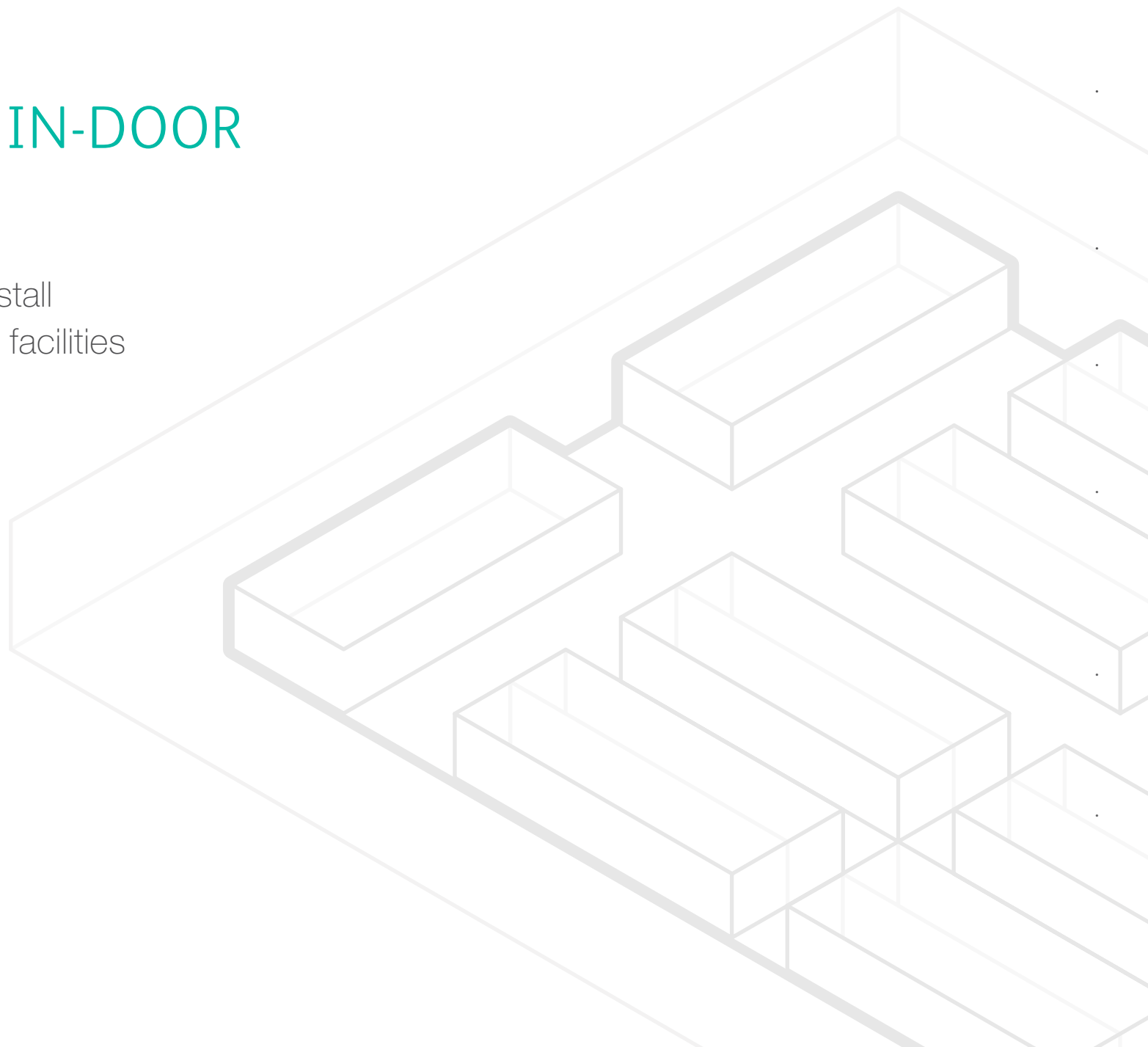


CareBox IN-DOOR

A design guideline to install
temporary medical care facilities
in existing buildings



ARUP

As the number of people affected by the coronavirus pandemic continues to rise globally, Arup has mobilised a multi-disciplinary team to engage directly with multiple governments, healthcare bodies and NGOs around the world, offering our technical support and guidance.

Healthcare systems across the world are seeking new opportunities to increase their bed capacity at all levels of patient care, from the critical shortage of ICU beds to the provision of field hospitals dealing with large numbers of patients. We have developed a range of scalable, modular and rapid build solutions which can be implemented on existing healthcare campuses or as standalone facilities. This guideline is one of three scenarios to provide specific healthcare spaces for Covid-19 or similar infectious diseases:

- 1.** Plug-in hospitals attached to existing healthcare infrastructures.
- 2.** Confined spaces such as existing multi-storey car parks.
- 3.** Non-confined spaces such as convention centres, sports halls or outdoor areas sheltered by tent or other temporary structure.

Through this collaboration, Arup has developed the CareBox project, applying robust engineering principles to address the immediate challenges of this pandemic. Arup is providing independent, multidisciplinary technical advice to governments, healthcare organisations, and international NGOs responding to the pandemic.

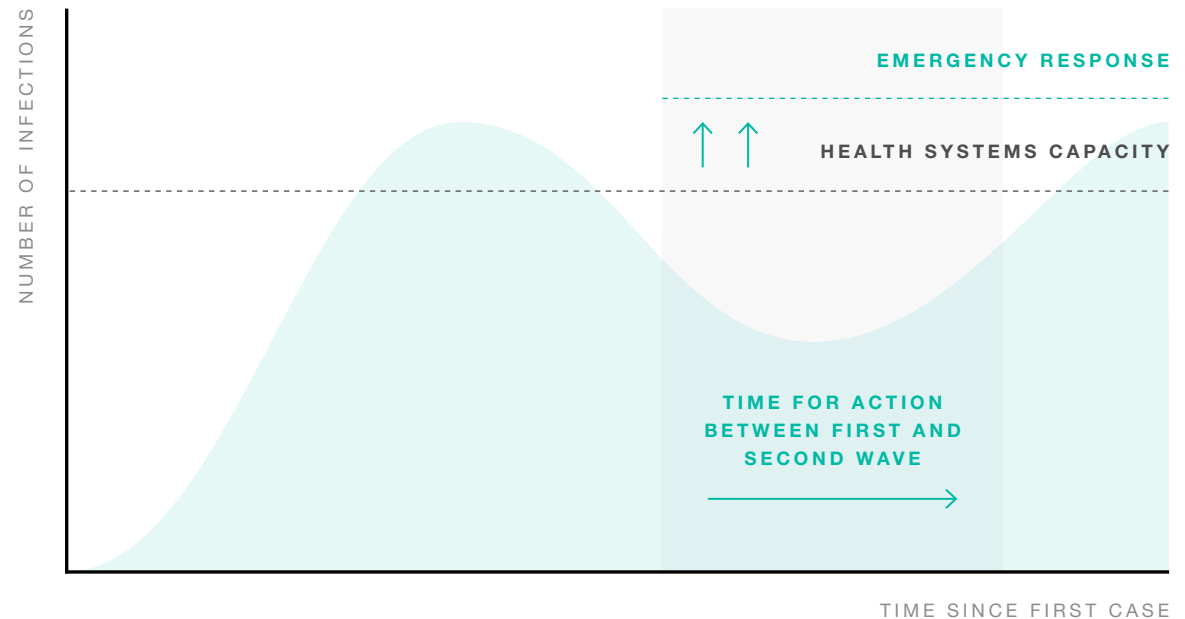
Preventing health system collapse

Flattening the curve is not the only action governments can take to prevent the collapse of healthcare systems. A parallel action is to rapidly increase the number of beds providing care to Covid-19 infected patients. This has been tried using different strategies in China, Italy, Spain, and now everywhere across the globe.

The first strategy is to increase the number of ventilation-assisted and intensive care beds inside the existing hospitals. This is happening everywhere but has a limit due to space constraints.

The next step is to open other beds elsewhere for temporary patients. Hotels are being used in many cities, but it fragments healthcare staff and requires the installation of medical gas utilities that are not easy to deploy.

The CareBox project is a Covid-19 specific modular solution, engineered for rapid deployment, optimization of transportation, replicability and scalability.



“The lessons I’ve learned after so many Ebola outbreaks in my career are be fast. Have no regrets. You must be the first mover. The virus will always get you if you don’t move quickly. Speed trumps perfection.”

Dr Michael Ryan,
Executive Director, WHO Health
Emergencies Programme.

FLATTENING THE CURVE

The priority should be to flatten the curve. But it could still exceed the capacity of the health system. In that case, it is essential to plan for an increase in capacity that can be implemented in a very short time.

Prefabricated modules

The CareBox project identifies a range of solutions, which can be adapted to suit the available space and facilities.

ADAPTABLE DESIGN

The success of any scenario is to apply the core basis of design to a specific location, adapting the principle without losing its values.

FAST PRODUCTION

Units are prefabricated off-site using a worldwide supply chain under clear design principles.

