Multi-Container Health Facility

Container Facility Fabricators:

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1. Introduction

Coronaviruses (CoV) are a large family of viruses that cause illness ranging from the common cold to more severe diseases such as Middle East respiratory syndrome (MERS-CoV) and severe acute respiratory syndrome (SARS-CoV). A novel coronavirus (nCoV) is a new strain that has not previously been identified in humans. Coronaviruses are zoonotic, can be transmitted between animals and humans. Detailed investigations found that SARS-CoV was transmitted from civet cats to humans, and MERS-CoV from dromedary camels to humans. Several known coronaviruses are circulating in animals that have not yet infected humans. Common signs of infection include respiratory symptoms, fever, cough, shortness of breath and breathing difficulties. In more severe cases, infection can cause pneumonia, severe acute respiratory syndrome, kidney failure and death.

The ongoing pandemic of coronavirus disease 2019 (COVID-19), is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The outbreak started in Wuhan, Hubei province, China, in December 2019. The World Health Organisation (WHO) declared the outbreak to be a public health mergency of international concern on 30 January 2020 and recognized it as a pandemic on 11 March 2020. As of 7 April 2020, approximately 1.42 million cases of COVID-19 have been reported in 209 countries and territories, resulting in approximately 81,200 deaths. Approximately 300,000 people have recovered. Each country demonstrating phases to the pandemic with various starting points. The typical phases of a pandemic are shown in figure 1.

Figure 1: Phases of an epidemic.

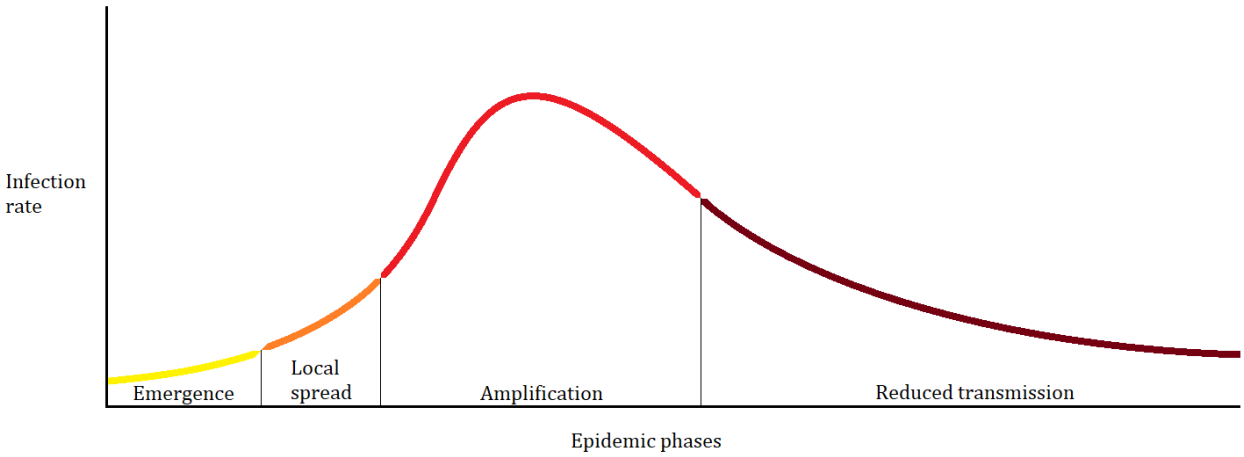


Table 1: Categorization of patients with severe acute respiratory infection.

