone including special needs patients (i.e. children, elderly, pregnant women, persons with disabilities and others).

5. **Cultural adaptability and participation:** Design should provide opportunities to ensure, respect, and enhance the engagement and understanding of local culture.

6. **Modularity**: Design should rely on the principles of modularity in order to provide flexible layout organization and surge.

7. **Constructability**: Design should allow for ease set-up through intuitive construction.

8. **Cradle to cradle and reuse design-based**: design should take into account life cycle assessment, as well as rely on reuse where possible (packaging, materials, and end-life material/components).

9. **Minimum and local maintenance:** Design should ensure low maintenance requirements, which can be carried out by the local workforce.

10. **Adaptability and Infection Prevention and Control (IPC):** Design should rely on an add-on system approach, in order to provide customizability and adaptability to the different needs (climate, local context, use, acuity, severity and infectious status). Moreover, spatial design should provide interaction with existing health facilities in order to enhance the health system integration.

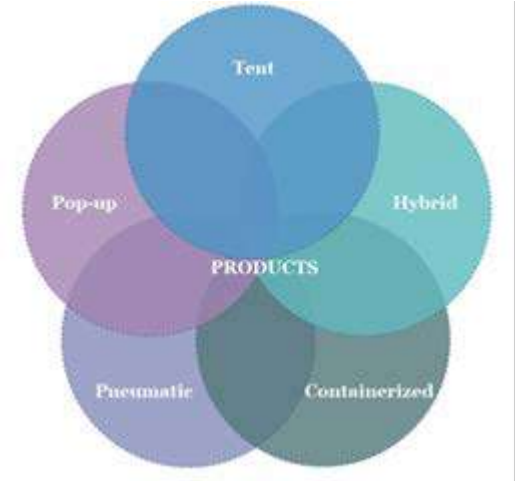
11. **Usability:** Design should be intuitive and facilitate wayfinding.

12. **Transportability:** Design should allow easy transport also on small size local transport, such as tricycles with flat beds, carts or tuk-tuks, carried by hand, on large and small boats, by donkey or other beasts of burden.

Comparative analysis

A team composed by 4 individual experts from WHO, UNHRD and the Téchne members Politecnico di Torino and Toronto University analysed existing solutions on the market and categorised them per product typology, product performances and compliance with agreed design principles as technical requirements. Products were divided into five product categories:

1. Tent
2. Hybrid
3. Containerized
4. Pneumatic
5. Pop-up



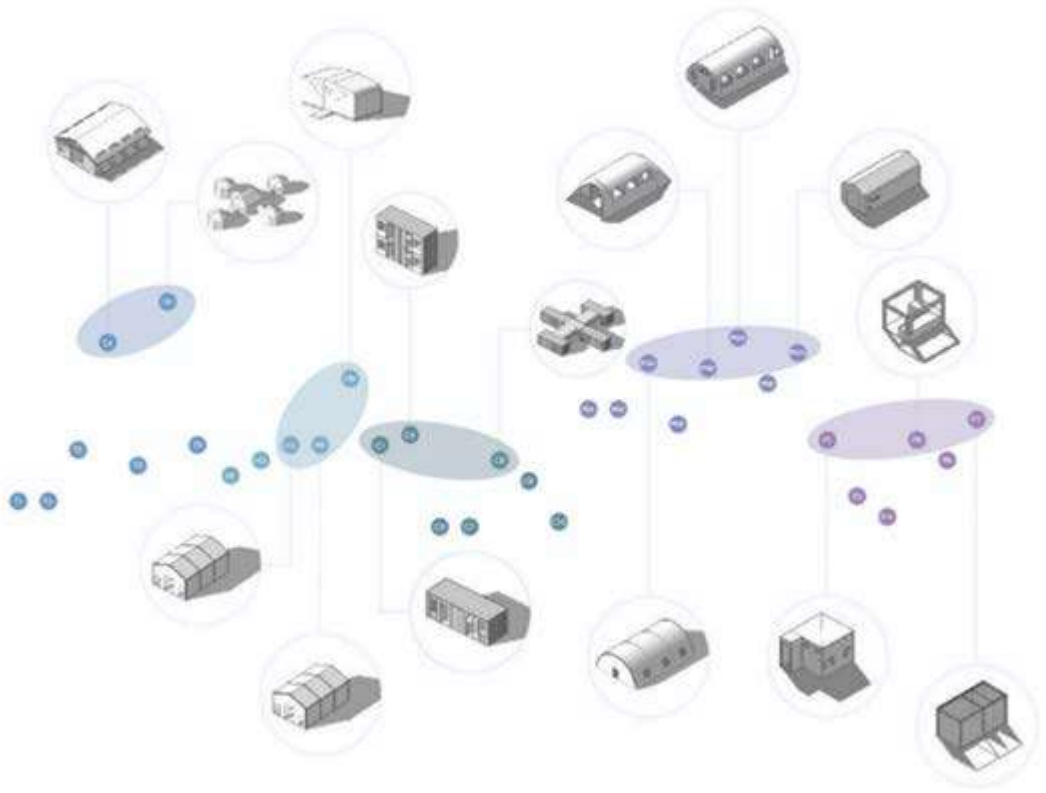
and 50 solutions currently on the market were afterward assessed against the design principles with a scale of 0 to 2, where:

• 0 is a product not answering a design principle

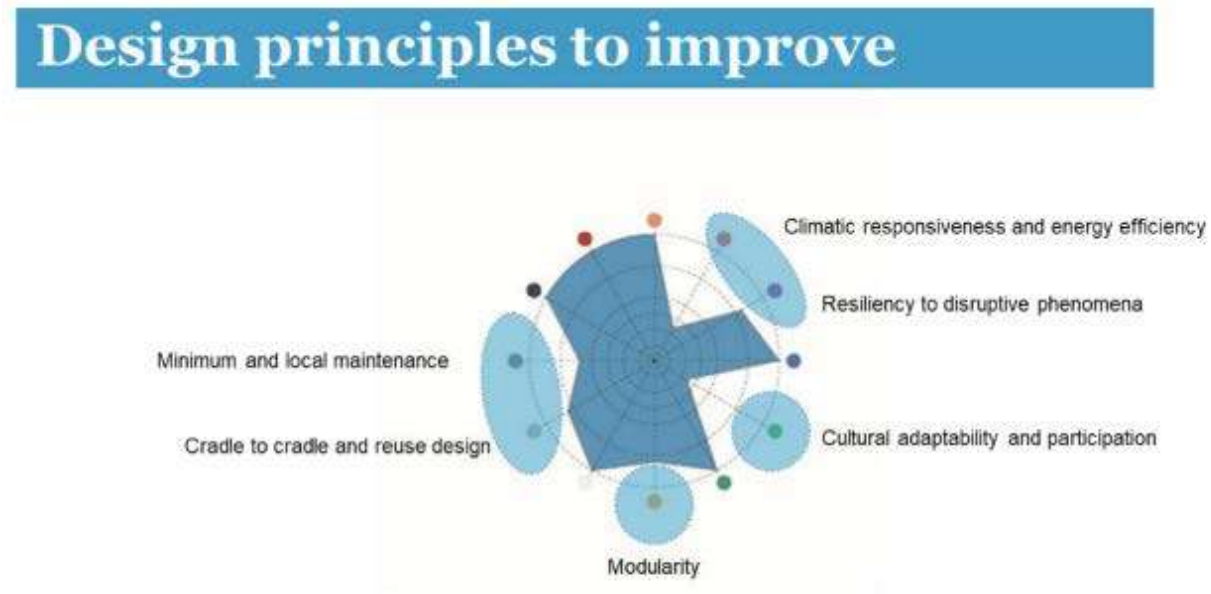
• 1 is a product partially answering a design principle

• 2 is a product completely answering a design principle

After the assessment, the team selected the 15 products that scored highest and studied in depth their technical performances.



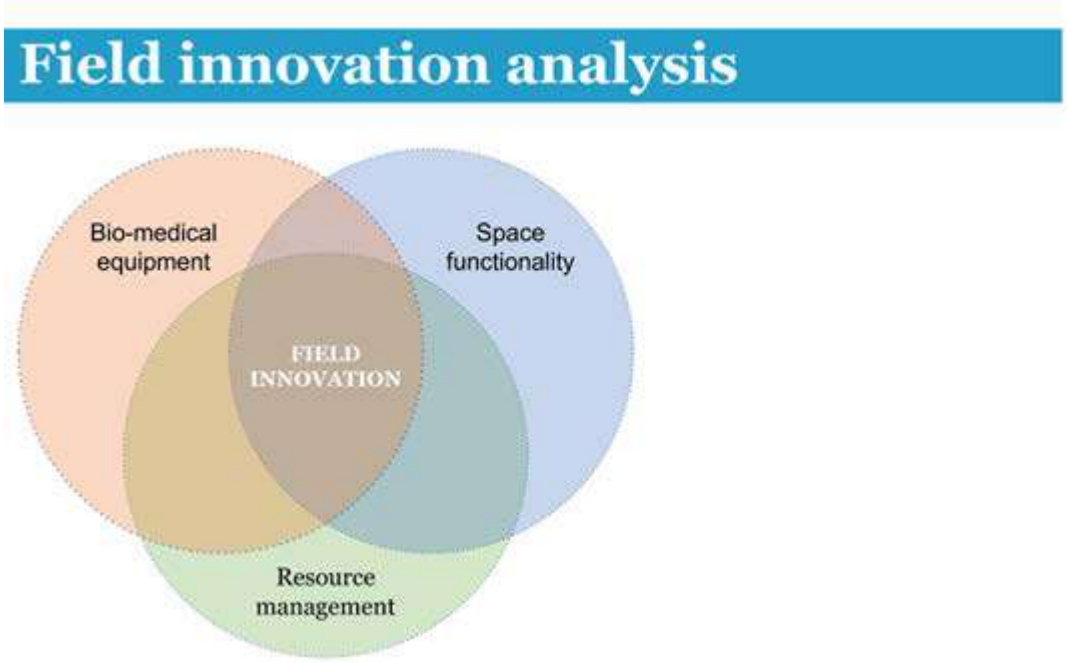
The results of the analysis on the 15 products demonstrated a need to improve the following design principles, for the successful development of an efficient and effective treatment module.



Even though the evaluation of existing solutions was not carried out by outside partners, and even though the weighing criteria were unilaterally decided by the INITIATE² Team, it nevertheless allowed the team to obtain a good understanding of which existing solutions could be drawn inspiration from for the conceptualisation of the IDTM.

Innovations from the field

A team composed by 4 individual experts from WHO, UNHRD and the Téchne members Politecnico di Torino and Toronto University analyzed the field innovations developed by INITIATE² partners and divided them into 3 categories: bio-medical equipments, spatial functionality ad resource innovation.



After the analysis, the team decided to focus on the space functionality and resource management categories and selected the following:

1. **Nursing/medical areas inside the patient's area**
   To ensure patients' surveillance

2. **Installation of a private viewing area in the morgue**
   To ensure body visibility and cultural acceptance

3. **Bio-secure Space**
   To rationalize the use of PPE and reduce the risk of contamination

4. **Creation of sliding furniture to transfer food or water from low risk to high risk zone**
   To allow transfer of items from low risk to high risk zone while rationalizing the use of PPE and reducing the risk of contamination

5. **Plexiglass and transparent surfaces**
   To allow maximum visibility of the patient from green area to red area

6. **Hard flooring**
   To ensure resistance to multiple use

Key Components

The Key Components were extracted from the existing products and field innovation analysis and from the pain points exercise ran with the INITIATE² partners. The 49 key components to be considered while developing the design of the infectious disease treatment module are the following innovations:

NO.	Key Component
1	Modularity through connection system/extensibility
2	Easy to disinfect materials
3	Excreta and wastewater management
4	Drainage management
5	Controlled building ventilation
6	Smooth hard flooring
7	Separated access and flow for staff and visitor
8	Central Staff Area
9	Ready to use within minutes
10	Ease of transport
11	Easy access to different water source and treatment
12	Access and exit routes must be integrated

13	Transparent Screen
14	Visitors area
15	Integrated indoor/outdoor distribution
16	Communication between staff, patients, and visitors
17	System for items transfer
18	Shutter System
19	Minimum 8m2
20	Integrated water storage
21	Reliable energy supply
22	Morgue with family space
23	Access for patients with reduced mobility
24	Connectivity of water system
25	Easy oral communication
26	Security
27	Double Roof/Shade Net
28	Visitor area protected with cover
29	Solar panel/photovoltaic
30	IPC + module dedicated to clinical care first
31	Accessibility for any kind of transportation and beds
32	Ad-hoc space for biomedical devices within the green area
33	Vector Control
34	Insulated material
35	Durable and easy-to-fix parts
36	Doffing
37	Use of sustainable and repurposable materials

38	Turnaround time/Reusability
39	Elevated Structure
40	Indoor and outdoor use
41	Screening area/Triage
42	Outside access for patients
43	Wind Resistance
44	Short/Culturally acceptable fencing
45	Permanent temperature control
46	Indoor latrines/showers, large enough for 2 pple
47	Intuitive layout and set up
48	Wall Integrated Manipulation Gloves
49	Alarm System for patients

Logistical, environmental, functional and economical product requirements

The following eleven elements have to be consider during the design process:

1. Supply chain

2. Climate

3. Hazards

4. Flexibility

5. Functionality (operation and IPC compliance)

6.Resource Management (Water, Energy, Waste)

7. Durability and maintenance

8. Post-operational Management

9. Cost

10. Timelines

11. Testing and certification

1. Supply Chain	
Ordering	Typically IDTM will be ordered by INITIATE² partners staff in programs and operations. They typically rely on INITIATE² partners' standard offshore offer and what is pre-positioned in their warehouses or with suppliers. In addition, INITIATE² partners staff could request clarifications in relation to all aspects of the IDTM, for example: durability in a certain climate and hazard profile, cost and onward transport and set-up implications. In addition, INITIATE² partners' staff could request solutions for specific challenges faced in the context they are working in, for example setting up the IDTM on rocky or sandy soil.
International transport – by supplier	IDTMs will be delivered by suppliers to INITIATE² partners' international pre-positioning warehouses across the globe, or directly to INITIATE² partners' country office warehouses.
Onward international transport	From international pre-positioning warehouses, IDTMs are transported, by INITIATE² partners, to country office warehouses. This is done as air-freight, sea or land transport. Common international transport practices apply such as optimized packaging and palletization.
Onward transport in operations	Onward transport is managed by either INITIATE² partners or its partners (depending on the partnership agreement). IDTMs received in the country office's warehouses are further transported to their final destination. Transport modes commonly used are all sizes and types of trucks and lorries, by air, smaller size local transport means such as tricycles with flat beds, carts or tuk-tuks, carried by hand, on large and small boats, by donkey or other beasts of burden. During onward transport, the IDTMs will be handled frequently and often under less than optimal conditions. Will be not uncommon for IDTMs to be transported under heavy rain, over bad roads and/or water, or under time pressure in relation to being under fire, working within a limited budget or under the urgency of bringing relief to affected populations. Transport is often done by local companies that have been subcontracted to perform this task. 'Last mile' transport is often done by the future operators of the IDTM, and at times even users of the IDTM, without any professional experience in logistics. During onward transport, it may be that packages are to be opened up for inspection by authorities. Due to these onward transport conditions, packages will be commonly opened up and transported further with the packages split up in parts. This requires easy identification of parts, to reduce the risk of loss or misplacement.
Pre-positioning	In contexts known for recurrence of emergencies, IDTMs can be pre-positioned by the operator. IDTMs can remain pre-positioned for up to

	several years, under difficult conditions due to climate conditions, frequent handling or absence of warehouse equipment.
2. Climate	
Climate	IDTMs will be used in the whole of the populated world, and as such all climatic conditions under the classification STANAG2895 MMS A1-A3, B1- B2 and C0-C2 are applicable. Critical conditions are hot, dry and dusty – risk of excessive heat building up in the IDTM; hot and wet – risk of excessive heat and humidity building up in the IDTM, in combination with heavy rains; cold – risk of excessive heat loss from the IDTM and internal condensation. Windows and doors are used to regulate internal temperatures. They are closed or opened up depending on need.
Climate condition	Minimum requirements for ventilation and temperature control may be maintained by climate conditioning through heating or cooling devices and air vents and/or preferably, when possible, by natural ventilation and sun shading which will optimize energy efficiency and be adapted to local conditions.
Winterization	For use of the IDTMs in cold climates, a winterization add-on may be considered in order to increase the insulation value of the IDTM.
3. Hazards	
Sittings	IDTMs will be set up in a variety of sites, ranging from entirely exposed to the elements to somewhat shielded by the vicinity of trees, buildings or walls. IDTMs will be set up in the entire variety of soil conditions that can be found in the populated world, with reference to ASTM-D2487. Site selection will be done by the operator of the IDTM and in some cases delay in site identification and preparation can occur. Site preparation commonly includes removing obstacles from the site, flattening the site with a soft slope for drainage, building a drainage trench around the IDTM site or pouring a concrete slab to install the IDTM on. This is managed by the operator. IDTMs will be set up in areas with ample space available as well as in densely occupied areas with a high competition for available space.
Hazards	IDTMs will be used in the whole of the populated world, and as such all hazard conditions can be applicable. The IDTM is to remain intact under a wind load of 80km/h (ideally 120km/h) in a broad variety of soil conditions,

	with reference to ASTM-D2487. The IDTM has to remain intact, without the addition of additional support elements, under a snow load of 300N/m². Some contexts in which the IDTMs will be used are vulnerable to fires, flooding or earthquakes.
Violence	Often IDTMs will be used in conflict situations. Fighting parties are made aware of the humanitarian use of IDTMs by clearly marking them with the INITIATE² partner logo. In some contexts however, such marking has an adverse effect on safety, and is removed.
4. Flexibility	
Cultural adaptation	IDTM will ensure cultural adaptation by enabling community engagement, either through space, product or procedures.
Health system integration	IDTM will be adaptable to existing health facilities by indoor or outdoor use.
Modularity	IDTM will be modular to allow fast configuration variation and space organization flexibility, easy to surge, move and expand.
Add-on system design	IDTM design will be based on an add-on system in order to allow a high degree of customizability and adaptability according to climate, use, dimensions and patients' clinical needs (acuity, severity and infectious status).
1. Functionality	
Set-up	IDTMs will be typically set-up / installed by its operators, with possible minor support functions performed by users of the IDTM. In many contexts, the set-up team has not received any training. Operators will refer to the set-up instructions included with the IDTMs. Therefore, the set-up instructions have to be universally understood, and the set-up and installation is to be kept simple and self-explanatory. In quite some contexts in which IDTMs will be used, the operators of the IDTM can access the internet to consult instructions on the web. Storing of packaging material and repair kits is done by the operators of the IDTM, as is labeling of the IDTM and storing of instructions.

Usability	IDTM will be easy to use and will include clear instructions and wayfinding solutions.
Function	IDTMs will be used to safely provide the high quality care needed with dignity, respect, comfort and compassion for patients affected by infectious diseases irrespective of the mode of transmission. IDTMs should allocate space for the following procedures: triage, treatment (including HDU (high dependency care), minor surgery and delivery), resuscitation, isolation, donning/doffing, patient's toilets and showers, morgue and nursing area. Some of the above mentioned procedures can be done within the same space. Watsan preparation, waste management, staff area, staff toilets and showers, storage and pharmacy are not part of the IDTM but should be considered during the design process.
Furnitures and finishes	IDTM will have furniture and finishes that are: cleanable, easy to maintain and repair, resistant to microbial growth, non porous and seamless.
Accessibility	IDTMs will be used also by people living with disabilities across all impairment groups. Critical is allowing easy access for people in a wheelchair, or making use of other mobility support devices. IDTM may be an adjustable space that allows the highest care to patients with special need as per Washington group guidelines.
Privacy	Depending on the actual function of the IDTM, a greater or lesser level of privacy is desirable. Operators may add inner liners or partitions to enhance patient privacy, which can be removed when needed.
IPC and flows	IDMT will ensure the correct IPC measures and flows accordingly to the different infectious diseases and modes of transmission (i.e. airborne, bodily fluids contact). Attention should be paid also to vector control.
Visibility	IDTM will allow medical teams, with minimal training, to comfortably ensure a continuous monitoring of an infected patient, while reducing the risk of contamination. Moreover will enable and promote transparency toward the community.
Safe access to the patient	IDTM will allow medical teams, with minimal training, to check vitals, administering solutes and adapting treatment from the exterior, all while reducing the risk of contamination of people and medical equipment.

Dead body management	IDTM will ensure the correct dead body management while respecting local funeral rituals and ensuring privacy from other admitted patients.
Noise	Measures have to be taken to increase acoustic comfort inside IDTM, whereas it could impact positively on the quality of services delivered.
Rigidizing	In some contexts, for example in areas with water saturated soils, the IDTMs could be fitted with a hard floor.
2. Resource Management (Water, Energy, Waste)	
Electricity	Operators of the IDTM may bring electricity and light into the IDTM, through solar energy or access to local supply.
Water supply	IDTM should ensure connectivity with reliable local water supply. If no water supply system is available, anticipate water trucking, including installation of storage and distribution systems. All equipment in contact with water or chlorine solutions will be made of plastic to avoid damage. All containers, pipes and taps should be clearly labeled or color-coded to avoid confusion between clean water and chlorine solution.
Waste water	IDTM should ensure that wastewater from patients' showers, sinks, handwashing points and laundry will be treated properly according to existing effluent standards.
Sanitation	IDTM will include isolation rooms with individual Menstrual Hygiene Management (MHM) friendly toilets and showers.
3. Maintenance and durability	
Maintenance	IDTM has low, simple and low-cost maintenance requirements. Maintenance procedures and schedule will be clearly specified in the instructions documentation. Regular cleaning and disinfection of IDTMs is done by the operators of the IDTM. Most likely the operators of the IDTM have received no prior training in maintenance of the IDTM.

Durability	IDTM will be typically used in the first four weeks of an intervention, with the possibility of integrating the solution under the form of a surge plan. An IDTM thus needs to keep its full functionality for at least 18 months, and preferable for 24 months to allow for leaway in the start of recovery or replacement by more durable solutions. Factors that are known to negatively impact the durability of emergency modules are exposure to UV, exposure to humidity causing rot, dust, insufficient drainage, strong wind, snow load, inadequate set-up, maintenance and operating.
Shelf life	The IDTM will have a shelf-life of minimum 5 years, under normal storage conditions, in dry, clean, and ventilated warehouses. It should be elevated from the ground, not piled, stored on pallets and pallet racks, not in containers or in tented warehouses.
4. Post-operational management	
Re-fitting, repacking and reusing	IDTMs may be taken down and stored for the rainy season, interrupting activities and keeping the IDTMs safe from wind and water damage. In other contexts, IDTM will perform a certain function for a short while, will be then packed up and moved to another location in the same operation, to perform the same or a different function. With the increase of quality of emergency modules such practices are expected to increase.
Transformation and re-use of pieces	The IDTM, after it has fulfilled its initial role, may be transformed or parts of it are re-used.
Discarding	In most contexts, there is little system in place to deal with emergency modules that are no longer usable. Operators of emergency modules resort to soil burial, burning, or find their way to the local recycling industry that does not always operate to the highest standards for environmental safety and people's safety and health. The choice of the IDTM building materials will take into consideration the above mentioned common discarding procedures and legislations.
5. Cost	

Purchase cost	The purchase cost of the IDTMs has to be kept as low as possible to enable reaching as large as possible portion of the affected population.
Operational cost	The quality of the IDTMs has to be in balance with the purchase cost and the additional cost presented by international sourcing, and with its intended function and duration of use. The cost of climate conditioning has to be kept as low as possible, by reducing heat building up inside the IDTMs in hot climates, and maximizing the insulation value of the IDTMs through winterization.
6. Timelines	
Emergencies	IDTMs will be commonly used in emergency settings, where timely delivery of services to affected populations can be life-saving. The capacity of INITIATE² partners to provide such services is dependent on the timely availability of fit-for-purpose spaces. Impacting negatively on the timely availability of IDTMs are mostly the mobilization and transport process and, once IDTMs have reached their final destination, the set-up complexity.
7. Testing and Certification	
Evidence or Research	IDTM will provide Evidence of Research and proof of relevant testing and certification
Policy Compliance	IDTM in all its parts will comply with main international products norms and standards https://europa.eu/youreurope/business/product-requirements/compliance/index_en.htm
CE marking	IDTM will carry CE marking

Link between Key drivers, design principles and product requirements

Key Drivers	Design Principles	Product Requirements
Humanized Care	Contact Enabling Design	Flexibility Functionality
Environmental Sustainability	Climatic Responsive	Climate

	and Energy Responsible	Resource Management
Disaster Resilience	Resilience to Disruptive Phenomena	Hazard
Accessibility and Inclusiveness	Accessibility and Inclusiveness	Functionality
Cultural Adaptation	Adaptability/Modularity	Flexibility
Deployment and installation rapidity	Constructability	Supply Chain
Circularity	Cradle to cradle and reuse design-based	Post-Operational Management
Sustainable maintenance	Minimum and local maintenance	Durability and Maintenance
Health System Integration	Adaptability/Modularity	Flexibility
Usability	Usability	Functionality Resource Management
Transportability and storability	Transportability	Post-Operational Management

Annex 4: Create phase, IDTM mock-up scenarios

Patient information	**Ernst Meier**	Age **46 y** Height 185 cm Weight 75 kg	Specials:
Briefing	Patient is isolated in the unit with confirmed infection with pathogen X (airborne transmission) on day 5 in quarantine. During lunch, the patient shows signs of difficulty in breathing. Patient history: no pre-existing conditions Medication: no medication		
Information for Instructors	Patient develops an allergic reaction to nuts in the meal he is eating. Rapid progress with respiratory distress and hypotension. No staff in the red area, needs to be donned before accessing the patient, medication needs to be provided to red zone		
Hot Seats	2x Nurse 1x Physician		
Instructorteam	2x Simulationinstructor 1x Technician 1x SimNurse		
Scenario issues	**Anaphylactic reaction with obstructed airway / circulatory problems**		
Learning objectives	• Critical incident is identified quickly • Patient is attended within adequate time • Adequate treatment is provided in adequate time • Medical Management kits are used correctly		

<table>
<tr><td> 
Material / Simulationequipment</td><td>Room

• Isolation Unit
• Stretcher / Bed
• Vital parameter monitor
• Defibrillator
• Oxygen / Airway
• i.v. / infusion / ampoule kit (adrenalin, corticoide)
• Emergency pack</td><td>Patient / Simulator

• Patient Simulator (SimMan 3G) or actor (+ Intubation mannequin)
• i.v. cannula / infusion right forearm</td><td>Gimmicks/Requisites

• Personal Protective Equipment 3x
• Lunch</td></tr>
<tr><td> 
Simulation Control</td><td colspan="3"><table>
<tr><th></th><th>Start settings</th><th>Process</th><th>Under therapy</th><th></th><th>Anamnesis</th></tr>
<tr><td>ECG</td><td>Sr</td><td>Sr</td><td>Sr</td><td rowspan="3">S</td><td rowspan="3">Dyspnea since lunch</td></tr>
<tr><td>HF</td><td>110 /min</td><td>160 /min</td><td>120 /min</td></tr>
<tr><td>SpO_2</td><td>93 %</td><td>85 %</td><td>91 %</td></tr>
<tr><td>BP</td><td>140/ 90 mmHg</td><td>70 / 50 mmHg</td><td>90 / 50 mmHg</td><td>A</td><td>Allergic to nuts</td></tr>
<tr><td>$etCO_2$</td><td>40 mmHg</td><td>30 mmHg</td><td>30 mmHg</td><td>M</td><td>-</td></tr>
<tr><td>RespR</td><td>20 /min</td><td>35 /min</td><td>/min</td><td>P</td><td>-</td></tr>
<tr><td>Temp.</td><td>37,8 °C</td><td>37,8 °C</td><td>°C</td><td>L</td><td>5 minutes ago</td></tr>
<tr><td>BloodSug</td><td>102 mg/dl</td><td>102 mg/dl</td><td>mg/dl</td><td>E</td><td>-</td></tr>
<tr><td>Pupils</td><td>3 mm / 3 mm , LR + / +</td><td>4 mm / 4 mm , LR + / +</td><td>mm / mm , LR /</td><td>R</td><td>-</td></tr>
</table>
Lungsound: Obstruction
Patient shows signs of dyspnea, coughing, obstruction.
Rapid progress with beginning altered mental status (GCS 8) due to hypotension.</td></tr>
<tr><td> 
Szenario Saver</td><td colspan="3">Too easy: progress of airway swelling with difficult airway (need for surgical airway)

Too difficult: fast response to adrenalin and mild anaphylaxis</td></tr>
<tr><td> 
Specials / Debriefing</td><td colspan="3">• Criteria to identify a critical ill patient
• Patient is attended within adequate time
  ○ Time needed for donning the PPE and begin of treatment
• Adequate treatment is provided in adequate time
• Medical Management kits are used correctly</td></tr>
<tr><td> 
Literature</td><td colspan="3"></td></tr>
</table>

Patient information	**Jonathan Schmid**	Age **12 m** Height 85 cm Weight 10 kg	Specials:
Briefing	Patient is brought to the isolation unit together with his mother, both suspect of infection with pathogen X (airborne transmission). Since 2 days dyspnea and coughing. Patient history: no pre-existing conditions Medication: no medication 1 Nurse with PPE in the isolation unit		
Information for Instructors	Within triage the patient's status worsens with altered mental status and progressing signs of dyspnea. • Hypoxia due to infection of lower airways • Hypotension due to septic shock		
Hot Seats	2x Nurse (1x with PPE in isolation unit) 1x Physician		
Instructorteam	2x Simulationinstructor 1x Technician 1x SimNurse 1x Actor (mother)		
Scenario issues	**2 Organ dysfunction (Hypoxia and septic shock) in pediatric patient**		
Learning objectives	• Critical incident is identified quickly • Patient is attended within adequate time • Adequate treatment is provided in adequate time • Medical Management kits are used correctly • Standard care can be provided to all patient groups • Visibility and physical contact is possible • Evaluation of unit-space for treatment of 2 patients (mother + child)		

	Room	Patient / Simulator	Gimmicks/Requisites
Material / Simulationequipment	• Isolation Unit • Stretcher / Bed • Vital parameter monitor • Defibrillator • Oxygen / Airway (Children) • i.v. / infusion / ampoule kit (for children) • Emergency pack	• Patient Simulator (SimBaby) and actor (mother)	• Personal Protective Equipment 3x

Simulation Control

	Start settings	Process	Under therapy	Anamnesis	
ECG	Sr	Sr	Sr		
HF	160 /min	190 /min	140 /min	S	Dyspnea with cough for 2 days
SpO_2	88 %	84 %	91 %		
BP	70/ 90 mmHg	50 / 35 mmHg	90 / 50 mmHg	A	-
$etCO_2$	40 mmHg	30 mmHg	30 mmHg	M	-
RespR	45 /min	55 /min	/min	P	-
Temp.	39,8 °C	39,8 °C	°C	L	1 day ago (did not want to eat)
BloodSug	66 mg/dl	68 mg/dl	mg/dl	E	-
Pupils	3 mm / 3 mm , LR + / +	3 mm / 3 mm , LR + / +	mm / mm , LR /	R	-

Lungsound: Pneumonia
Patient shows signs of dyspnea, coughing.
Rapid progress with beginning altered mental status (GCS 8) due to hypotension.

Szenario Saver

Too easy: Getting comatose -> need for intubation

Too difficult: getting better when given i.v. volume

Specials / Debriefing

- Critical ill pediatric patient is identified quickly
  - Scores / signs of critical ill pediatric patients
- Patient is attended within adequate time
  - Without risk of self-endangerment of staff
- Adequate treatment is provided in adequate time
  - Treatment of hypoxia and hypovolemia
- Medical Management kits are used correctly
- Visibility and physical contact is possible
- Evaluation of unit-space for treatment of 2 patients (mother + child)

Literature

Annex 5: Create phase, IDTM mock-up instructions

Materials

Mock-up

Materials:	Quantity
Cardboard roll 1 meters wide	20 meters
Tape 2 different colors 50m (Green, Red)	2 x 10 rolls
Masking tape (strong) 50 m x 50 mm	7 rolls
Plywood 30mm, 50x50 cm or 40x50 cm	15 pcs
Timber profile 40x40 mm x 2m	15 pcs
Screws pack 2cm woodscrews	1 pack
Steel L-shaped clamp. approx. 50x50 mm(or 60/70) x 40 mm	60 pcs
Cutter	1 pcs
White Chalks	40 pcs
Rope approx. 1,5 mm	200 meters
Surveying Tape Measure 50m	1
All metal push pins 1 cm long approx	Set of 150 pc

Cardboard

Colored tape

Masking tape

Plywood

Timber profile

Steel L-shaped clamp

Metal pins

Rope

Chalk

Materials

Simulation

Materials:	Quantity
Patient Intensive Care Bed	1
Ventilator T1	1
Infusion Pumps	5
Personal Protective Equipment	10
Medication	
Infusion Stands	1
Patient Monitor	1
SimMan 3G	3
SimBaby	1
Wheelchair	1
Stretcher	1
Preped Medical Catheters 2 Set	2

Site

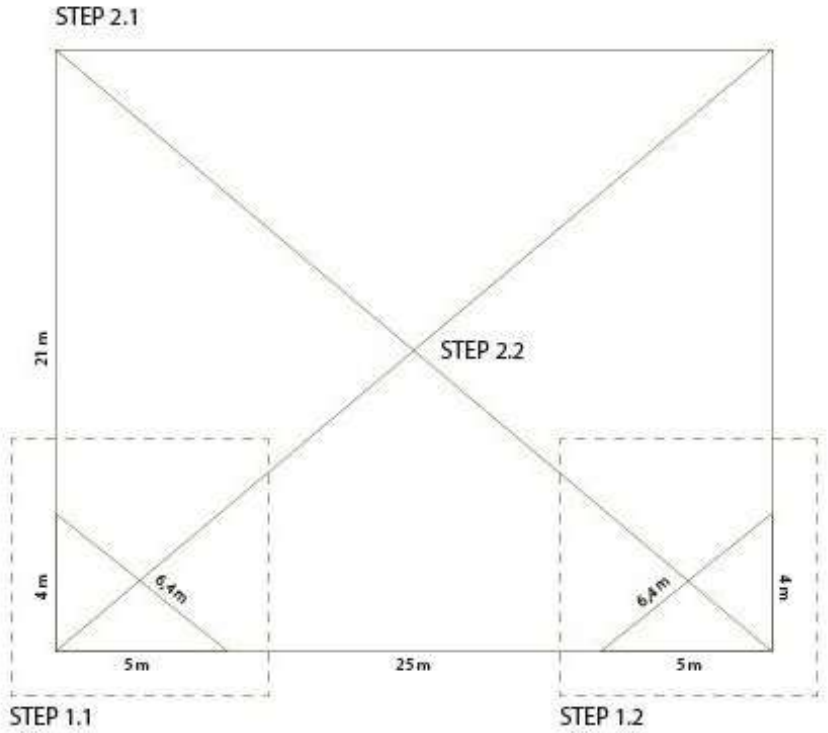
The site should be characterize by:

- Minimum site dimension of 29 x 25 meters
- Flat surface
- Hard finishing, to write with chalks

Further considerations:

- Parking areas, pavement courtyards, gyms or canteen are suitable locations
- Covered areas allow to run the simulation with bad weather

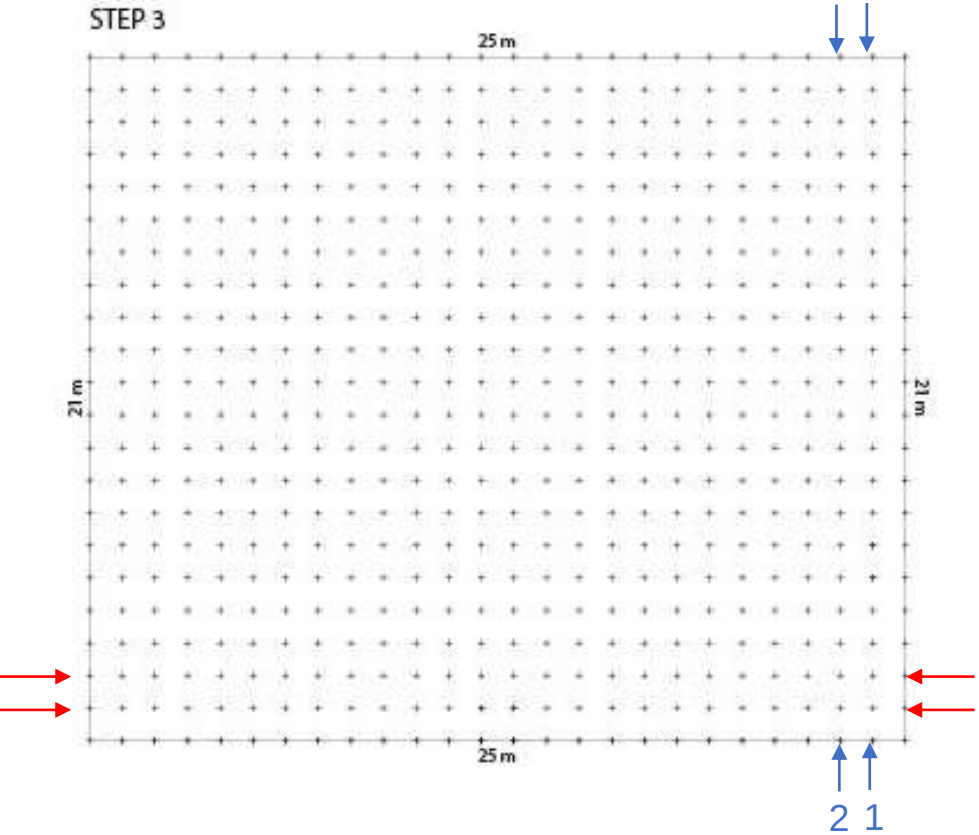
Steps mock up set up



STEP 1: draw a 90* angle
1.1. Draw a triangle with 1 side of 4 m, 1 side of 5 m and 1 side of 6,4 m.
1.2. Repeat the same on the opposite side

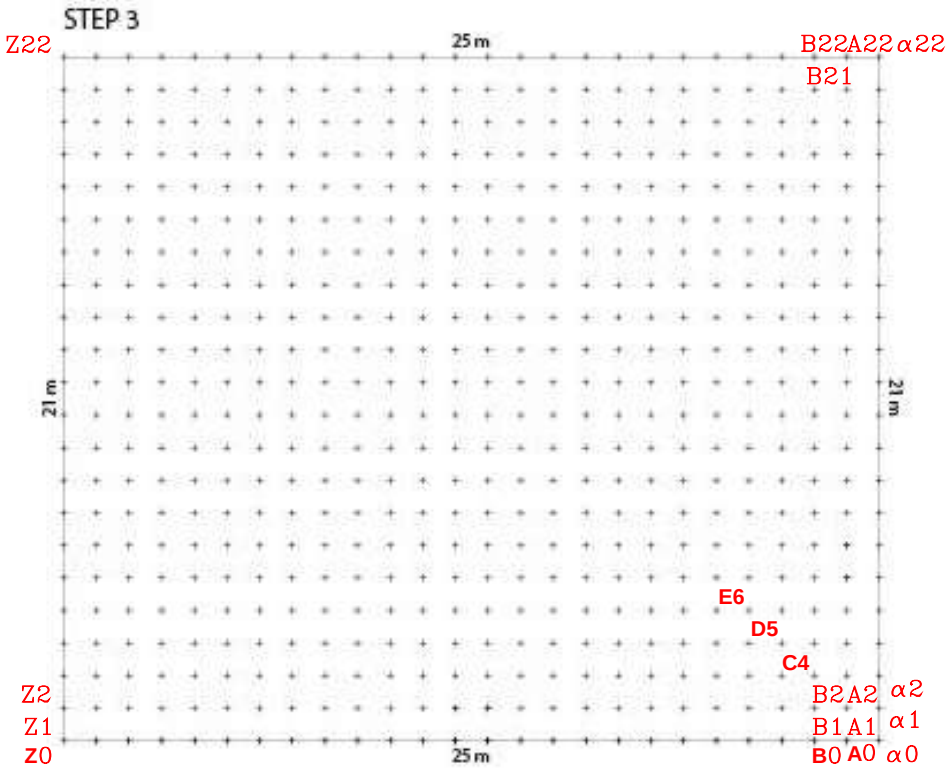
STEP 2: draw the exterior fancies of the treatment center
2.1. Following the 90* angles, draw a rectangle with 2 sides of 25 m and 2 sides of 21 m
2.2. To check if you draw correctly the rectangle, measure the diagonals that should have a dimension of 32,65 m each

Steps mock up set up



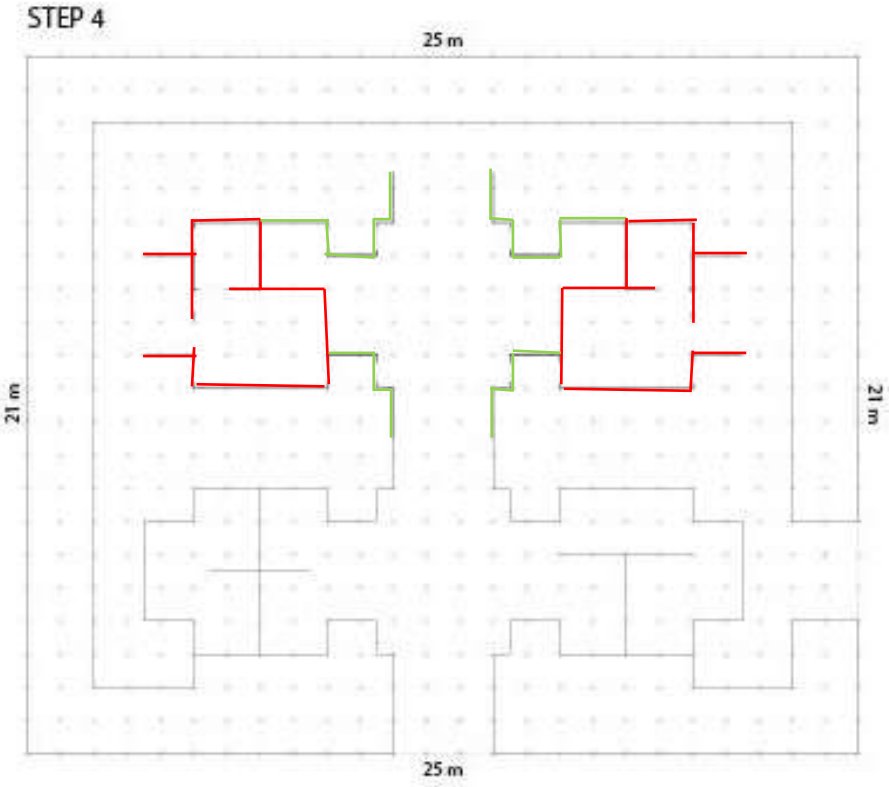
STEP 3: the grid
Draw a grid 1 m x1 m.
1)Start from the line highlighted with red arrows in the drawing
2) Continue with the parallel lines
3) Conclude with perpendicular lines highlighted in blue

Steps mock up set up



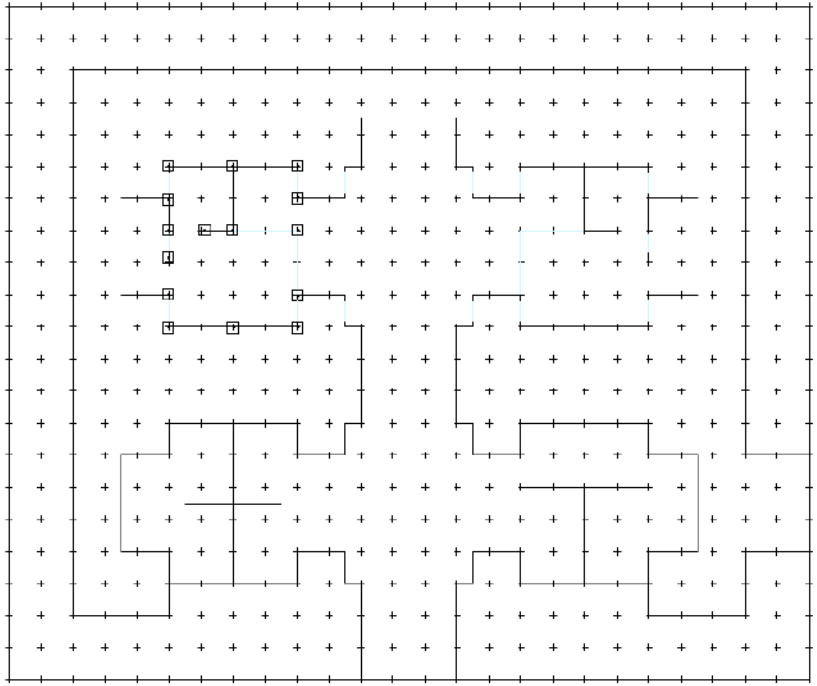
STEP 3: the grid
Draw a grid 1 m x1 m.
4) Write the coordinates in each cell
Use the English alphabet

Steps mock up set up



STEP 4: the module
4.1. Based on the grid 1 m x1 m, start drawing the INITIATE2 module. The tape on the ground simulates the presence of walls/vertical partitions
Use red tape to delimitate red zones and fences
Use green tape to delimitate green zone
Use white tape for the other areas

Steps mock up set up



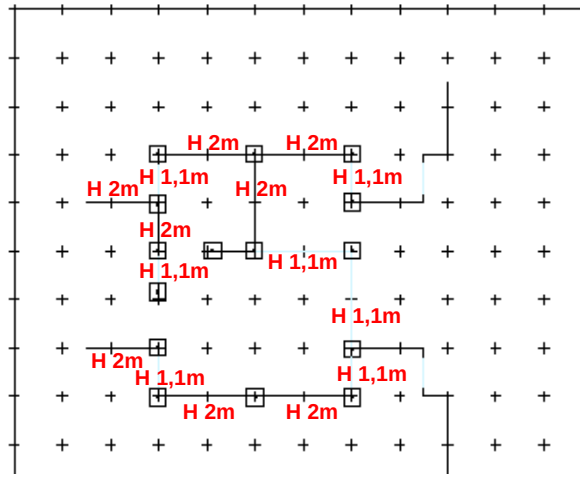
STEP 5: Poles

Fix the timber profiles on plywood bases using the *Steel L-shaped clamp.*

The poles should be located in the highlighted corners.