TRANSPORTABLE

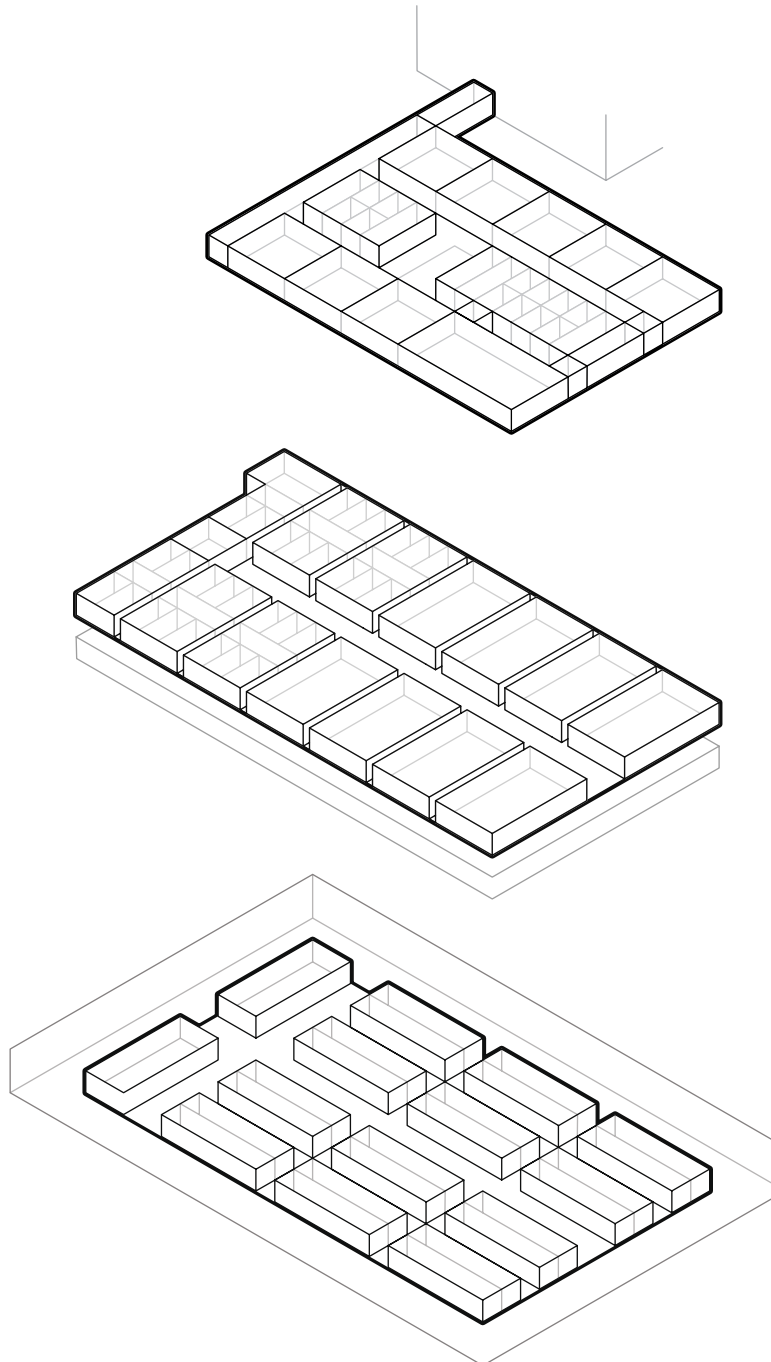
Modules and elements are shipped as flat panels in containers to allow for ship, truck or air cargo.

EASY TO DEPLOY

Once on site, their assembly is easy and repetitive, with a simple modular solution which can be implemented quickly.

COST-EFFECTIVE

The use of modular technologies enables economies of scale to maximise the speed of construction in an efficient manner.



A

PLUG-IN

One or more wards connected to an existing hospital.

B

MULTI-STOREY

Modules deployed in multi-storey car parks, next to a hospital or not.

C

IN-DOOR

Beds and equipment inside existing convention centres or sport halls.

Converting existing buildings into temporary medical facilities

We are living in unprecedented times, the unimaginable is now real and part of the world reality.

Times like these require quick action, technical skills and a lot of creativity. In the growing and urgent need of creating new temporary medical facilities to deal with the spread of Covid-19 and save lives, existing buildings are in many cases the fastest and safest way of implementing these facilities.

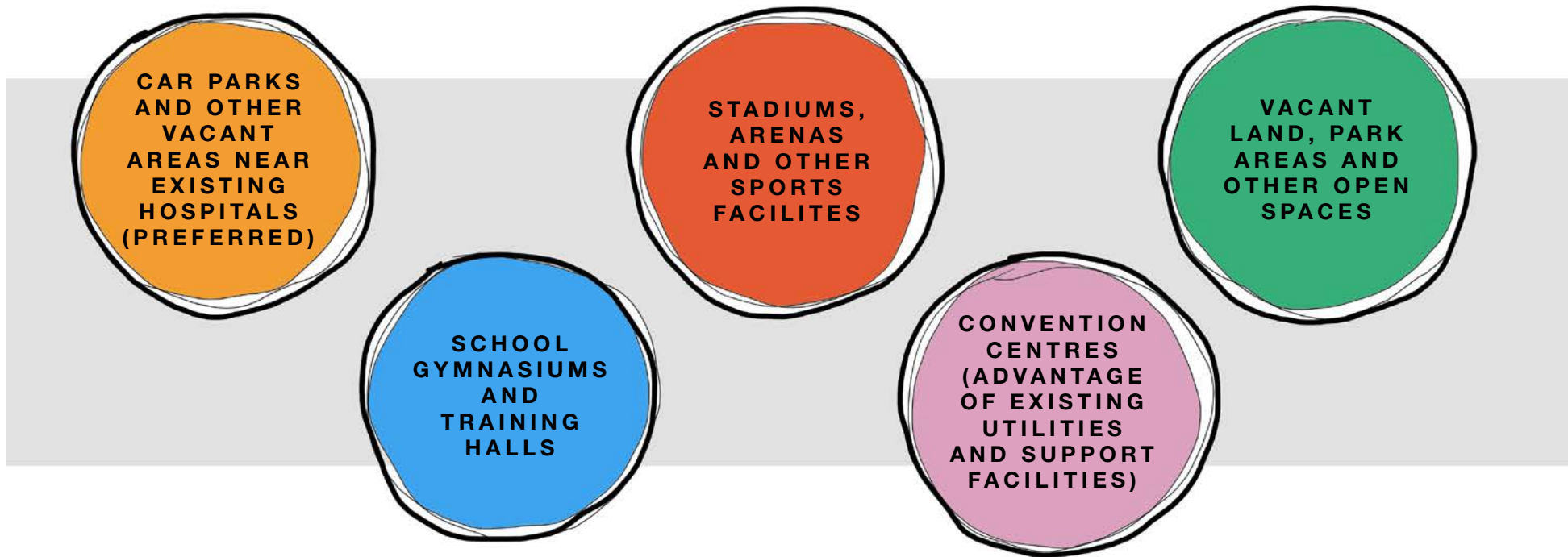
Building clinical spaces in available buildings requires a change in mindset to ensure that the essential service provision and model of care are appropriate for the patient.

Close collaboration with clinicians, healthcare teams, designers and the supply chain will facilitate positive outcomes and development of bed capacity to address the surge in demand. We are working with clinical planners and healthcare providers to understand their needs and are delivering tailored solutions to meet the needs of the different markets.