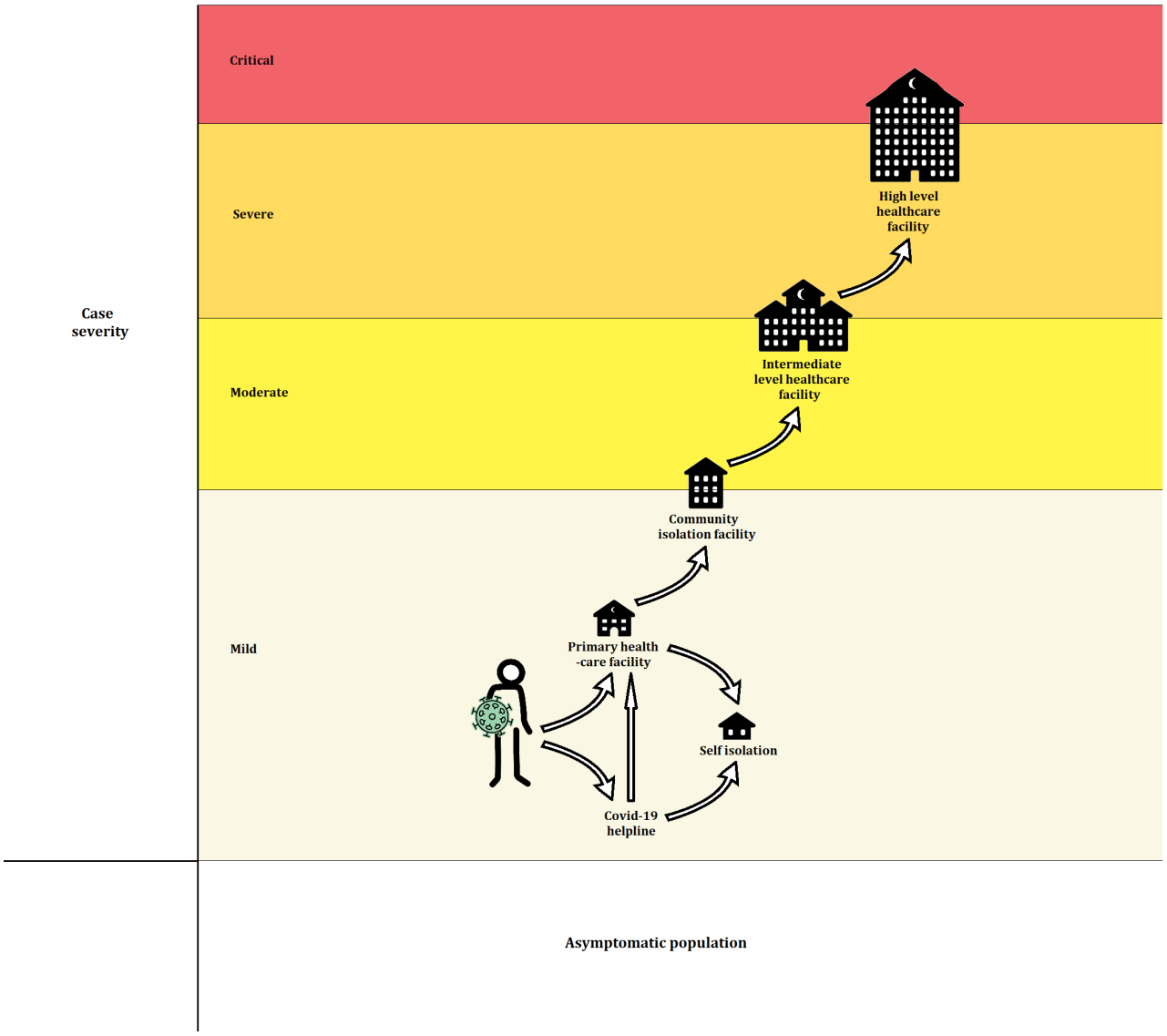
Mild and moderate	Uncomplicated illness	Uncomplicated upper respiratory tract viral infection; people may have non-specific symptoms such as fever, cough, sore throat, nasal congestion, malaise, headache or muscle pain Elderly people and people with immunosuppression may present with atypical symptoms These patients do not have any signs of dehydration, sepsis or shortness of breath
	Mild pneumonia	Pneumonia but no signs of severe pneumonia Child: cough or difficulty breathing and fast breathing (age < 2 months, ≥ 60 breaths/min; age 2–11 months, ≥ 50 breaths/ min; age 1–5 years, ≥ 40 breaths/min) and no signs of severe pneumonia
Severe	Severe pneumonia	Adolescent or adult: fever or suspected respiratory infection, plus one of: respiratory rate > 30 breaths/min, severe respiratory distress, or SpO2 < 90% on room air Child: cough or difficulty in breathing, plus at least one of: central cyanosis or SpO2 < 90%; severe respiratory distress (e.g. grunting, very severe chest indrawing); signs of pneumonia with a general danger sign (inability to breastfeed or drink, lethargy or unconsciousness, convulsions) Other signs of pneumonia may be present: chest indrawing, fast breathing (age < 2 months, ≥ 60 breaths/min; age 2–11 months, ≥ 50 breaths/min; age 1–5 years, ≥ 40 breaths/min) Diagnosis is clinical; chest imaging can exclude complications
Critical	Acute respiratory distress syndrome	Onset: new or worsening respiratory symptoms within one week of known clinical insult Chest imaging (radiograph, CT scan, lung ultrasound): bilateral opacities not fully explained by effusions, lobar or lung collapse, or nodules Origin of oedema: respiratory failure not fully explained by cardiac failure or fluid overload; need objective assessment (e.g. echocardiography) to exclude hydrostatic cause of oedema if no risk factors present Oxygenation (adult): Mild acute respiratory distress syndrome: 200 mmHg < PaO2/FiO2 ≤ 300 mmHg with PEEP or CPAP ≥ 5 cmH2O *(7)* or non-ventilated *(8)*Moderate acute respiratory distress syndrome: 100 mmHg < PaO2/FiO2 ≤ 200 mmHg with PEEP ≥ 5 cmH2O *(7)* or non-ventilated *(8)*)Severe acute respiratory distress syndrome: PaO2/FiO2 ≤ 100 mmHg with PEEP ≥ 5 cmH2O *(7)* or non-ventilated *(8)*)When PaO2 is not available, SpO2/FiO2 ≤ 315 suggests acute respiratory distress syndrome (including in non-ventilated patients)