Only one patient room will be set up with poles and partition for simulation purpose

Steps mock up set up

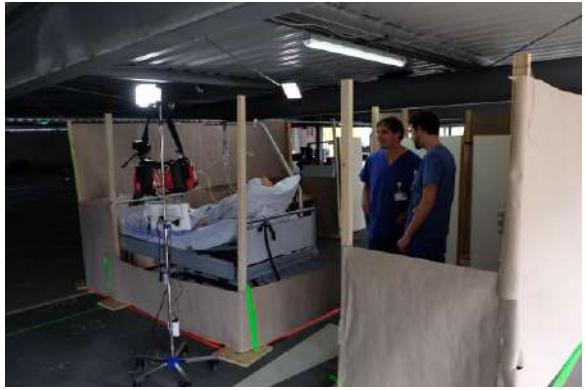


STEP 6: Partitions
Use metal pins to fix the cardboard on poles, simulating the module partitions.
Check before the openings (doors, windows) location

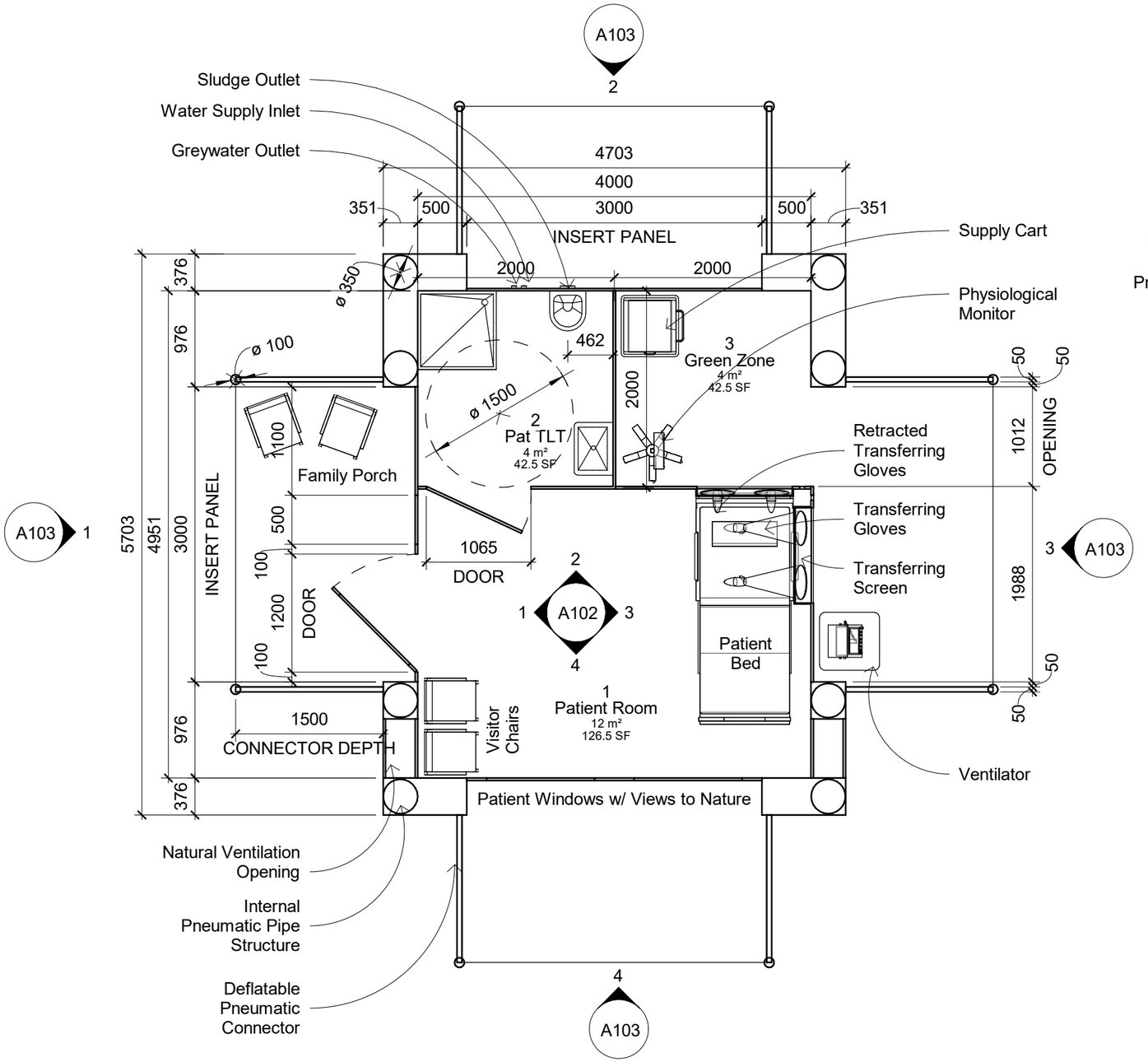
Simulation





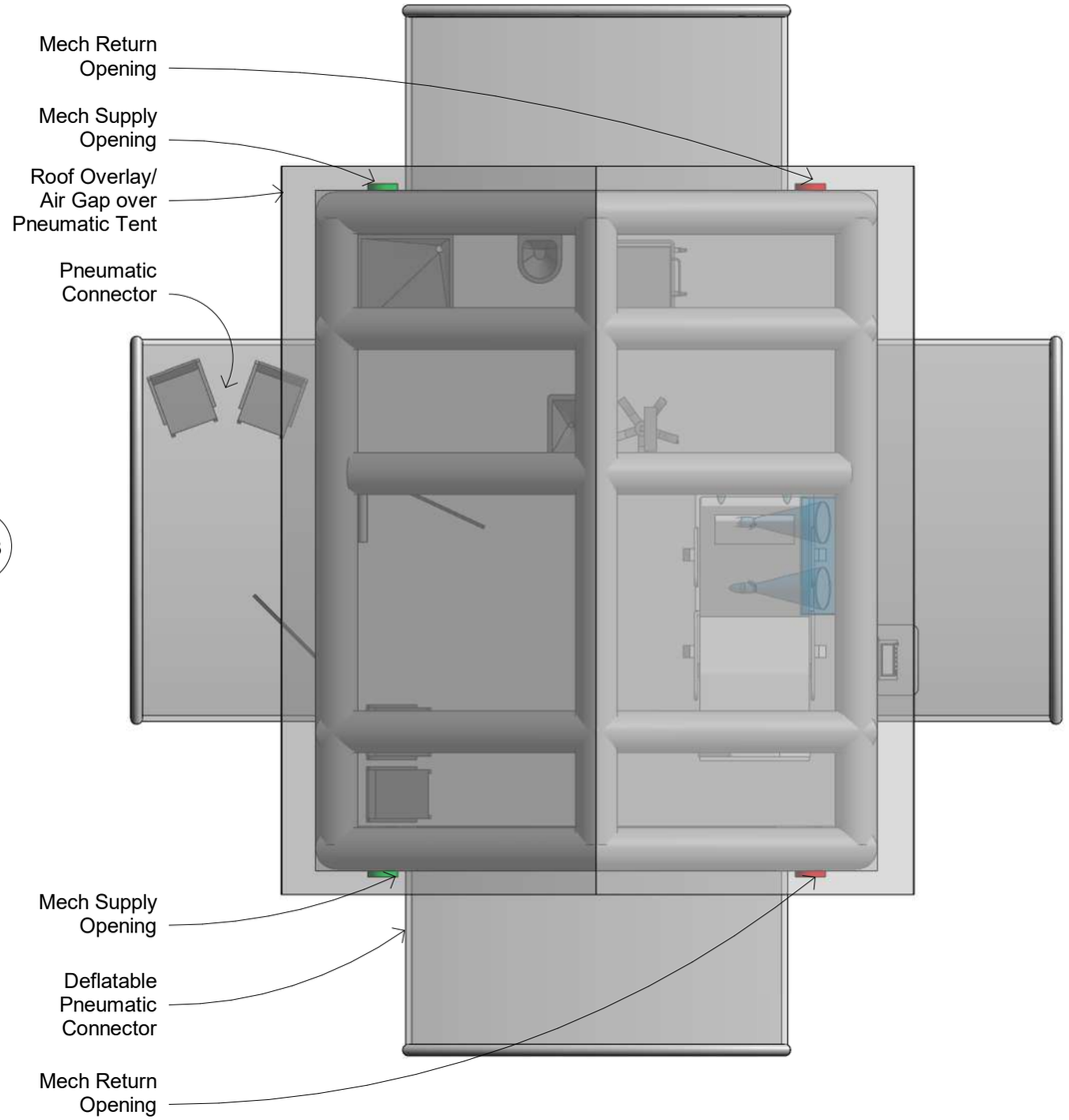



Annex 6: Create phase, Design Proposal

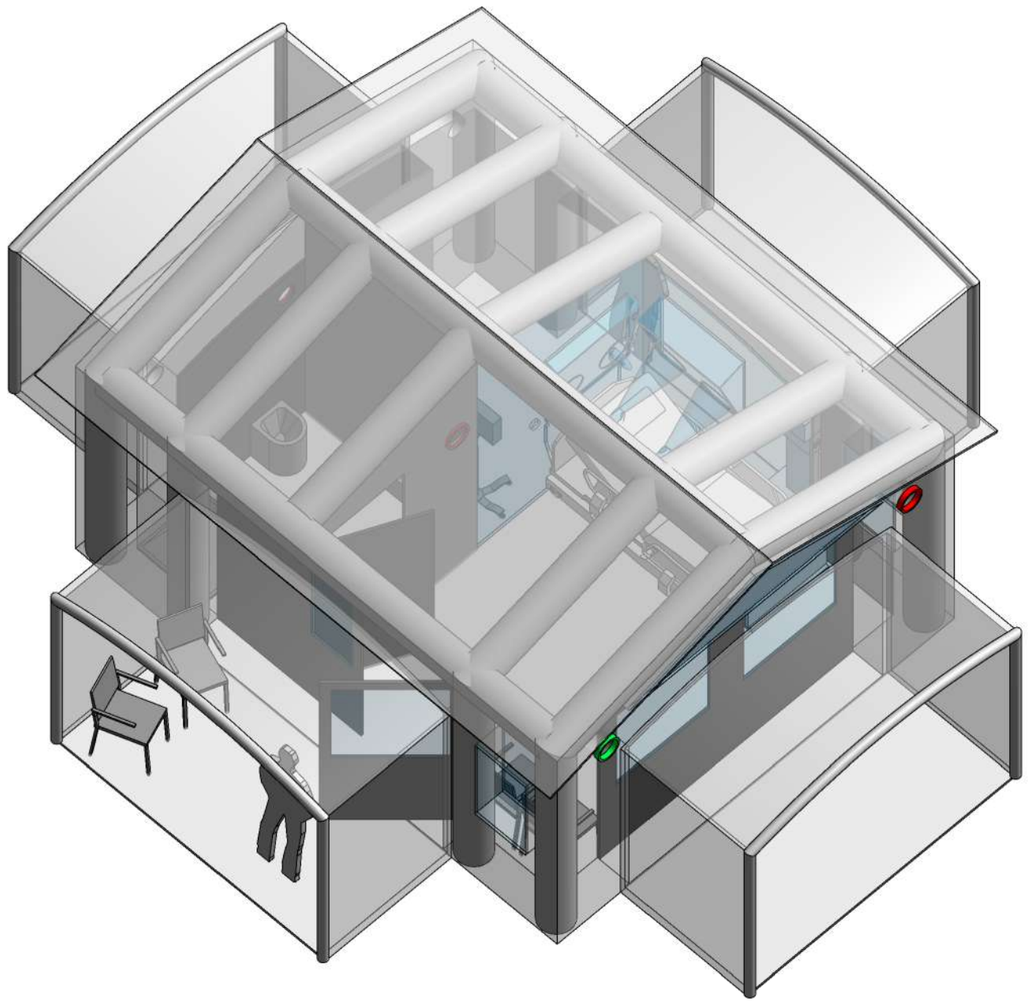


1 Floor Plan

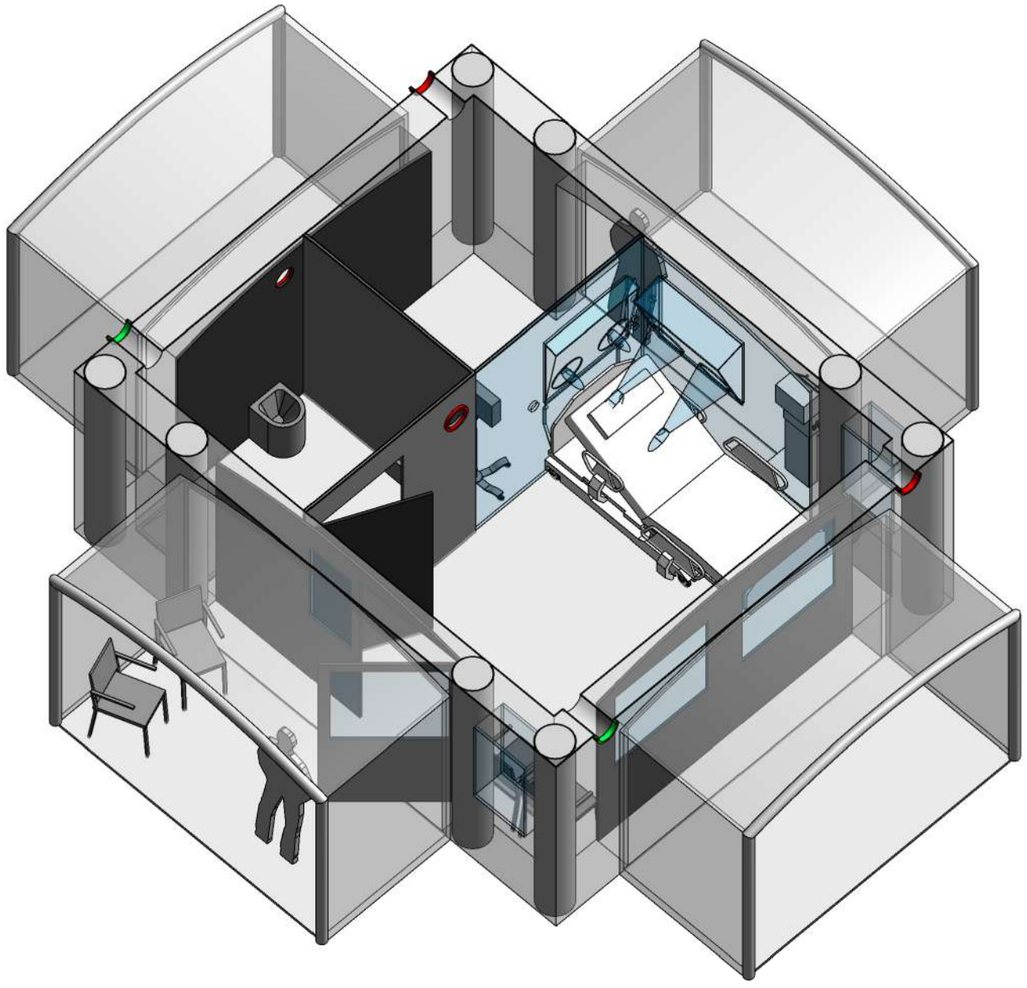
1 : 50



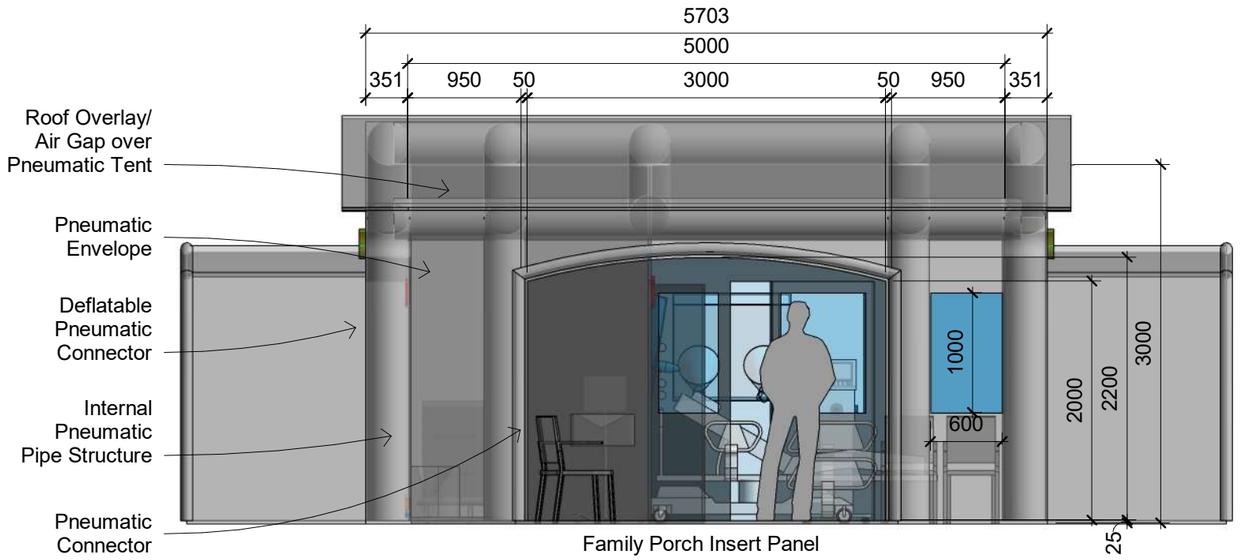
2 Roof Plan



1 3D - Patient Pod w/Roof

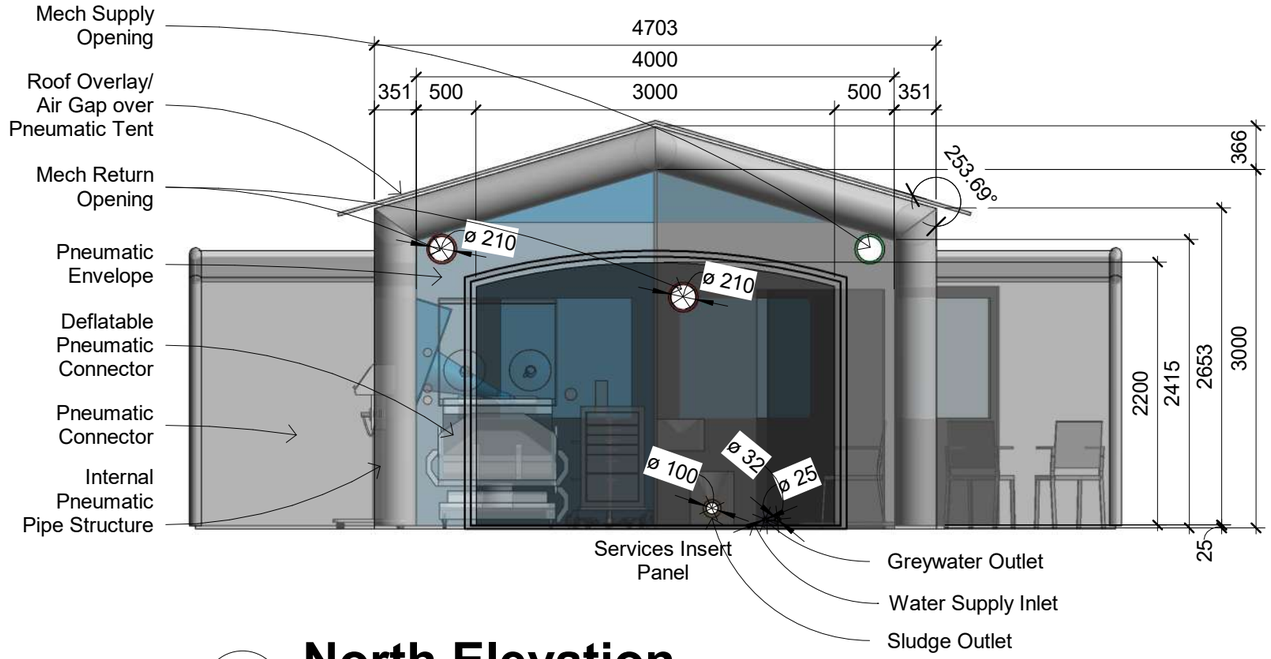


2 3D - Patient Pod w/No Roof



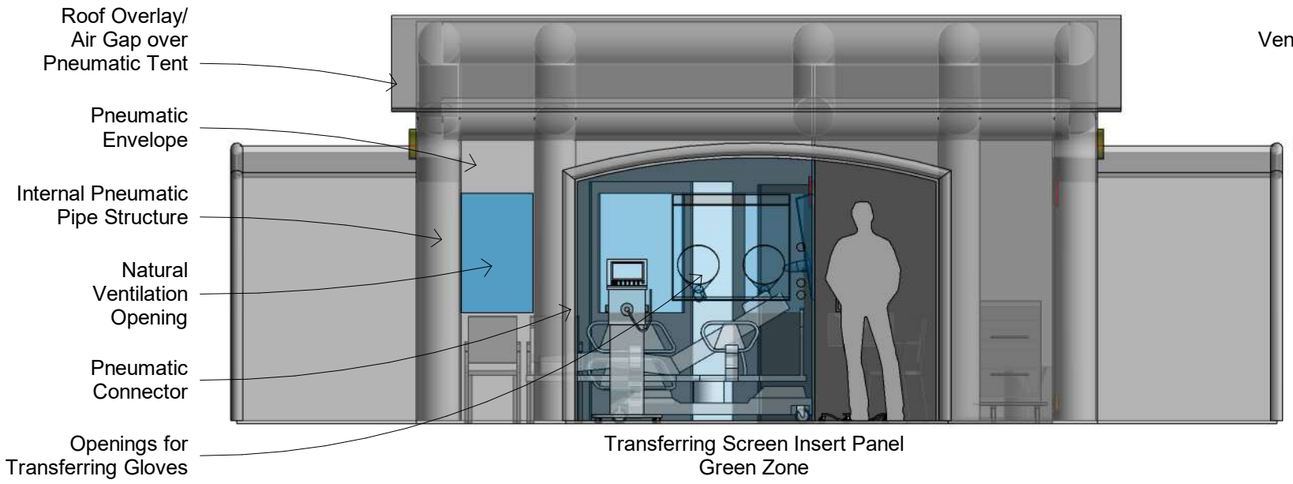
1 West Elevation

1 : 50



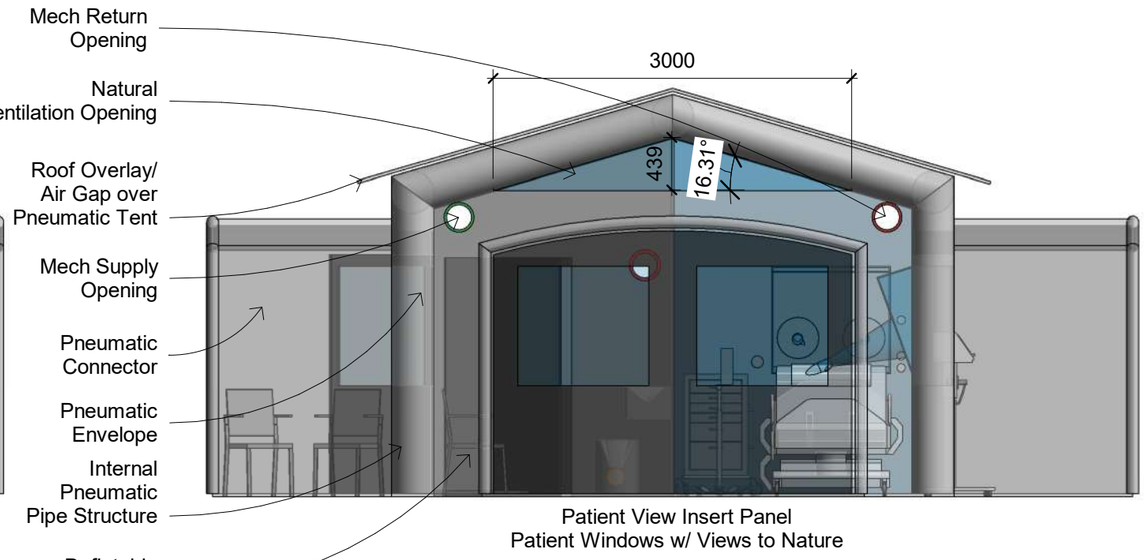
2 North Elevation

1 : 50



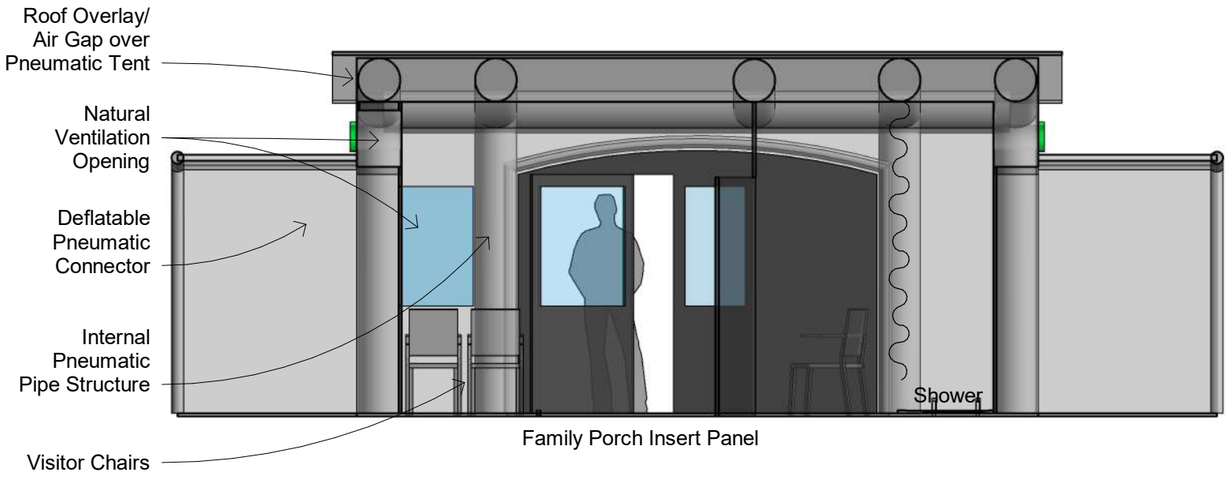
3 East Elevation

1 : 50



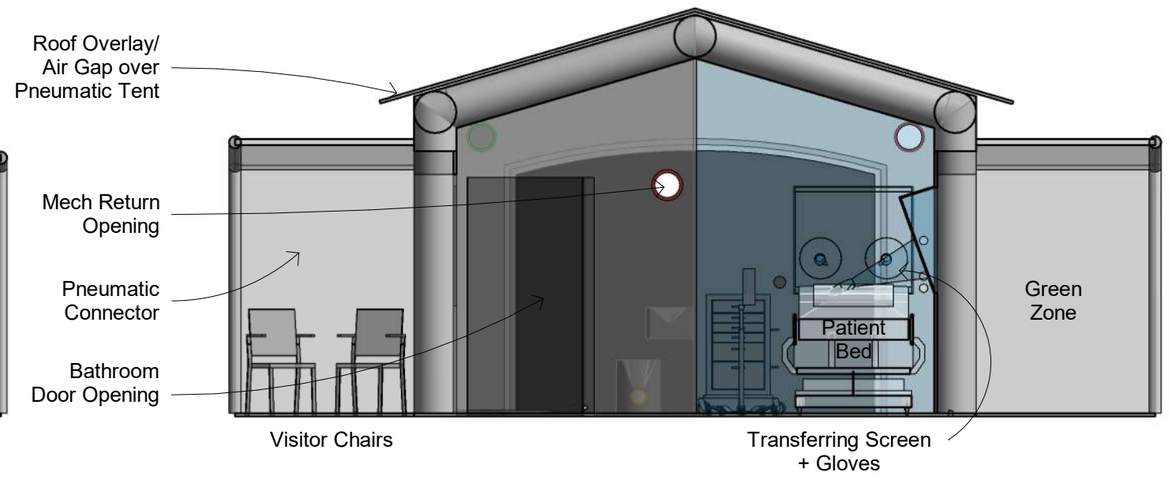
4 South Elevation

1 : 50



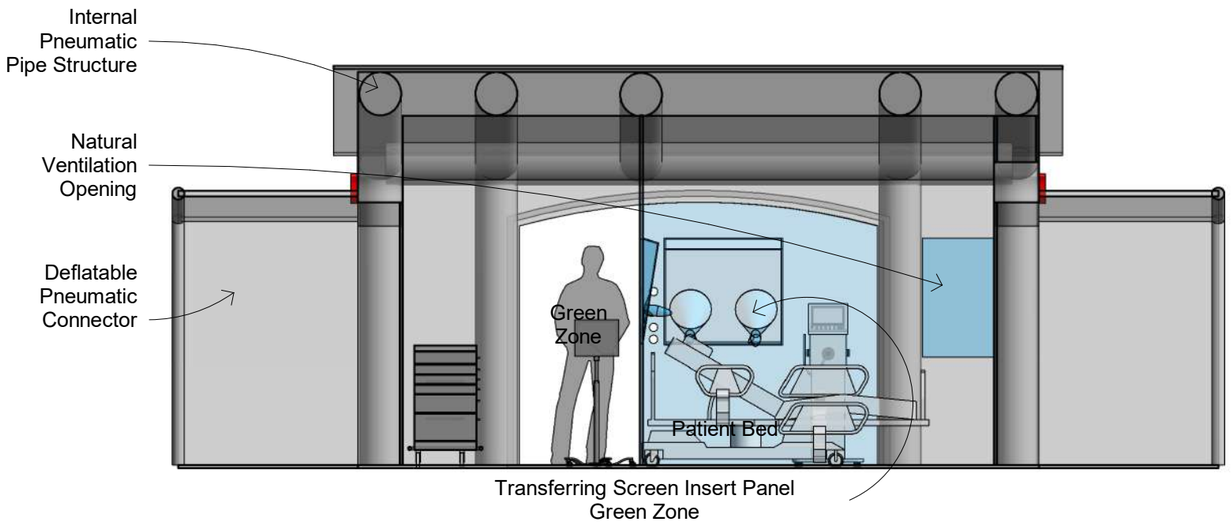
1 West Interior Elevation

1 : 50



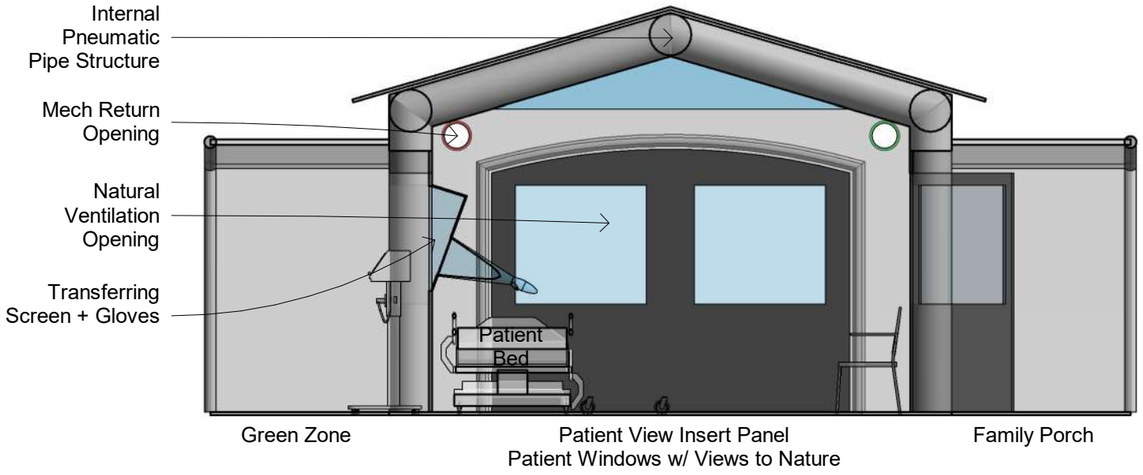
2 North Interior Elevation

1 : 50



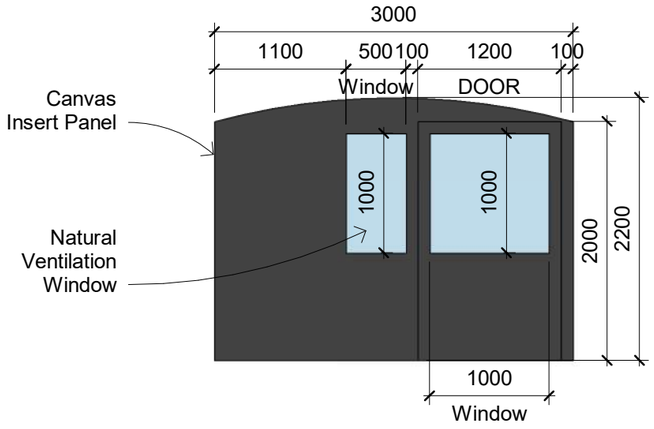
3 East Interior Elevation

1 : 50



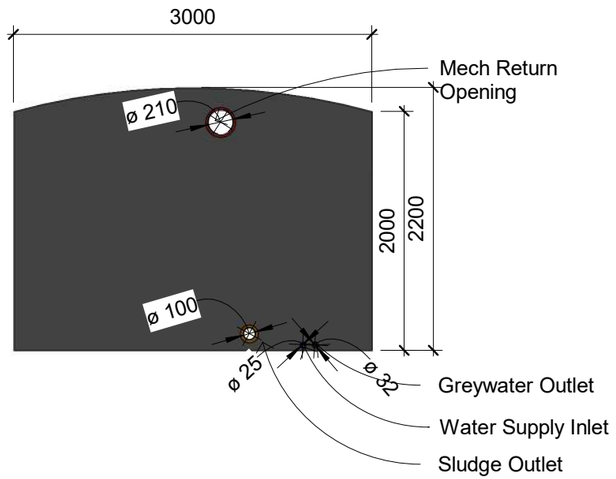
4 South Interior Elevation

1 : 50



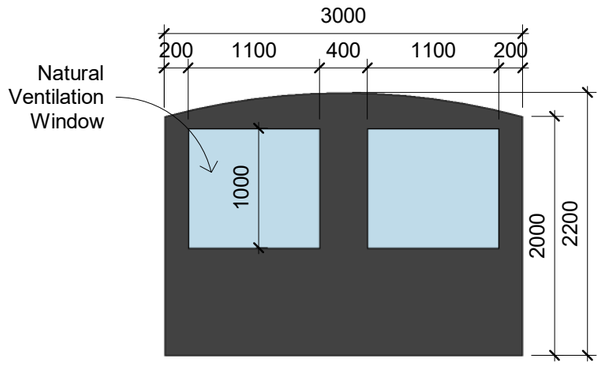
1 Family Porch Insert Panel

1 : 50



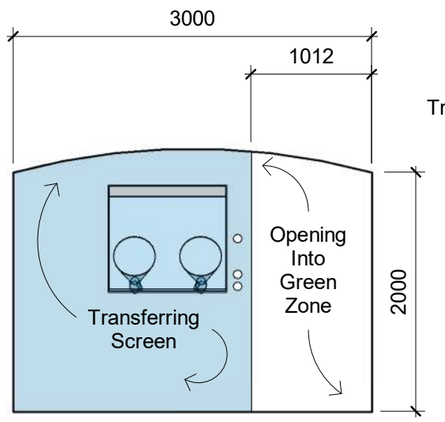
2 Services Insert Panel

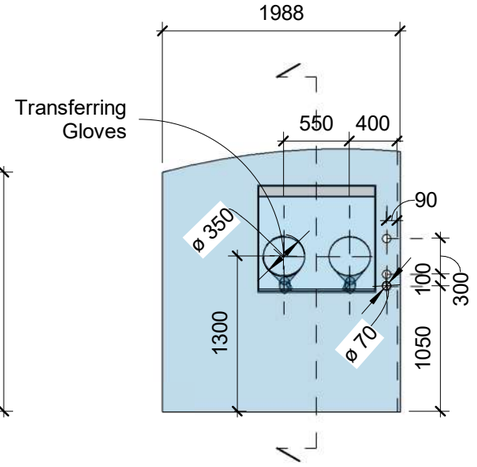
1 : 50



3 Patient View Insert Panel

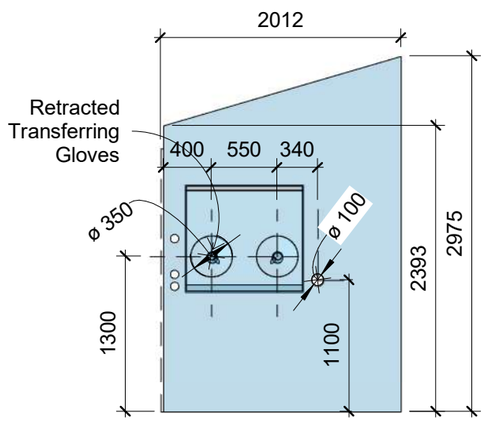
1 : 50

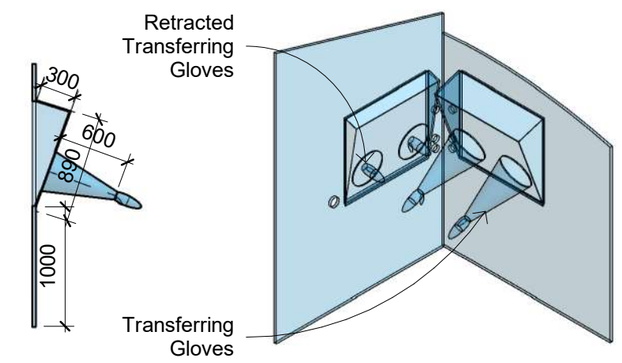




4 Transferring Screen Insert Panel

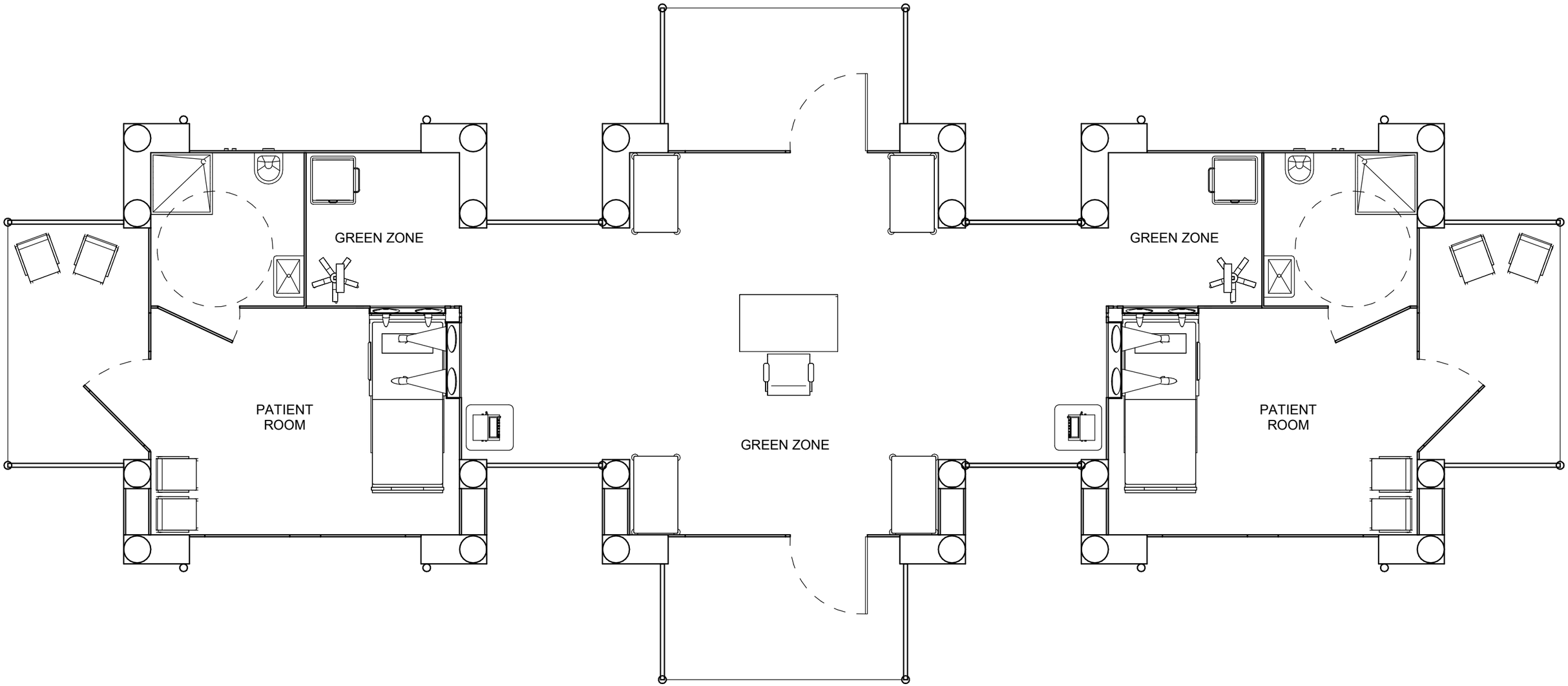
1 : 50





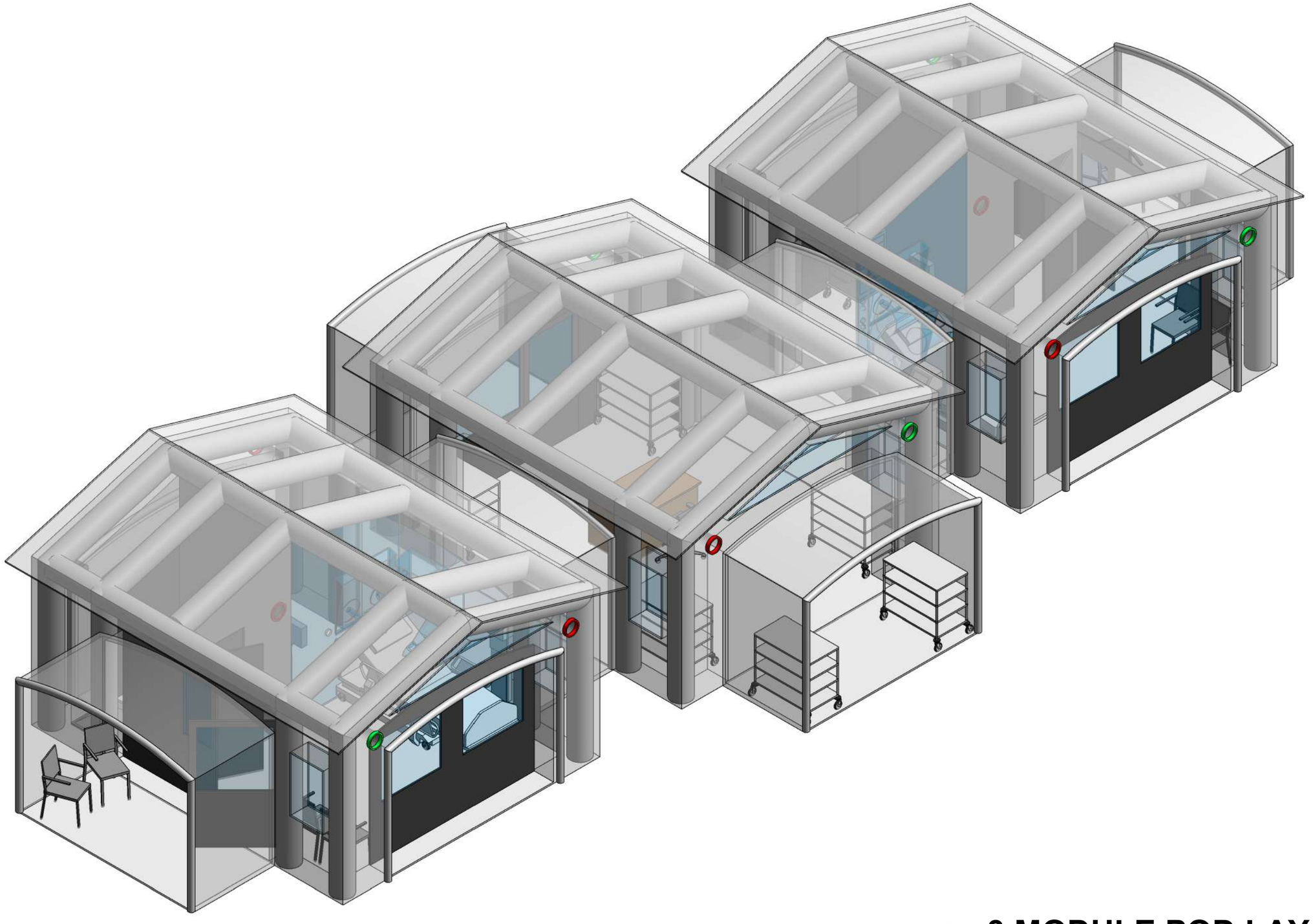
5 Transferring Screen from Green Zone

1 : 50

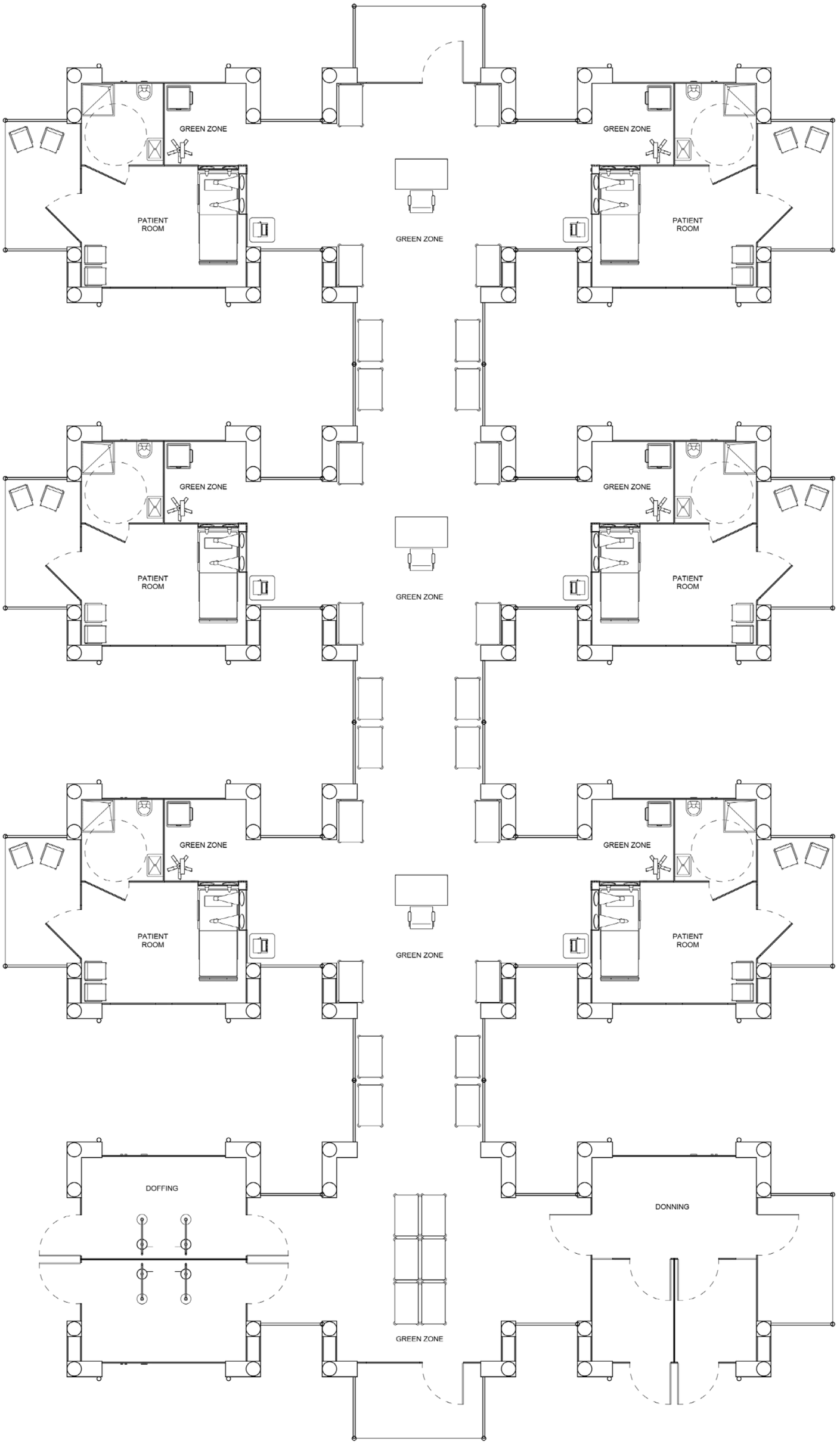


1 3 Pod Layout

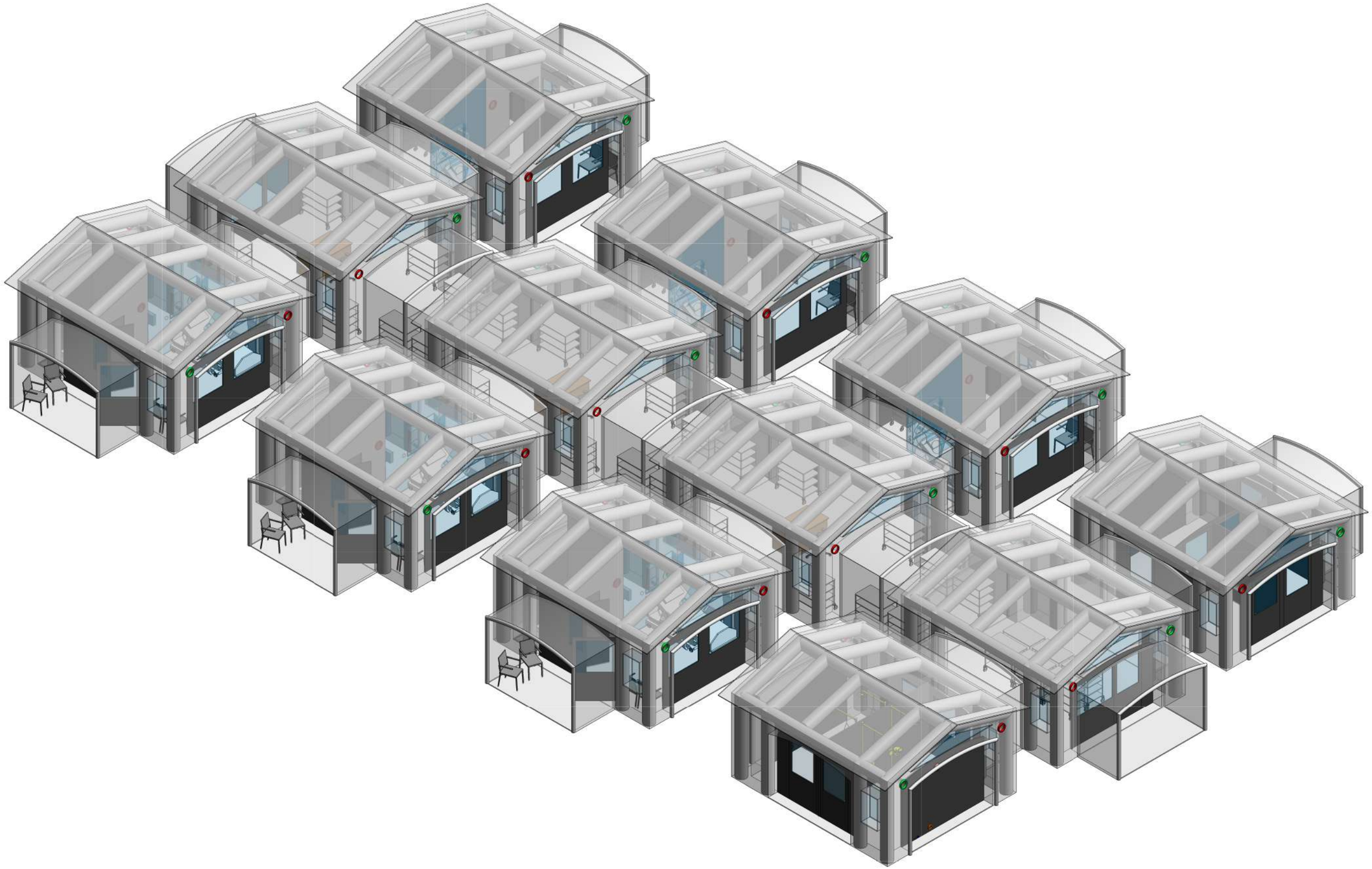
1 : 50



1 **3 MODULE POD LAYOUT - 3D**



1 **12 Pod Layout**
1 : 50



1 **12 MODULE POD LAYOUT - 3D**

Annex 7: Create phase, Natural ventilation

Theoretical background

Quantitative modelling and theories are largely used in different fields to properly quantify risks and probabilities of hazardous events. Epidemic modelling has struck back again in these days due to the COVID19 emergency. The quantitative models describe the probability for an individual, or for a group of people, to be infected in specific conditions (type of environment, time of exposure, source characteristics, etc.). There are mainly two types of approaches: Wells-Riley (WR) model and the Dose–Response Model.
The W-R theory was developed during ’70s and ‘80s and constitutes the scaffold for the airborne transmission of multiple epidemics such as tuberculosis, measles and influenza. The theory ascribes the responsibility of airborne transmission to very small particles called “droplet nuclei”, a conglomerate of organic matter, containing micro- pathogens and emitted through the respiratory activity. Being extremely lightweight, droplet nuclei are scarcely influenced by the gravity field and follow mainly the typical Brownian motion. This characteristic makes concrete the possibility of having particles floating in the airfrom several minutes to hours starting from their original emission. The presence of droplet nuclei floating in the air influences drastically the infection path, not anymore related only to direct/indirect contactsbetween people and fomites, but also to the interaction with “the air you breathe and the environment you live”. Droplet nuclei, generally identified as particles with aerodynamic diameter lower than 5 μm, may be generated following two different paths: directly emitted by infective subjects through talking, sneezing, breathing, or because of evaporation of bigger droplets after the emission. The diameter distribution of emitted droplets covers a wide range, with a large component of particles bigger than 20μm.After the emission, the fall of droplets is mainly driven by the gravity field and disturbed by the local air convection but, if the evaporation of water through this phase is sufficiently fast, once the diameter is smaller than 5μm the initial droplet becomes a droplet nucleus.

Given this physical condition, the possibility to get the infection after the interaction with a droplet nucleus is a stochastic event strongly connected to the residence time of a susceptible person in a closedvolume (V) containing dispersed droplet nuclei. The WR model quantifies the probability of this event. The formulation exploits a Poisson probability distribution and the concept of quanta (q): a statistical entity, specific for a type of disease, defining the needed number of infective particles leading to numberof infected person equal to the 63.2% of the susceptible sample. The WR model is based on different hypothesis and limitation:

1. The selected volume must contain at least one infectious subject.
2. The minimum viral load, called “quantum” must be known and must be constant.
3. The susceptible person is considered infected by breathing one quantum.
4. The quanta distribution in the volume is considered homogeneous as well as a perfectly mixed air.
5. The viral load is removed at a constant rate by the fresh air stream.
6. Steady-state conditions with initial quanta concentration equal to 0.

The WR model is suitable in case of quick evaluation, due to the minimum set of data requested. The assumption of perfectly mixed indoor air, that implies a homogenous concentration of pathogen, allowsa simple relation between probability of contagion and air change/ventilation flow rate to be leveraged. Nevertheless, it is reasonable to think that the pathogen concentration is higher closer to the infectioussubject and it will be affected by the airflow topology in the indoor volume. This is particularly true wherethere is not mechanical ventilation or indoor fans that ensures a forced mixing of the air.

Various modifications to this model were proposed to consider filtration, air disinfection, respiratory