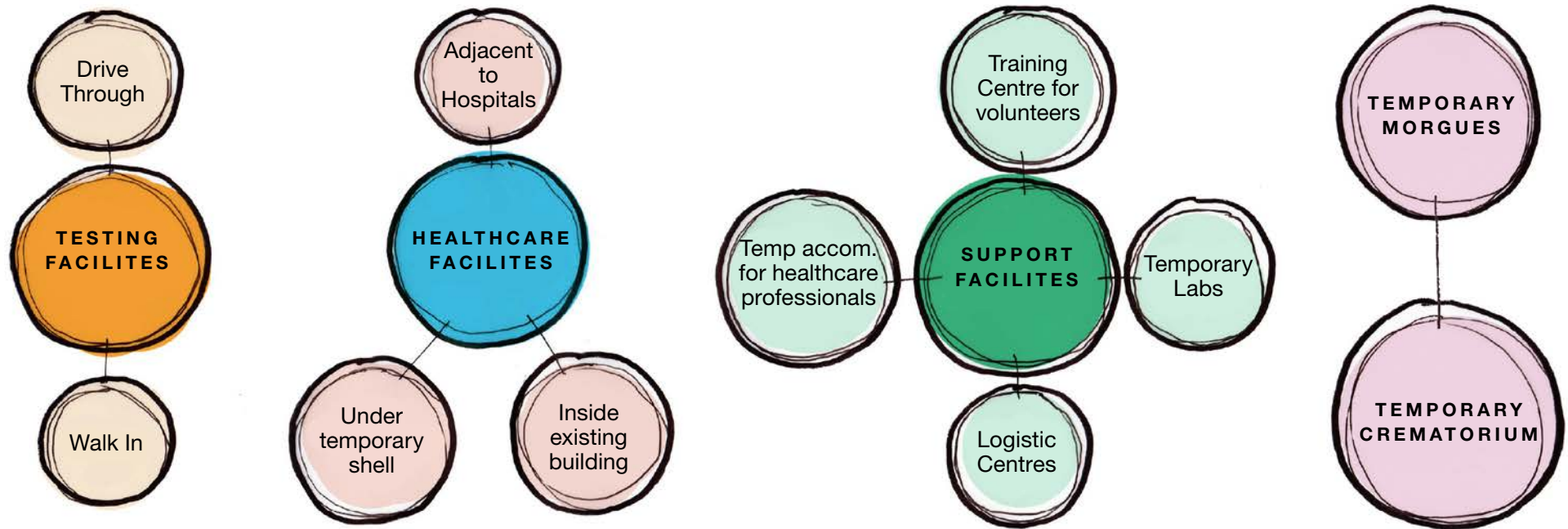


Types of existing facilities or spaces

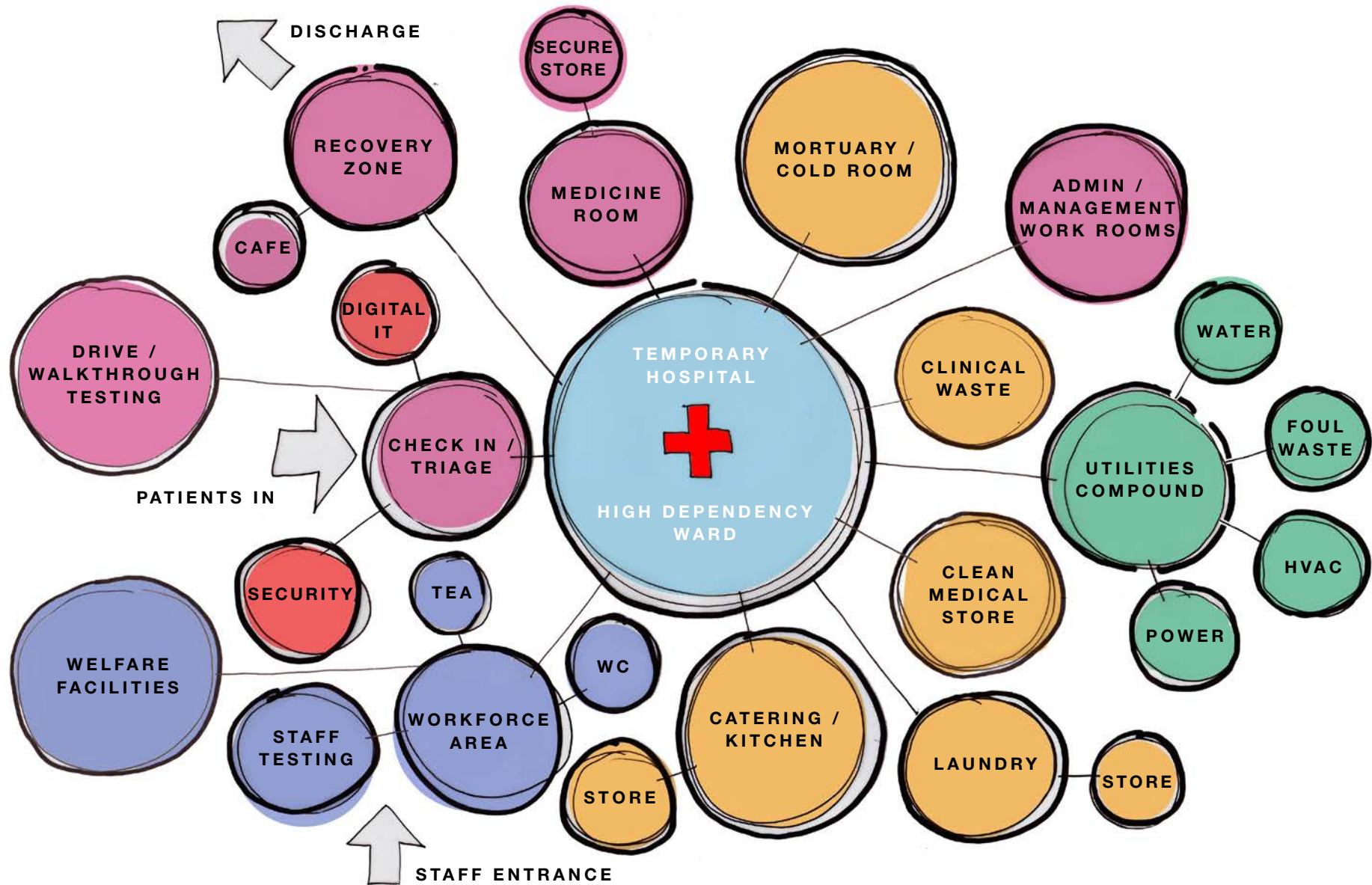
Existing buildings or vacant land (using a tent) are in many cases the fastest and safest way of implementing temporary medical facilities.



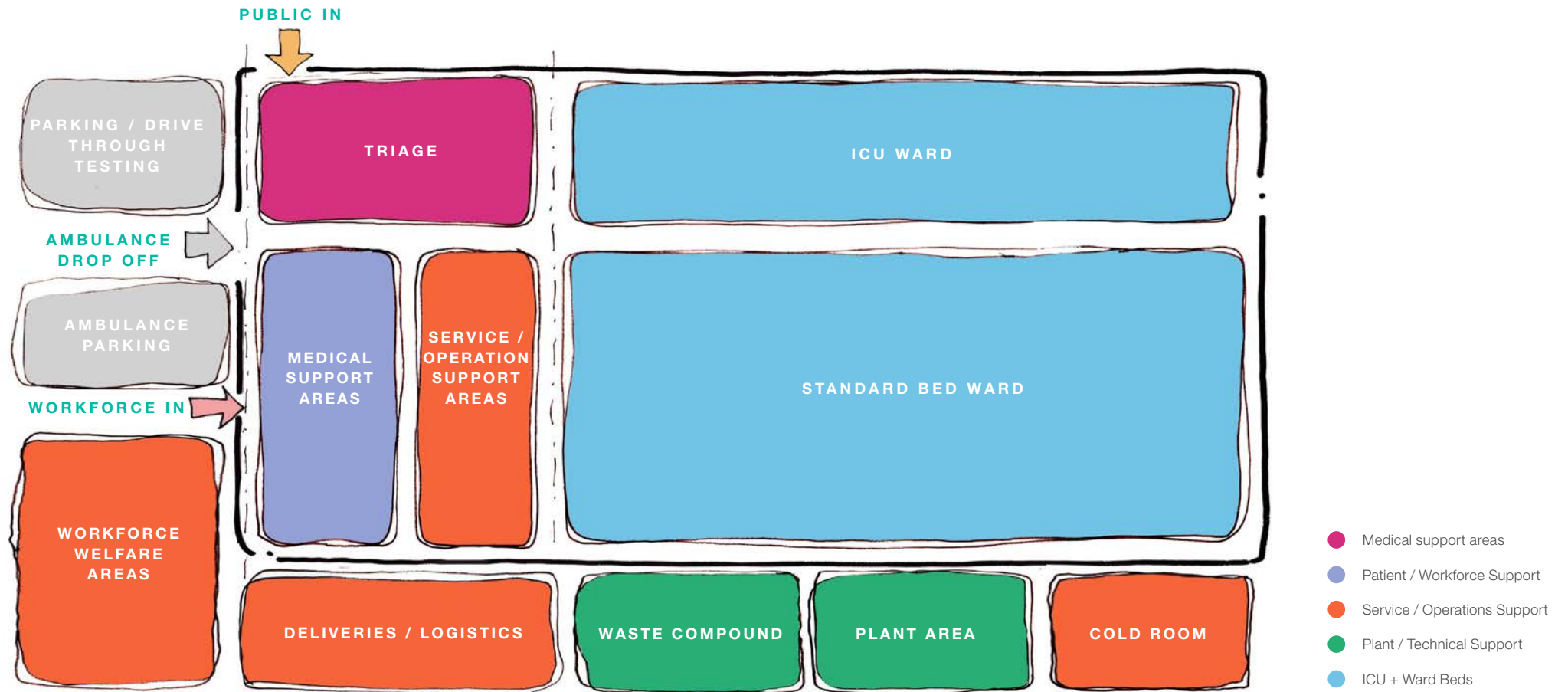
Key temporary facilities required



Temporary hospital facilities diagram

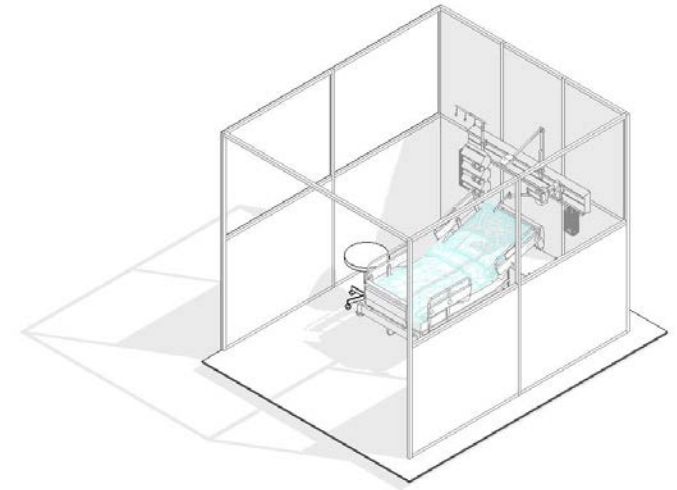
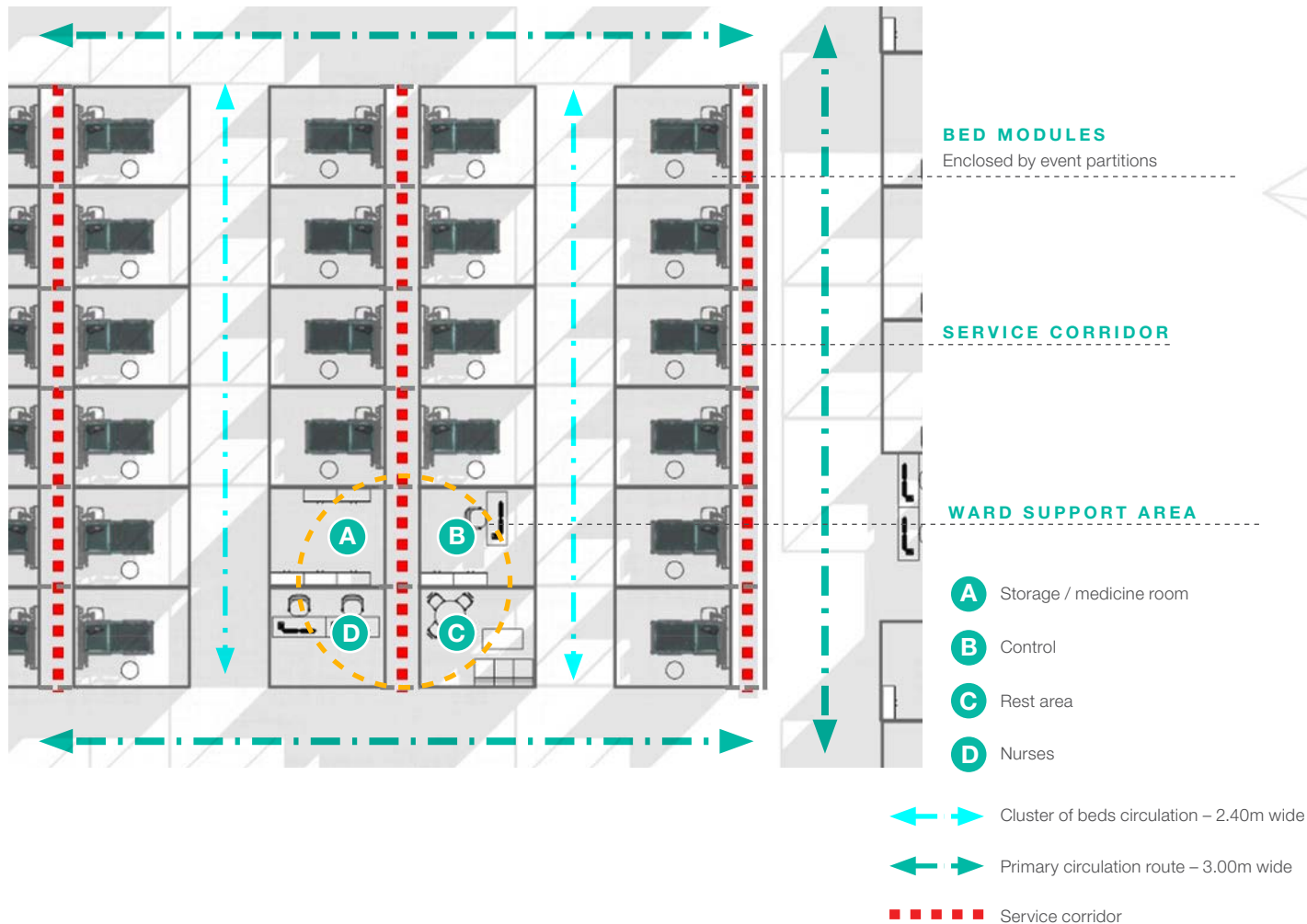