		Oxygenation (child): Bilevel non-invasive ventilation or CPAP ≥ 5 cmH2O via full face mask: PaO2/FiO2 ≤ 300 mmHg or SpO2/FiO2 ≤ 264Mild acute respiratory distress syndrome (invasively ventilated): 4 ≤ OI < 8 or 5 ≤ OSI < 7.5Moderate acute respiratory distress syndrome (invasively ventilated): 8 ≤ OI < 16 or 7.5 ≤ OSI < 12.3Severe acute respiratory distress syndrome (invasively ventilated): OI ≥ 16 or OSI ≥ 12.3
	Sepsis	Adult: life-threatening organ dysfunction caused by dysregulated host response to suspected or proven infection, with organ dysfunction. Signs include altered mental status, difficult or fast breathing, low oxygen saturation, reduced urine output, fast heart rate, weak pulse, cold extremities, low blood pressure, skin mottling, or laboratory evidence (coagulopathy, thrombocytopenia, acidosis, high lactate, hyperbilirubinemia) Child: suspected or proven infection and two or more systemic inflammatory response syndrome criteria, of which one must be abnormal temperature or white blood cell count
	Septic shock	Adult: persisting hypotension despite volume resuscitation, requiring vasopressors to maintain mean arterial pressure ≥ 65 mmHg and serum lactate level > 2 mmol/L Child: any hypotension (systolic blood pressure < 5th centile or > 2 standard deviations below normal for age) or two or three of: altered mental state; tachycardia or bradycardia (infant: heart rate < 90 beats/min or > 160 beats/min; child: heart rate < 70 beats/min or > 150 beats/min); prolonged capillary refill (> 2 s) or warm vasodilation with bounding pulses; tachypnoea; mottled skin or petechial or purpuric rash; increased lactate; oliguria; hyperthermia or hypothermia *(30)*

Table 2: Key recommendations based on case severity and risk factors.

Risk factors	**Case severity**	**Isolation**	**Required resource**	**Role of containers facilities**
None	Mild	Self-isolate	Home support	Community testing & follow-up and referral
None	Moderate	Isolation	* Health facilities, if resources allow, * Community facilities (e.g. stadiums, gymnasiums, hotels) with access to rapid health advice (i.e. adjacent COVID-19 designated health post/EMT-type 1, telemedicine).	* Health facilities relief, * Testing facilities, * Isolation facilities.
Present	Moderate	Isolation, Oxygen therapy if required	Health facilities.	* Health facilities relief, * Testing facilities, * Isolation facilities, * Intermediate level medical care including provision of oxygen therapy.
Present	Severe	Isolation, Oxygen therapy	Health facilities.	* Health facilities relief, * Testing facilities, * Isolation facilities, * Intermediate level medical care including provision of oxygen therapy, * High level medical care including, mechanical ventilation.
Present	Critical	Isolation, Mechanical ventilation	Health facilities.	

Figure 2: COVID-19 patient's journey through the healthcare system.



2. Objectives

To convert shipping containers into units that are suitable for a Quarantine Mobile Clinic for the isolation of COVID-19 patients. These units are:

1. Example 1 (7 X 40 Ft containers);
a. 5 Containers, each one consist of 3 bedrooms with an en suite bathroom for each room. Each container will be electrically powered by up to 6 KW modular roof-top Solar System.
b. 2 Containers, each one consist of 1 registration room and 1 nursing room.

2. Example 2, 3 X 20 Ft containers, that could be used for the Triage Rooms, Laboratory, the Medical Imaging Room (X-Rays/CT Scan), Toilets or other units. Each container is electrically powered by up to 3 KW modular roof-top Solar System.