protection, etc. For instance, the Gammaitoni – Nucci model (GN) allowed to overcome the limitation represented by steady-state conditions through the adoption of differential equations. Using the GN model it ispossible to consider an initial quanta concentration in the room different from 0. This fact for instance isnecessary to simulate the passage of an infectious subject over dynamic evolution of the model. Nevertheless, the assumption of air perfect mixing remains a required condition for the GN model. Nonetheless, it is known that a perfect mixing is far from being achieved and local effects in the volume can playa role in pollutant distribution, depending on the air system configuration features, like air supply and exhaust positions, supply air velocity, supply air temperature and turbulence characteristic of the supplyjet. Moreover, different particles can interact in different ways with the air flows in an indoor environment,depending on their size and on the local air flow turbulence conditions. In the case of naturally ventilated buildings, the perfect mixing hypothesis is not always verified due to primary air streams that causedifferent volume distribution of fresh and exhaust air. Nevertheless, the hypothesis of perfect mixing is closer to the reality when large fresh air flow rates are involved even in the case of natural ventilation. Indeed, the larger the Air Change Rate the bigger the contaminant dilution effect and thus the influence of internal gradients of concentration.

Methodology and methods

To assess the performance of the IDTM simulations were undertaken through Energy Plus - Design Builder. This software allowed the ACR of the patient room to be calculated on an hourly basis. The TMY of city Bangui (368 a.s.l.), in Central African Republic were used as reference to simulate the climatic boundary conditions. Each room was listed as a single zone and it was considered occupied by a single patient 7/7 days and 24/24 hours.

Moreover, Computational Fluids Dynamic calculation was used to explore the contaminant behaviour in conditions of natural ventilation flow. CFD 3D is a powerful tool, yet the computational activity is highly demanding, and cannot be used to make simulation of hourly values for 1 year. CFD 3D is used to check specific conditions, in particular it provide: 1) indoor airflow paths and ventilation efficiencies in the volume, and 2) outdoor airflow paths and ventilation efficiency in relation to of other structures in a complex site. In particular, pressure coefficients at the windows of any tents in a complex site are used as input to the 1D dynamic simulations to produce refined set of hourly values for yearlong simulations.

Simulations in support of the design process

During the creating phase, natural ventilation simulations have been carried out for each phase of the design development to assist and provide data regarding the building physics behaviour of IDTM in relation to the proposed design characteristics. Different configuration of windows and windows dimensions have been explored (as showed in the image below). The options explored were: A) window on the aisle side enlarged (from 60x75 to 60x100); B) all windows maximized (always 60x100); C) Normal windows + triangular grid on the smaller side at the roof (20cm offset from the pitch); D) Enlarged aisle-side window + triangular grid; E) All windows maximized + triangular grid; F) 1 additional window (60 x100) on the smaller side positioned 50 cm from the southwest corner; G) 2 additional windows (60 x100) one 50 cm southwest and the other 50 cm southeast; H) Solution F + triangular grid; and I) Solution G + triangular grid.

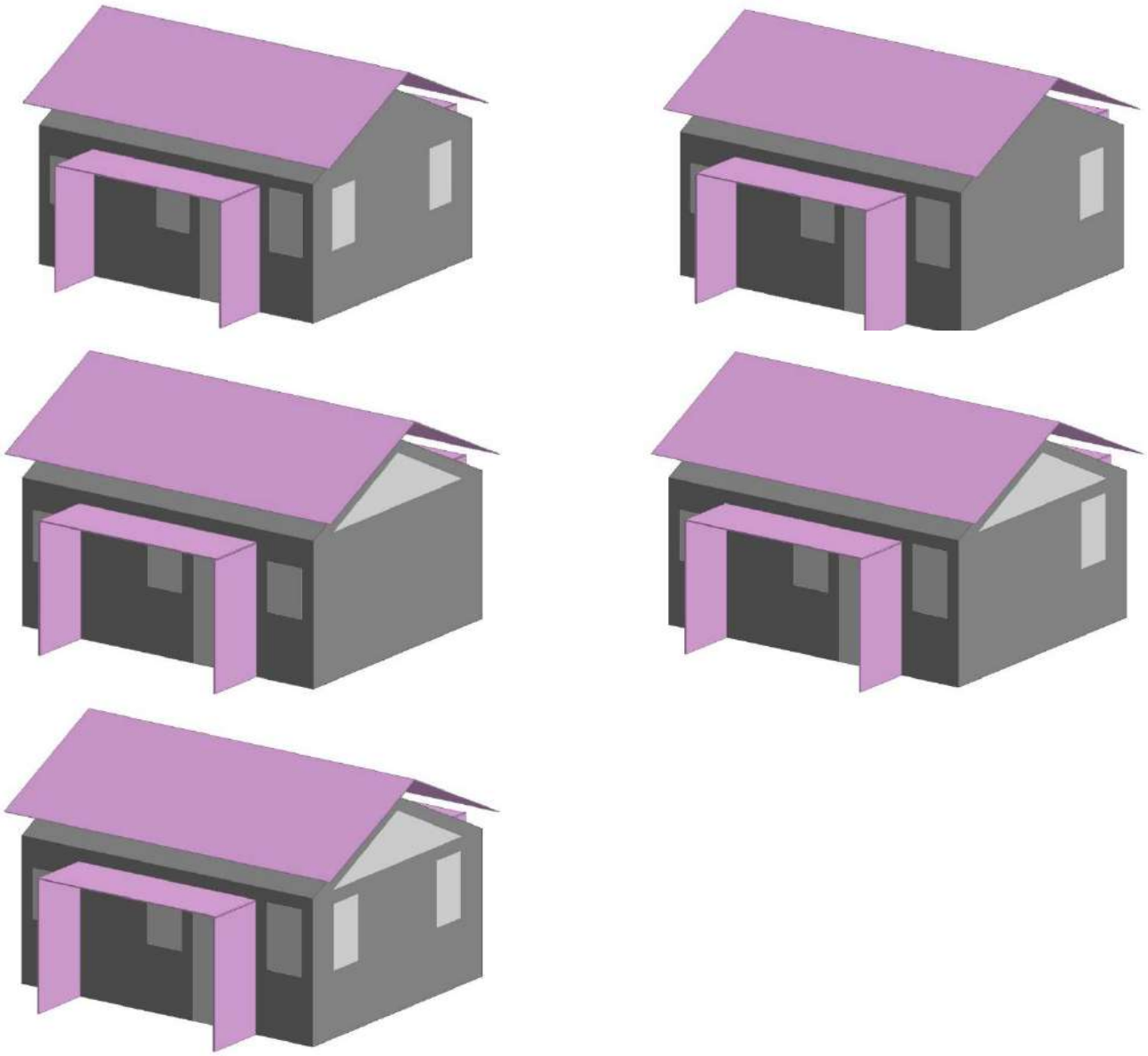


Figure 1: Different configurations of windows explored to optimise natural ventilation strategy

Proposed Natural Ventilation Strategy

The natural ventilation strategy envisioned for IDTM is characterised by independent ventilation systems for each space inside the module, with the aim of avoiding cross contamination between red and green areas and between the different patients rooms. To ensure this approach a reiterative process with double feedback loop between design proposals and computational simulations was put in place. The simulations were set to verify the compliance of IDTM with the WHO requirement for airflow rate of 160 l/s, as well to analyze the dispersion of contaminant patterns between modules in the multiple IDTM configuration setting.

The natural ventilation strategy has been simulated and verified by analysing a module against disadvantageous microclimatic conditions, to test its behavior in a challenging context. The context that was selected for the analysis was the city Bangui (368 a.s.l.), in Central African Republic. The climate is tropical with a temperature range between 40.2°C and 12°C, with local winds with an average speed of 1.3-1.4 m/s. The simulations have been run to analyse natural ventilation and thermal conditions for the weeks from 1st to 7th of September and from 20th to 26th of April, considering the windows always open anytime the temperature was above 18°Celsius, and with a presence of a mosquito net, for the patient room.

The results for the analysis concerning the period from 1st to 7th of September show that 47% of the time that was simulated, the 160 l/s was achieved, 10% of the time the airflow rate was between 80 and 160 l/s, 6% was between 60 and 80 l/s and the remaining 37% was below 60 l/s.

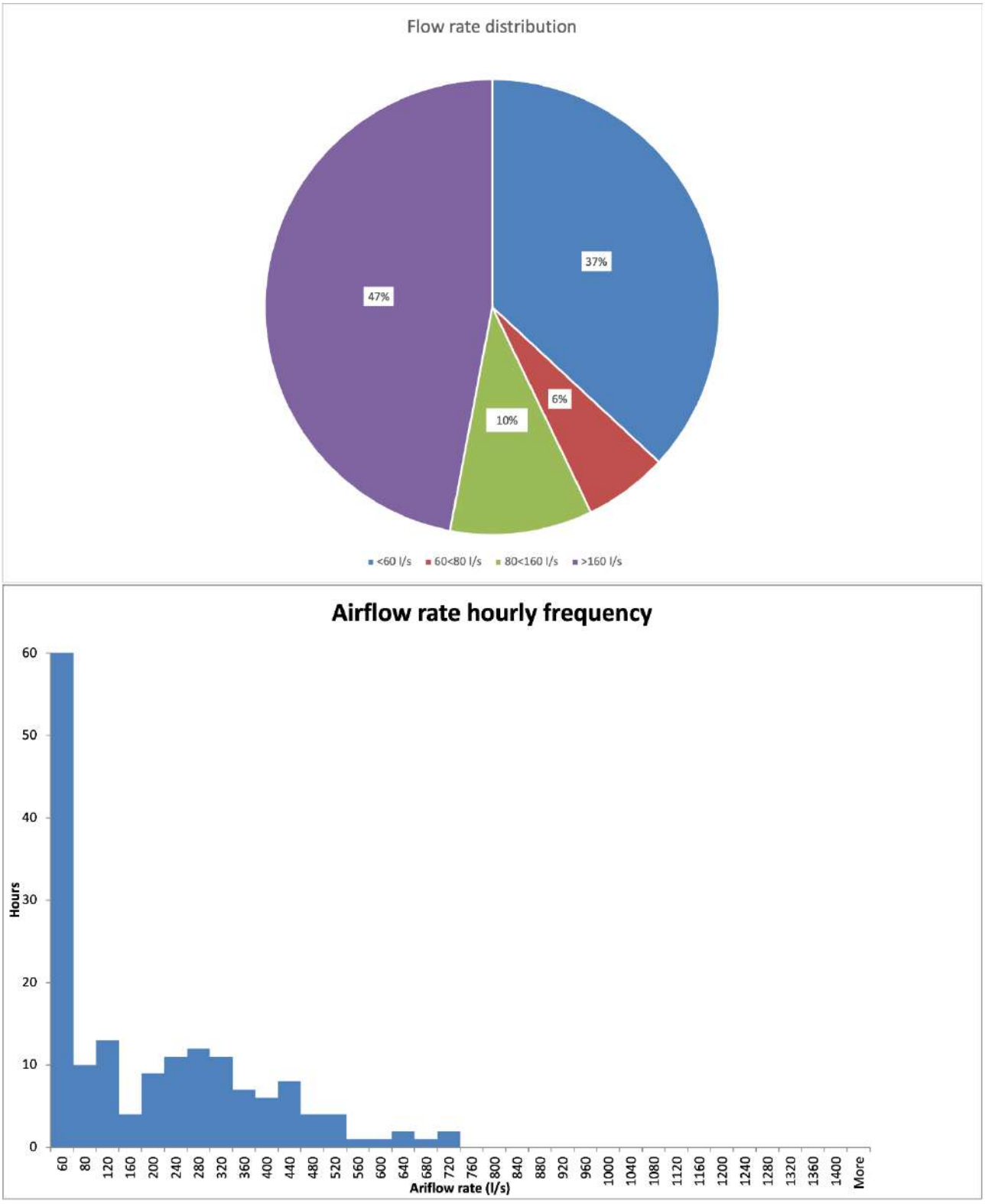


Figure 2: Air Flow Rate Distribution and Hourly Frequency for the week from 1st September to 7th September

The results for the analysis concerning the period from 20th to 26th of April show that 47% of the time that was simulated, the 160 l/s was achieved, 10% of the time the airflow rate was between 80 and 160 l/s, 6% was between 60 and 80 l/s and the remaining 37% was below 60 l/s.

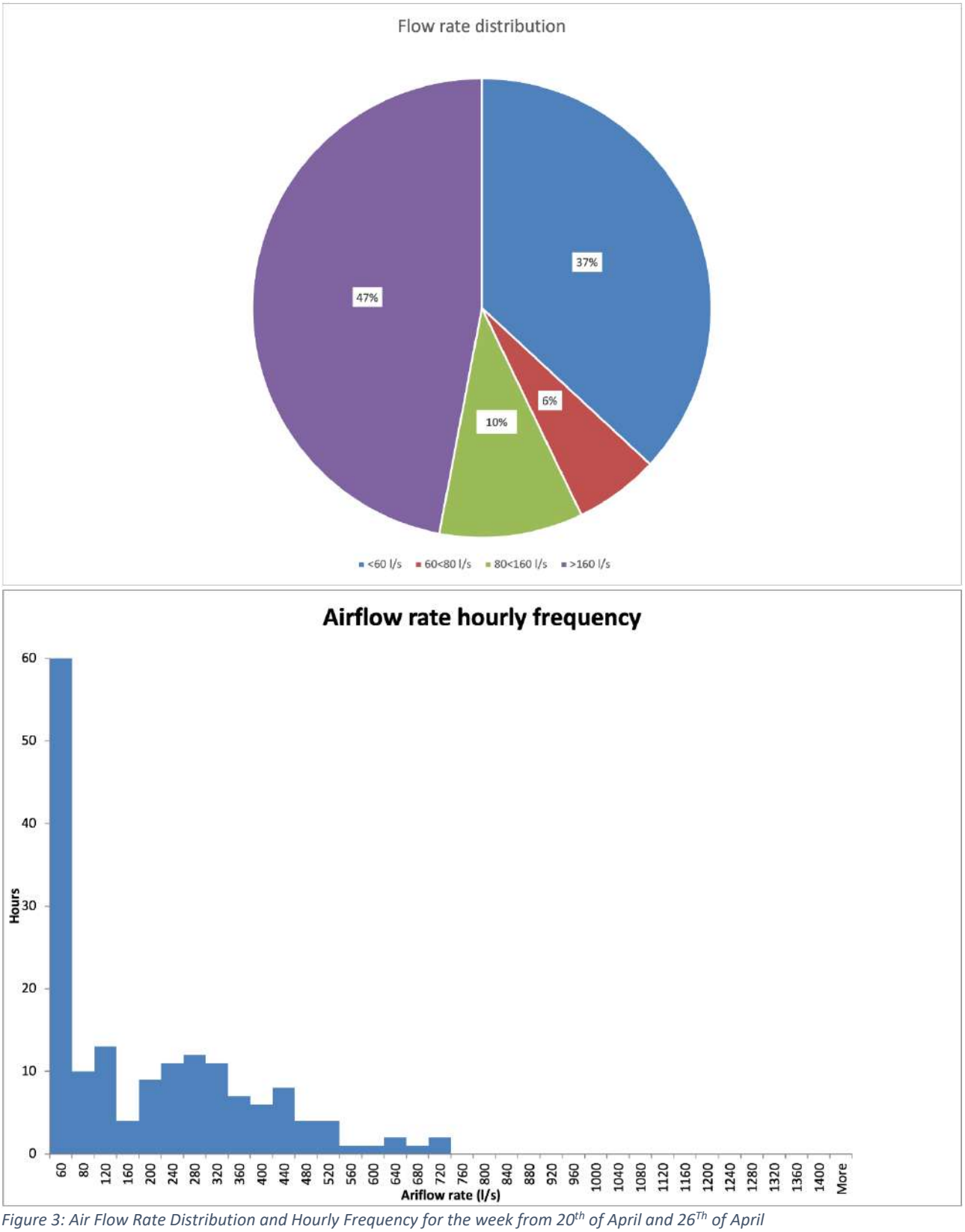
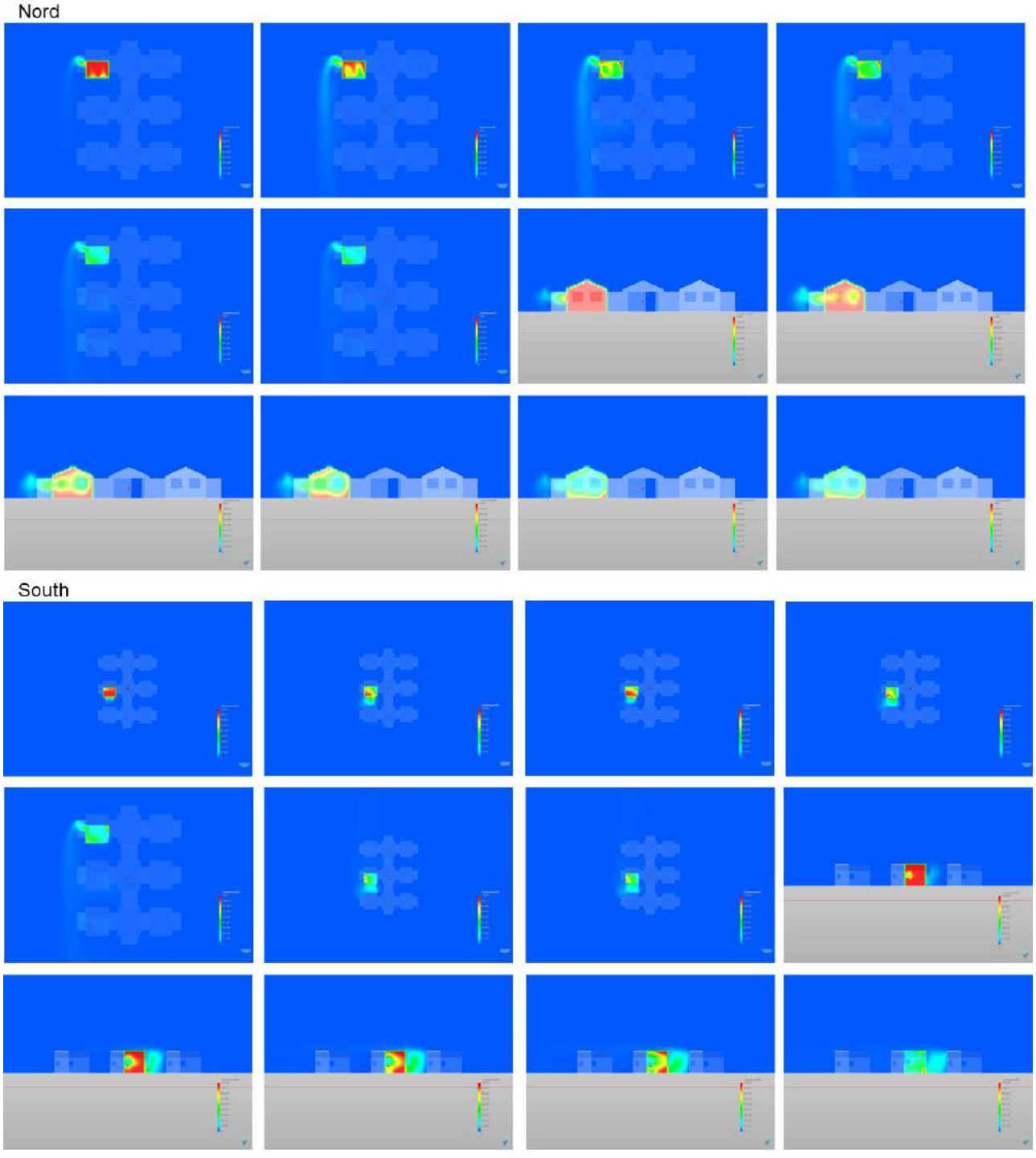


Figure 3: Air Flow Rate Distribution and Hourly Frequency for the week from 20th of April and 26Th of April

Overall, the results showed that in disadvantageous microclimatic conditions, the required 160 l/s of airflow rate could be achieved on an average 50% of the days over an entire week with the most

extreme microclimatic conditions of the year. Yet, the remaining 50% can be achieved with the introduction of a low energy consumption fans, to assist the air flow movement and extraction.



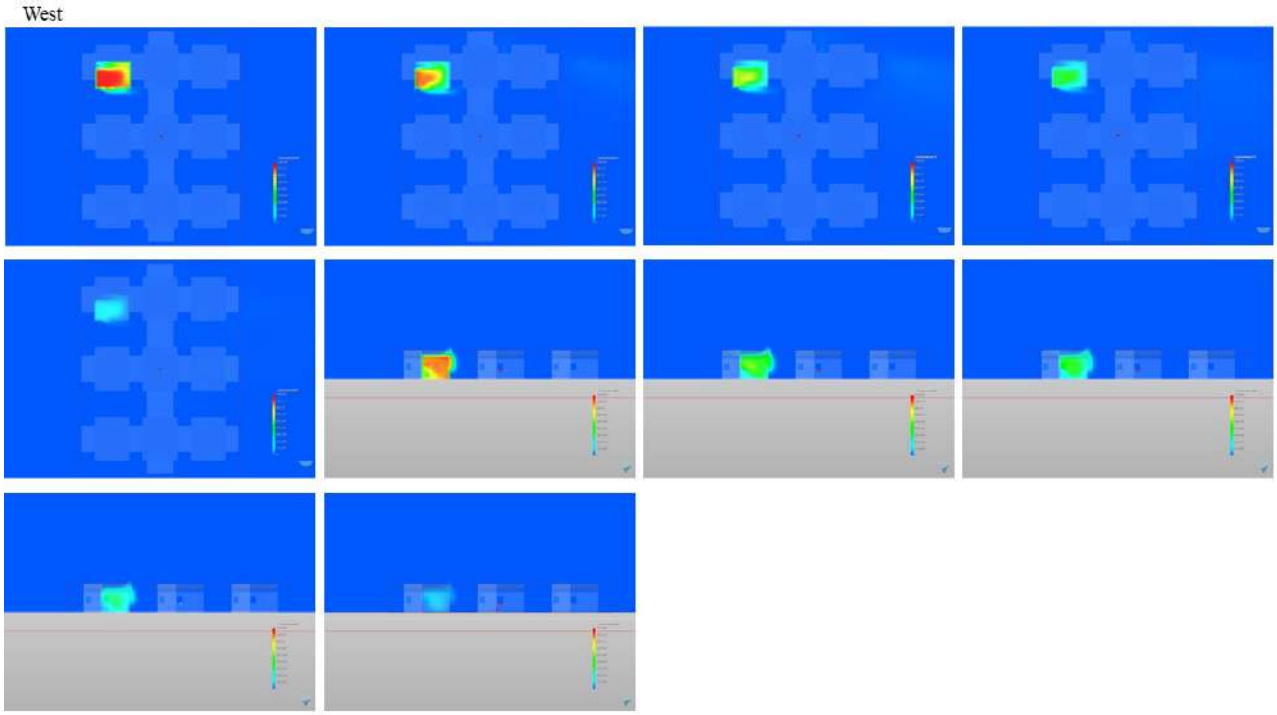
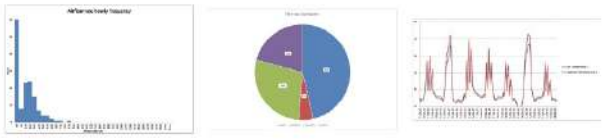


Figure 4: CFD simulations for camp configuration with North, South and West Wind

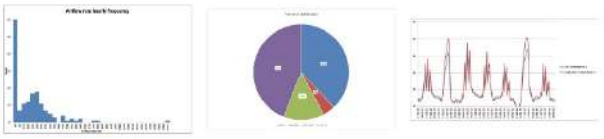
The results of the analysis of contaminant dispersion patterns of the multiple IDTM configuration setting shows that no significant contamination seems to occur between pods. The analysis have been run by analyzing North, South and West wind direction. Due to the symmetry East direction wind would provide the same results than West direction. The images below shows, for each wind direction, the pattern of contaminant from inside the red zone to the outdoor, within 200 seconds time step, within the simulation conditions mentioned above.