SARI treatment centre operational plan



The ward

3.00m x 3.5m bed modules /20 Beds



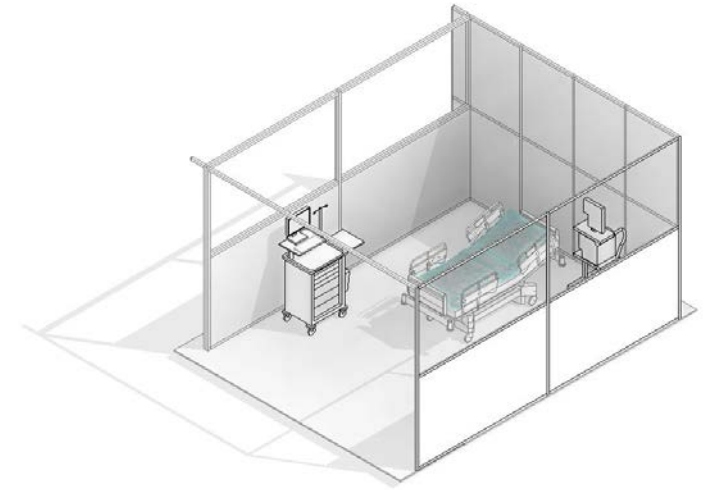
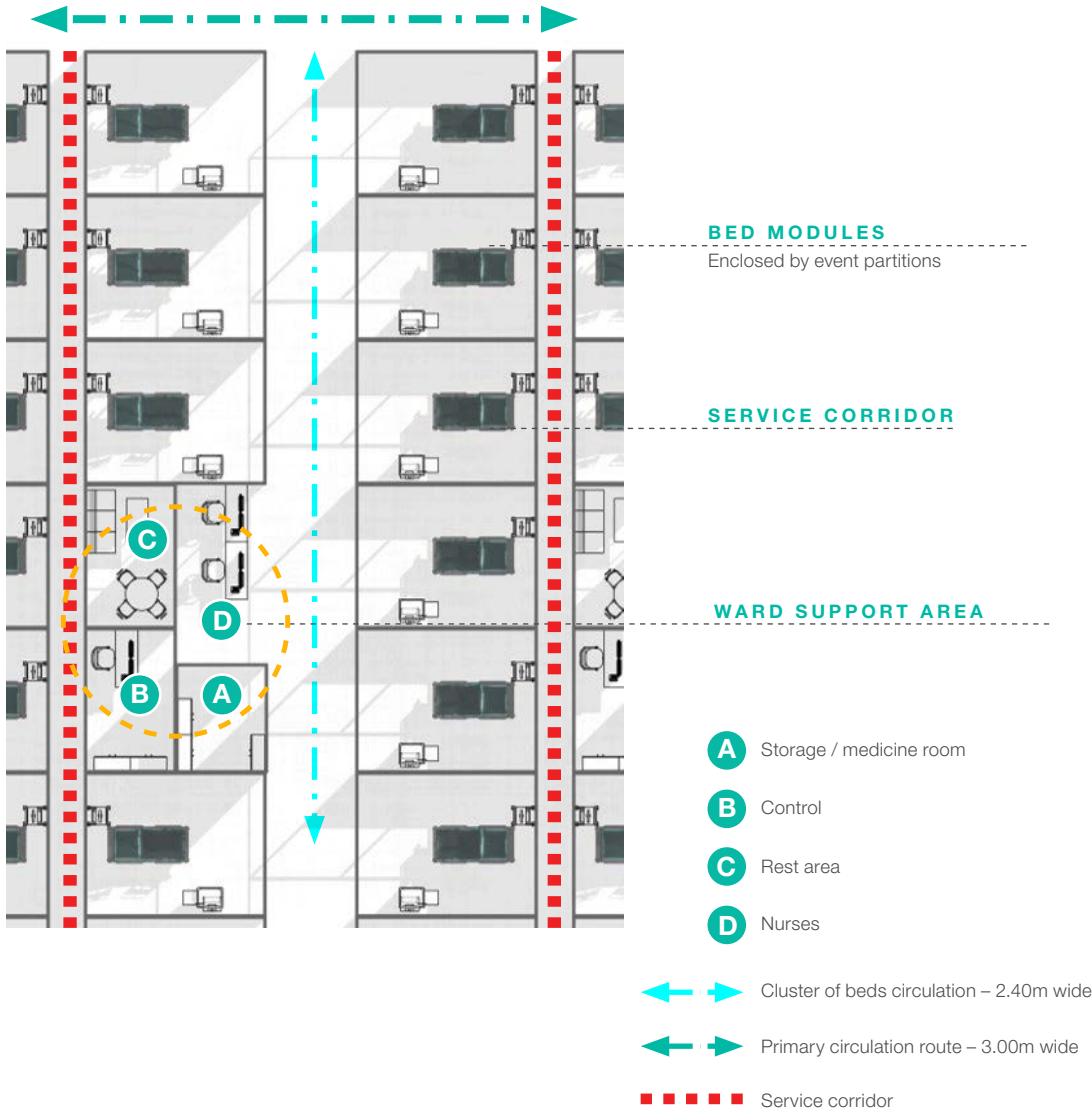
When using event partitions or similar fragile elements for enclosure, ensure the use of a bed with chock to stop the bed wheels before the bed meets the end wall.

Recommended modulation of bed modules is 3.10m x 3.60m. In this example we adapted to 3.00 x 3.50m in line with most common dimensions found in event type partitions.

Ideally 01 support area for every 18 to 24 beds.

The ICU

4.00m x 5.00m bed modules /10 Beds



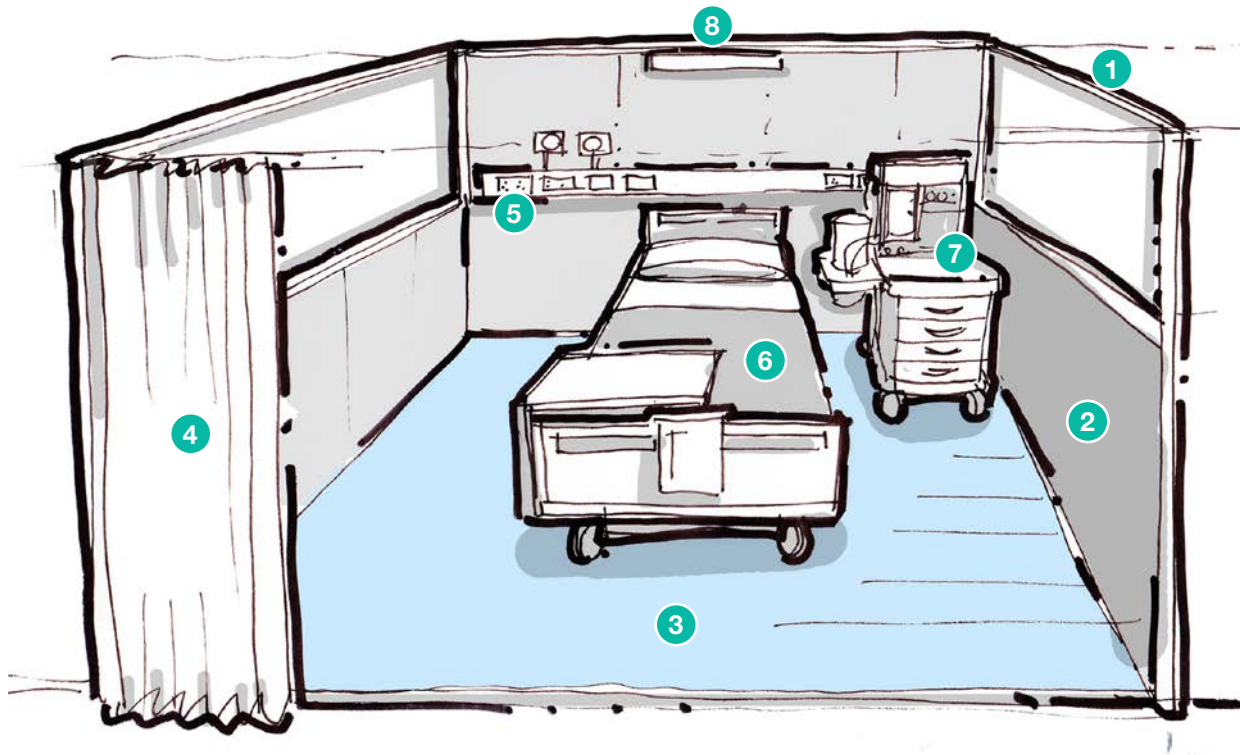
When using event partitions or similar fragile elements for enclosure, ensure the use of a bed with chock to stop the bed wheels before the bed meets the end wall.

Ideally 01 support area for every 6 to 10 beds.

Bed module

Bed care modules require adequate circulation space around bed with medical equipment and furniture. A typical standard care bed module is aprox. 3.10m x 3.60m. For ICU bed modules the ideal dimensions are 5.00 x 4.00m. Slight

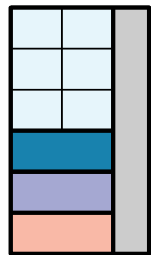
variations on these dimensions can be accepted and agreed in each specific case. Besides the dimensions the key difference between standard care and ICU care is in the equipment used.



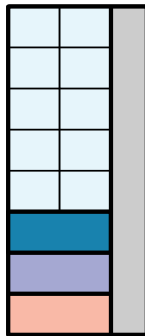
- 1 Lightweight steel frame system
- 2 Infill partition panels / washable laminate panels
- 3 Vinyl washable flooring
- 4 Optional privacy screen / curtain
- 5 Power / utility points (oxygen supply)
-overhead cabling / bottled oxygen
- 6 Furniture - Bed / overbed table
- 7 Medical equipment – Respirator /a multi
parameter monitor
- 8 Lighting

Approximate dimensions / areas for implementation of temporary ICU care wards

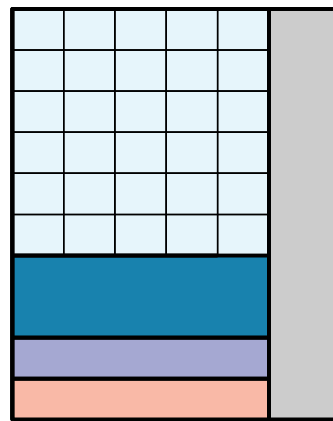
- Bed area – 4.0m x 5.0m per bed
- Ward support modules – 01 module for every 6 – 10 ICU beds
- Medical support areas - estimated
- Services / Operational support areas - estimated
- Circulation / services corridors



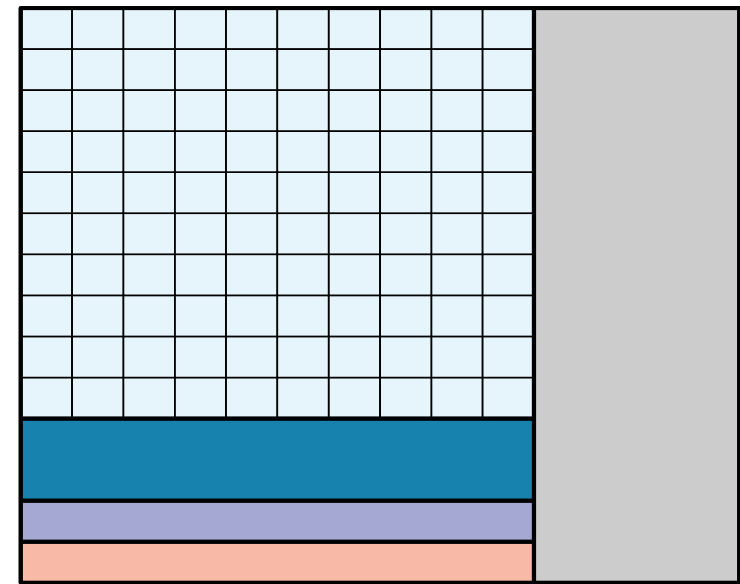
6 BED WARD
13.5 X 24M



10 BED WARD
13.5 X 32M



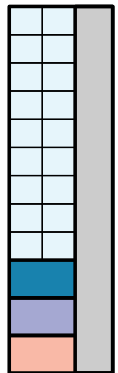
30 BED WARD
32 X 40M



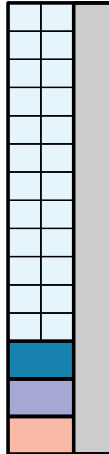
100 BED WARD
70X 56M

Approximate dimensions / areas for implementation of temporary standard care wards

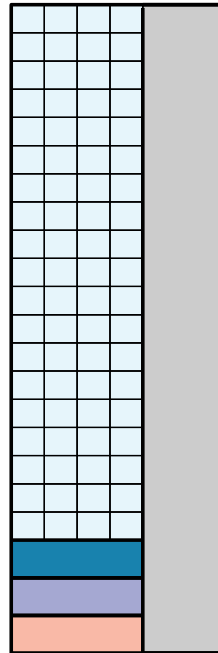
- Bed area – 3.0m x 3.5m per bed – adapted from 3.1m x 3.6 guidance for optimised use of event partitions
- Ward support modules – 01 module for every 18 – 24 beds
- Medical support areas - estimated
- Services / Operational support areas - estimated
- Circulation / services corridors



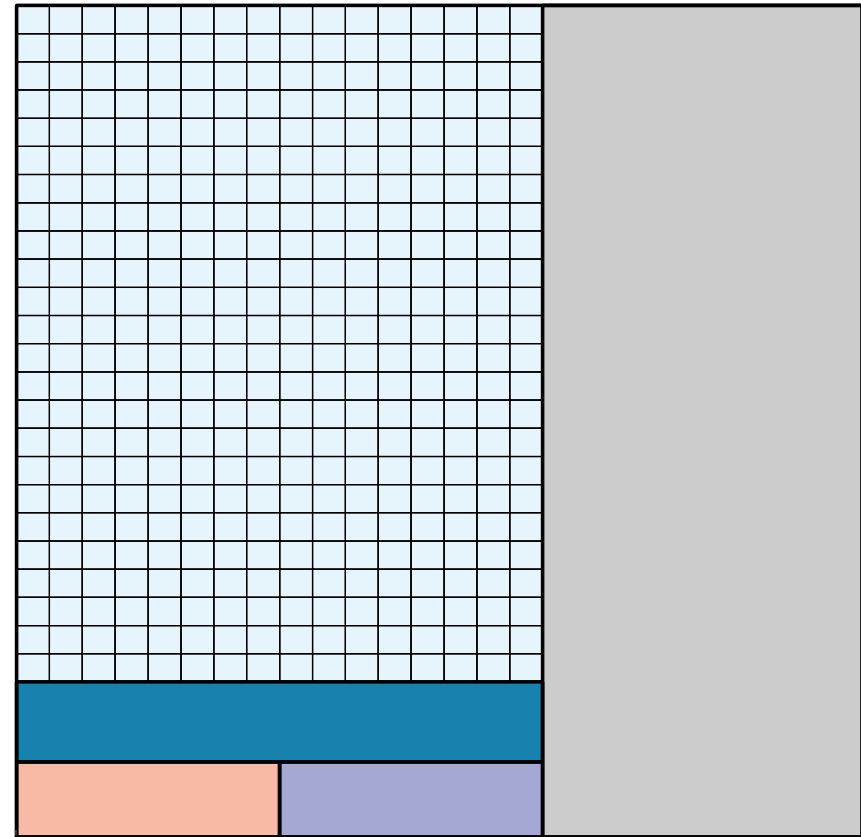
18 BED WARD
11 X 45M



24 BED WARD
11 X 51M



72 BED WARD
22.5 X 69M



384 BED WARD
88.5 X 90M

Requirements to bear in mind

The highlighted requirements have been developed in the following pages.

MEDICAL GASES

Critical gases such as oxygen and vacuum

ELECTRICITY

Power, distribution, control, safety

HVAC

Heating, air conditioning, HEPA filters

WATER & SEWAGE

Potable water, DHW, drainage, sewage

PLANT & UTILITIES

Medical Gases, water treatment and storage, temporary generators

CIVIL & STRUCTURES

Ground capacity, foundations, structure

ACOUSTIC & LIGHTING

Comfort at the wards beyond temperature

MEDICAL EQUIPMENT

Required for patient treatment & control

CLINICAL PLANNING

All medical functions in place

WASTE MANAGEMENT

Removal of waste at every step

SUSTAINABILITY

Circular economy, energy saving

LOGISTICS

Ambulance access, air ambulance, general parking, mortuary

SUPPORT SERVICES

Catering, staff change, laundry, laboratory, triage, image diagnostic, etc.

Accessibility

Accessibility and access for all should be a primary consideration when designing a temporary hospital facility.

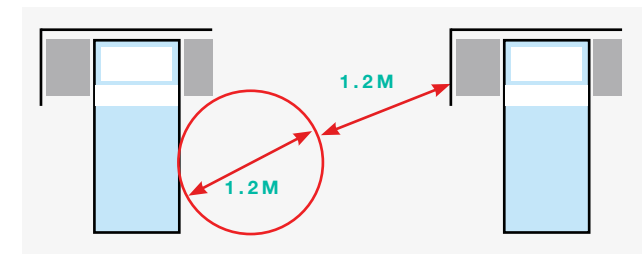
ACCESSIBILITY

- Corridors should have minimum width of 2m
- Clearance of 2100mm / 2400mm between consecutive (aligned) doors will allow easy, uninterrupted / unobstructed passage of stretchers and beds – required for both access and egress.
- Assisted use bathroom would typically have a room size of 3m by 4m.
- Staff accommodation - accessibility to be considered for key areas -
 - ✓ Staff welfare – toilets, showers, kitchen, administration / meeting / consultation rooms.
 - ✓ Circulation – access, egress, to/from patient beds (1200mm width).
 - ✓ Furniture – adjustable height (desks, sinks, etc.)

EVACUATION

- ✓ Consideration of how patients will be evacuated, storage space needed for additional evacuation aids (mattress, bed, chair etc.).
- ✓ Doors to accommodate sufficient width (1100mm minimum clear opening) for beds and stretchers.
- ✓ If some (more mobile) patients are expected to escape independently, then door opening forces should be within 30N and visual/audible warning to be provided to notify people of the need to escape. Consideration could also be given to the provision of handrails along corridors to assist with this (and for general circulation) – but might add additional hygiene / cleaning requirements, and could be mitigated through provision of mobility aids (storage space for these required).

- Signage - height to be suitable for both standing and seated persons, high contrast, tactile and legible (including pictograms).
- Avoid stepped thresholds. Where ramps are provided, these should be as shallow as possible but not steeper than 1:12 in any instance (as this will pose health and safety risks).
- Finishes and materials – to consider thermal and acoustic comfort in complement to infection control (e.g. legibility of communication, impact of external temperature, access to daylighting – for wellbeing of both staff and patients)
- Doors – vision panels will help to prevent injury across different sides of the door in this fast paced environment.



WARDS that need to accommodate larger patients and where a hoist is used should have 2100mm turning / transfer space adjacent to beds.

Fire safety

Fire presents a major risk to the life safety of patients and staff, and to the continuity of essential healthcare. Temporary Covid-19 healthcare facilities present unique challenges that must be assessed and addressed in the fire safety strategy.