Natural Ventilation Studies – design development optimisation configurations

1 window increased (100 x60 cm)

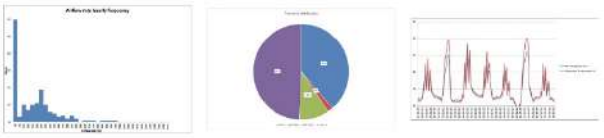


1 window added (100 x60 cm)

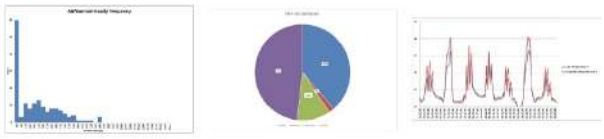


All windows increased

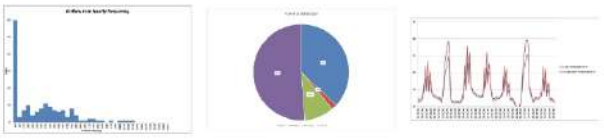
2 windows added (100 x 60 cm)



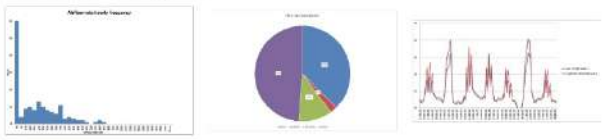
Regular windows + triangular vent



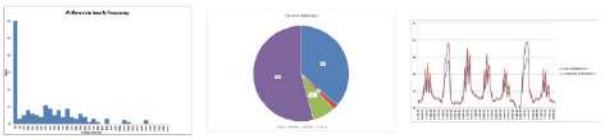
1 window added+ triangular vent



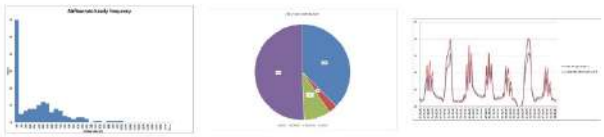
1 window increased + triangular vent



2 windows added + triangular vent

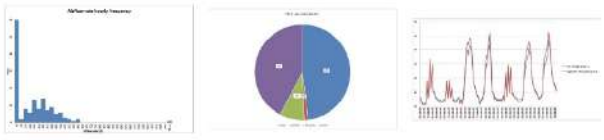


All windows increased + triangular vent

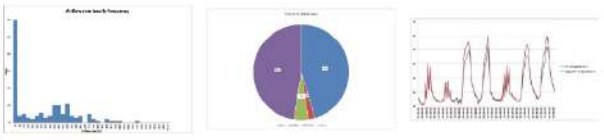


Location: Bangui
Week: 1/09-6/09

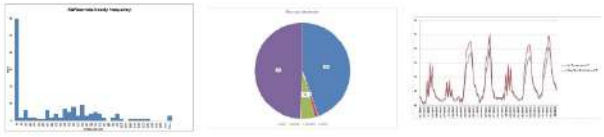
1 window increased (100 x60 cm)



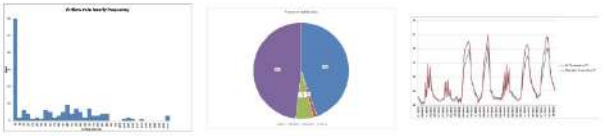
1 window added (100 x60 cm)



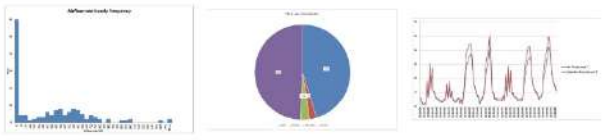
All windows increased



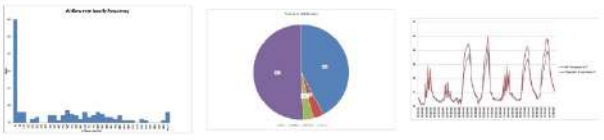
2 windows added (100 x 60 cm)



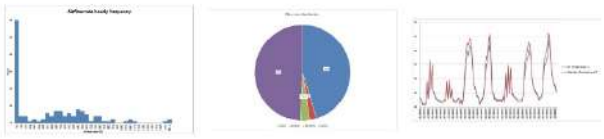
Regular windows + triangular vent



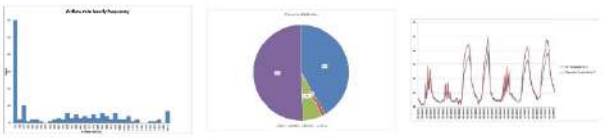
1 window added+ triangular vent



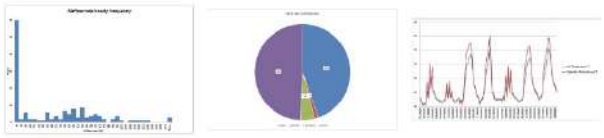
1 window increased + triangular vent



2 windows added + triangular vent

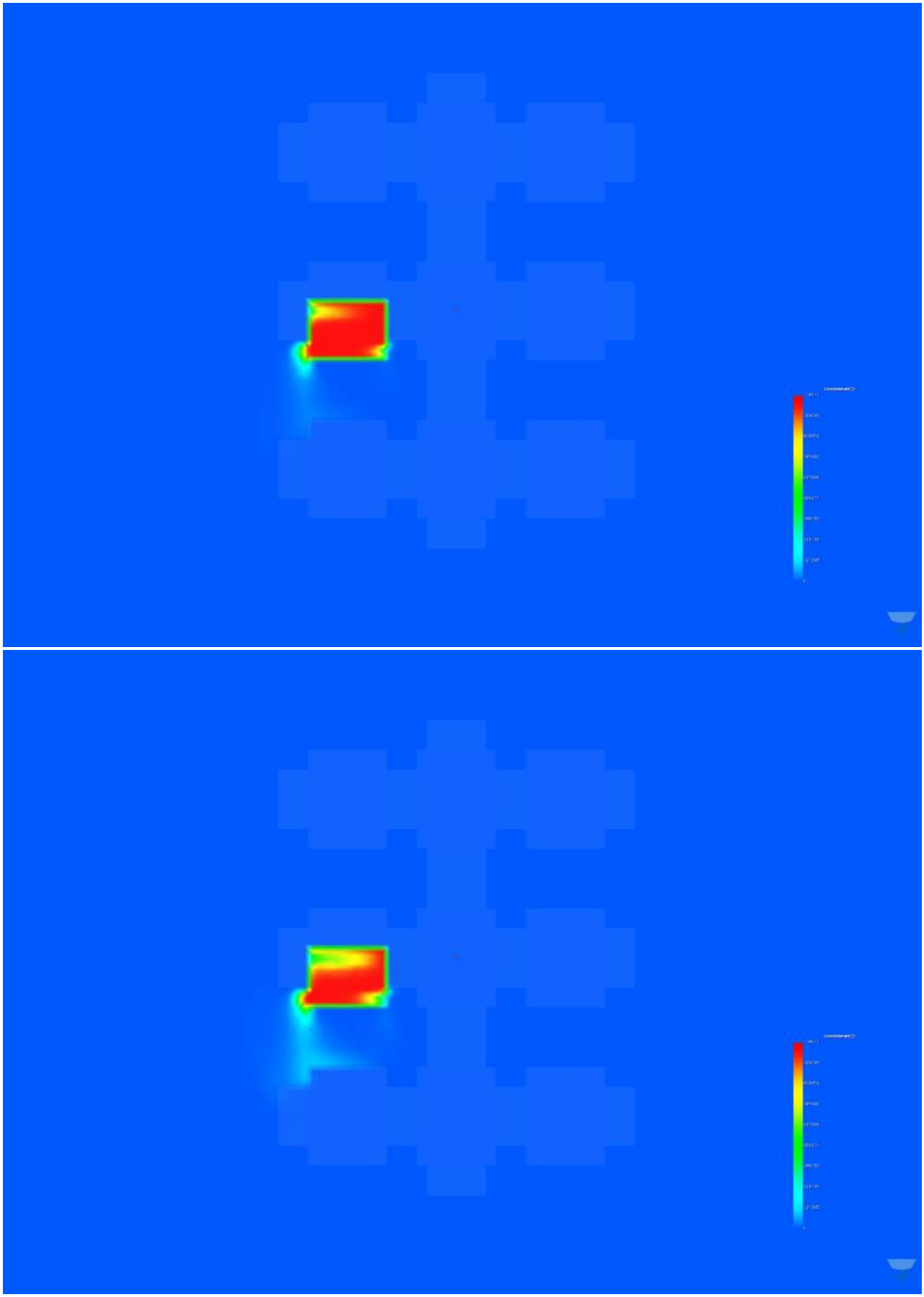


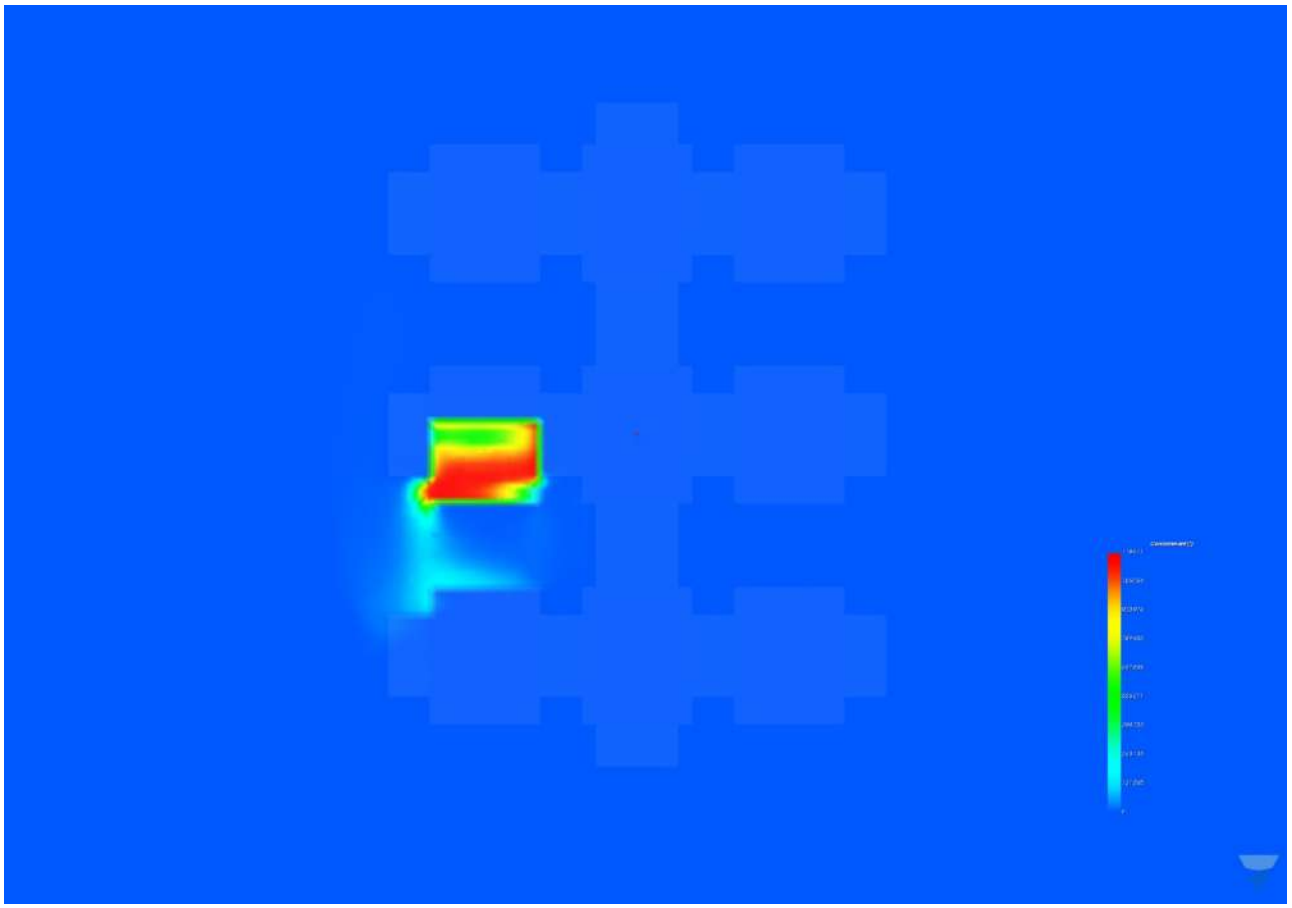
All windows increased + triangular vent

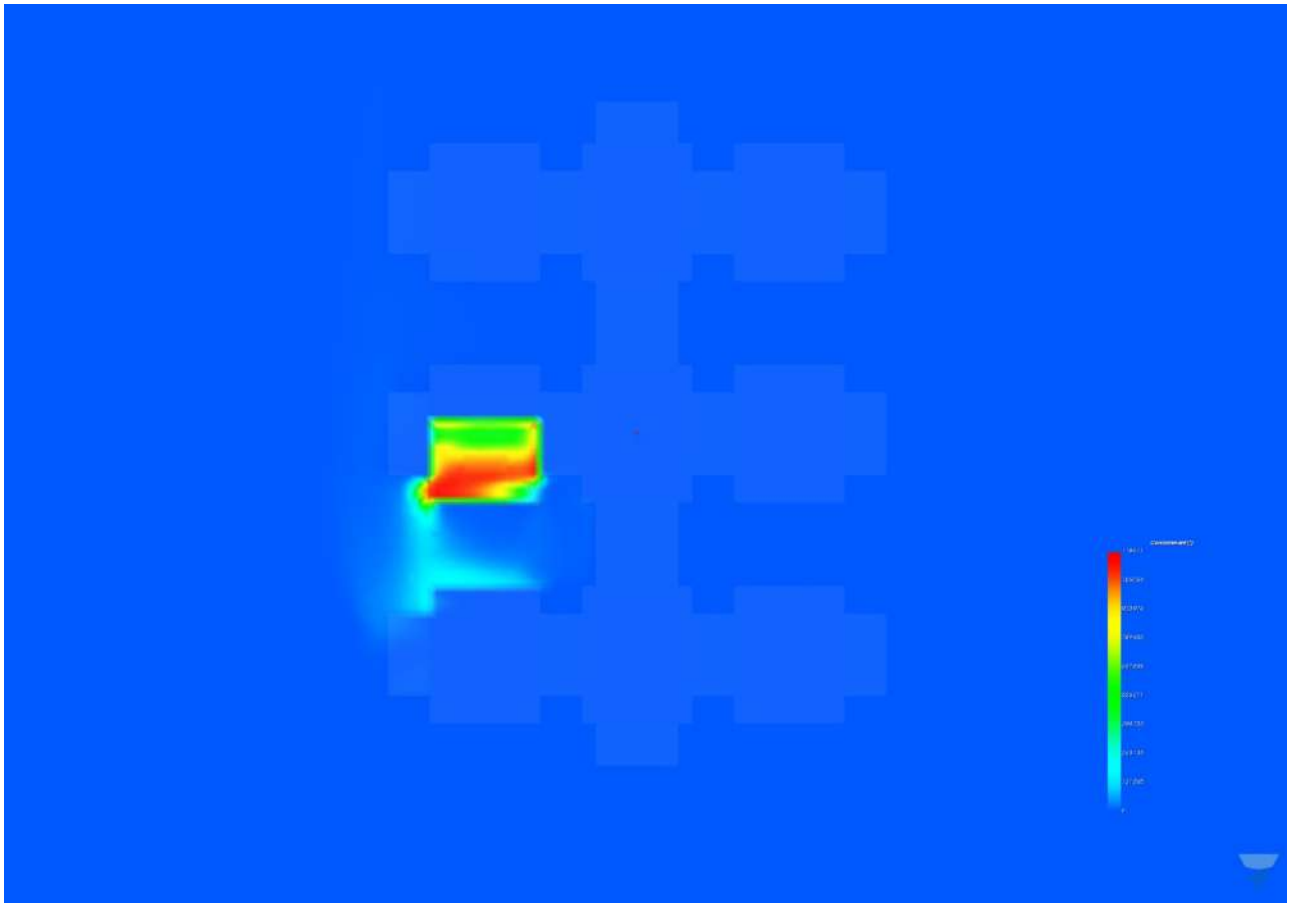


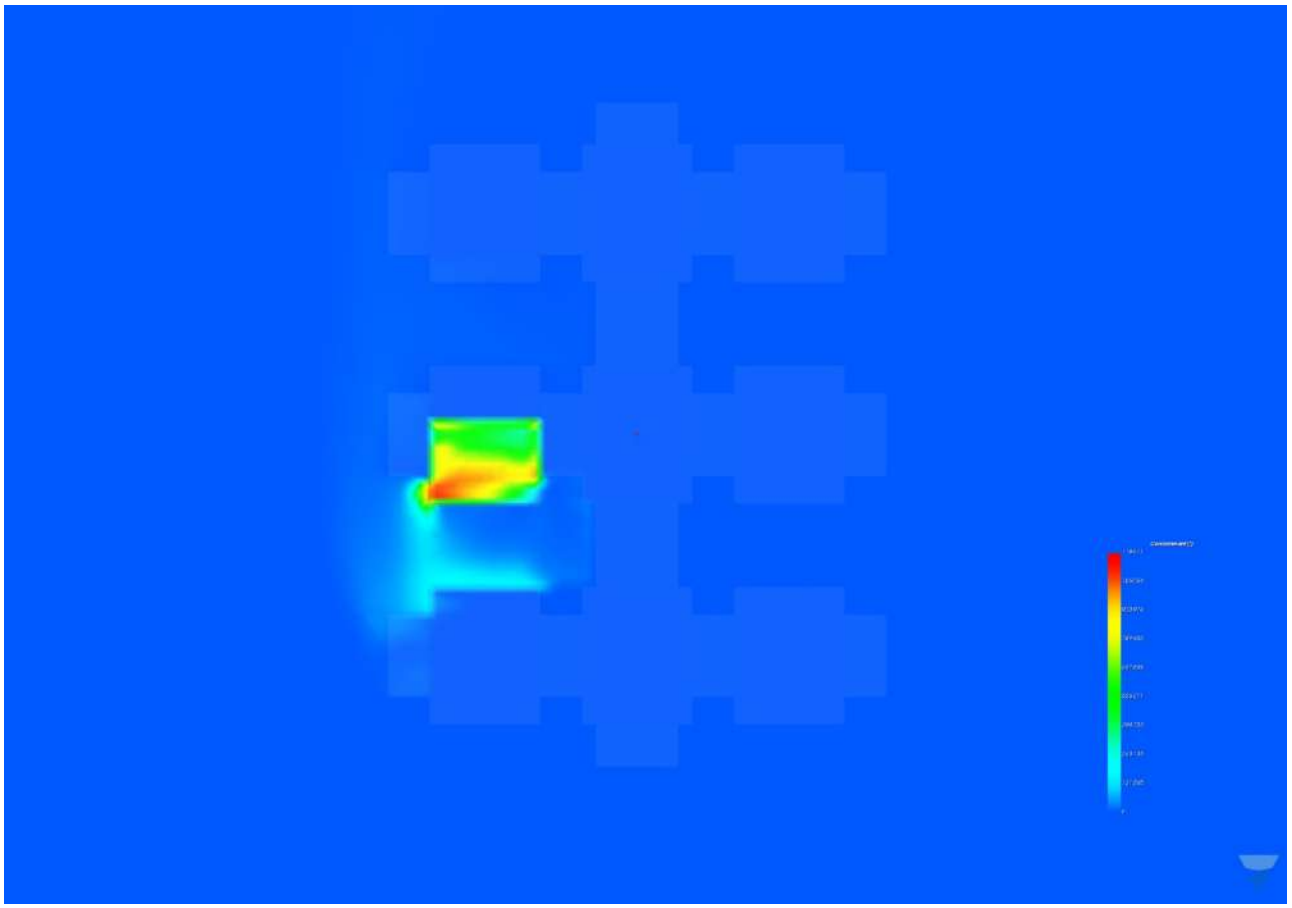
Location: Bangui
Week: 20/04-26/04

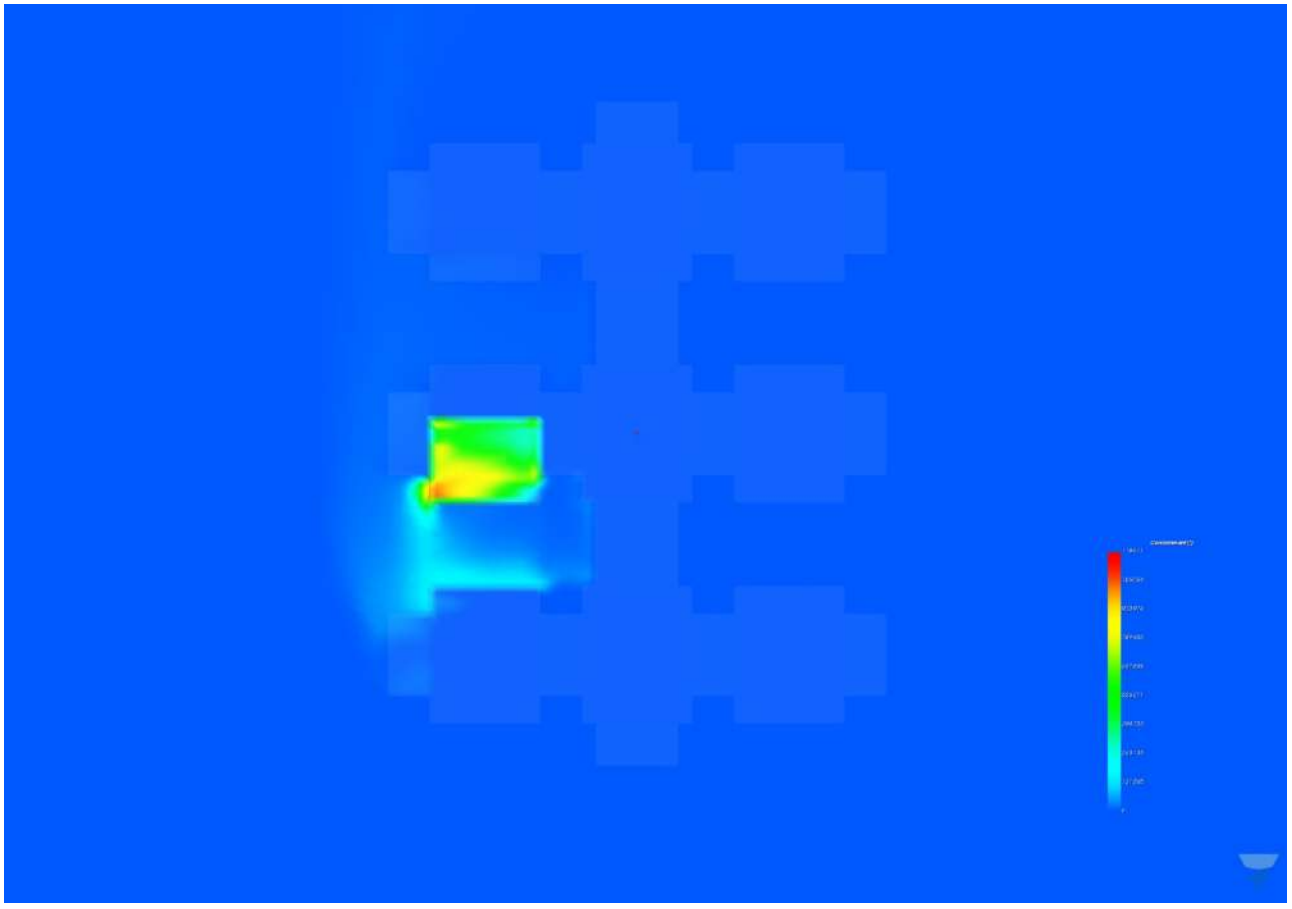
CFD Study - Camp Configuration / Middle Tent - South Wind