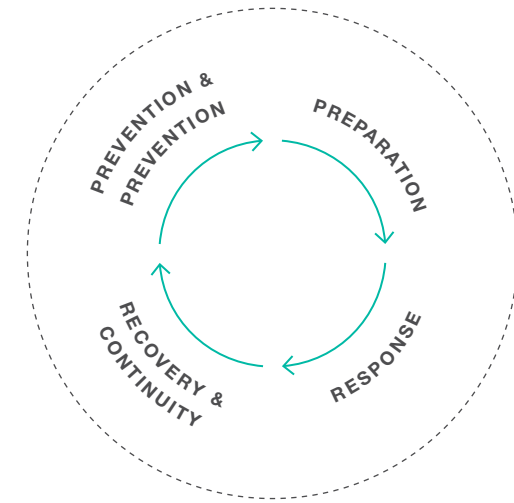
Many or all patients are likely to be high-dependency, bedbound and served by fixed O2 feeds. ICU patients will likely be intubated on ventilators and sedated. Relocation of a patient is usually protracted, requiring connection of a portable O2 bottle and multiple staff to move their bed and all associated equipment. As such, in the event of fire, patient evacuation or relocation should be avoided unless essential. Instead, to reduce the likelihood of significant fire occurring, the focus should be on prevention, mitigation and intervention as part of a crisis response framework.

Oxygen-enriched atmospheres increase the likelihood and potential severity of a fire. Rapid-build hospital construction also presents challenges sourcing non-combustible construction and installing passive and active fire protection measures.

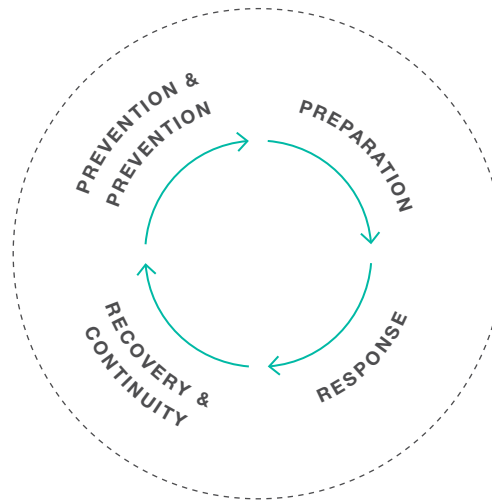
In the face of these challenges and the various other expected project constraints, the fire safety strategy must be based on risk-reduction and an ALARP approach (As Low As Reasonably Practicable). A range of potential fire safety measures may be appropriate, some of which are summarised on the following pages. To establish effective and suitable measures for a particular temporary hospital facility, the fire safety strategy must be developed in partnership with relevant stakeholders including the hospital operators and the local fire and rescue service.

Should a fire occur, early intervention to tackle the fire will be key. Prior to arrival of the local fire brigade, intervention will be via dedicated fire teams on site, preferably by retained firefighters or alternatively non-clinical staff trained in firefighting. Clinical staff should not be relied upon for firefighting intervention.

To support handover, daily fire safety management and emergency response, clear fire safety information must be developed, including on roles and responsibilities, emergency action plans, maintenance, monitoring and housekeeping protocols.



Fire safety



PREVENTION & MITIGATION

- **Electrical fires:** qualified electrical installers, robust residual circuit breakers, certified installations and portable appliances.
- **Stored combustibles & waste:** minimise and remove from wards ASAP.
- **Oxygen-enriched fire risk:** provide adequate ventilation; install oxygen enrichment sensors and alarms; train staff to cap all O2 feeds when connecting temporary O2 bottles (for daily movement and evacuation).
- **Ignition risk from static:** consider checkpoints for testing / discharging static from people / equipment; avoid clothing / PPE prone to static.
- **Construction:** non-combustible walls and ceilings (e.g. gypsum board, metal frame, mineral wool infill – avoid foam insulation, chipboard partitions, plastic canopies, etc.)
- **Linings:** non-combustible wall and ceiling linings.
- **Fires in ancillary / existing accommodation:** separate by 30-minute fire-separation walls with fire doors (including smoke seals, door closers), fire-stopping (at joints, pipes, cables) & fire dampers (at grills, ductwork) and / or provide suppression, commensurate with the fire hazard / risk.
- **Fire spread between bed rows:** provide reasonable separation between rows of beds; 5 m is advised as a benchmark.

PREPARATION

- **Early warning:** smoke detection throughout ward and all ancillary / existing areas in the building; manual call points; linked to nurses' monitoring stations.
- **Exits from rooms / bays:** doors / openings to be suitably sized for movement of beds + all required equipment, as well as space for staff re-entry simultaneously.
- **Exits from wards:** at least 2 exits to another ward / protected corridor / outside; exits to be remotely located to minimise single-direction travel distances; avoid dead-end corridors.
- **Fire exit doors:** double-doors, outward-opening to allow bed movement.
- **Signage:** clear, conspicuous, graphical emergency signage (back-lit or by lights).
- **Temporary O2:** keep sufficient bottles available to support patient relocation.
- **External exit routes:** weather protected; avoid steps (use ramps).
- **Emergency lighting:** all internal areas & external escape routes.
- **Fire extinguishers:** provide throughout (type appropriate to fire class and occupancy).
- **Fire blankets:** provide throughout.
- **On-site fire teams:** retained professional firefighters (preferably) or trained non-clinical staff.
- **Facilities for firefighters:** assess and retain / adapt existing hydrant network or alternatively deploy fire water truck continuously on site; temporary fire mains; hoses out and ready.
- **Information for firefighters:** floor plans showing firefighting facilities, access, key risks, etc.

RESPONSE

- **Investigation and intervention:** rapid attention by nearest clinical or non-clinical staff to confirm a fire and initiate response (e.g. fire blankets, fire extinguishers, patient relocation).
- **Patient relocation:** a phased approach is necessary to minimise disruption to essential healthcare:
 - **Phase 1:** evacuate occupants in immediate danger away from the fire location; mobilise as many staff as possible to assist.
 - **Phase 2:** relocate the above occupants to an area remote from the fire location, but retain them within the building.
 - **Phase 3:** if fire is not extinguished, continue to relocate other occupants away from the fire; evacuate to outside the building if necessary.
- **ICU patients:** should be relocated only as absolute last resort.
- **Contamination:** avoid relocating 'dirty' Covid-19 ward to 'clean' areas.

RECOVERY & CONTINUITY

- **Continuity:** relocate patients to other wards / areas with fixed O2.
- **Ward separation:** provide reasonable separation between wards (as per separation of beds); 5m is advised as a indicative benchmark.
- **Overflow capacity:** provide sufficient space and O2 provisions, etc. in other temporary wards to house relocated patients + beds + equipment.
- **Ongoing care of ICU patients:** separate ICU from wards by fire-resisting walls with fire doors, fire-stopping and fire dampers; avoid routing ICU services through fire-resisting walls.
- **Post-fire smoke clearance:** via doors, vents and portable fans.

REQUIREMENTS

Fire safety

Installing temporary healthcare facilities in existing spaces presents unique challenges. Egress of bed-bound patients and achieving fire compartmentation are key issues that must be considered during detailed design.

RISK POSED BY FIRE IN ANCILLARY ACCOMMODATION

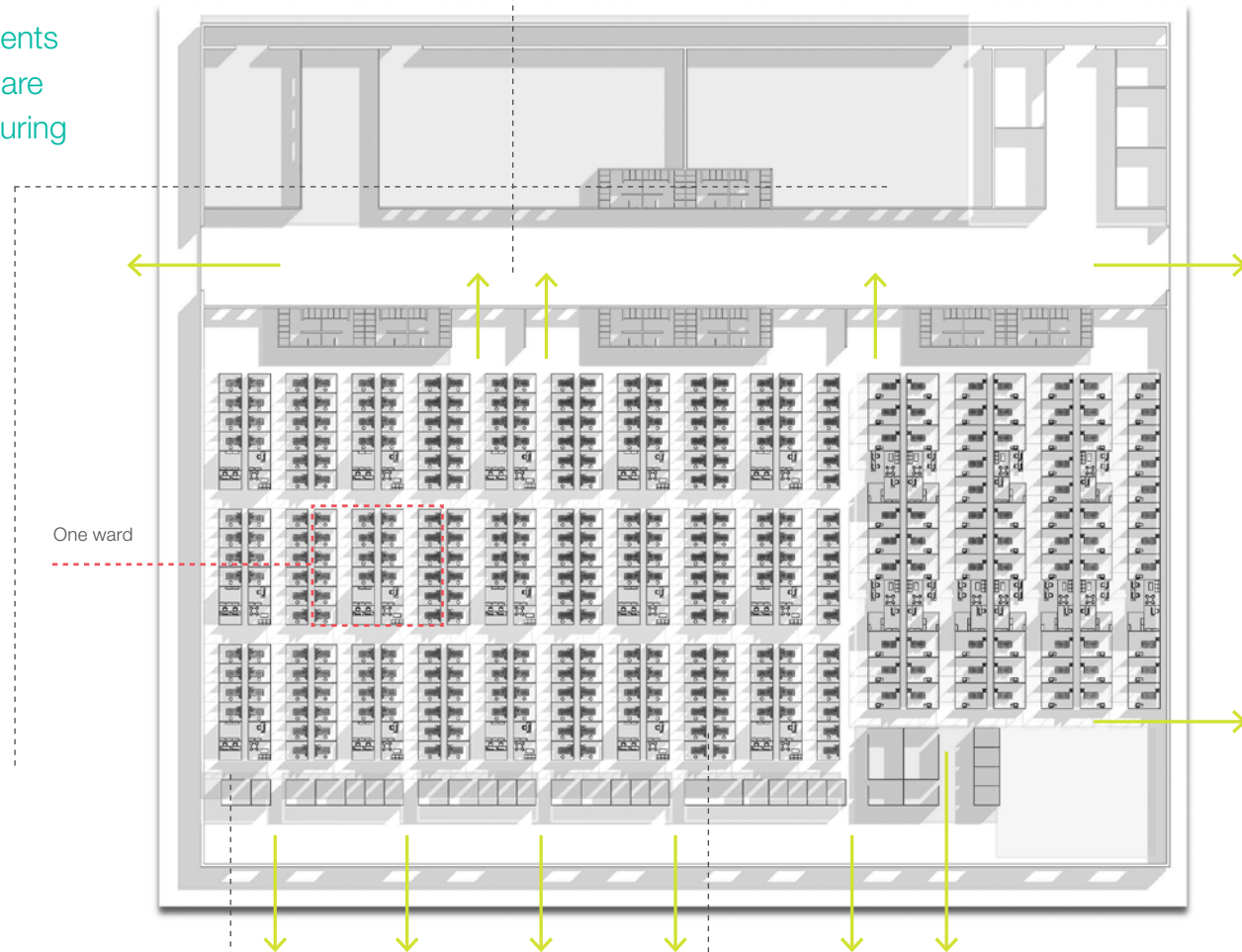
Disused building areas or areas supporting the temporary hospital (e.g. staff welfare, administration, plant) present a risk to the patients. These areas should be provided with active fire protection (e.g. suppression) and/or passive fire protection (e.g. fire-separation walls) commensurate with the fire hazard and risk they present. At a minimum, all parts of the building should be provided with automatic fire detection and alarm.

WARD FIT-OUT MATERIALS

To limit the area affected by fire and the numbers of patients needing to be evacuated, combustible materials should be minimised. It is recommended that non-combustible construction is used for fit-out partitions, etc.

MEANS OF EGRESS

The evacuation strategy focuses on moving the patients in immediate danger away from the fire, but retaining them within the building. If the building has fire compartmentation, patients could be relocated to an alternate compartment. Continued relocation of more patients can be instigated as necessary. All wards and areas should be provided with multiple exits in alternate directions. Exits to outside should also be provided to support building evacuation in the event that a fire is not controlled or contained.



SEPARATION BETWEEN ROWS OF BEDS

To reduce the risk and speed of fire spread, it is recommended that reasonable separation is provided between rows of beds. 5m is advised as an indicative benchmark. Where this is not feasible, reduced dimensions should be reviewed and substantiated as part of the fire strategy.

REQUIREMENTS

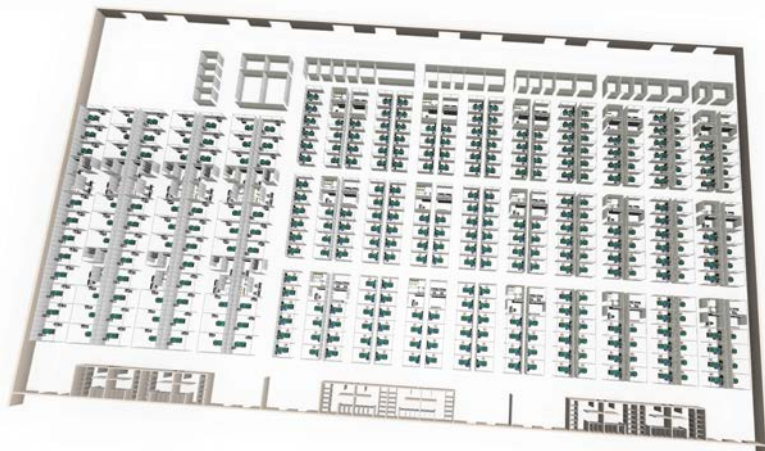
Partitions

A With partitions

Temporary event partitions usually come in modules of 1.00m or 0.5m. It is important to work with the modulation available to avoid bespoke solutions that can increase cost and time of installation.

Important aspects to consider when choosing temporary partitions:

- use of non combustible materials
- must be easy to clean and disinfect
- must be easy to install



FULL HEIGHT

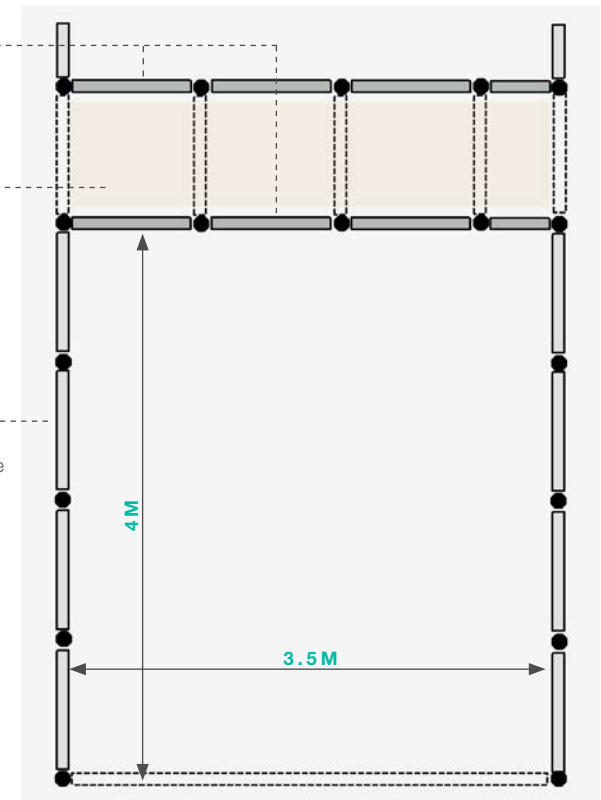
Solid panels to the back of bed.

SERVICE CORRIDOR

Service corridor (O2 / temporary power) in-between bed cubicles.

MODULE FRAME

Half solid panels to allow visibility (can be left open (frame only) or use translucent panels).



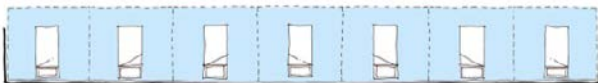
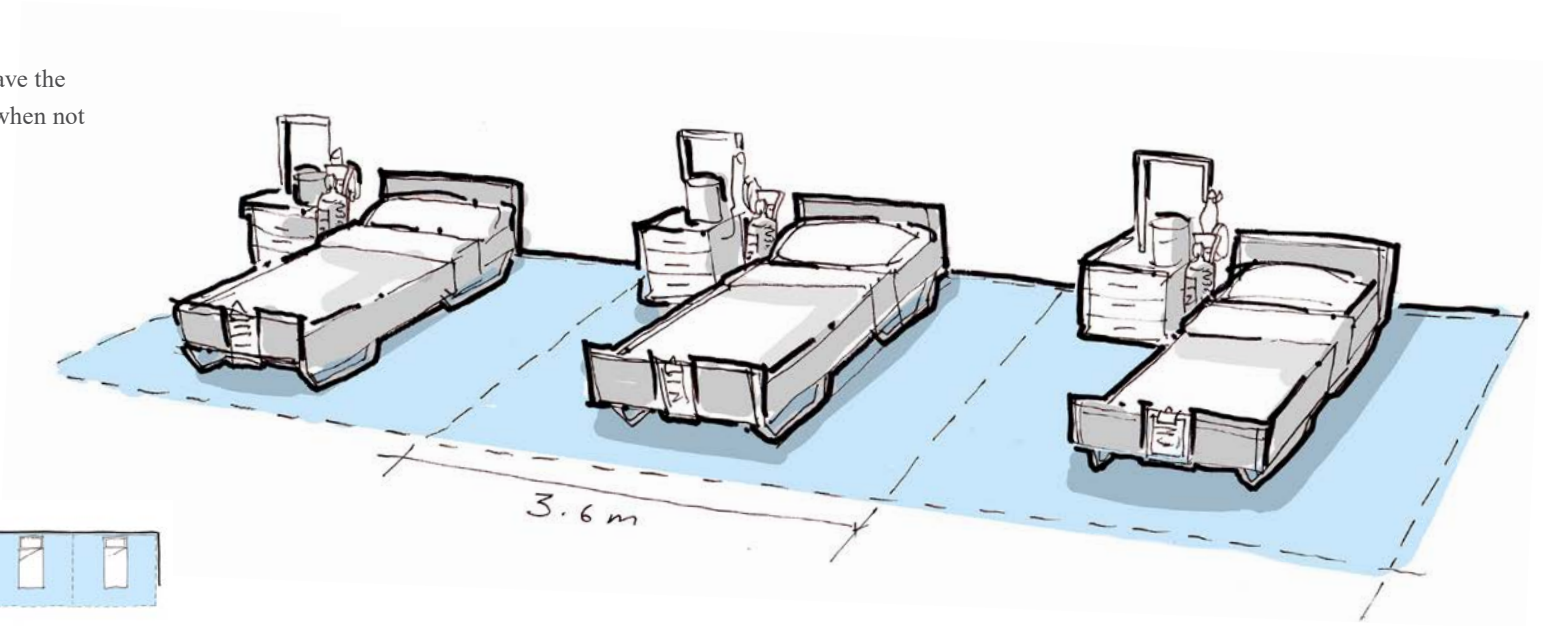
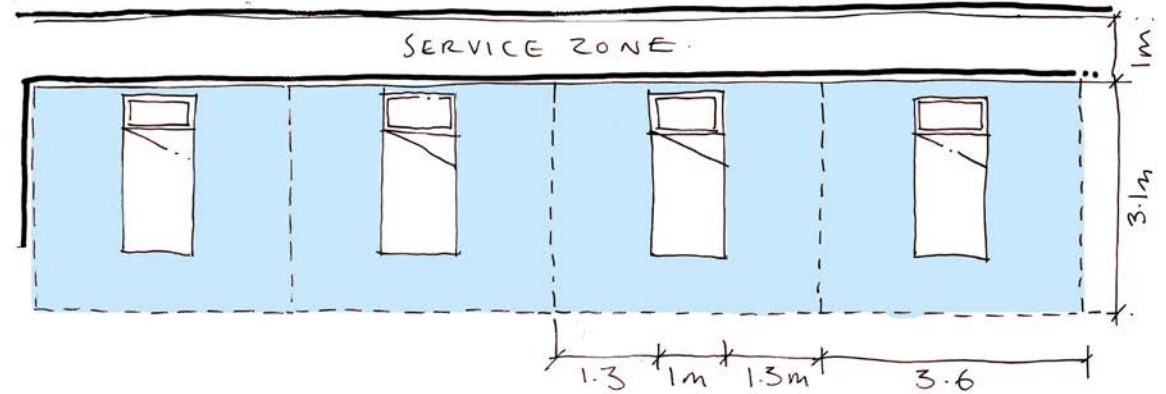
Partitions