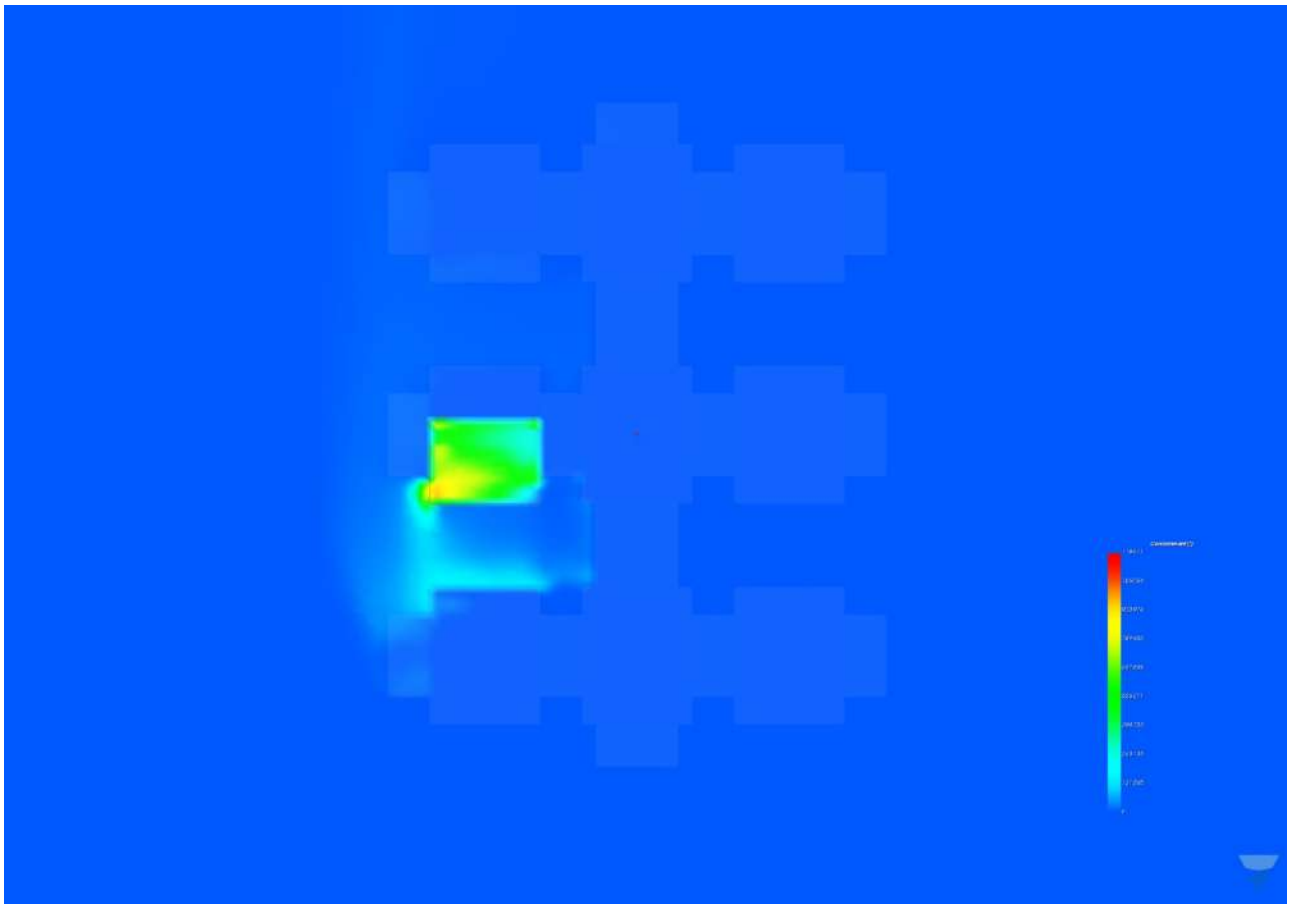


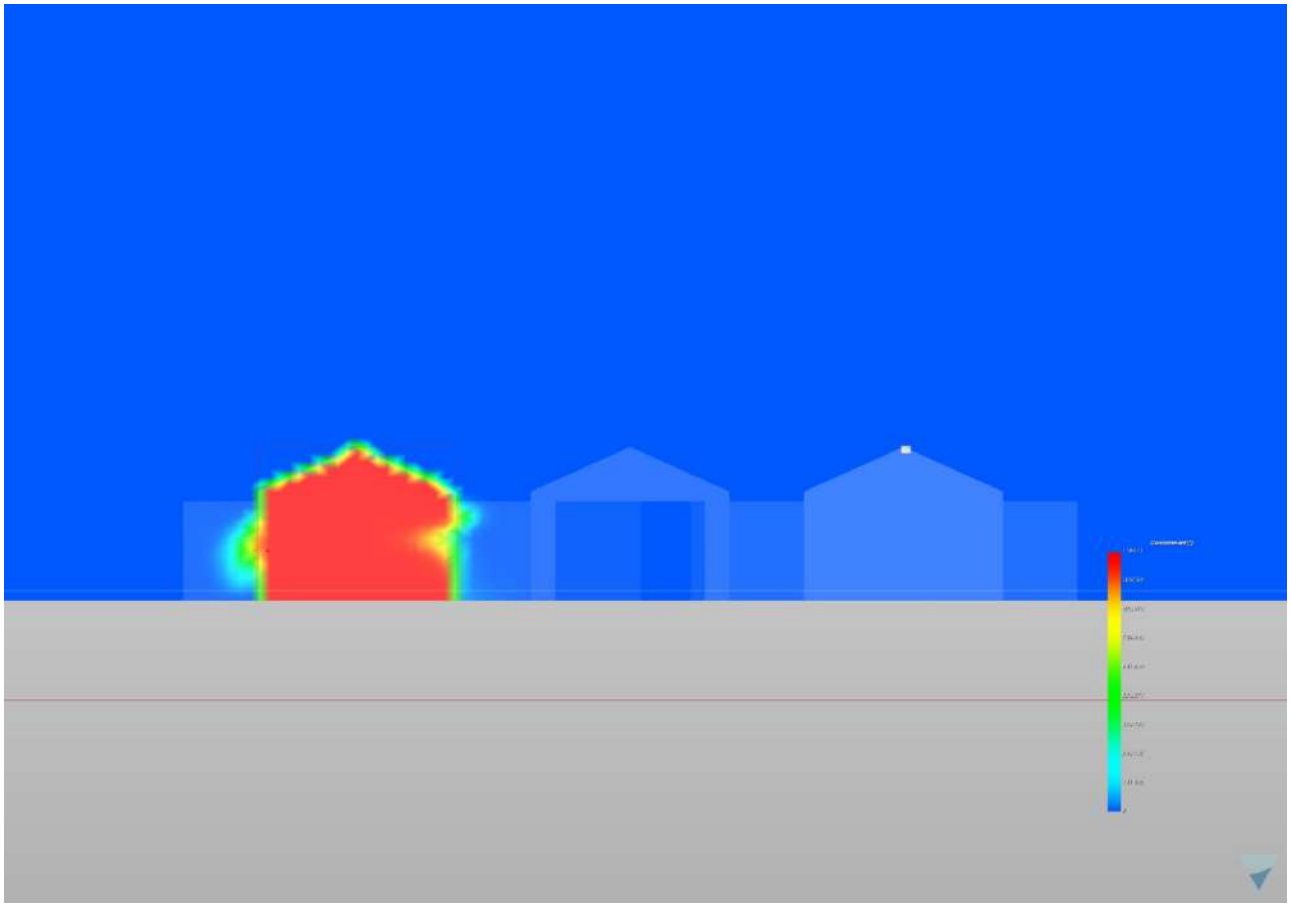


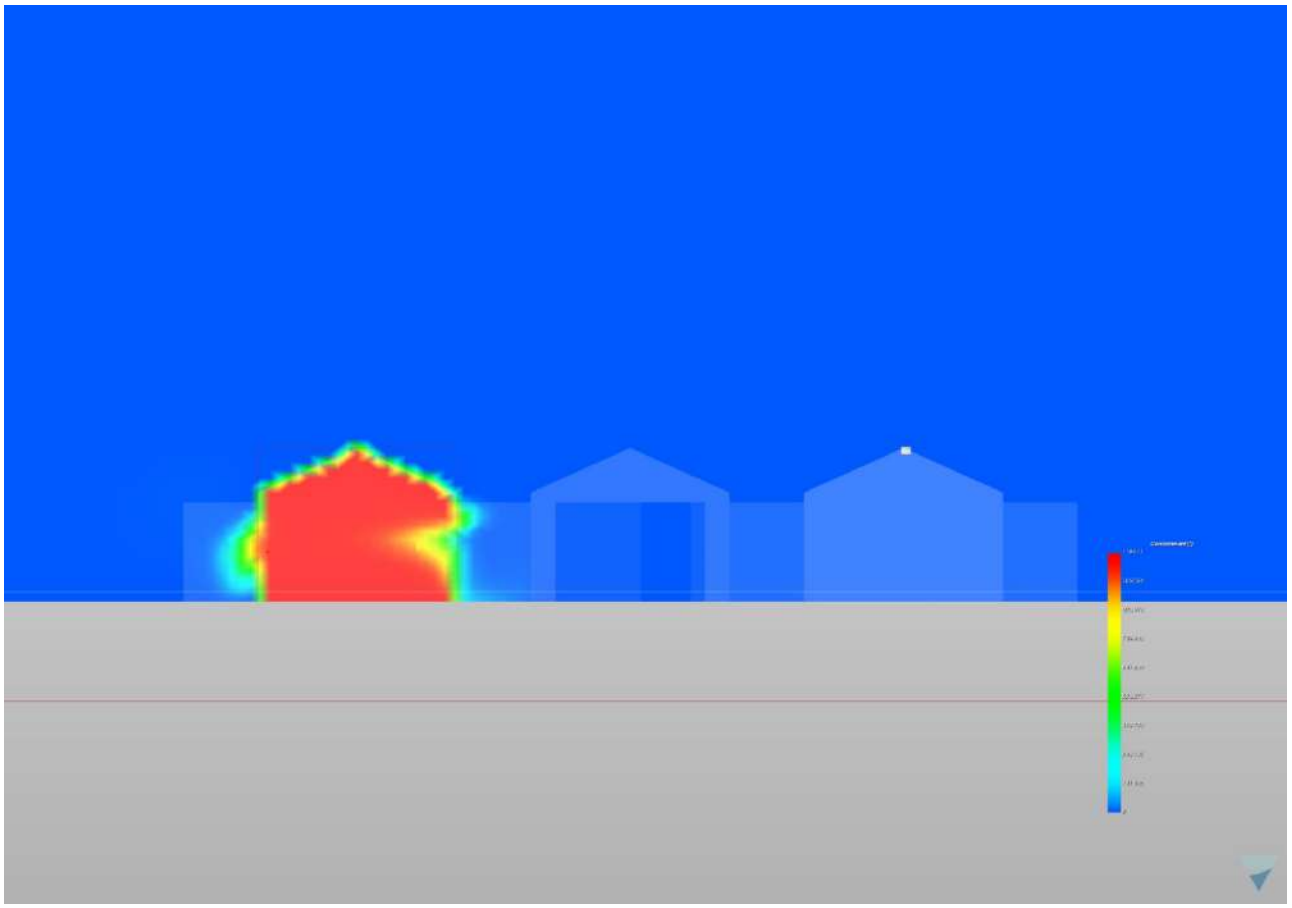


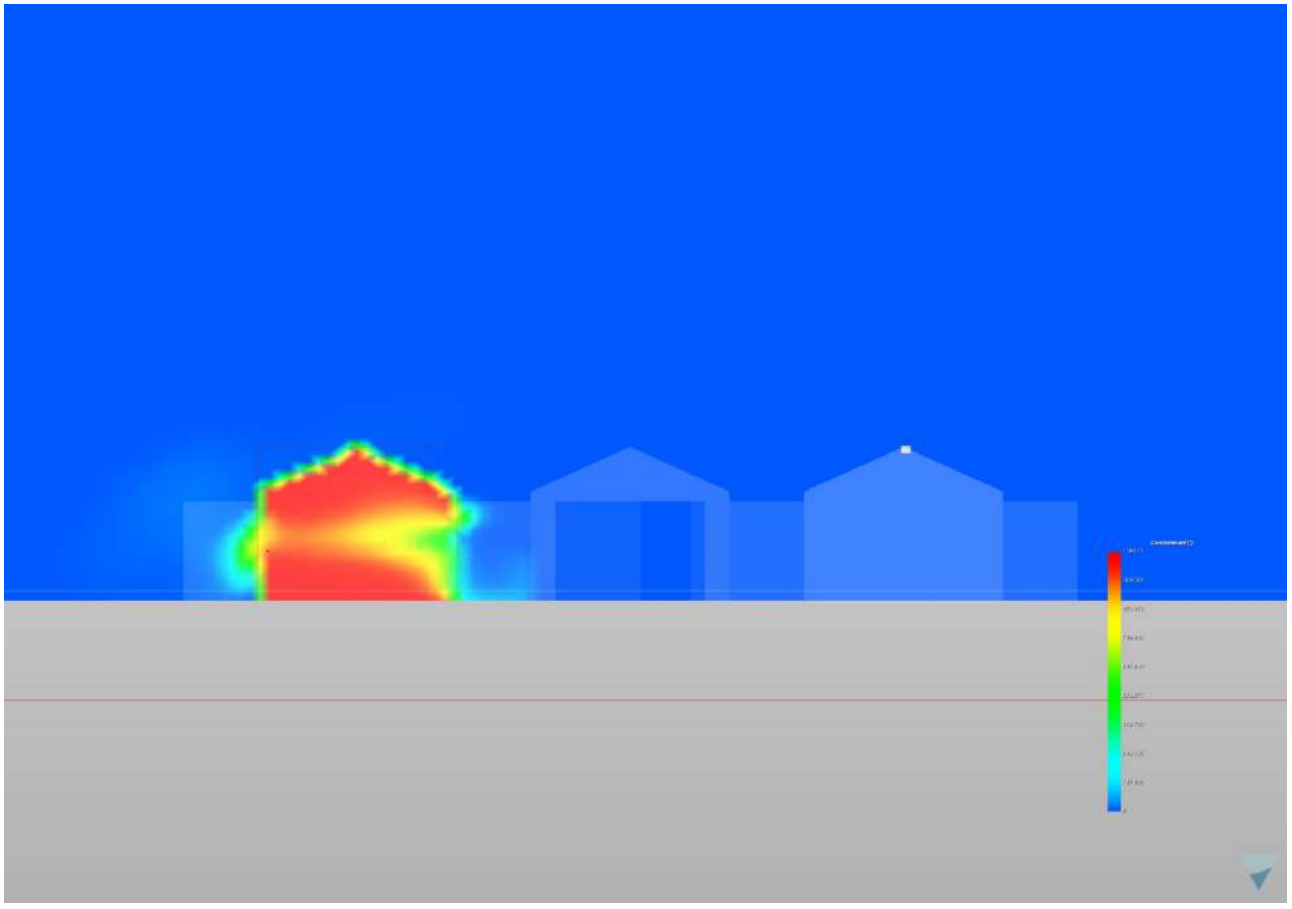


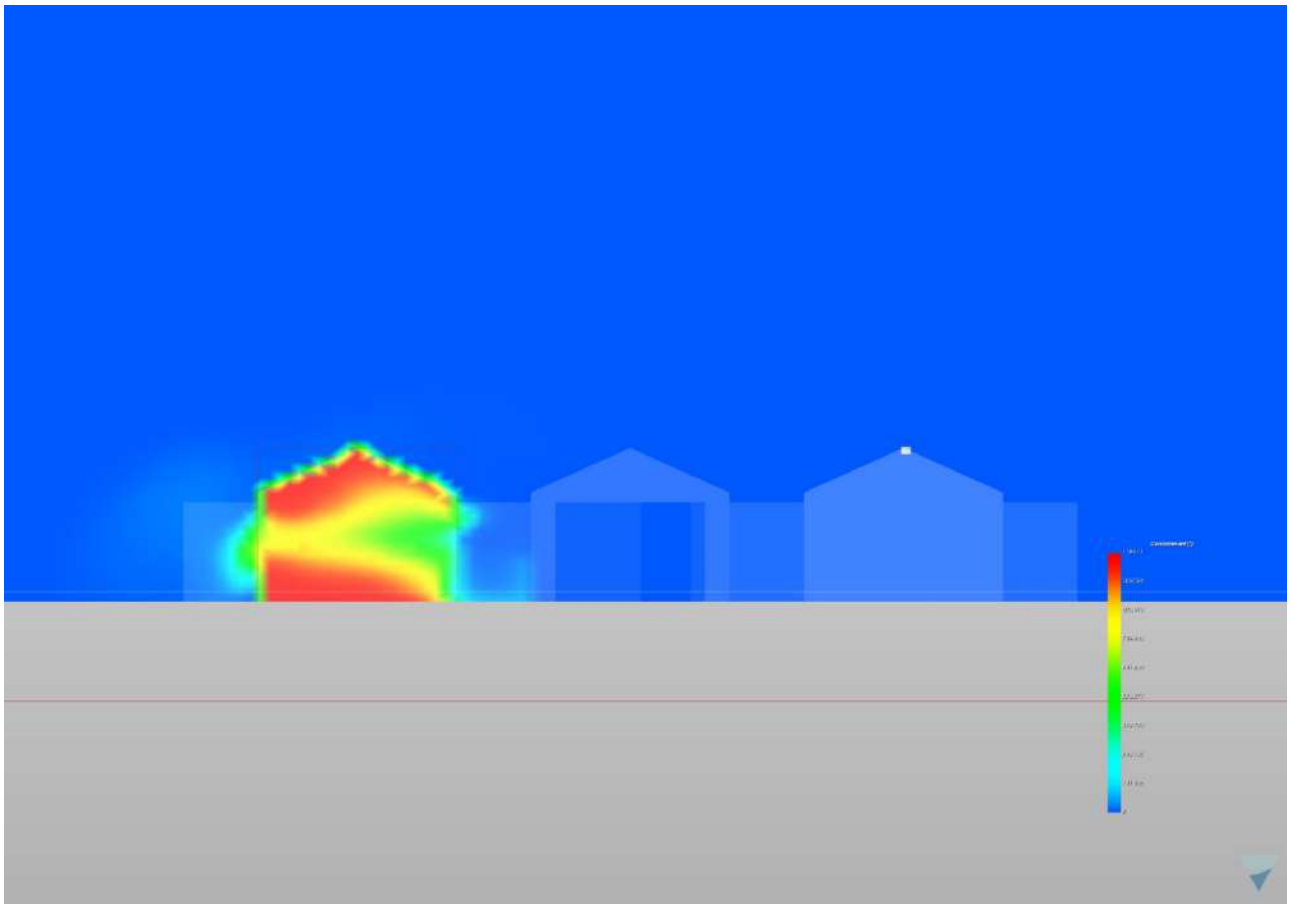


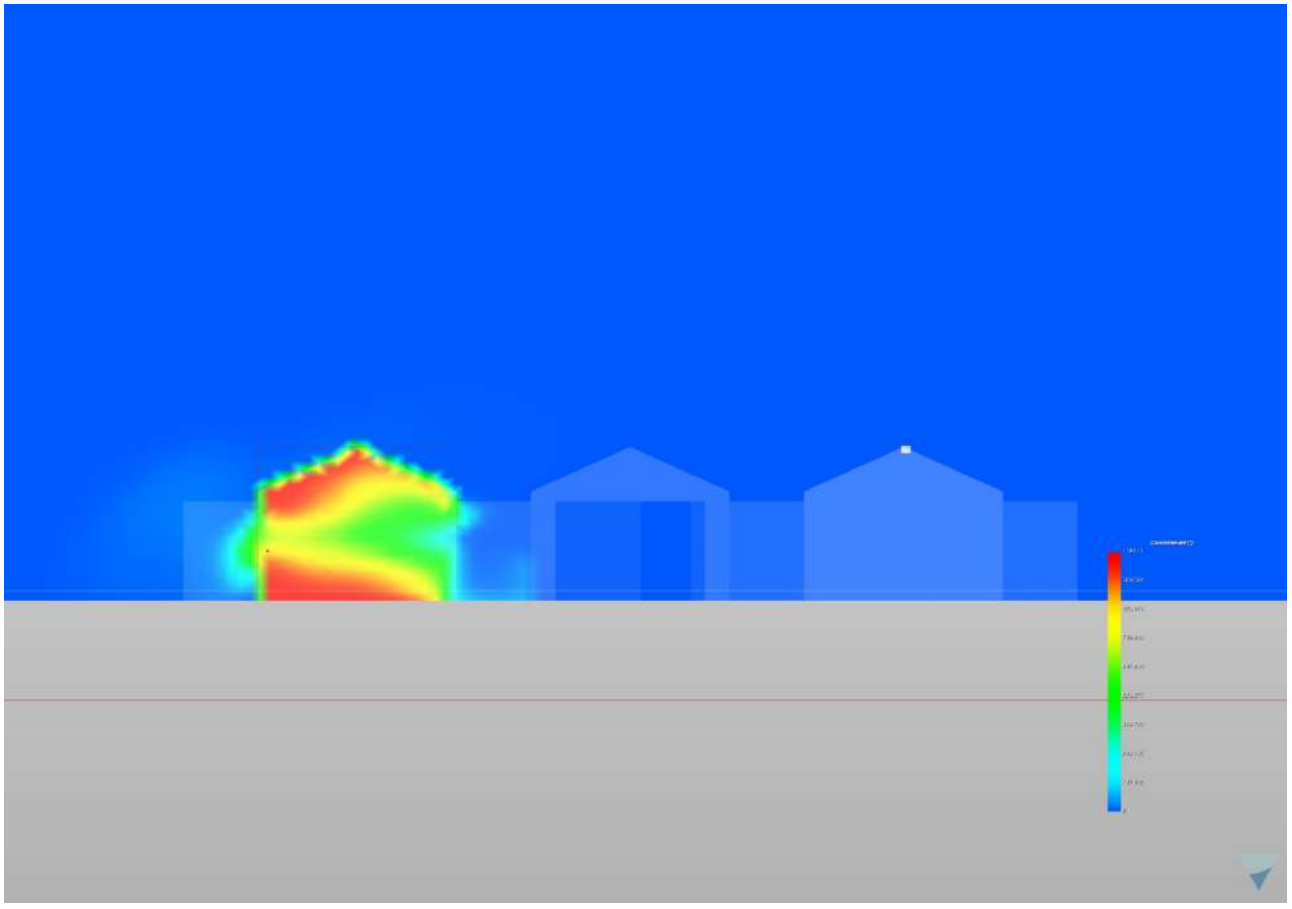




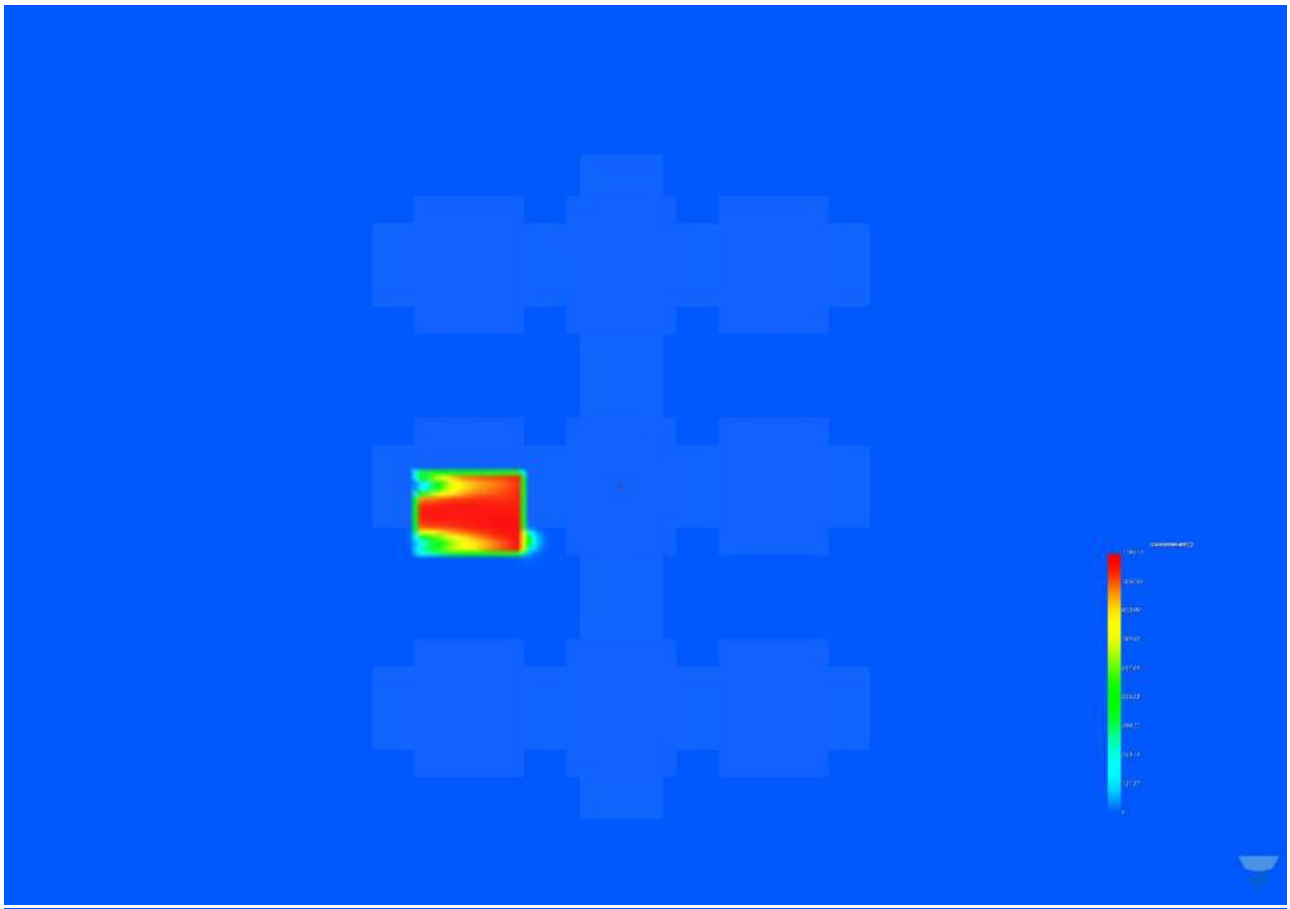


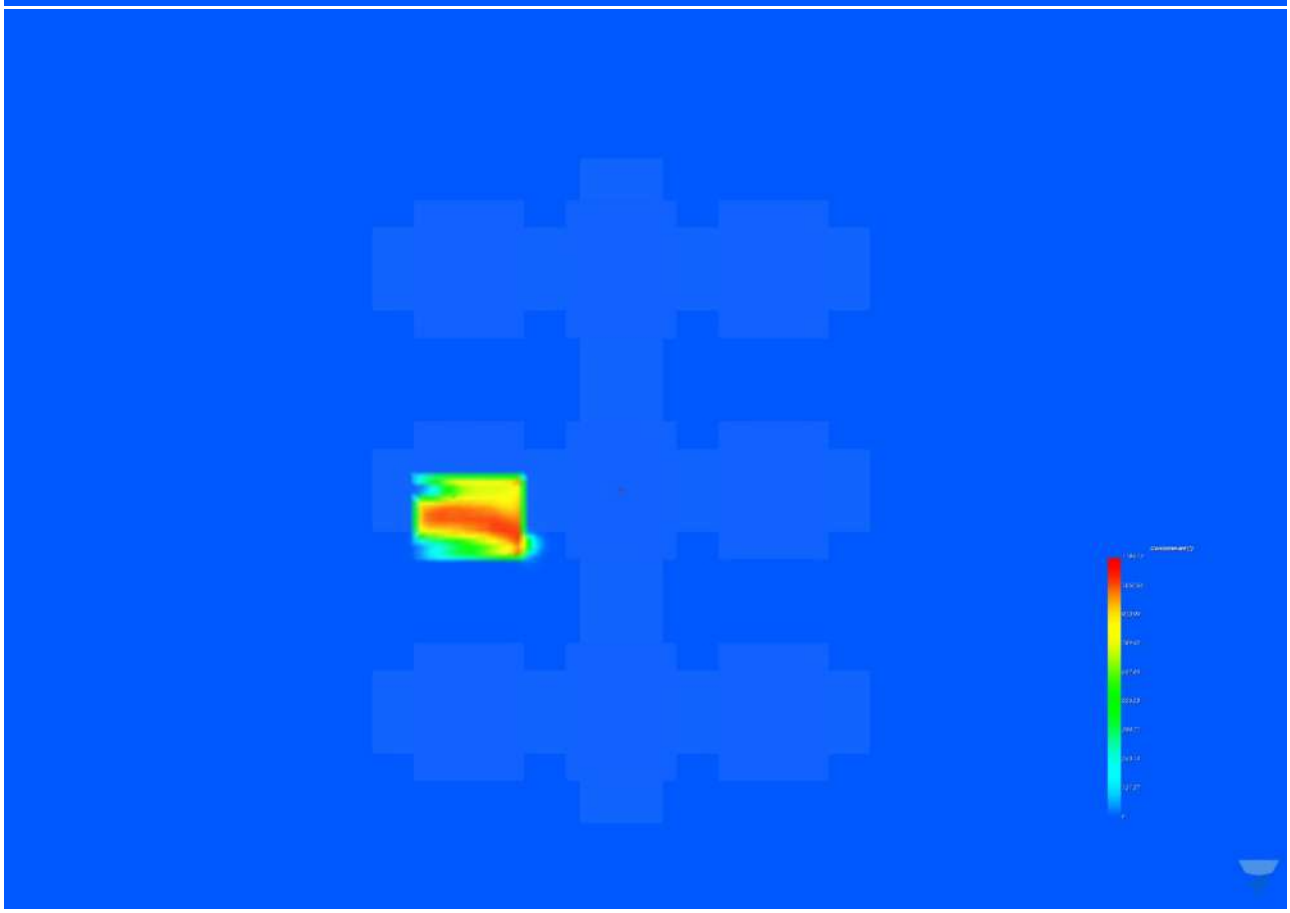


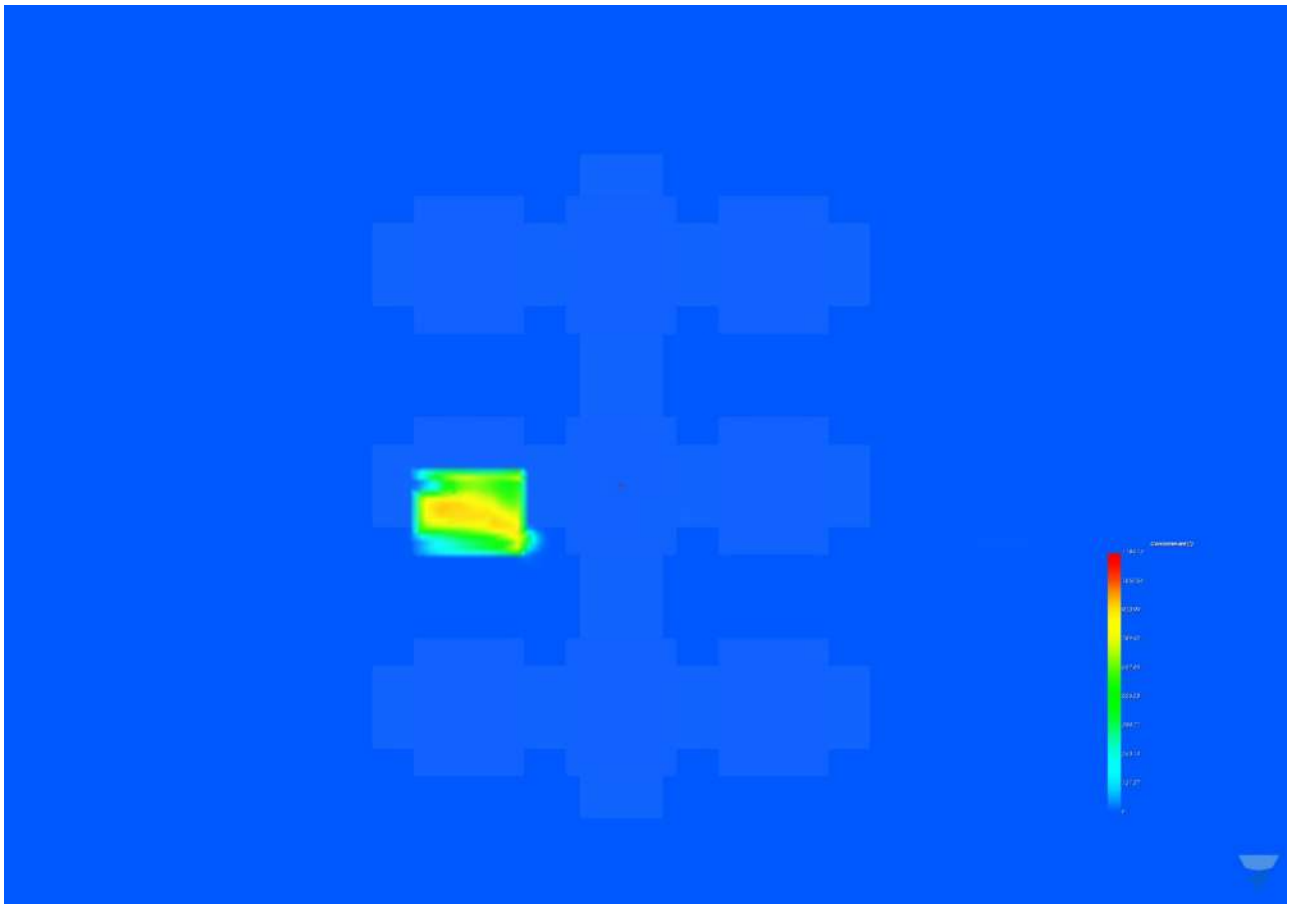


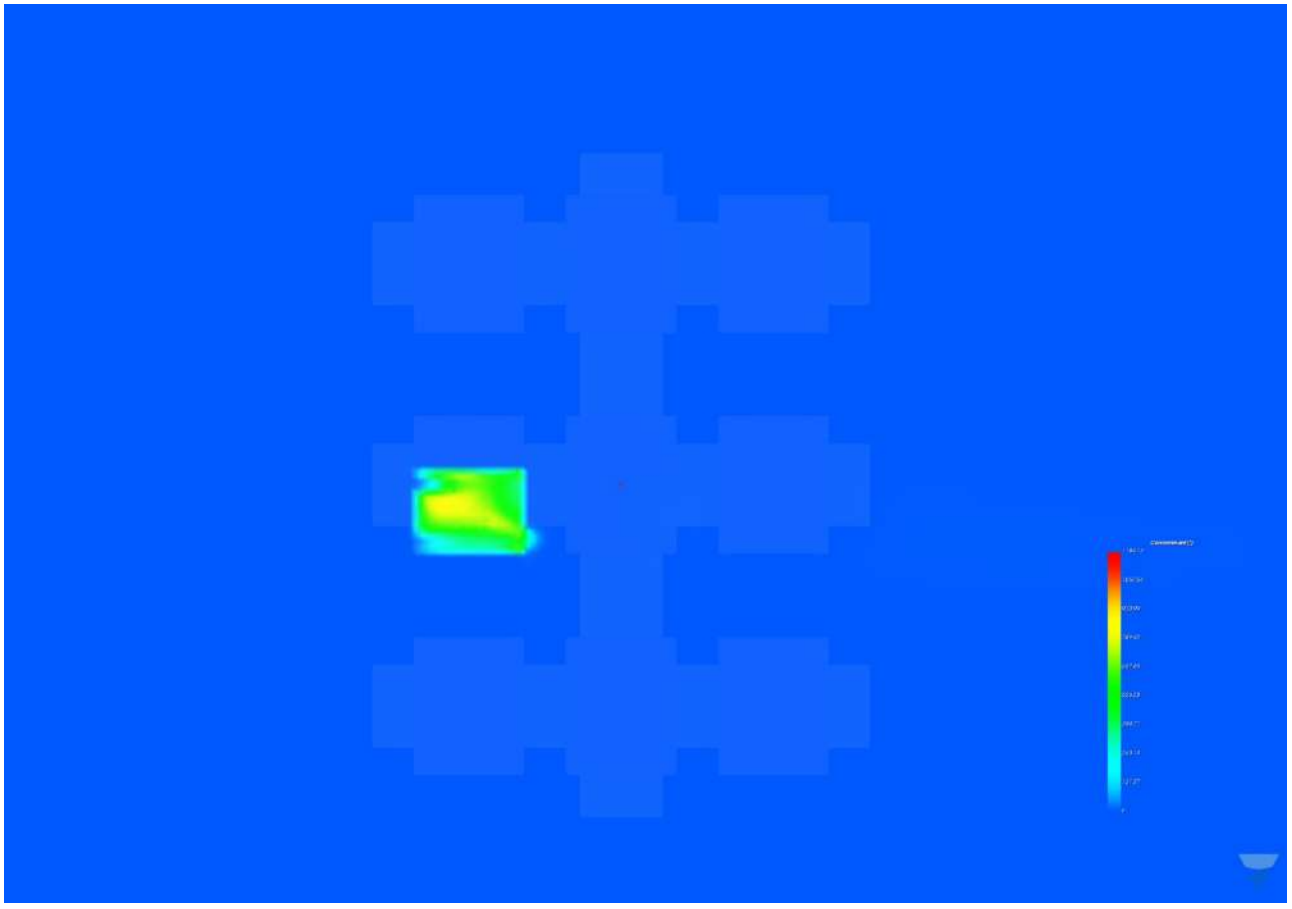


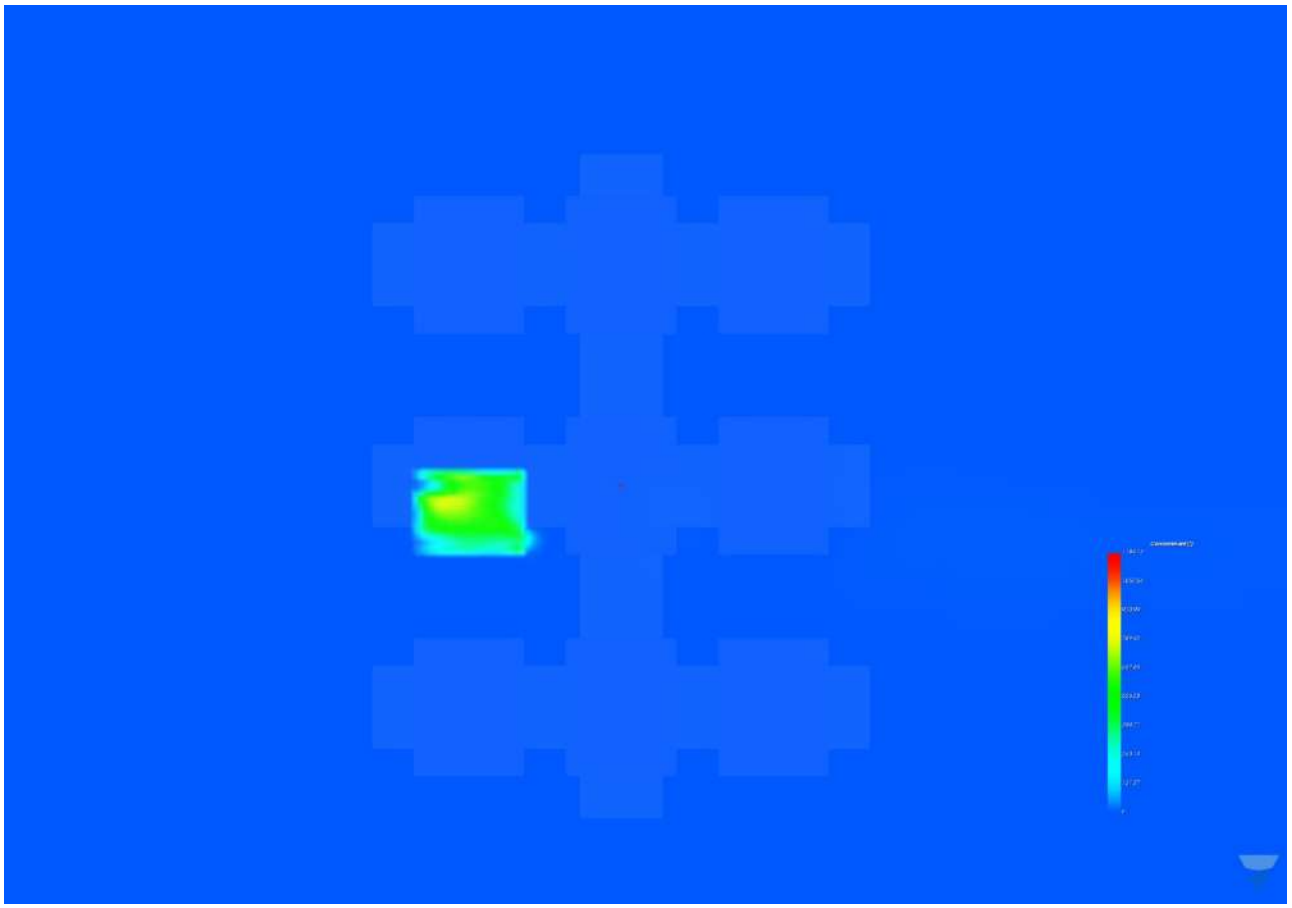
Middle Tent – West Wind

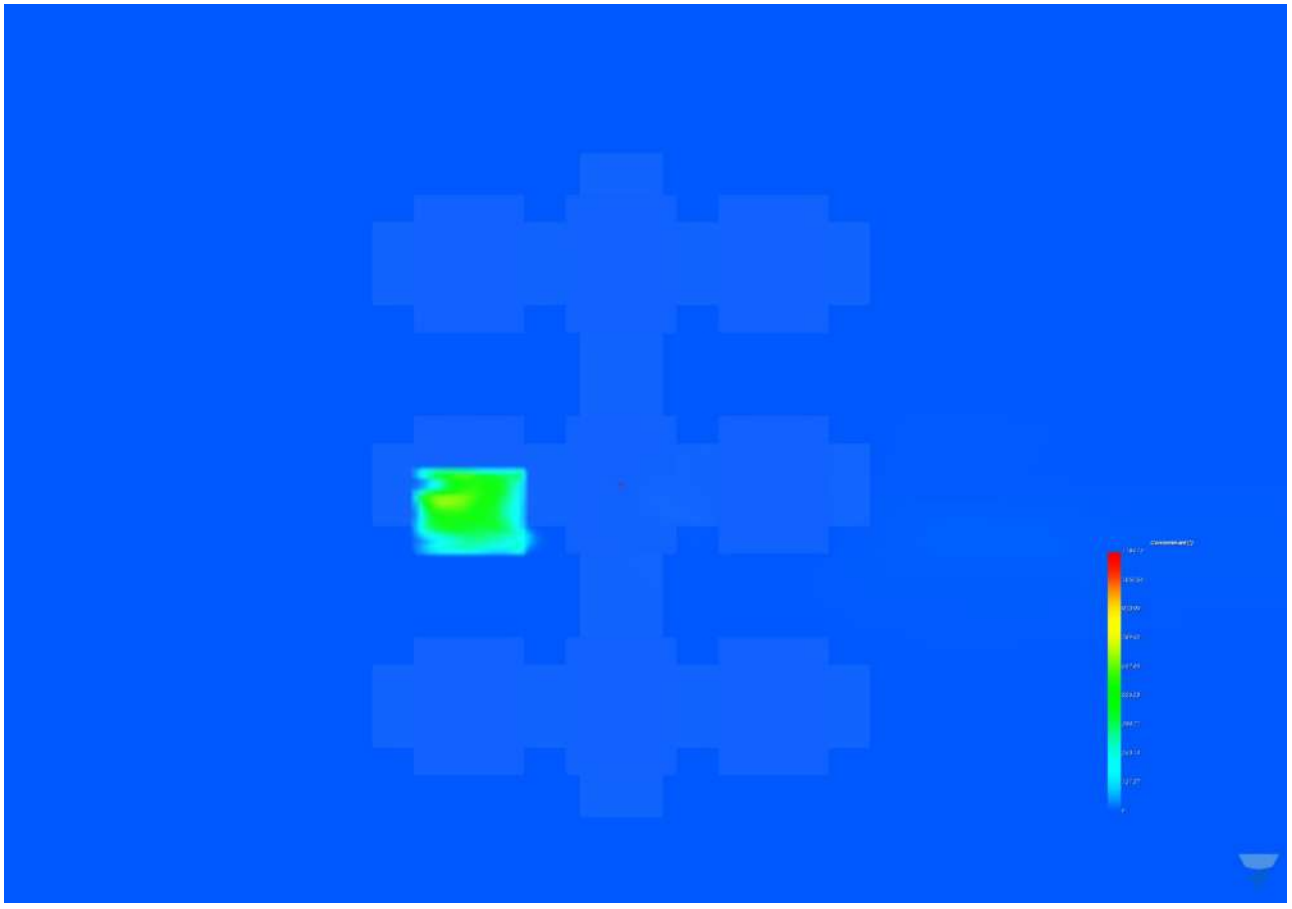


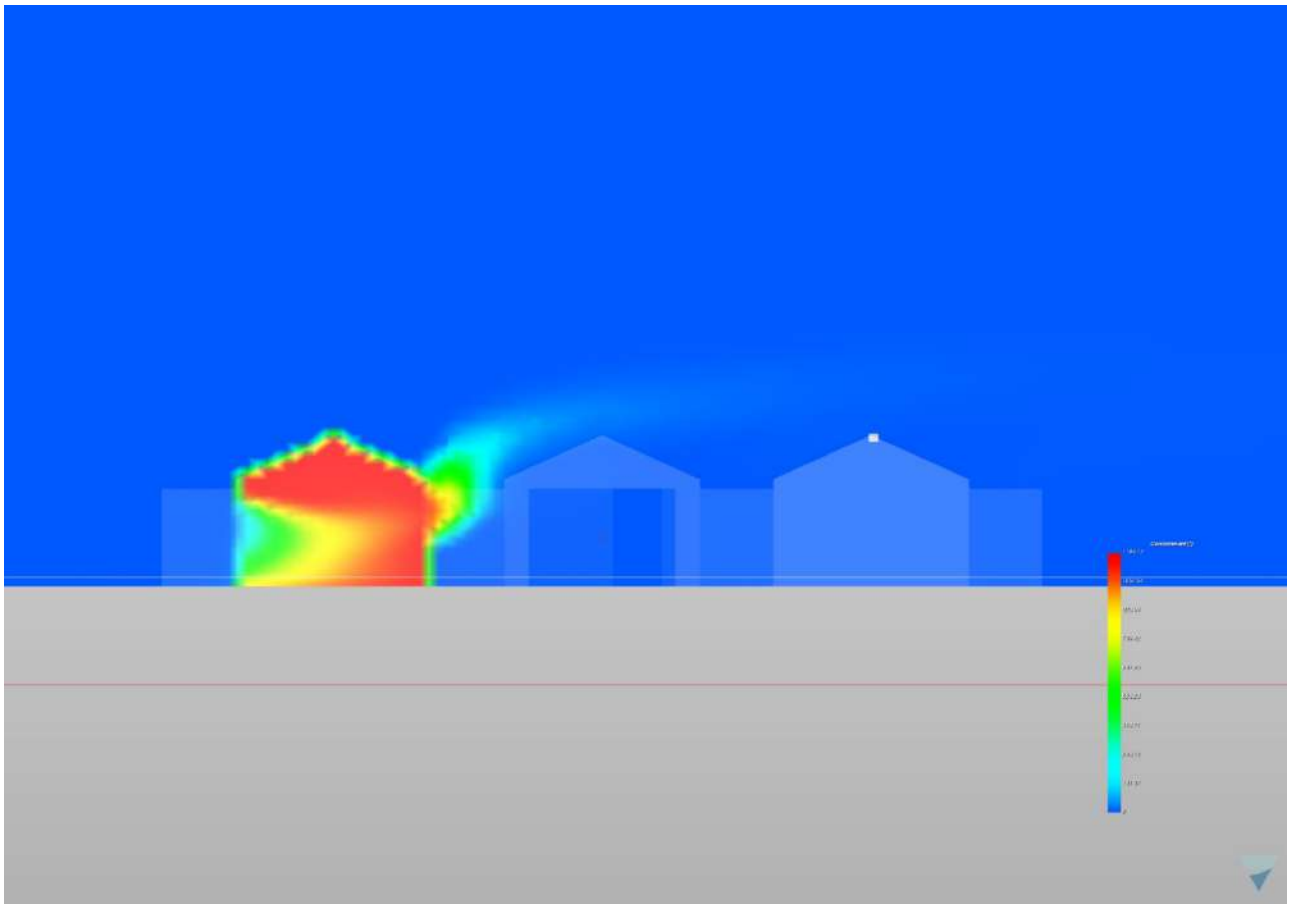


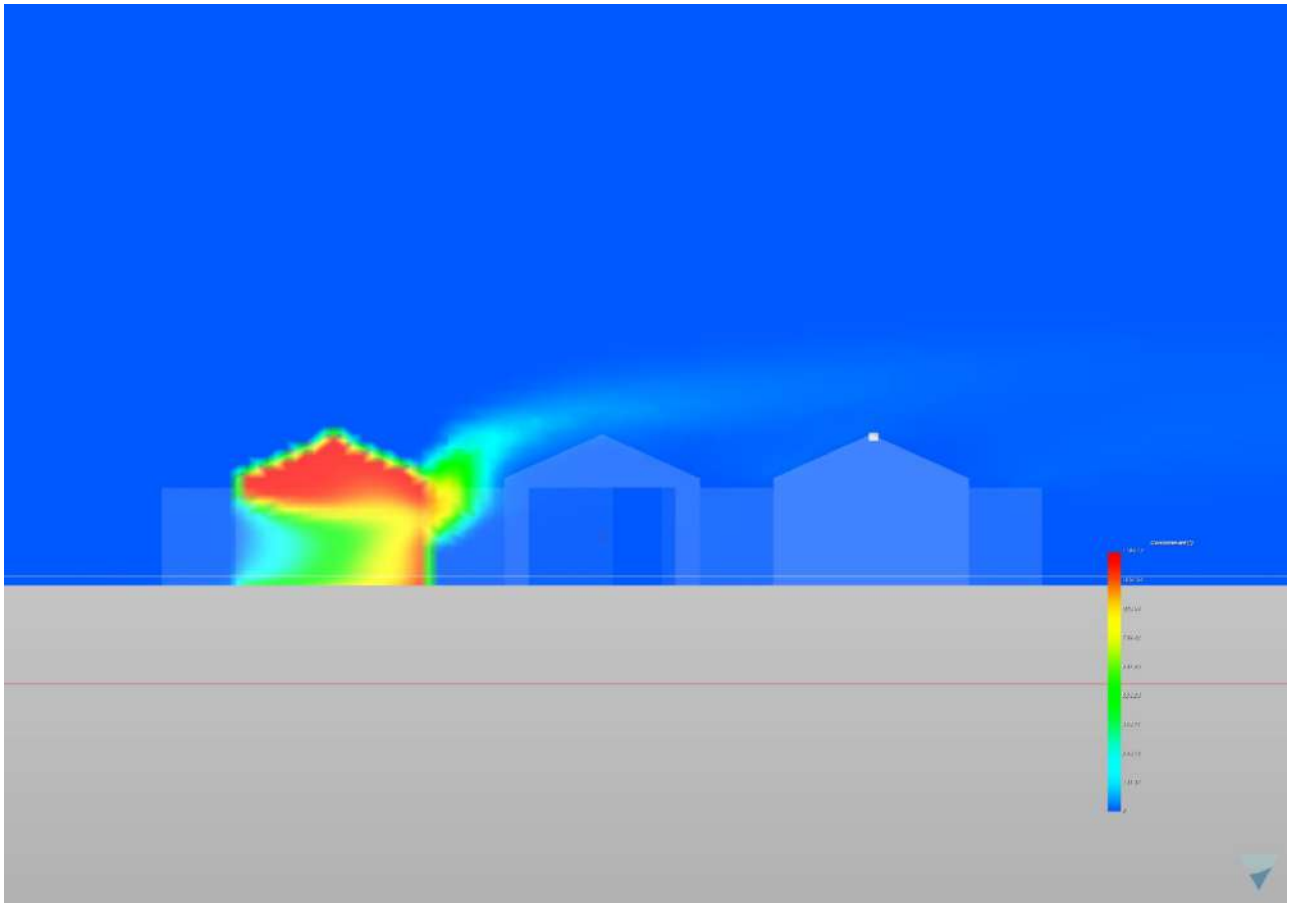


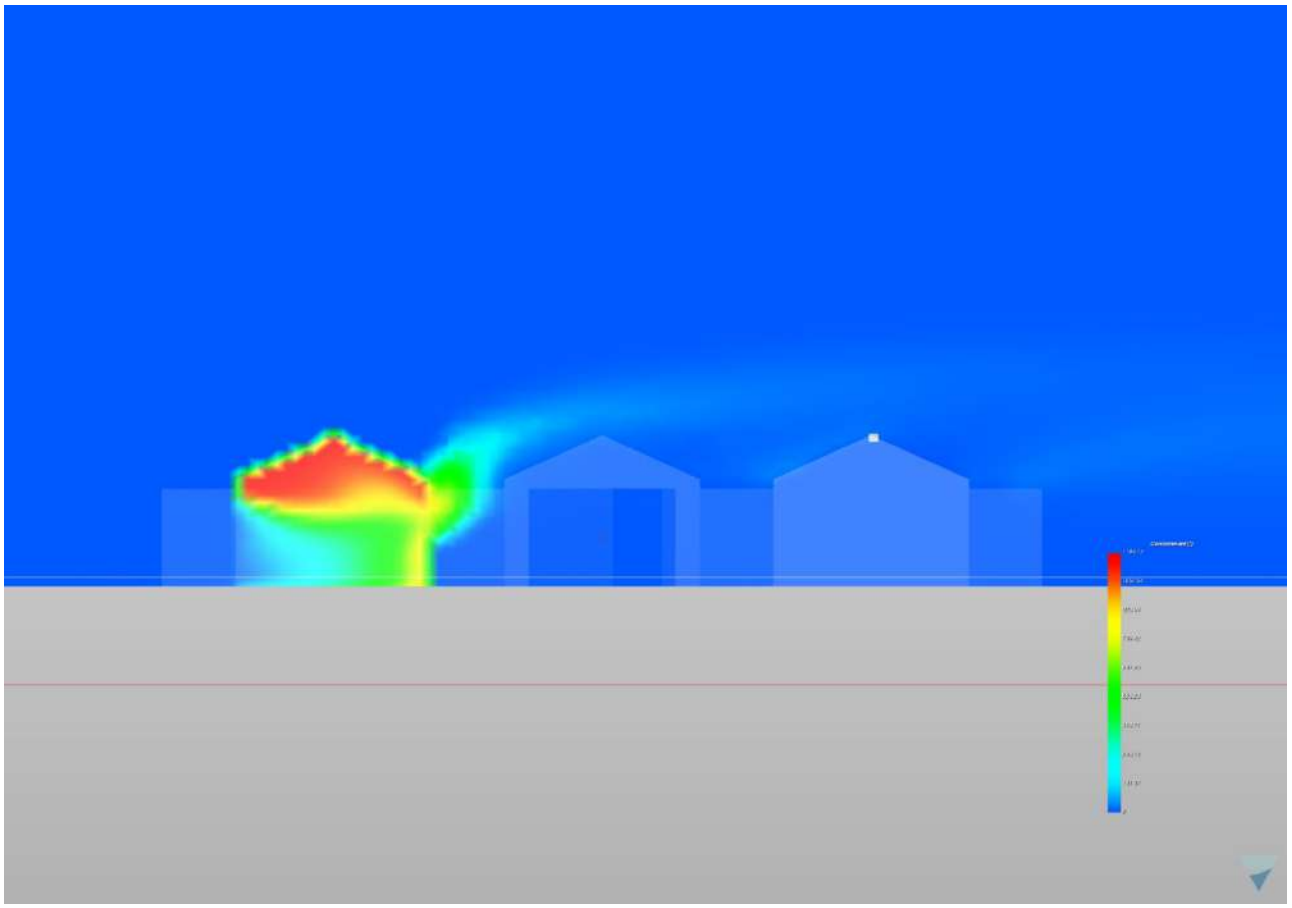


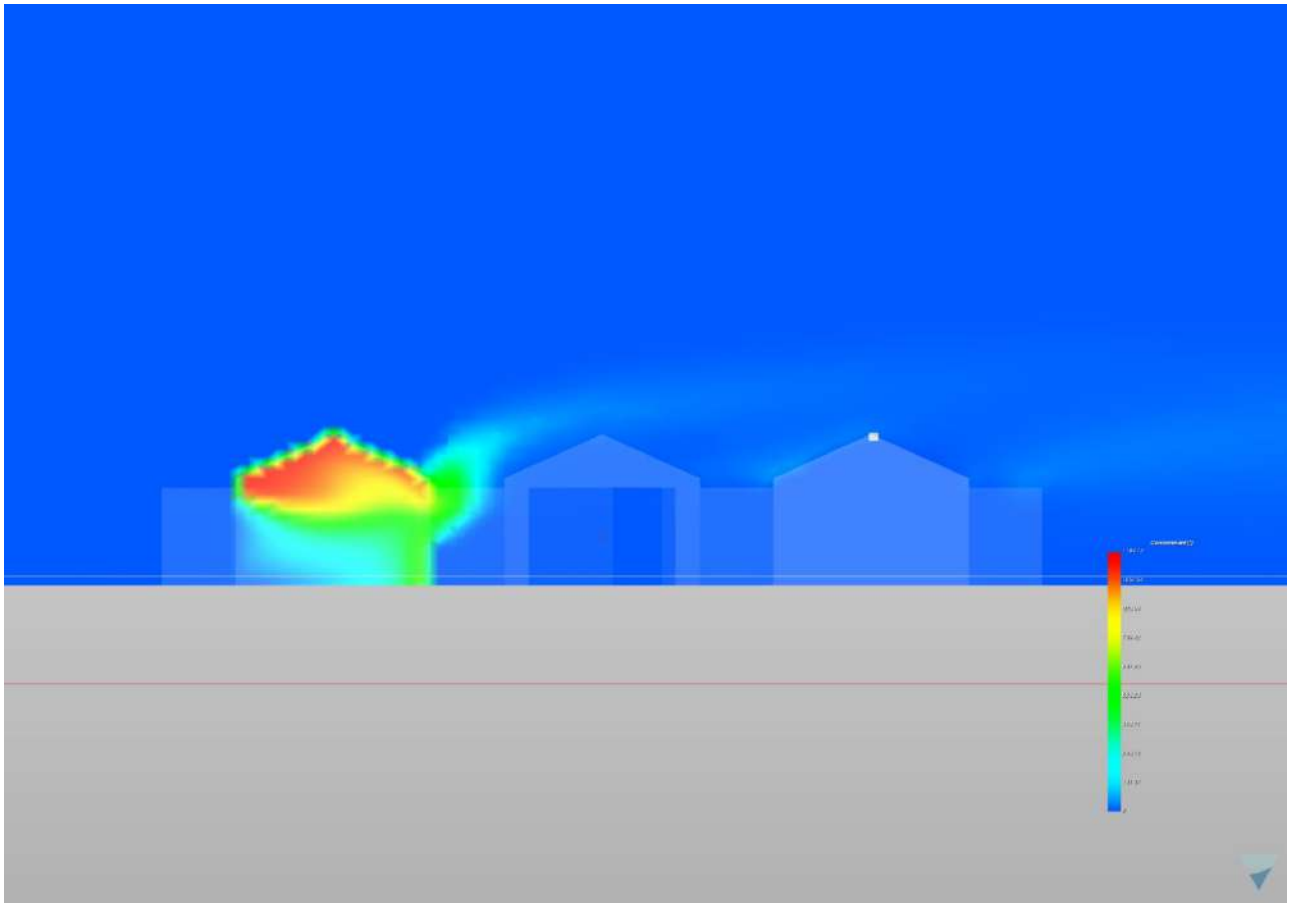


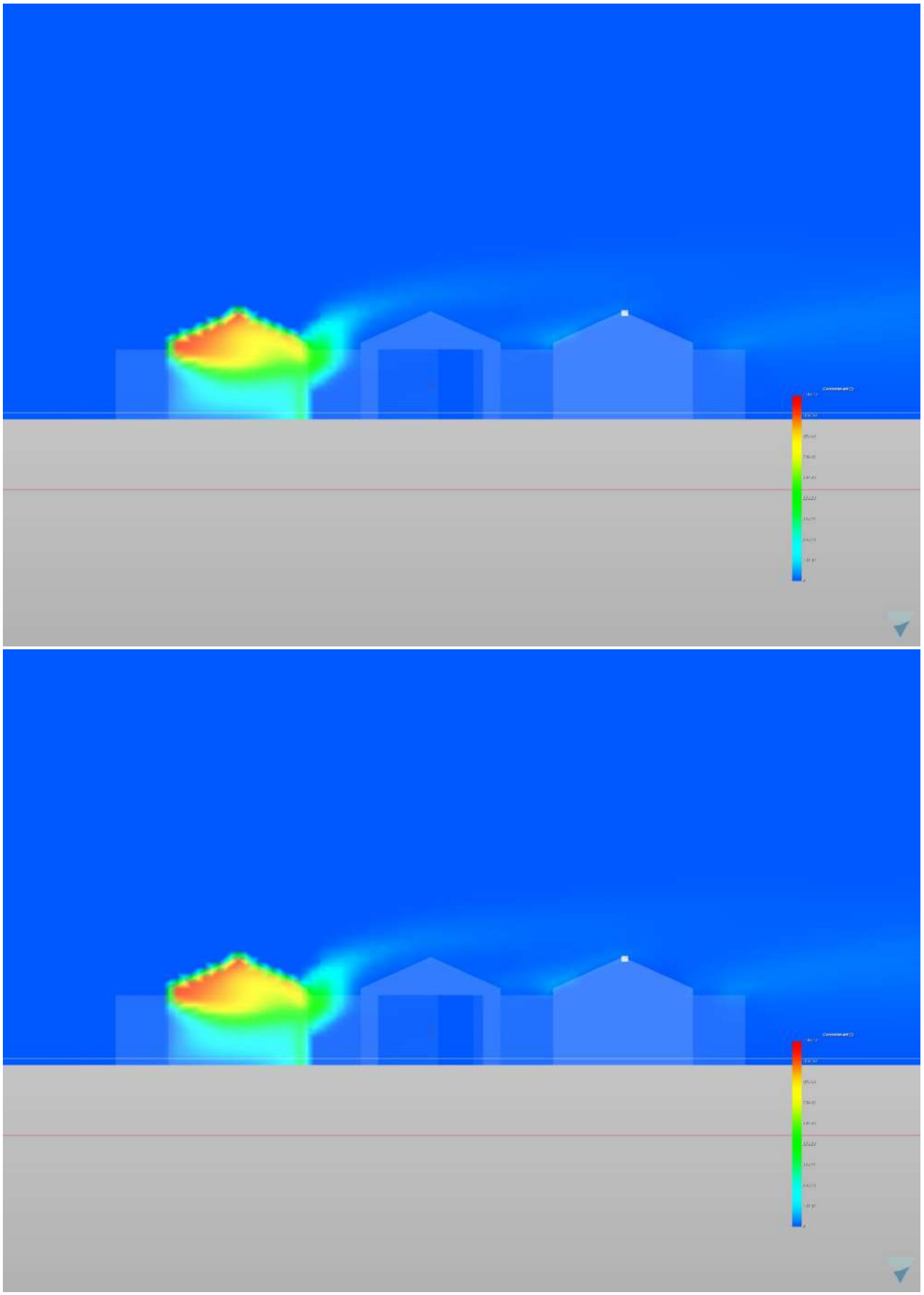




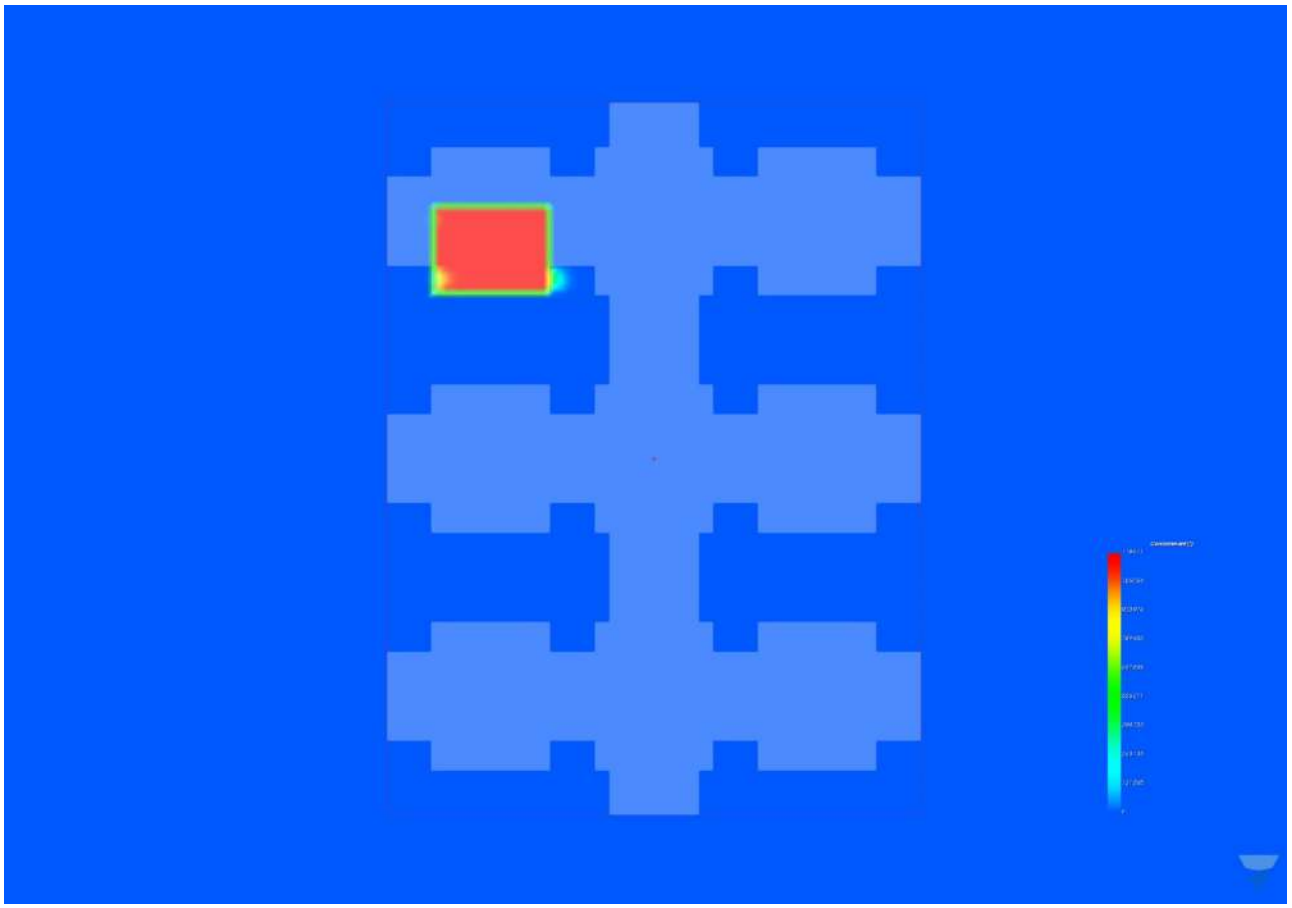


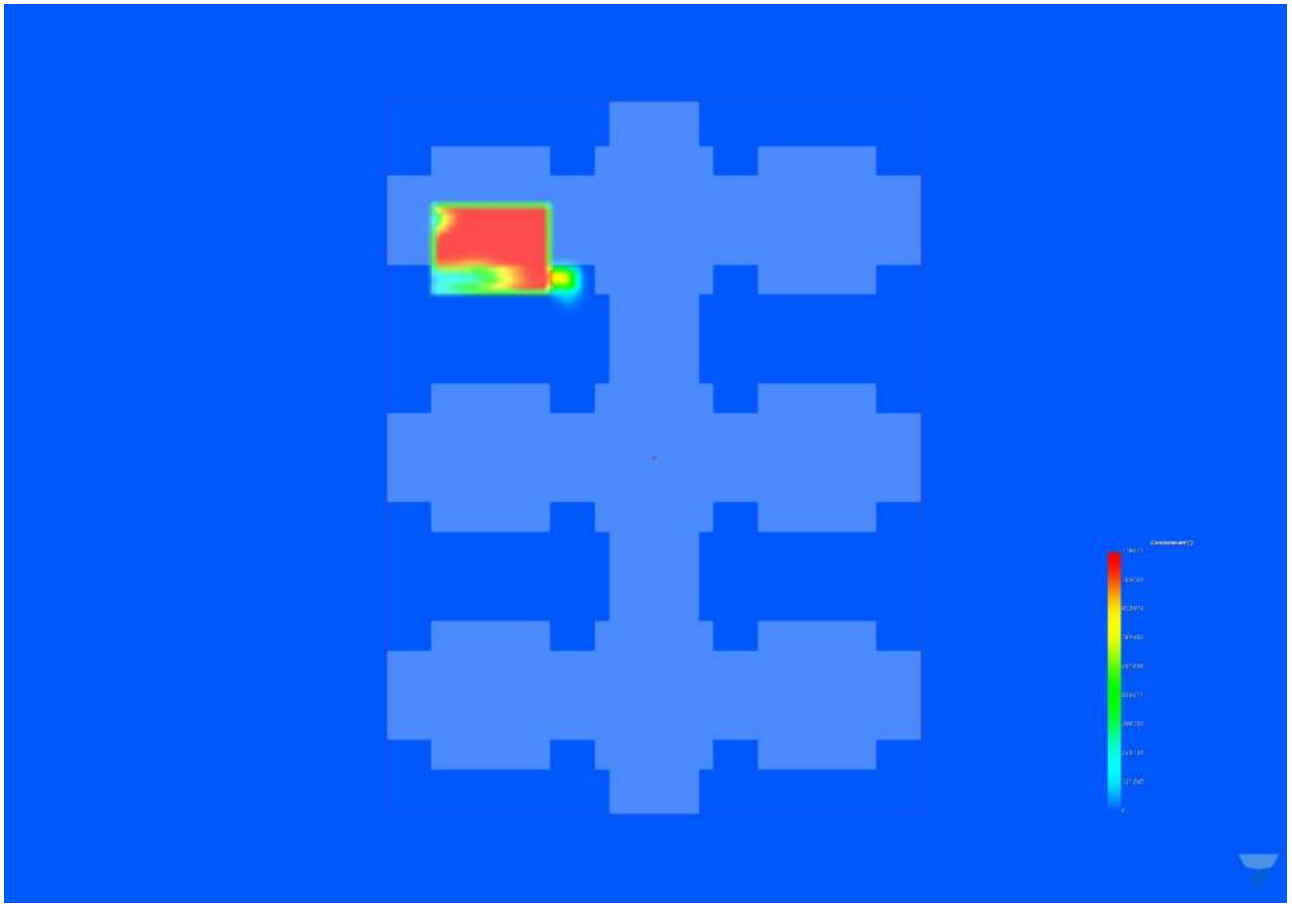


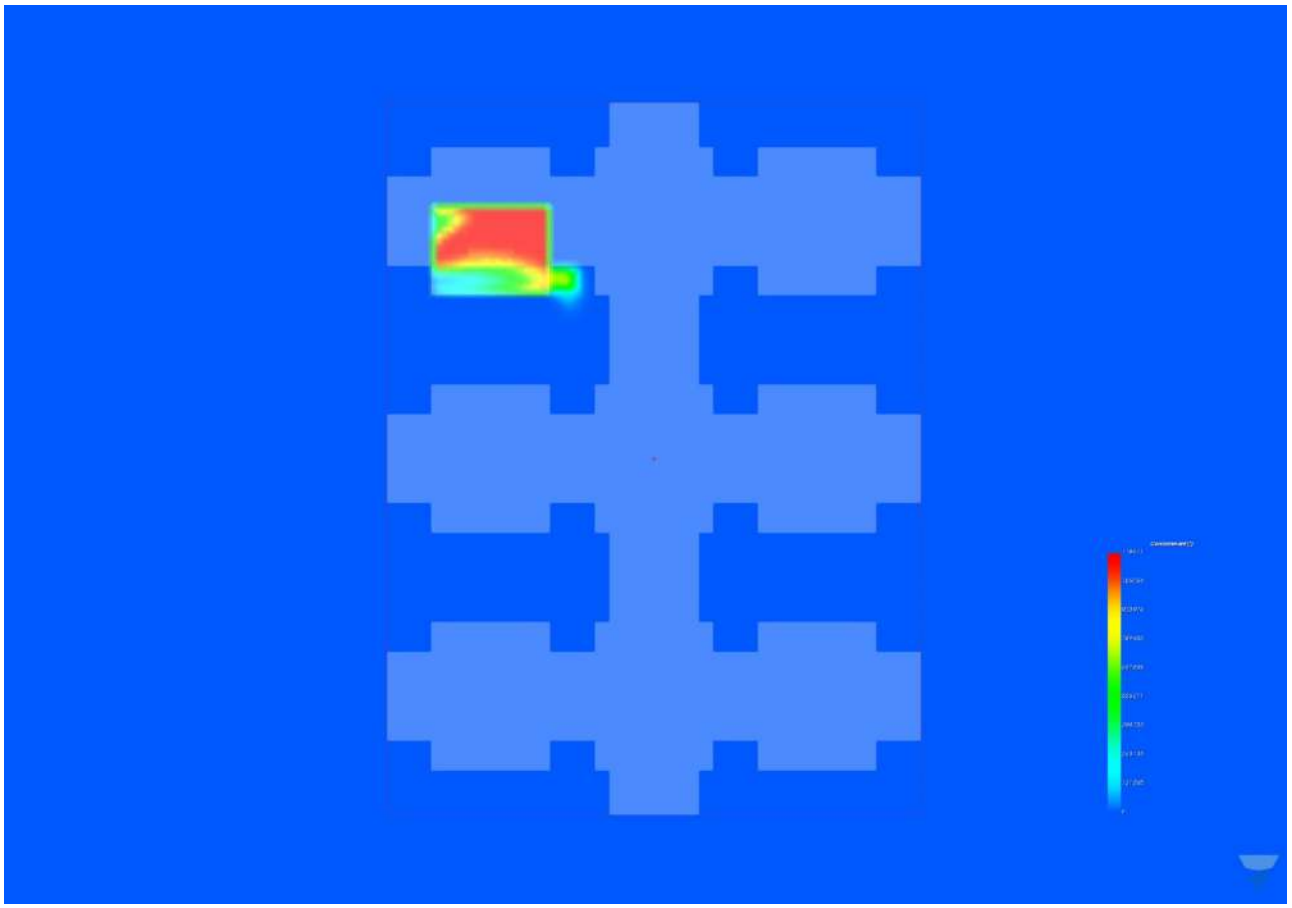


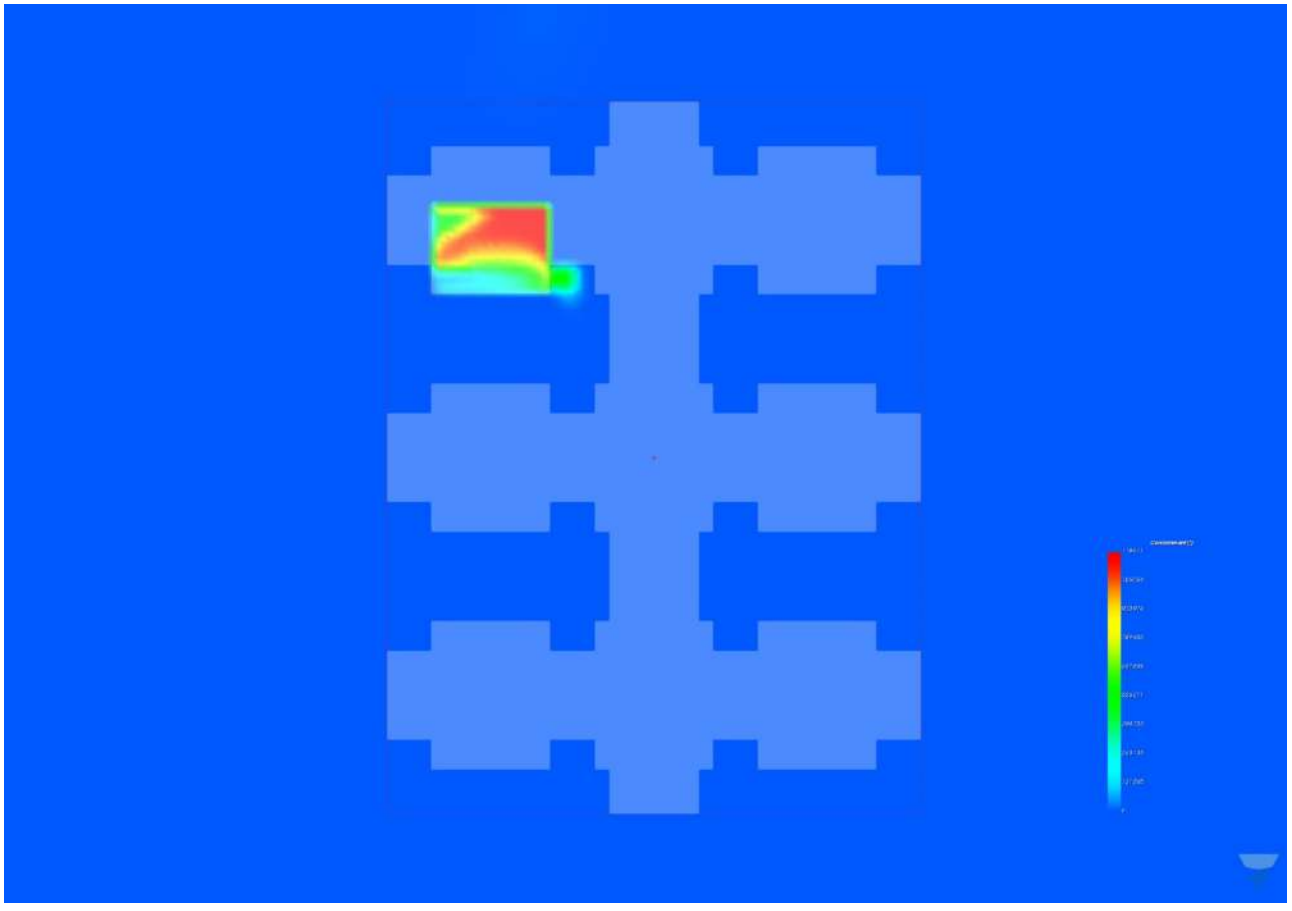


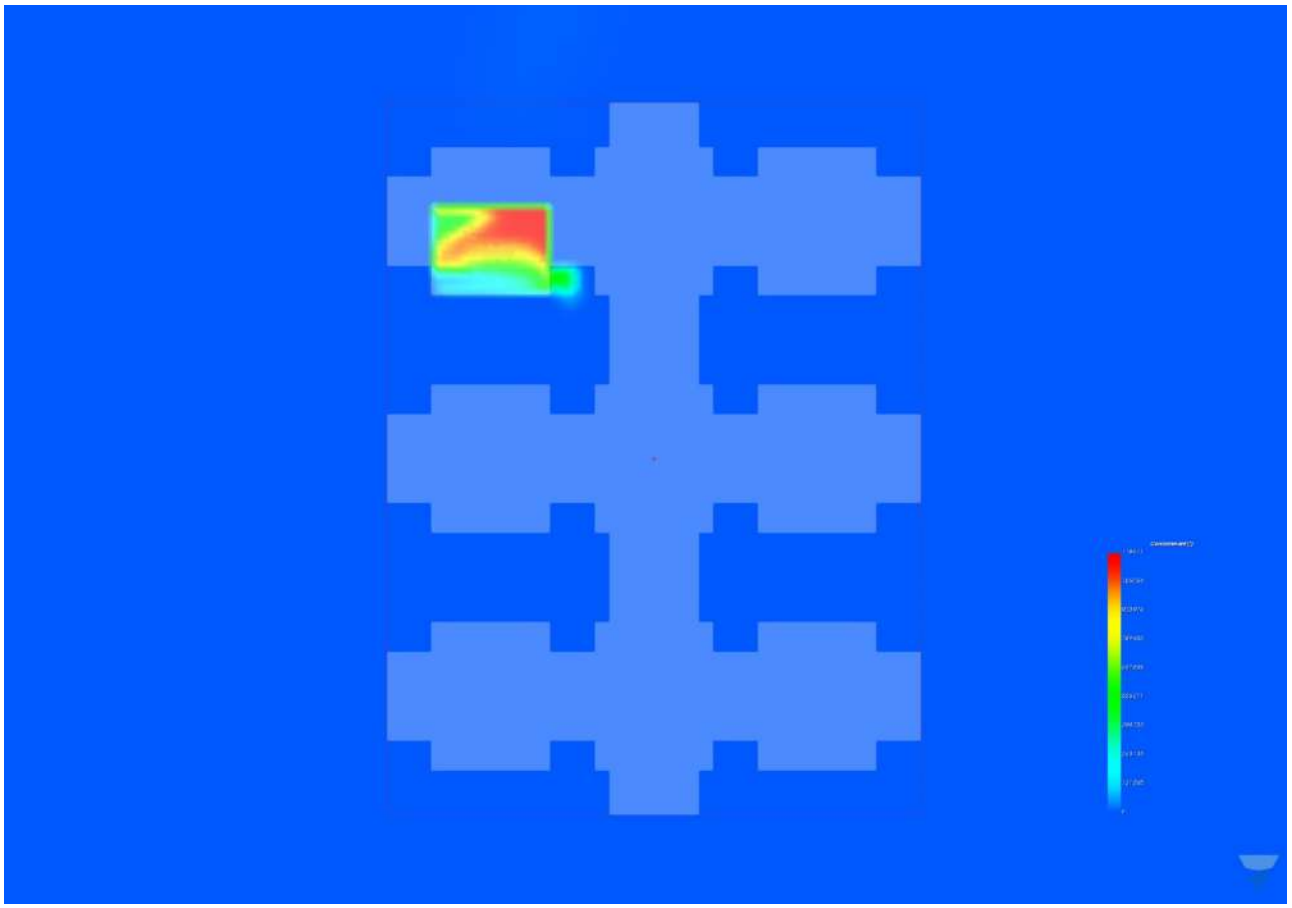
Top Tent – South Wind

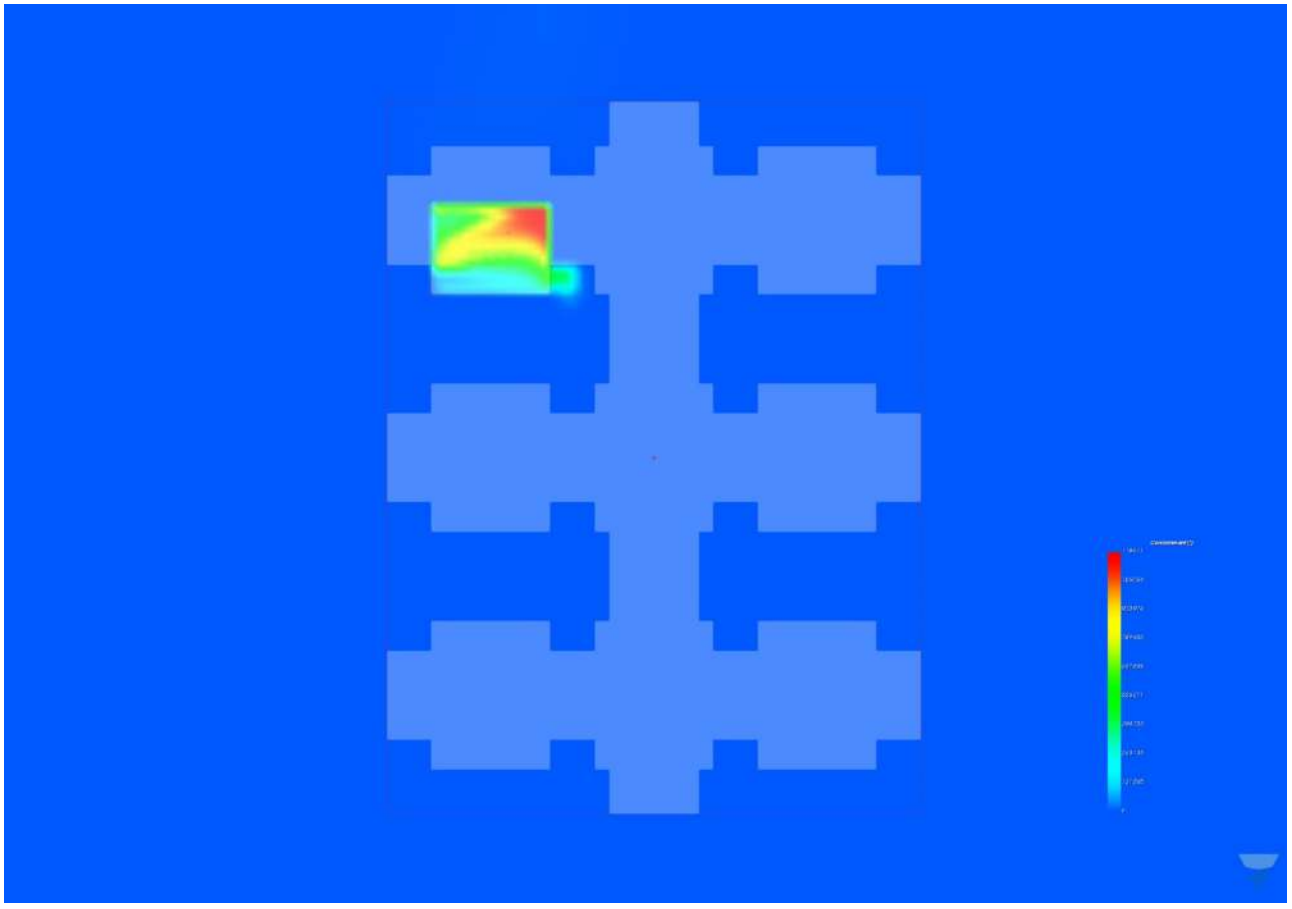


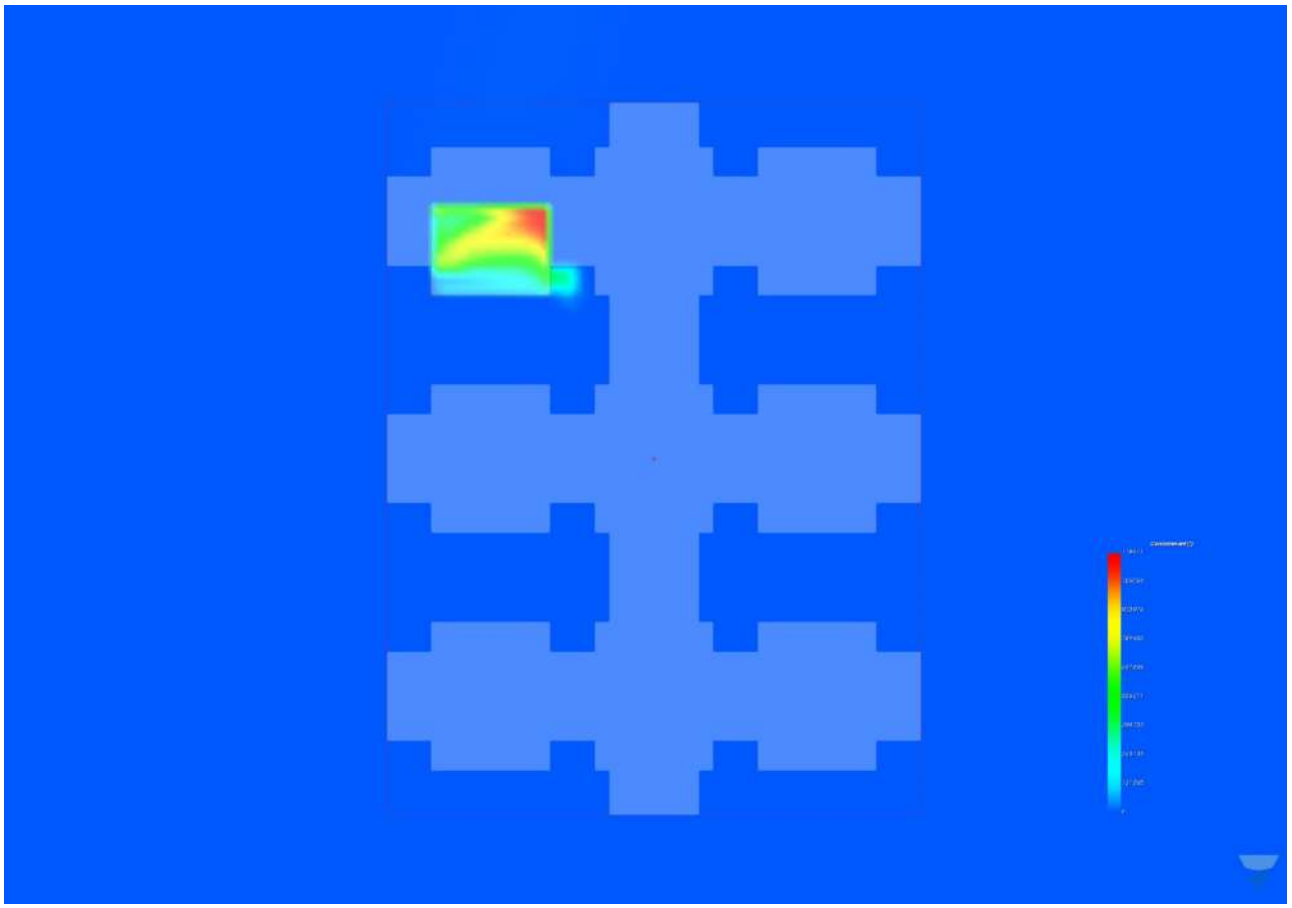


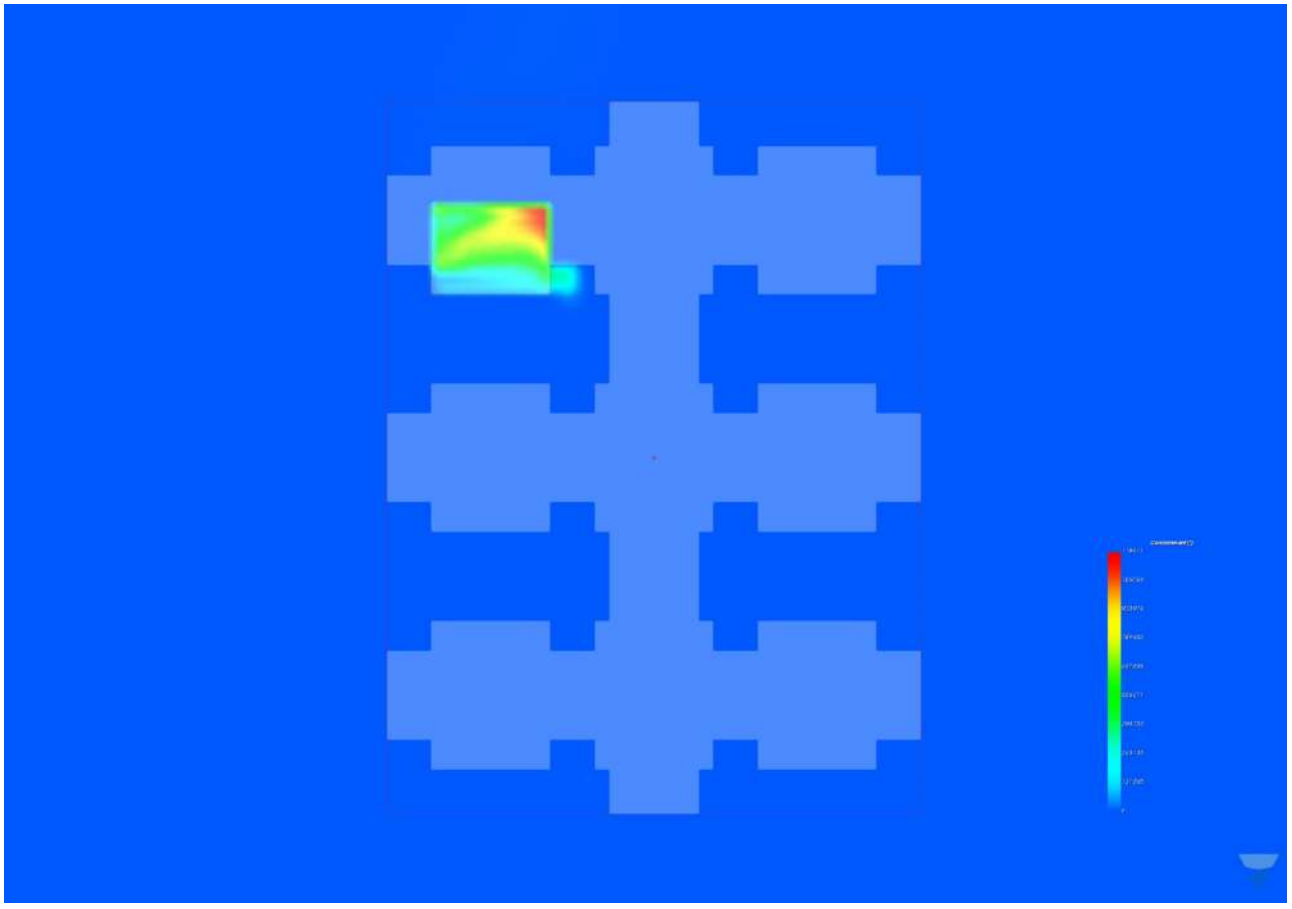


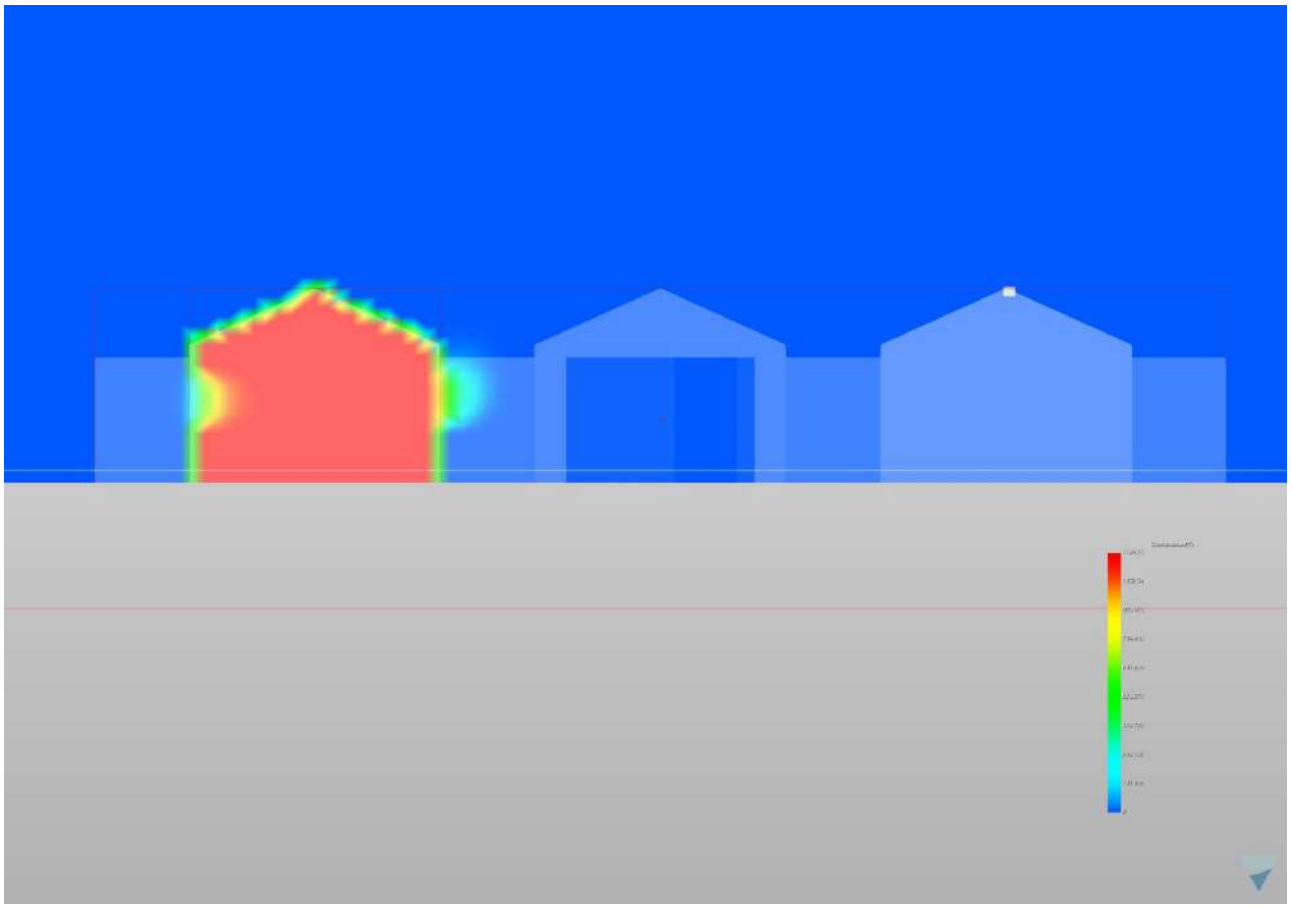


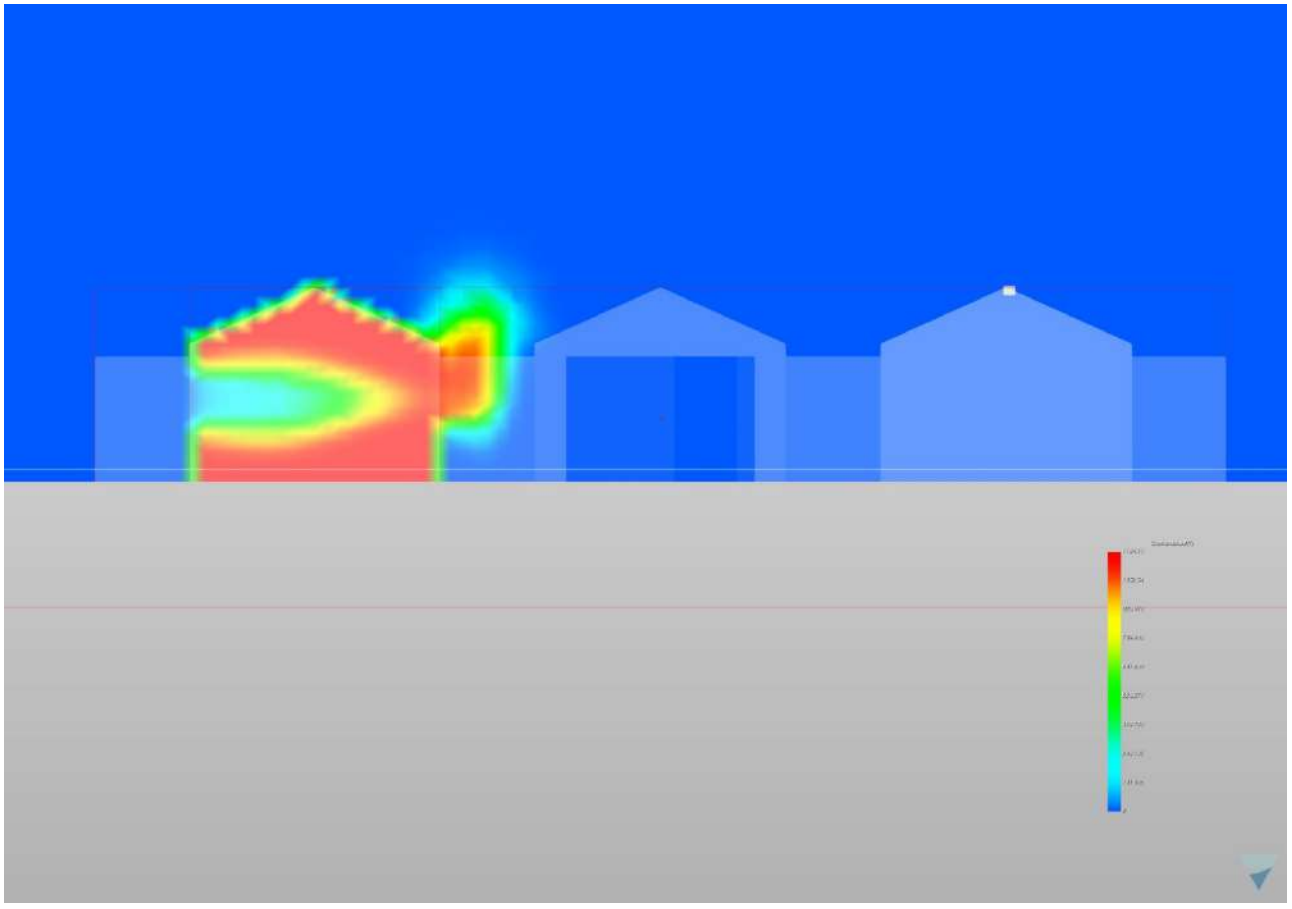


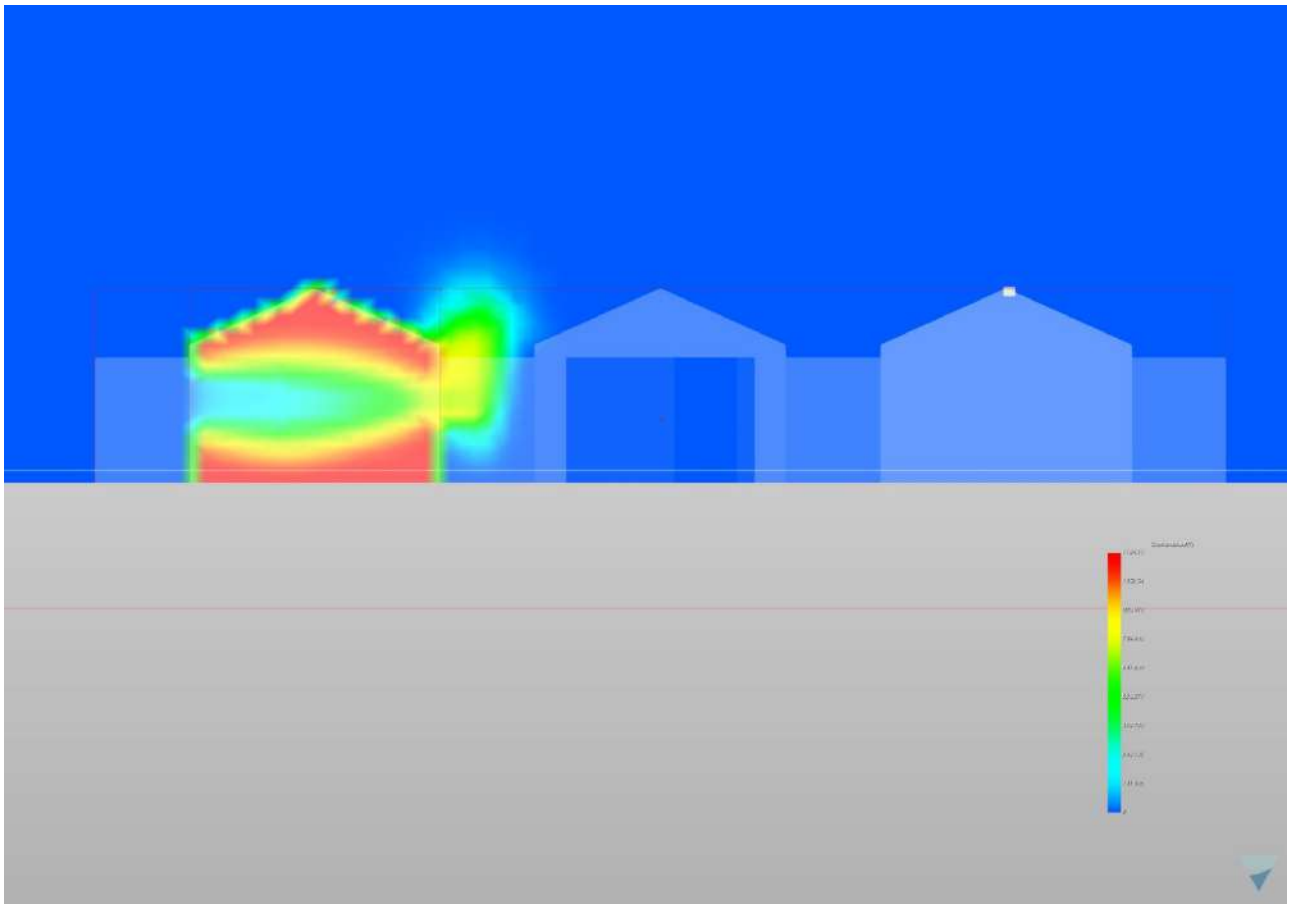


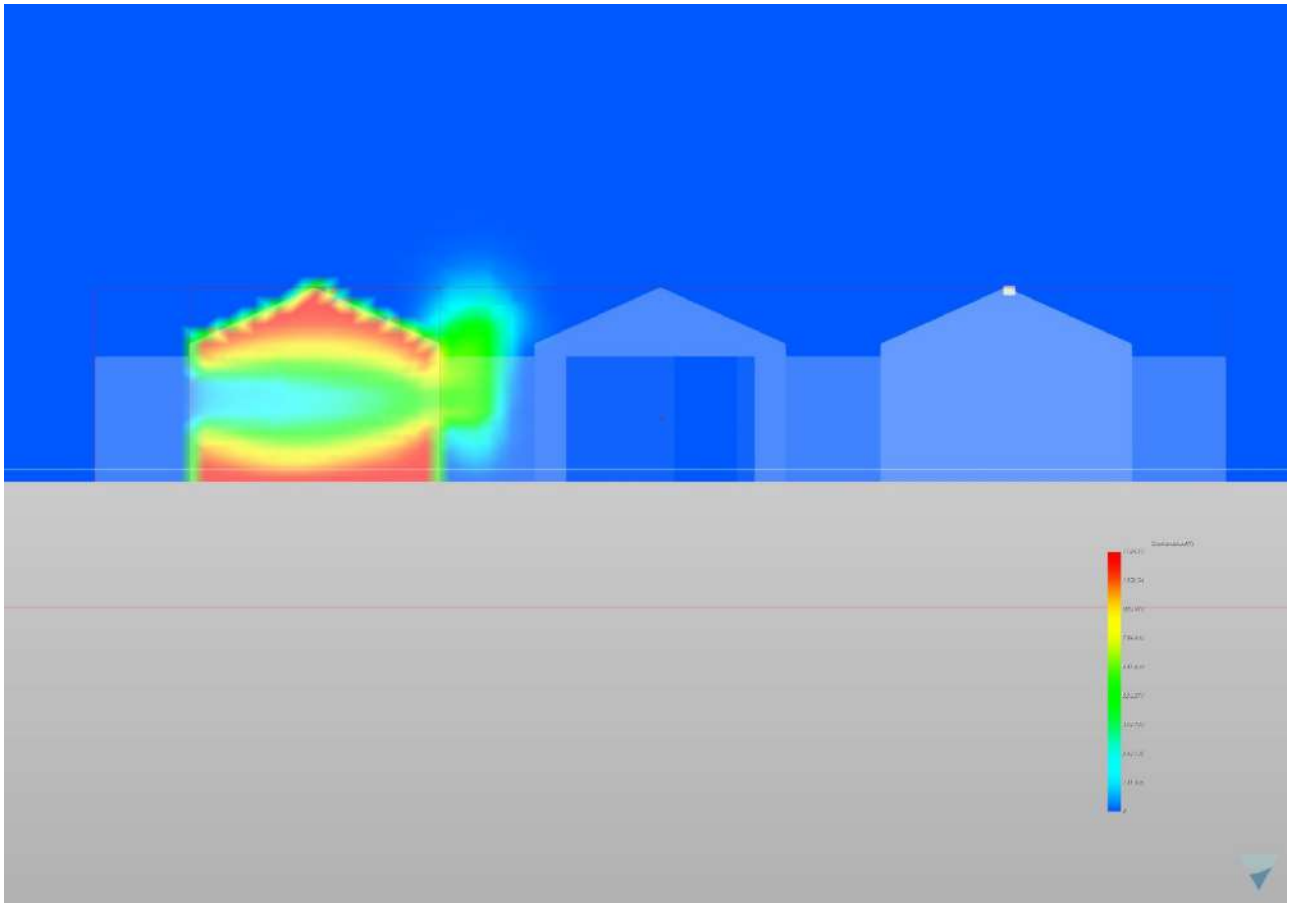


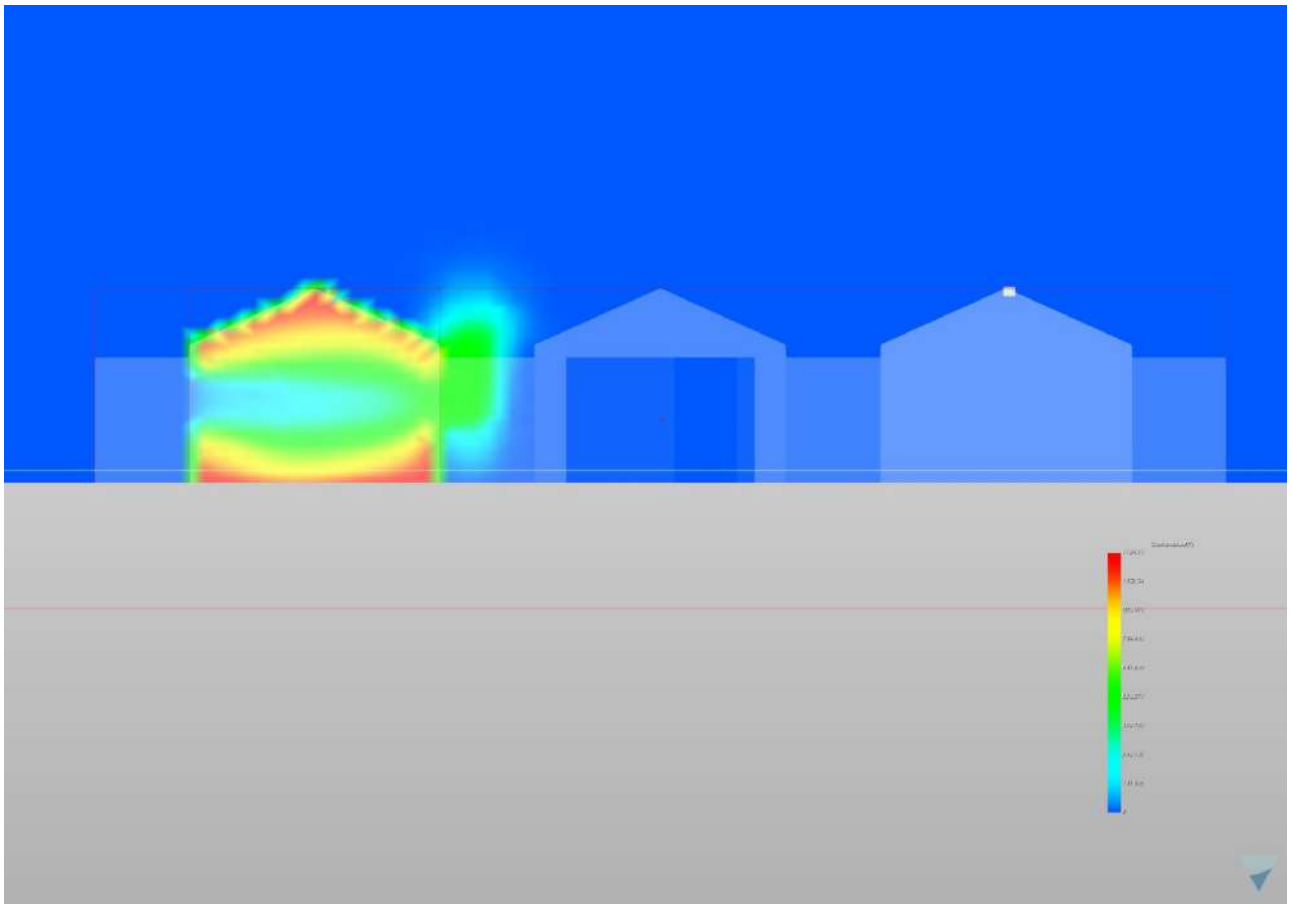


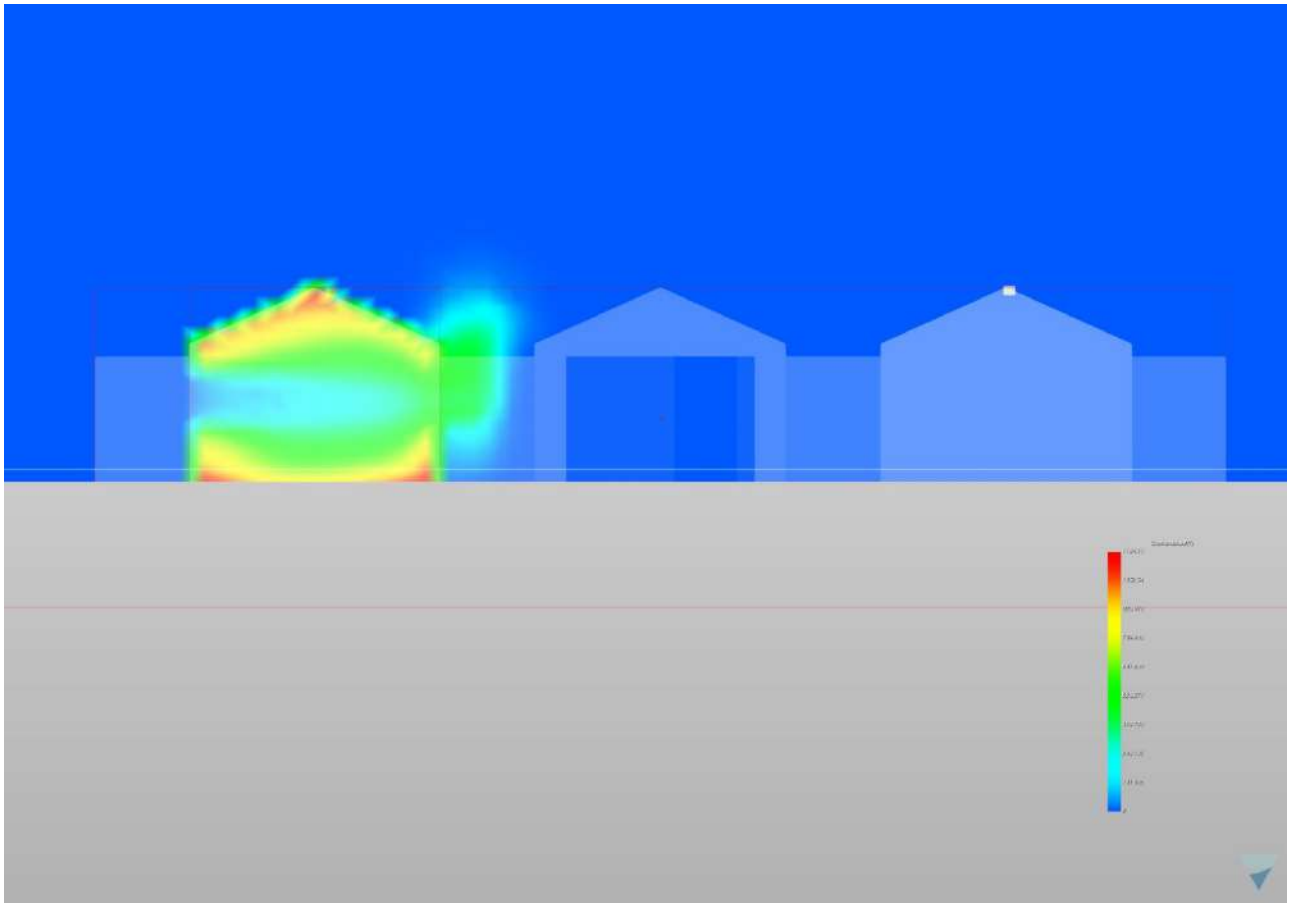


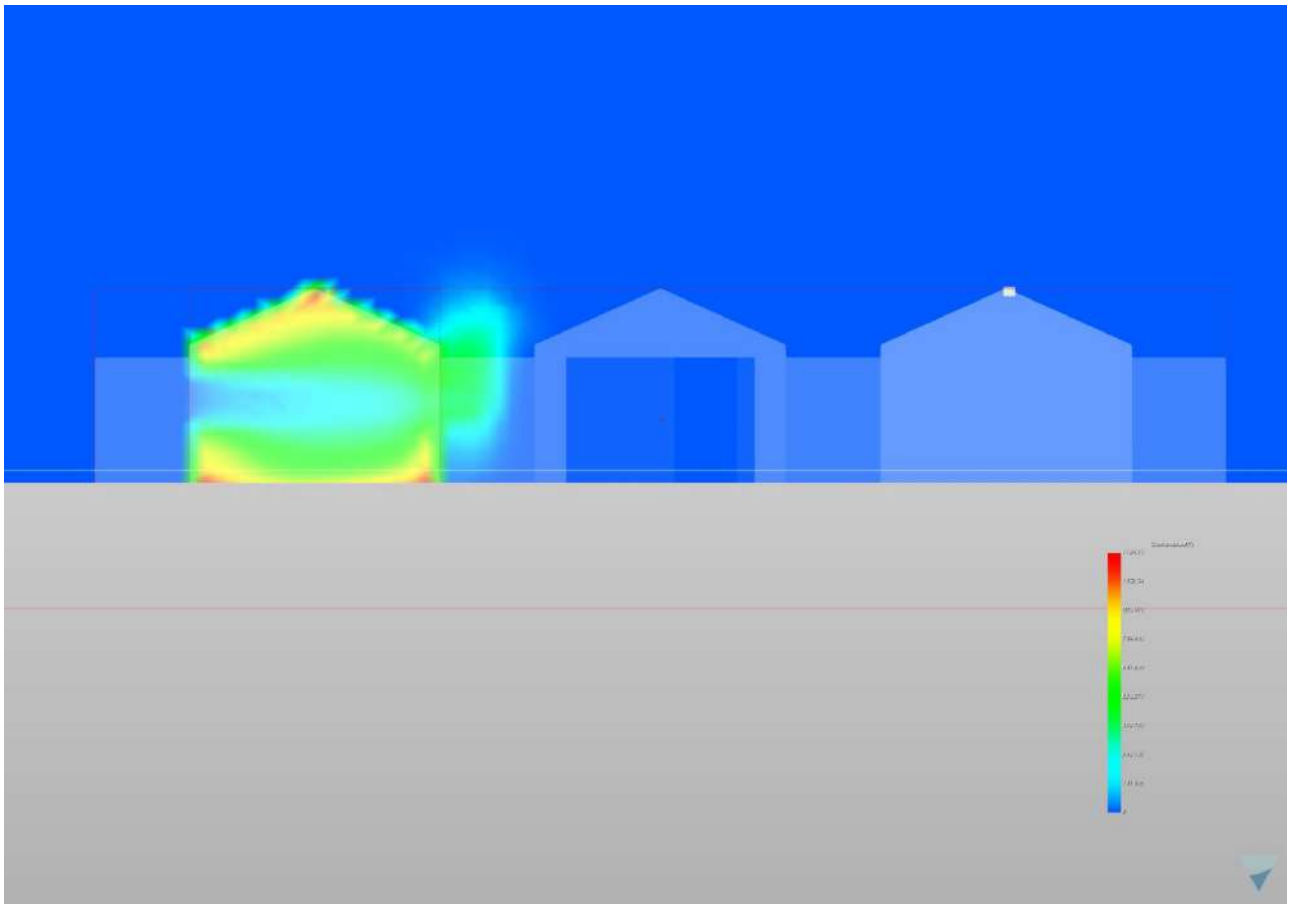


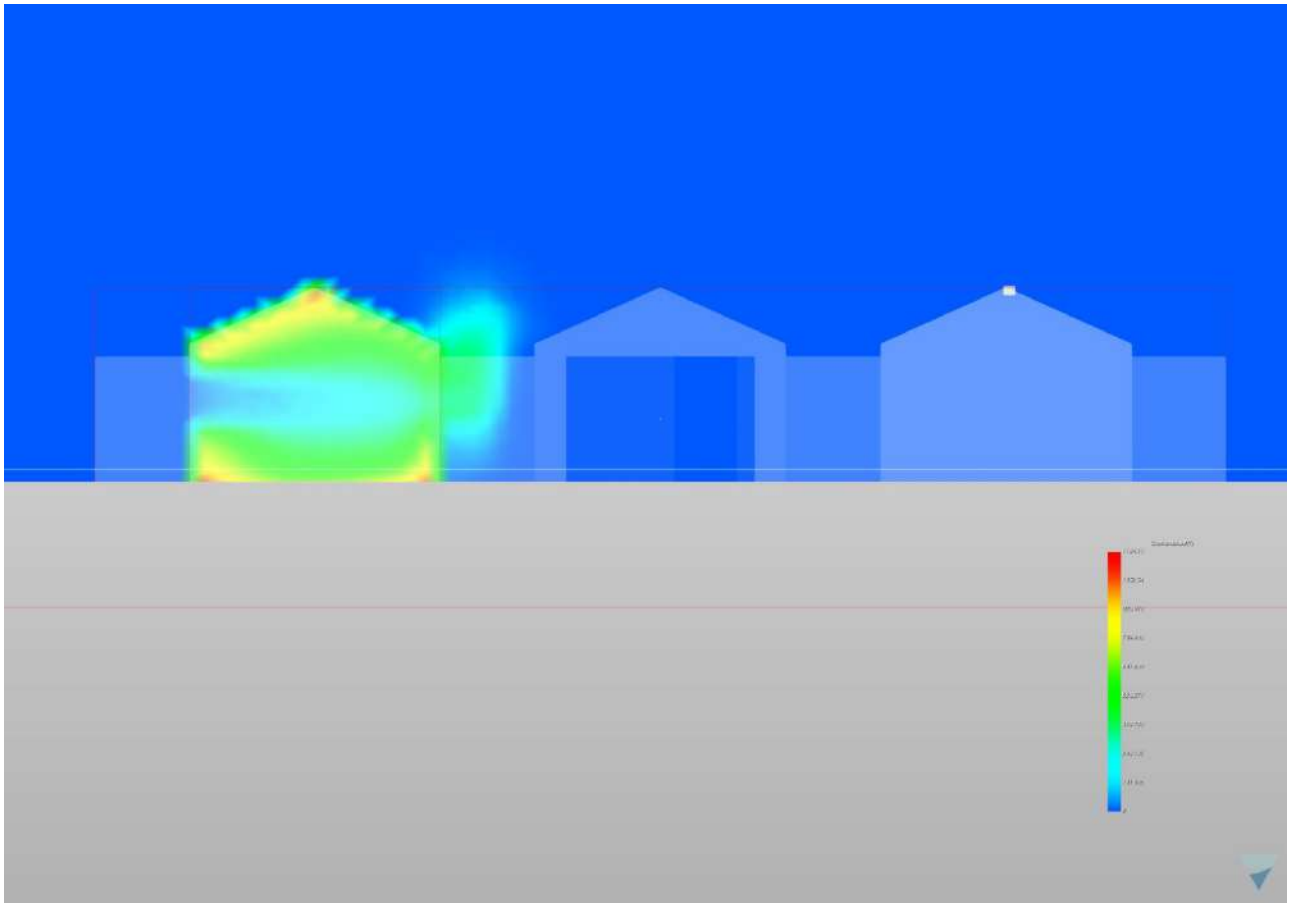




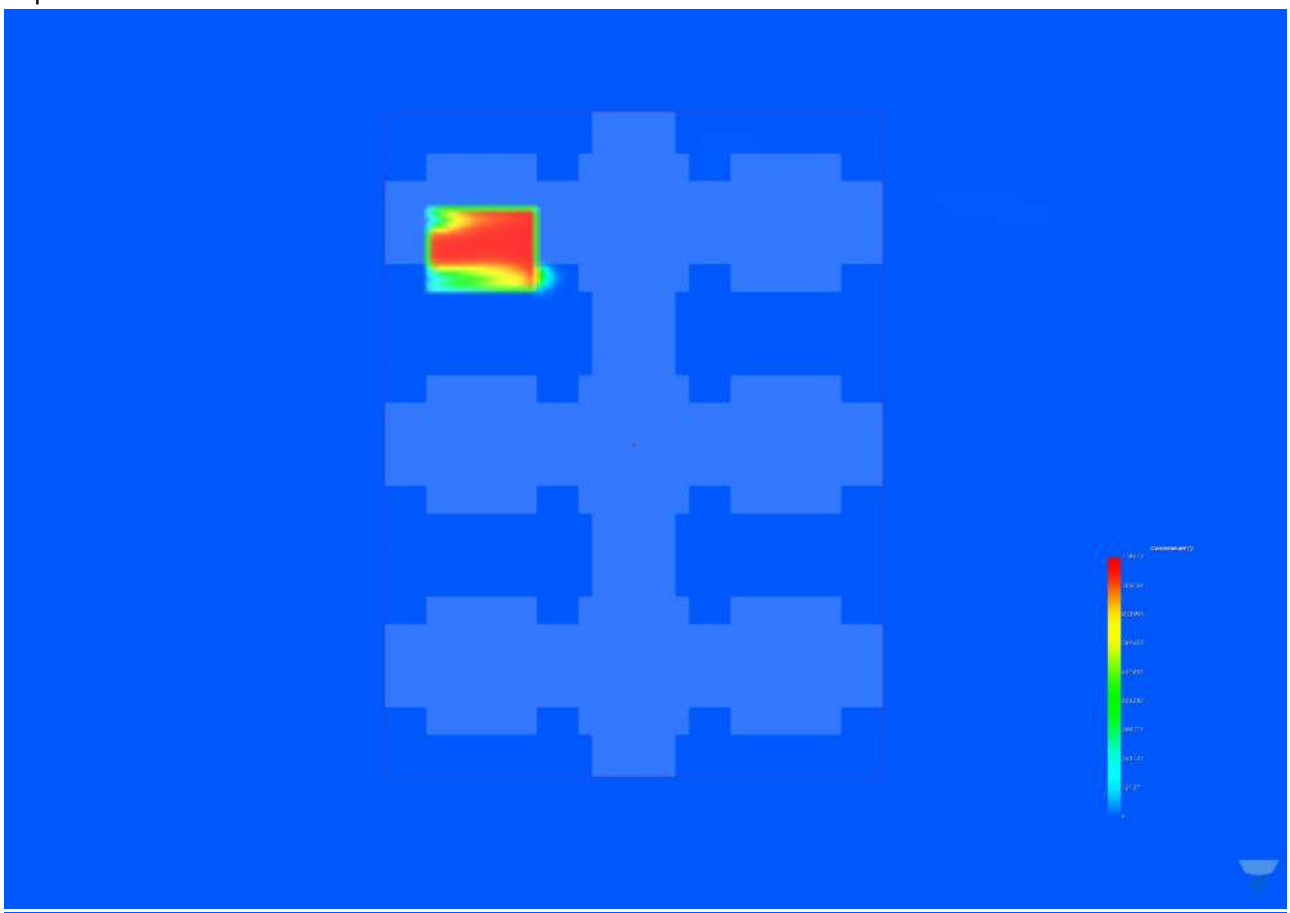


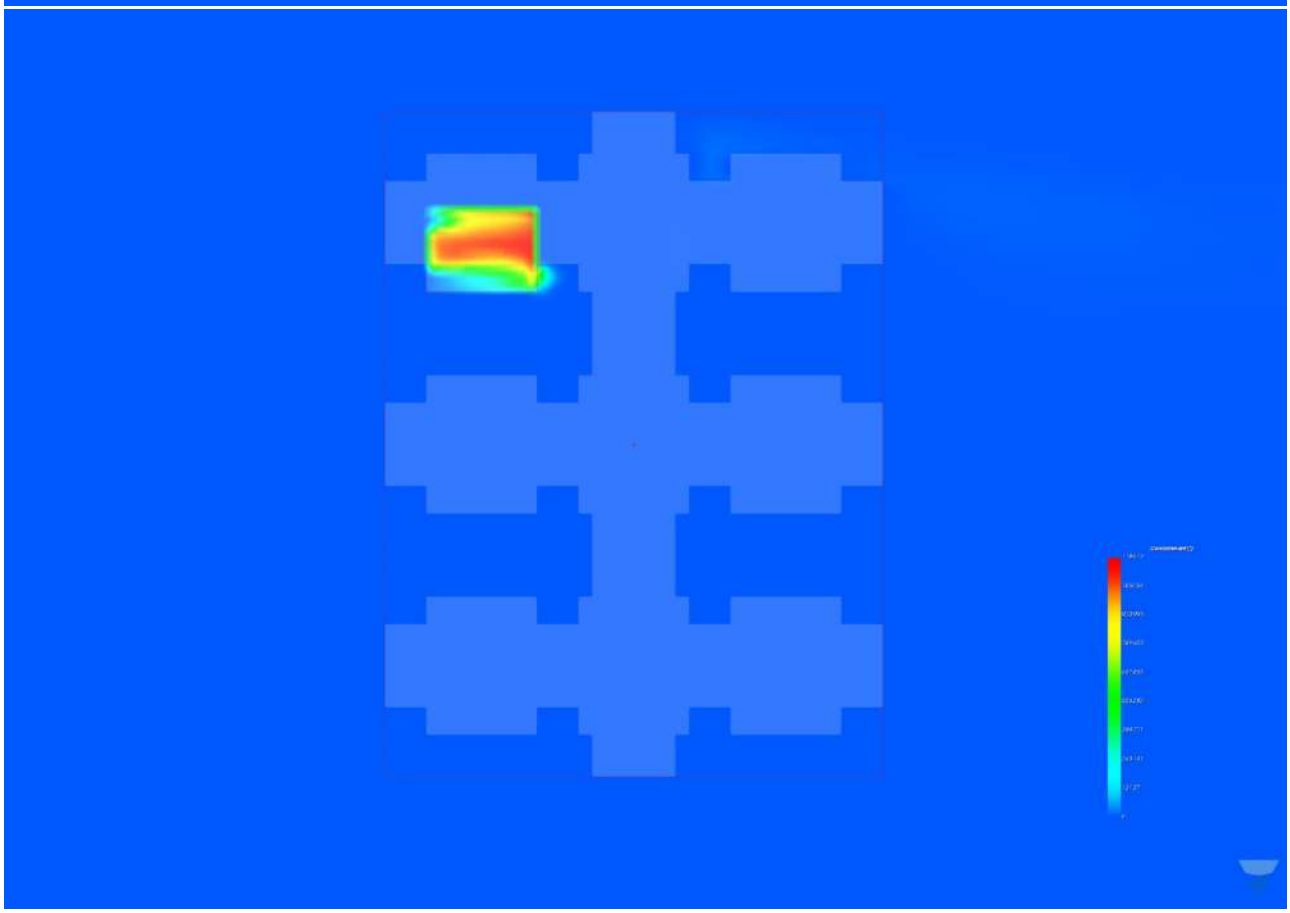


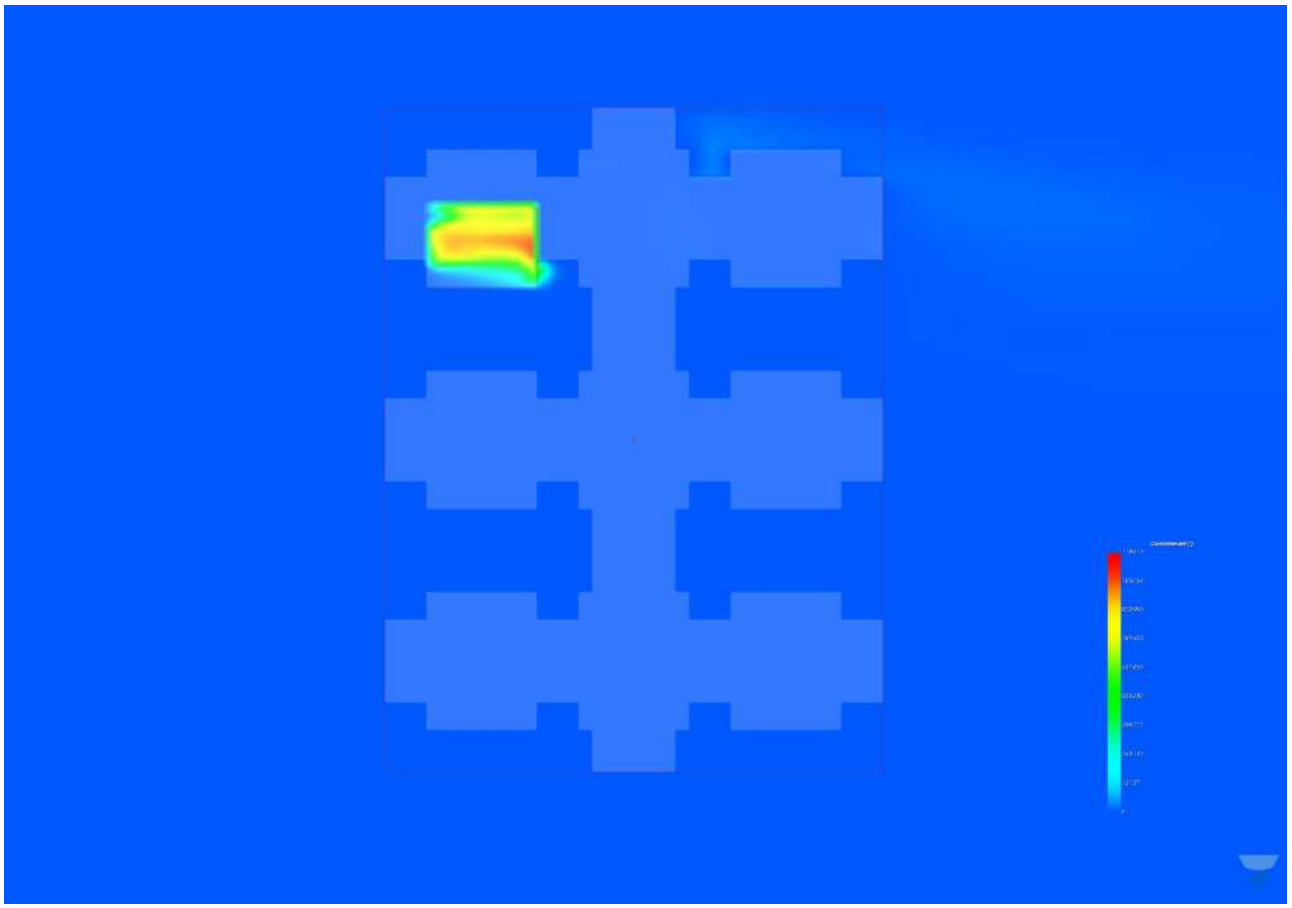


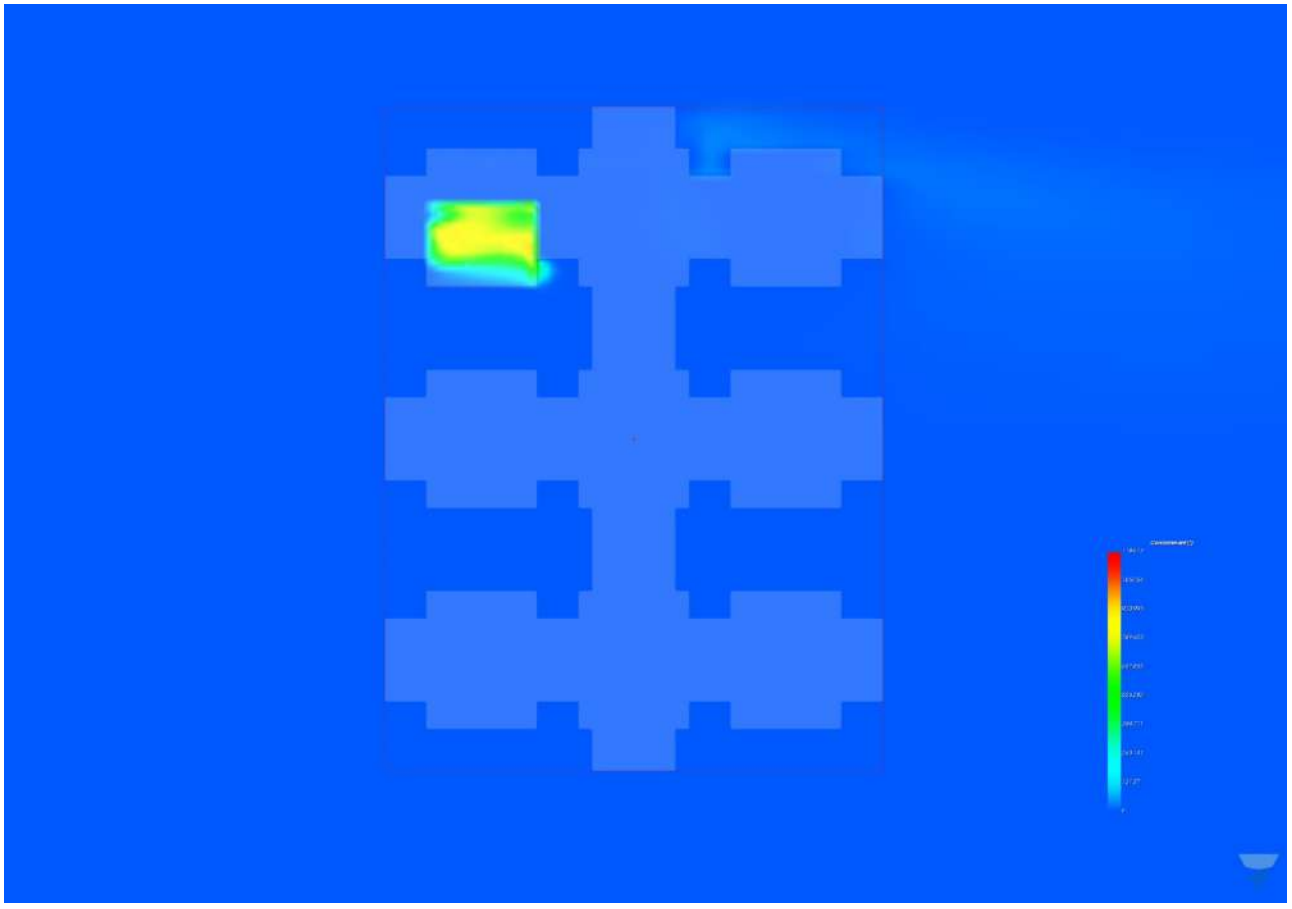


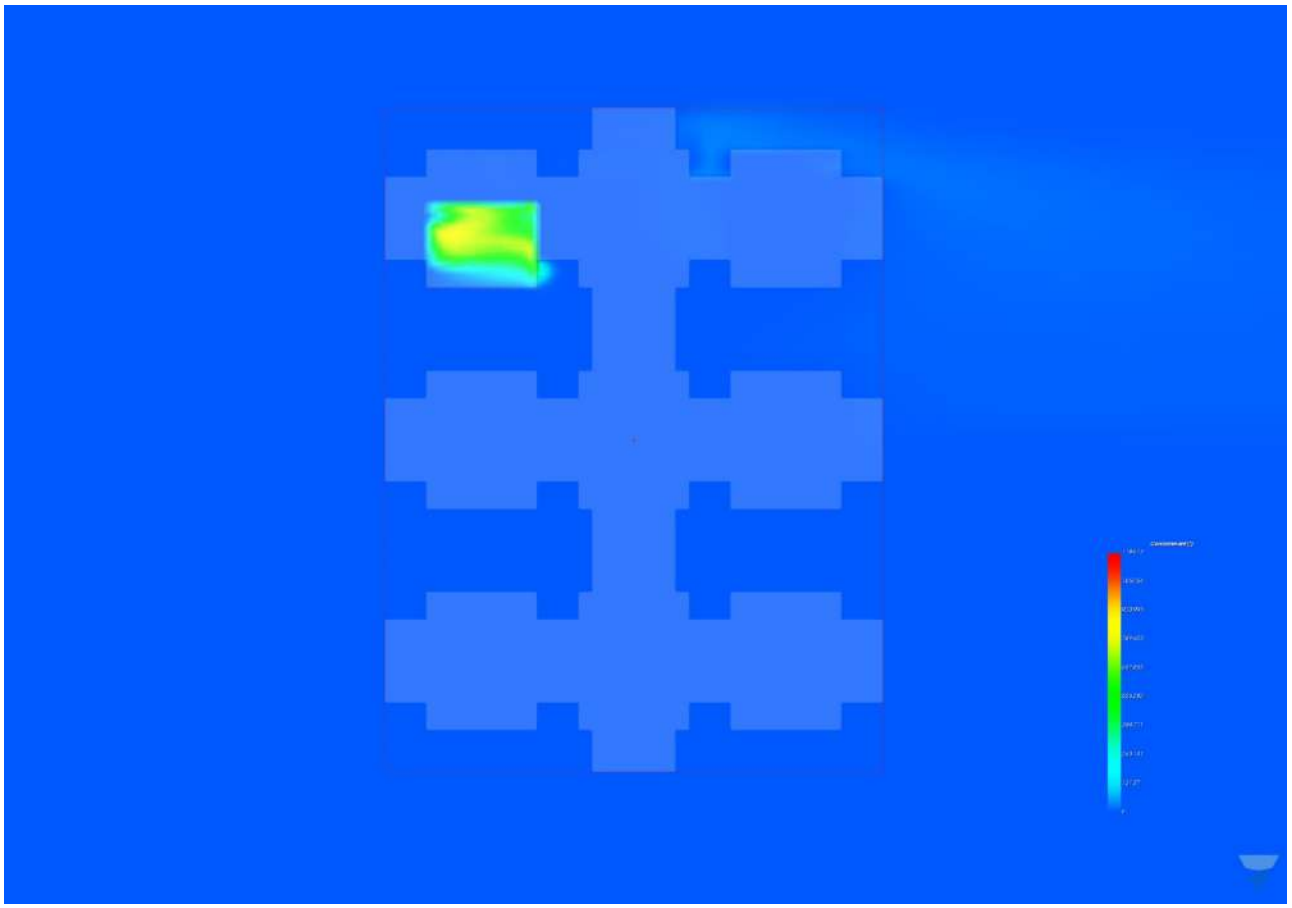
Top Tent – West Wind

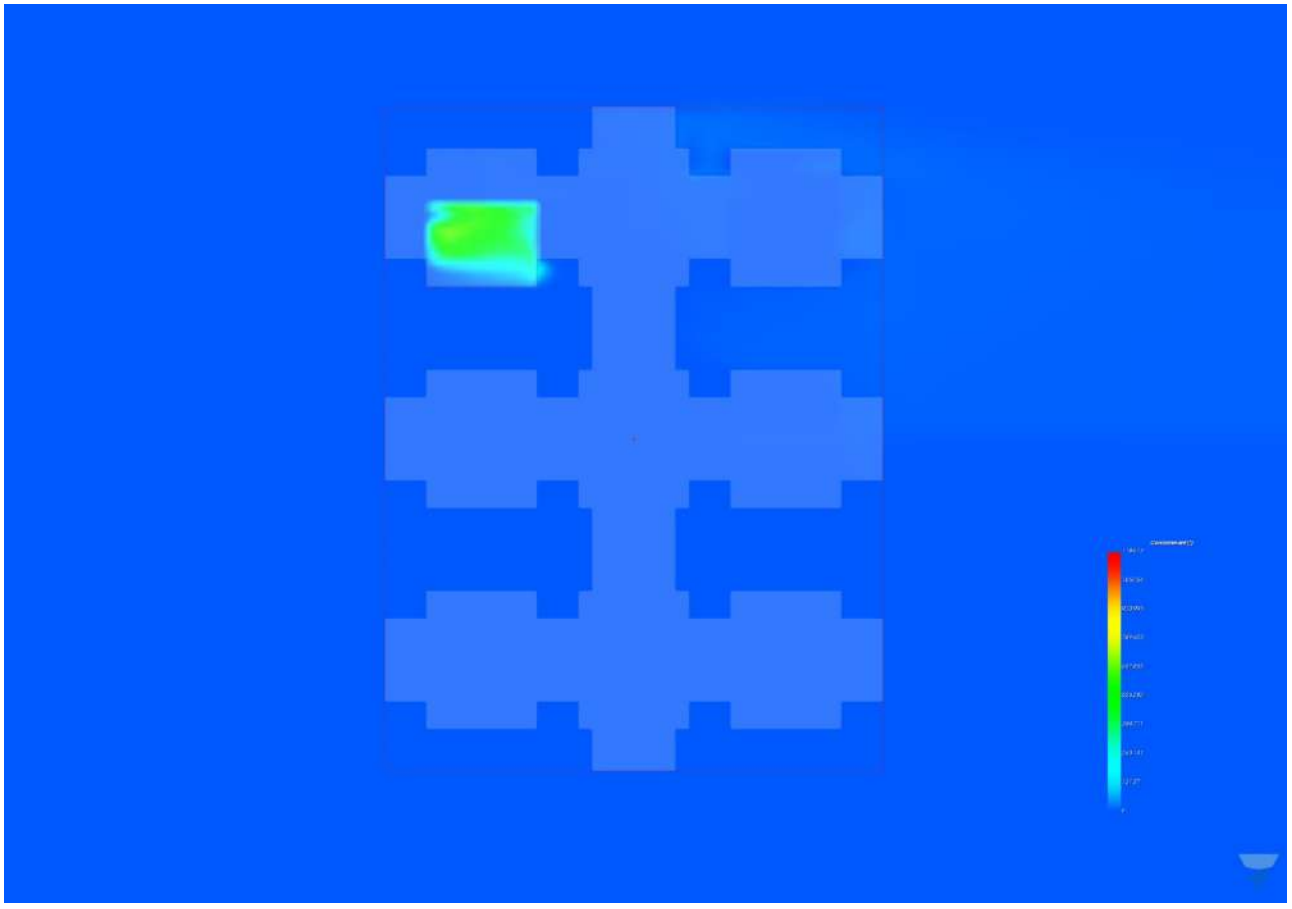


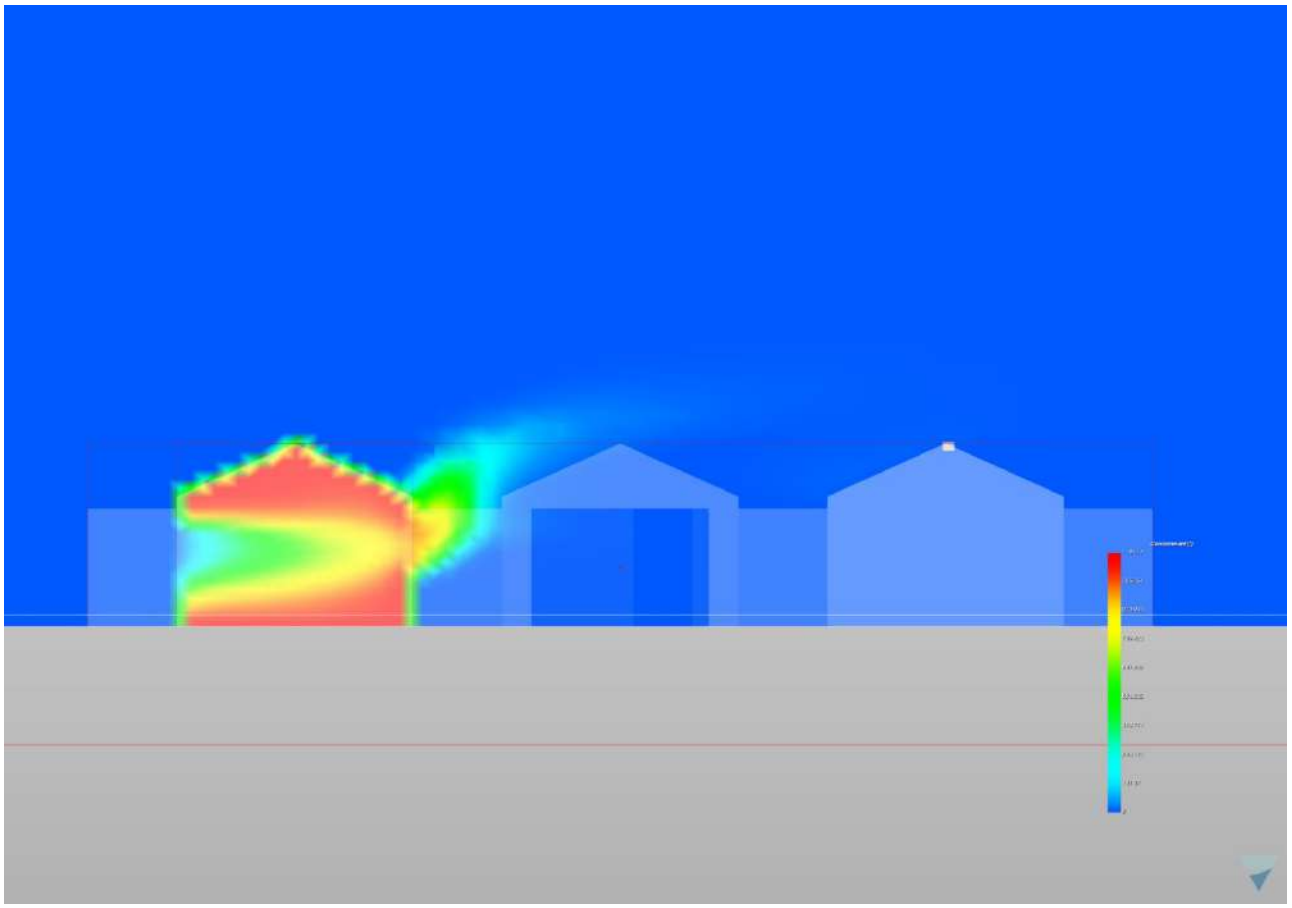


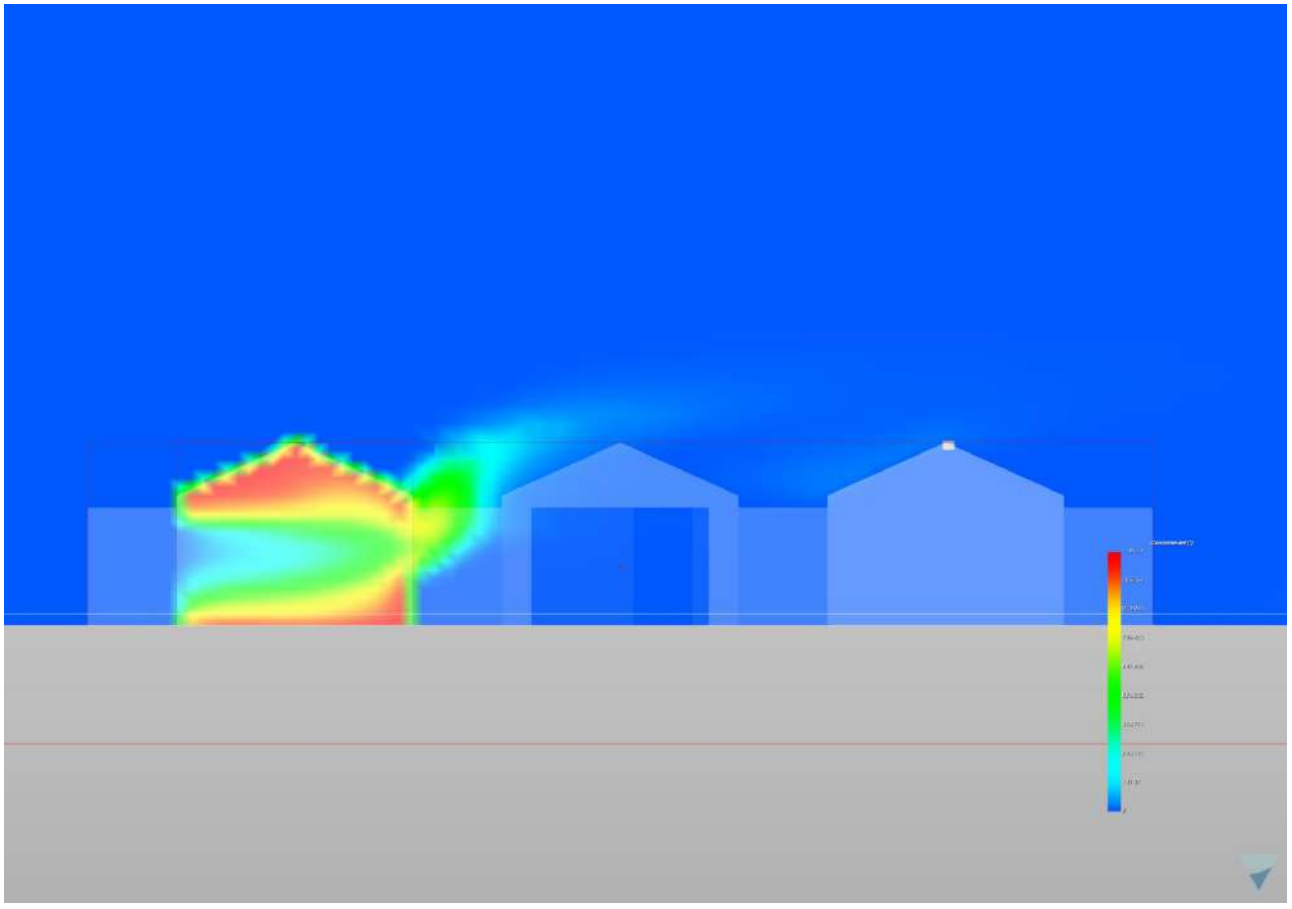


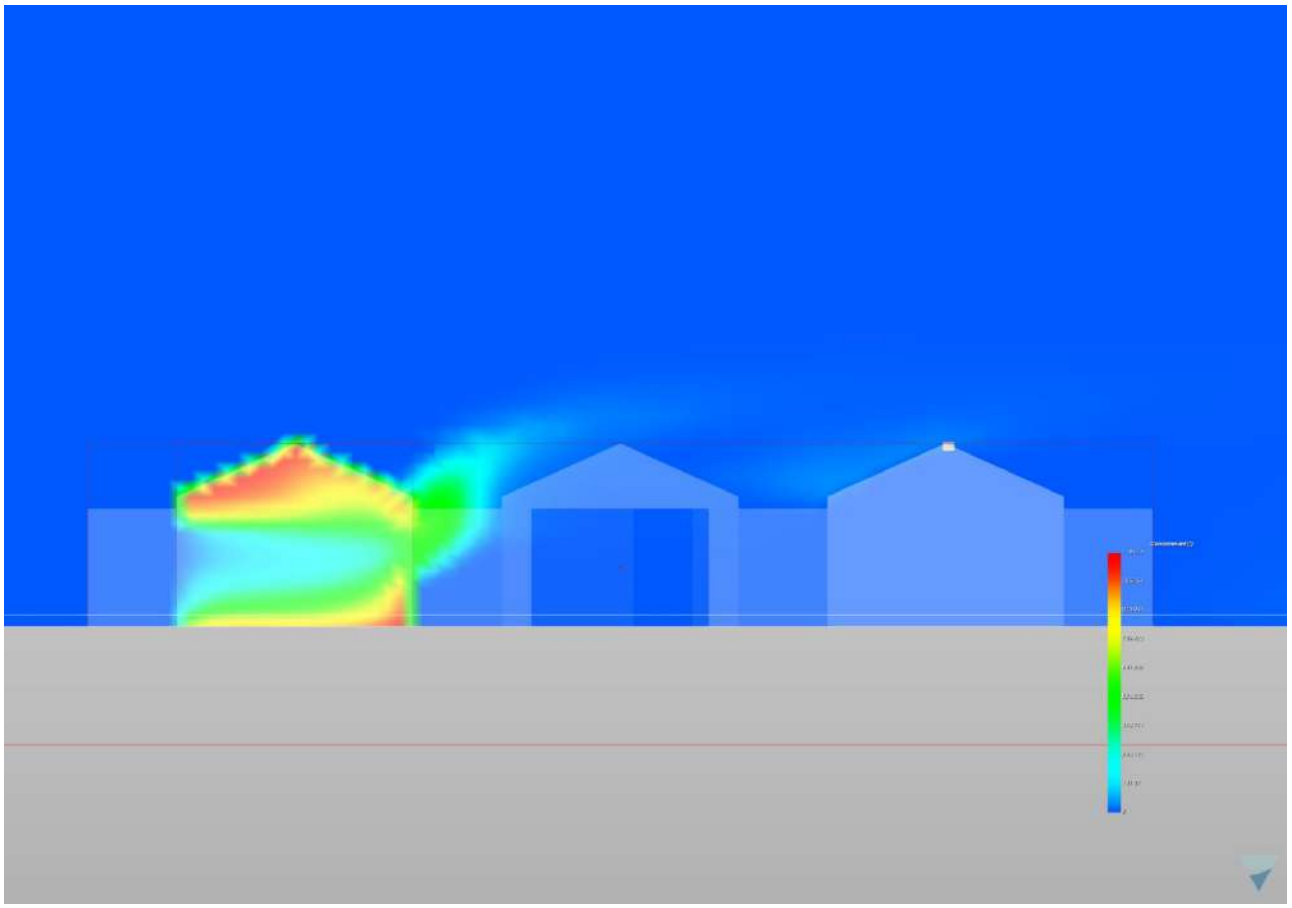


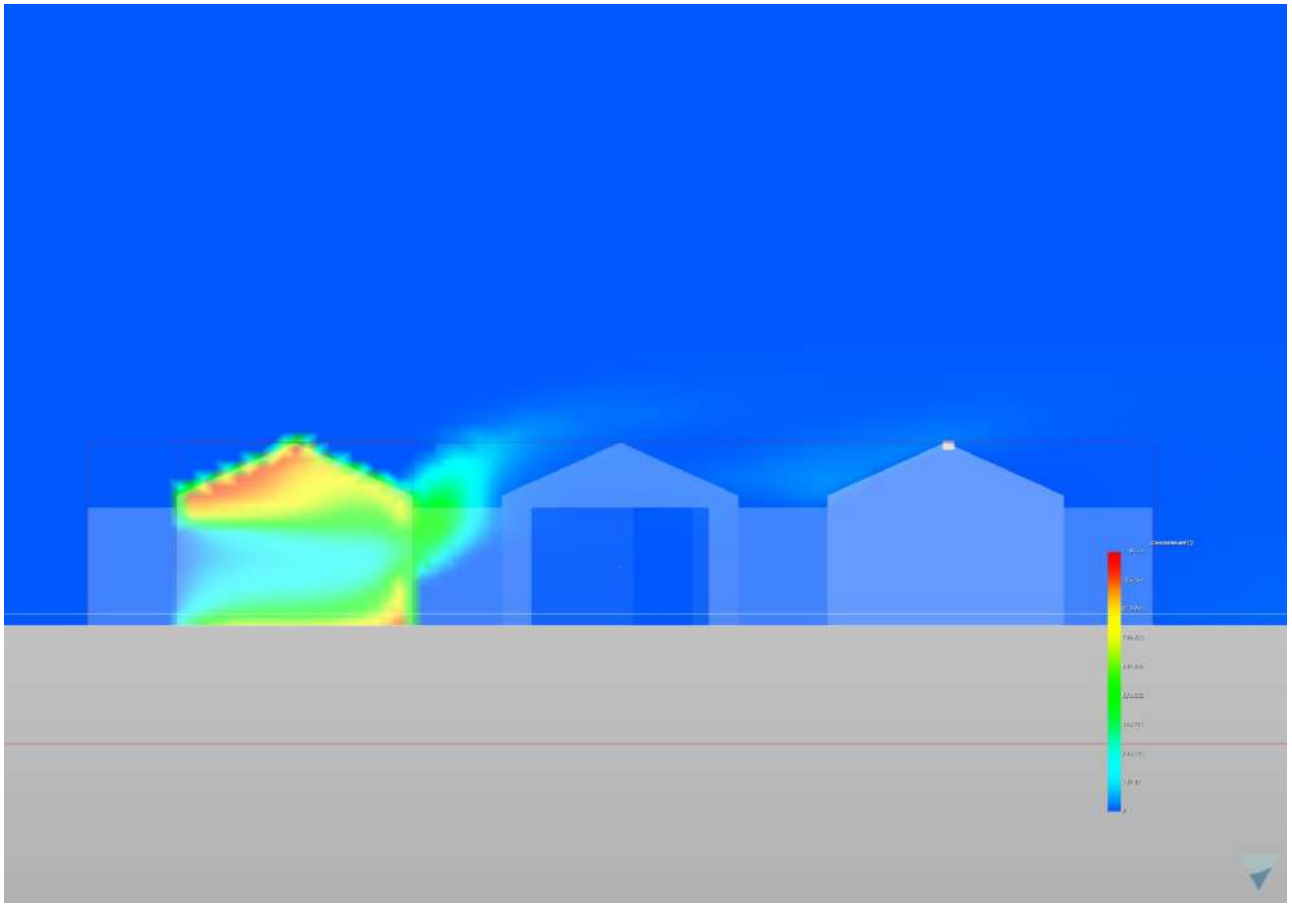


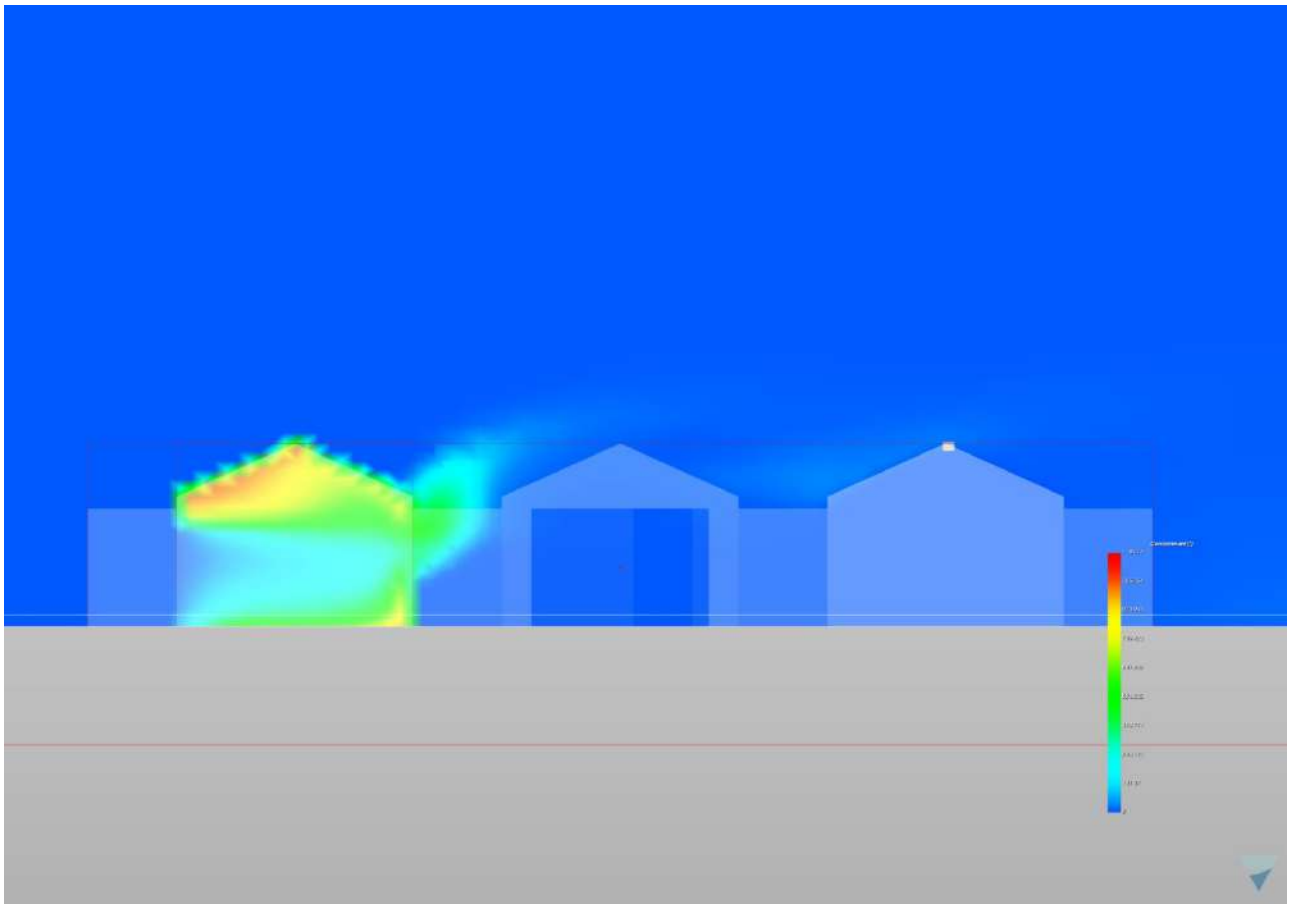


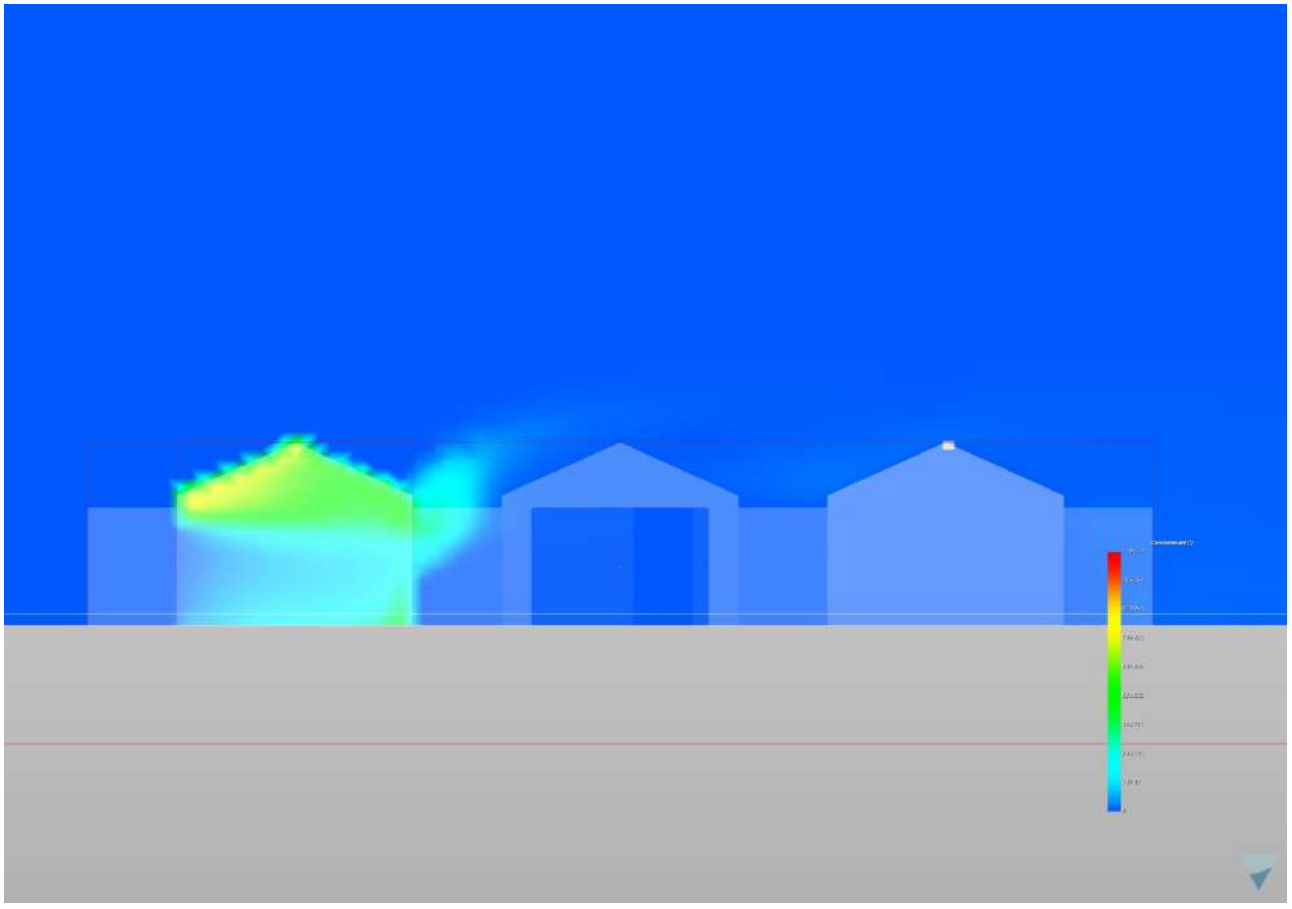






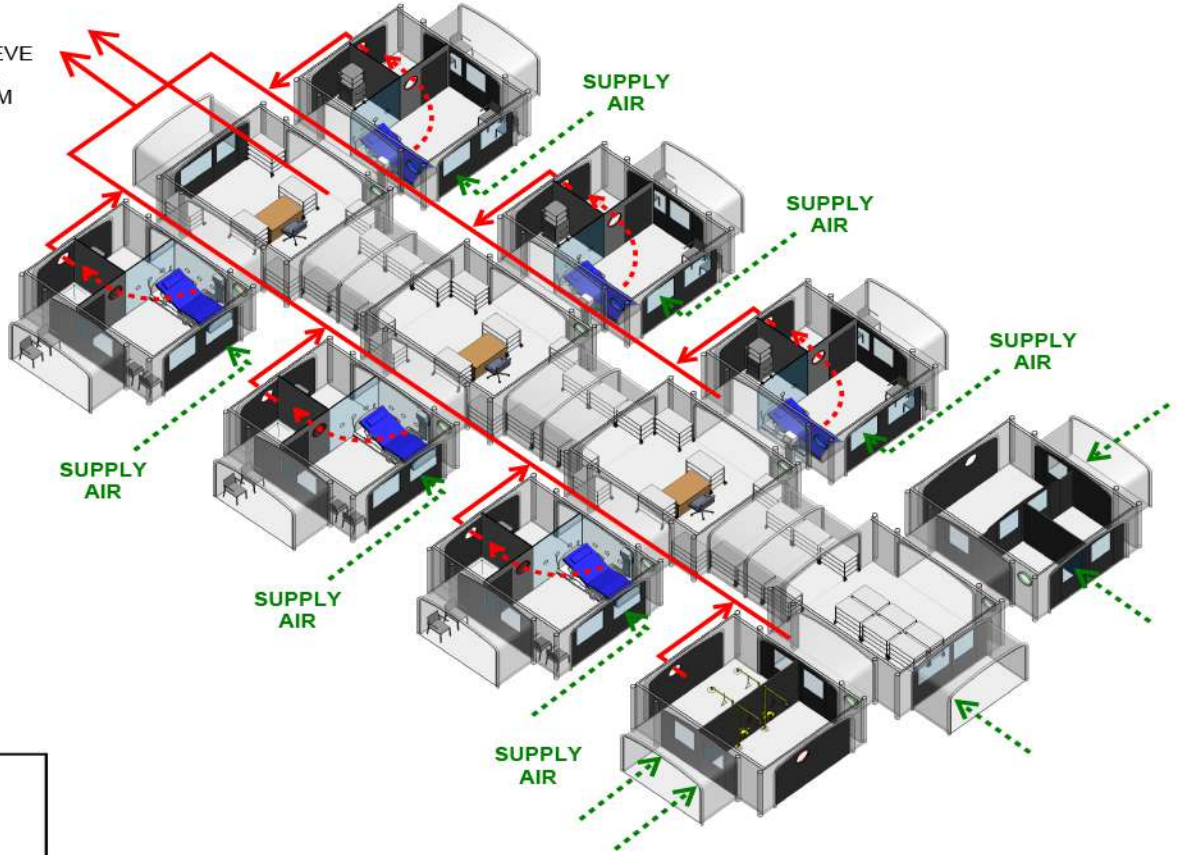






Annex 8: Create phase,
Hybrid ventilation configuration options

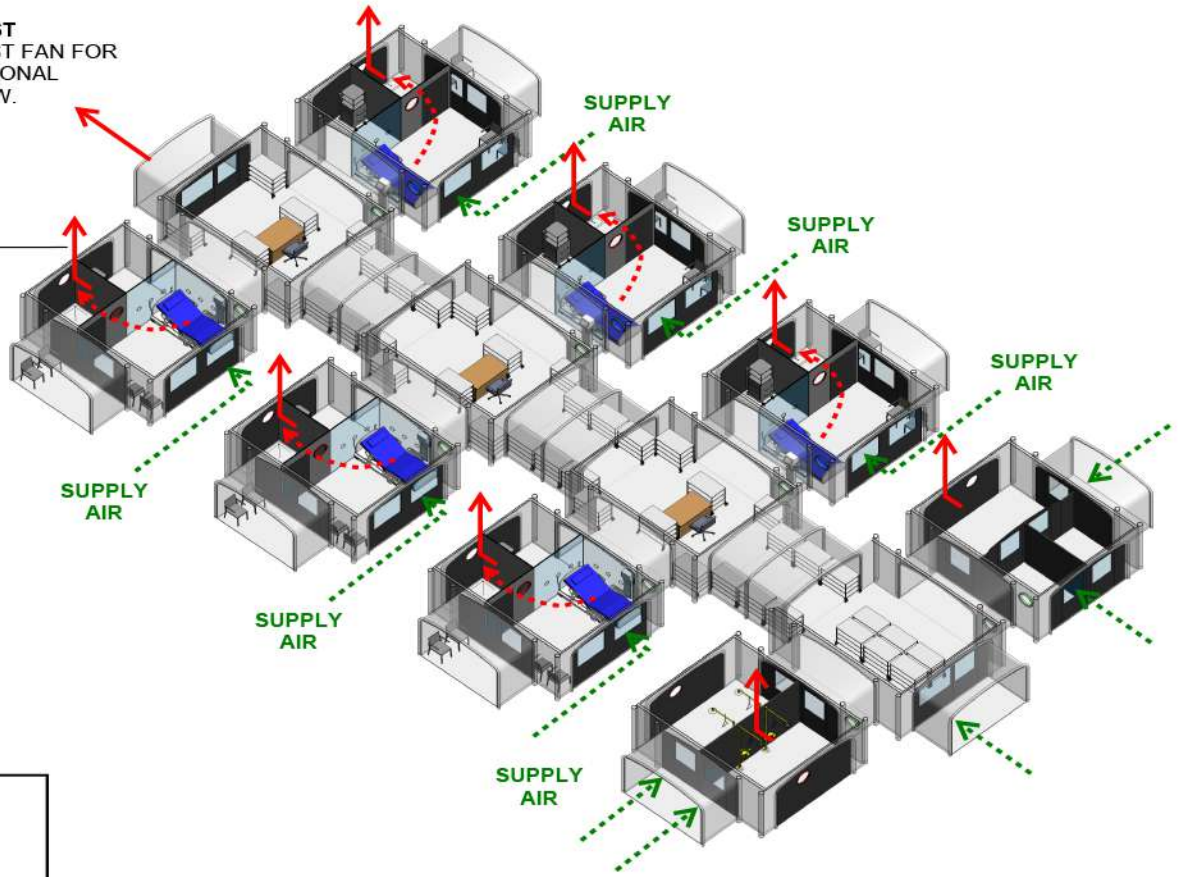
EXHAUST
MINIMUM 4M SEPARATION AND FENCING TO RESTRICT ACCESS.
EXHAUST FAN TO ACHIEVE DIRECTIONAL AIRFLOW.
HEPA FILTER IF MINIMUM DISTANCE IS NOT ACHIEVED.



HYBRID VENTILATION
HORIZONTAL EXHAUST

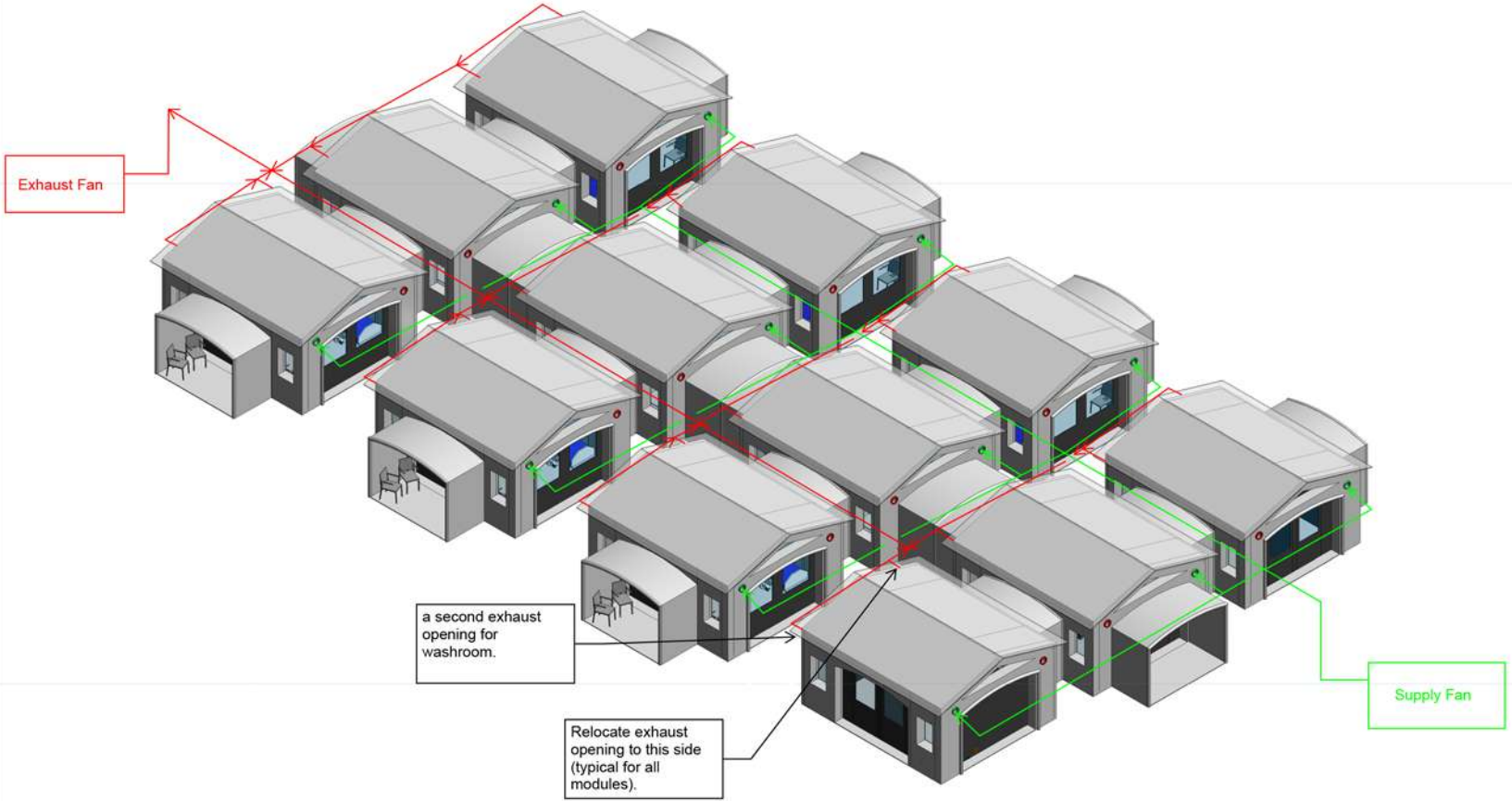
EXHAUST
EXHAUST FAN FOR DIRECTIONAL AIRFLOW.

EXHAUST
MINIMUM 1.5 M ABOVE THE ROOF TO ACHIEVE 2 M FROM PEOPLE.
INLINE FAN OR WHIRLYBIRD.



HYBRID VENTILATION
VERTICAL EXHAUST

Annex 9: Create phase,
Heating and cooling ventilation configuration



1 **3D - 12 Pod Layout**

Annex 10: Deliver phase, list of medical equipment

List of Medical Equipment for Ebola and Severe Acute Respiratory Infections (SARI) ICUs

List of medical equipment for Ebola					
For the ICU		**Quantity**	**Patient Group** *Note: Different patient groups may require different models or sizing for accessories*		
Biomedical Equipment	**Use**	**Per bed/ICU**	**Adult**	**Pediatric**	**Neonate**
Essential Items • **The selection of the accessories and consumables for this equipment will depend on the context and clinical skills capacity and availability.** • **Specifically for oxygen supply, it is recommended to have the primary source and back up supply (e.g., bedside oxygen concentrators and high-pressure cylinders).**					
Patient monitor multiparametric, basic with Accessories (e.g., pulse oximeter, blood pressure cuff, cables, batteries)	To monitor vital signs: ECG, respiration rate, temperature, blood oxygen saturation (SpO2), non-invasive blood pressure; optional invasive blood pressure, capnography EtCO2.	1 per bed	□✓	✓	✓
Defibrillator (external with accessories)	To select between manual, semiautomatic or automatic.	1 per ICU/area	✓	✓	✓
Electrocardiograph with accessories	To have the most accurate indication of the functioning of the heart	1 per bed	□✓	✓	✓
Gas regulator: vacuum regulator, O2 flowmeter, medical air flowmeter	To adjust flow rate and pressure required, depending on the oxygen supply source (i.e., cylinders, pipe network or concentrators).	2 per bed (2X O2, 2XVacuum and 2X Medical Air)	✓	✓	✓
Oxygen cylinders	To transfer patients from another hospital/ambulatory to the current ICU.	1-2 (per ICU as backup supply)	✓	✓	✓

	Used as back-up supply if the facility is piped with medical oxygen.				
Oxygen concentrators	To concentrate the oxygen from ambient air and deliver to patients. This is useful in the absence of piped medical oxygen outlet in the facility.	1 per bed (in the absence of medical oxygen outlet) Or 1-2 per ICU as back-up	✓	✓	□✓
Hospital bed (mechanical)	For hospitalized patients in need of health care	1 per bed	✓	✓	✓
Basic thermometer	For body temperature measurement	1-3 per ICU	✓	✓	✓