B Without partitions

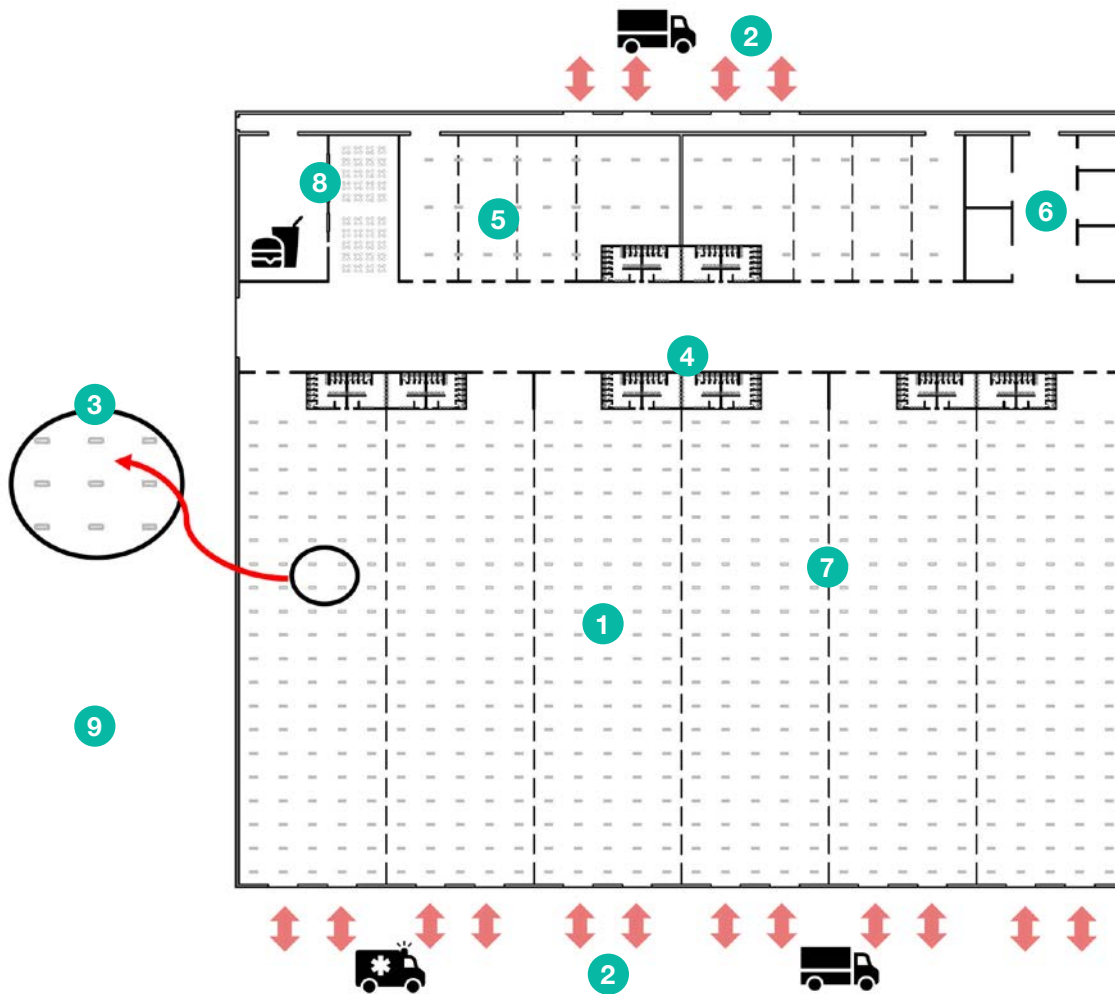
A basic field hospital layout could be the most cost effective and quick solution to provide.

As a more cost / construction time effective solution partitions can be used around a cluster of beds instead of around each bed. In this case it is important to mark up each bed area on the floor.

Whenever possible each bed module should have the recommended dimensions of 3.10m x 3.60m when not individually enclosed by partitions.



Benefits of using a convention centre



- 1** Covered area and with levelled surface for implementation of temporary suitable floor finishes.
- 2** Usually Halls have large doors with vehicle access that can be used for deliveries and ambulance access.
- 3** It is very common to find containment routes with easy access to connect temporary services with utilities grid and to run temporary cables / pipes.
- 4** Existing toilets and other facilities.
- 5** Conference rooms that can be configured into rest areas for staff or administrative spaces.
- 6** Existing smaller spaces and facilities to be used as offices / storage to support the operation.
- 7** Usually there are floor to ceiling movable walls that add flexibility of creating distinct areas.
- 8** Existing catering facilities, often with an equipped kitchen.
- 9** Adjacent car parks can be used for temporary plant / utilities area such as O₂ tanks and power generators. They can also be used to accommodate testing walk in / drive through facilities.

EXAMPLE

Installing treatment wards and support areas in a convention centre

SERVICES / PATIENT / WORKFORCE

Support areas like kitchen, rest areas, changing rooms and others can be accommodated in existing facilities such as kitchens, conference rooms, etc.

STANDARD CARE WARD

The 282 bed unit example had an area of approximately 6700m². In this example 18 beds per support area.

TREATMENT SUPPORT

Support areas such as change rooms, assisted toilets / showers, medicine room and blood test lab (when applicable)

EXISTING AREAS

Existing areas such as cloak rooms / small storage and conference rooms can be used to accommodate administrative spaces, storage and other facilities etc.

ICU WARD

The 69 beds unit example had an area of approximately 2750m². In this example 6 beds per support area.

ICU SUPPORT AREA

Area to have assisted toilets / shower units, laundry and cleaning cupboards and staff changing rooms.

SERVICES / OPERATIONAL SUPPORT

Areas such as laundry cupboards, storage, cleaning cupboards, etc., with easy access from the loading area / doors.

TRIAGE AREA

The triage should include the following:

- 5% of Total Number of Beds
- Vehicle / Ambulance access
- Access to dedicated toilets
- Ensure direct access to ward without crossing the ICU



Access and internal circulation

PATIENT ACCESS

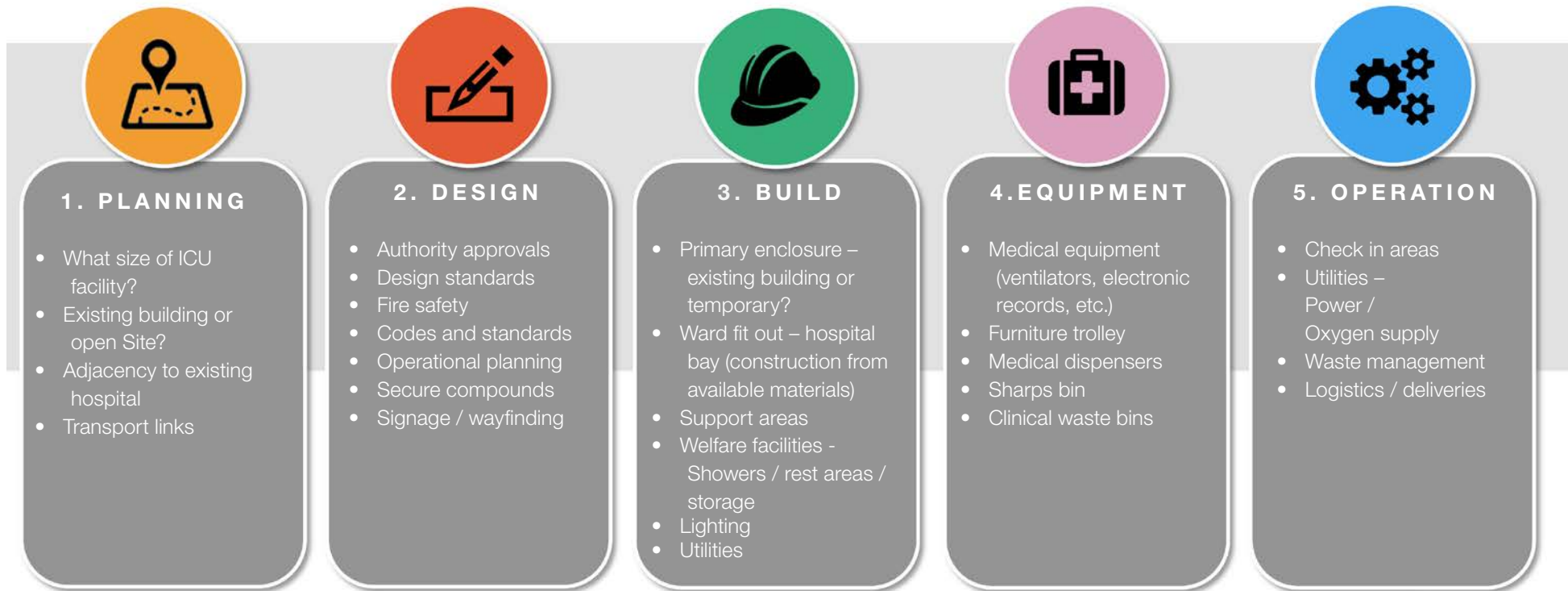
Utilities and containment routes

Service corridors – cabling / pipes – can be created with temporary partitions and be used to distribute power, water, drainage and medical gases. In many cases convention centres have underfloor containment that can be connected to these corridors.

Additional storage area for hazardous material may be required. Ventilation equipment in addition to the existing system may be required to achieve high specifications of clean x dirty air flows. Additional waste water treatment may be required before going into mains depending on local regulations.



Implementation stages



Post lockdown

LOOKING FORWARD - as normal life resumes (post lockdown), it is likely temporary facilities will be required for checking and storage.

EVIDENCE SUGGESTS the virus is likely to spread again and further lockdowns will be required. Having secure storage near previous hospital sites would enable these facilities to be quickly deployed and operational with minimal delay.

AS RESTRICTIONS ARE LIFTED on people movement, it is likely that entry checks will be carried out, monitoring the health of people entering work and leisure facilities. These could be temporary 'check in' security points, outside of the buildings secure perimeter.





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IMPORTANT NOTE

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