Suction device with accessories (manual)	Used to remove fluids — like mucus, blood, saliva, or phlegm — that are causing obstructions on the airway or respiratory system and infectious materials from wounds. The accessories should be plastic for single-use only.	1 per bed	✓	✓	✓
Resuscitator bag with accessories	Used to inflate the lungs during procedures including intubation The accessories should be plastic for single-use only.	1-3 per ICU	✓	✓	✓
Nasogastric tubes	1. To remove bodily fluids from the stomach to prevent	Single-use only	✓	✓	✓

	vomiting and possible aspiration. 2. To give medication or food when the patient is ventilated and/or is having trouble swallowing.				
Advanced items • **The selection of these equipment will depend on the context and clinical skills capacity and availability.**					
Syringe pump with accessories	Sophisticated pump used to deliver small quantities of intravenous medications and fluids.	1-5 per bed	✓	✓	✓
Infusion pump with accessories (e.g., intravenous bag, tubing set and support pole)	For higher volumes, consider infusion pumps instead of syringe pumps	1-5 per bed	✓	✓	✓
Enteral feeding pump	To assist intake of food via the gastrointestinal (GI) tract.	1 per bed	✓	✓	✓
Indwelling urinary catheter	To measure the amount of urine produced and to control bladder function.	Single-use only	✓	✓	✓
Electric hospital bed	To transport critically ill patients, support the patient comfortably, and provide room to carry portable oxygen cylinders, suction equipment, emergency resuscitation equipment, intravenous infusions and their pumps, as well as transport monitor and ventilator	1 per bed	✓	✓ Consider additional mum and child bed	Incubator Or Newborn baby bed
Electronic probe thermometer	For the body temperature	1-3 per ICU	✓	✓	✓
Infrared thermometer		1-3 per ICU	✓	✓	✓

Examination lamp	For local illumination of the patient's body during diagnostic procedures and minor procedures	1 per bed	✓	✓	✓
Suction device with accessories (electric)	Used to remove fluids — like mucus, blood, saliva, or phlegm — that are causing obstructions on the airway or respiratory system and infectious materials from wounds. The accessories should be plastic for single-use only.	1 per bed	✓	✓	✓
Laryngoscope or Video laryngoscope with Accessories (e.g. blades, handles, tubes, stylets, mask airway)	Intubation assist device. To be able to put the tip of the endotracheal tube into the trachea for ventilation or general anesthesia. Accessories should be for single-use only.	1-3 per ICU	✓	✓	✓
Oto/Ophthalmoscope	Oto (ear), and ophatlmo (eye)	1 per ICU	✓	✓	✓
Blood chemistry analyzer, portable with cartridges and solutions	For patient's blood chemistry (blood gases – O2 and CO2), electrolytes (sodium, calcium, potassium) and other components (urea, hemoglobin)	These equipment might be needed for some patients. However, they should be borrowed from another	✓	✓	✓
Ultrasound machine with probes and accessories	Certain tissues can't be visualized well with x-rays and some situations require		✓	✓	✓

	to avoid x-rays, but visualization of internal structures is still needed	department (Radiology & Laboratory). No need to consider purchasing them for the single isolation rooms.			
Portable X-Ray (digital)	For patients who can't move. Need of radiology technicians and a radiologist. Lead Personal Protective Equipment have to be purchased for the safety of the users.		✓	✓	✓
Phototherapy lamp or light blanket	Used to break down the bilirubin for newborns with jaundice	1-2 per NICU			✓
Additional items for severe acute respiratory infections (SARI) ICU • It is not necessary to have all the listed equipment. The selection of the patient ventilator will be depending on the context and clinical skills capacity and availability; as well as the capacity for cleaning, disinfection and sterilization at facility level for some accessories.					
Ventilator and accessories (e.g., breathing tube)	Support patients to breathe for themselves, or can take over breathing for a patient completely. Accessory tubing should be for single-use only.	1 per bed	✓	✓	✓
Continuous positive airway pressure (CPAP) and accessories	To apply continuous positive airway pressure, which helps keep the lungs inflated. Accessory tubing should be for single-use only.	1-2 per ICU	✓	✓	✓
Bilevel positive airway pressure (BiPAP/BPAP) and accessories	To apply BiPAP/BPAP to non-intubated adult or paediatric patients, allowing	1-2 per ICU	✓	✓	✓

	clinicians to adjust pressures for inspiratory and expiratory phases of a breath. Accessory tubing should be for single-use only.				
High-flow nasal cannula (HFNC), heated humidified high-flow (HHHF) therapy or high-flow nasal oxygen (HFNO) and accessories	To deliver high flow rates with heated humidification to non-intubated adult or paediatric patients. Accessory tubing should be for single-use only.	1-2 per ICU	✓	✓	✓