Scope of Work

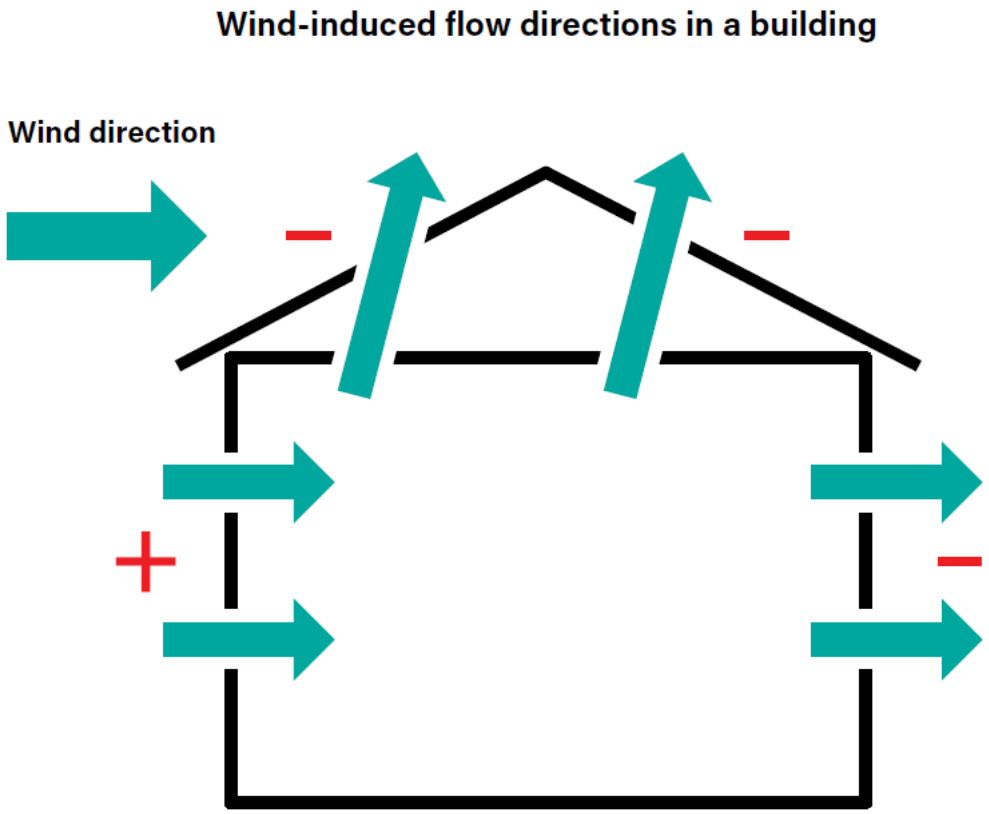
1. Design and engineering for the conversion of shipping containers into modular health facilities used for testing, isolation and treatment of COVID-19 suspected/confirmed powered by solar energy.
2. Project planning & controlling.
3. Supply of all necessary materials to convert the shipping containers (supplied by others) into mobile clinic units.
4. Supply of solar power systems to empower up to 6 KW.
5. Installation of solar power system to the mobile clinic units and facilities.
6. All technical support & documentation required for statutory & regulatory approvals.

3. General considerations

Ventilation requirements

Natural ventilation
Natural forces (e.g. winds and thermal buoyancy force due to indoor and outdoor air density differences) drive outdoor air through purpose-built building envelope openings, such as windows, doors, solar chimneys, wind towers and trickle ventilators. This natural ventilation of buildings depends on climate, building design and human behaviour.
When wind strikes a building, it induces a positive pressure on the windward face and negative pressure on the leeward face. This drives the air to flow through windward openings into the building to the low-pressure openings at the leeward face (Figure 3). It is possible to estimate the wind pressures for simple buildings. Its recommended that isolation/patient care rooms utilise mechanical ventilation means.

Figure 3: natural building ventilation



Mechanically ventilation

Mechanically ventilated room is equivalent to the airborne infection isolation room described by the United States Centres for Disease Control and Prevention (CDC), which should have special features in air handling and airflow direction, including:
a negative-pressure differential greater than 2.5 Pa (0.01 inch water gauge), or an airflow differential greater than 56 l/s (125 cfm) exhaust versus supply; clean-to-dirty airflow; sealing of the room, allowing approximately 0.046 m2 (0.5 square feet) leakage; more than 12 air changes per hour for a new building, or more than 6 air changes per hour for an existing building (equivalent to 40 l/s for a room measuring 4 × 2 × 3 m for an old building);an exhaust to the outside, or a high-efficiency particulate air (HEPA) filter if room air is recirculated. Natural ventilation can be used in airborne precaution rooms. The purpose of this document is to provide basic design guidance for the use of natural ventilation for infection control.

Exhausted air

Air from the room can be exhausted directly to the outdoors, where the droplet nuclei will be diluted in the outdoor air, or passed through a special HEPA filter that removes most (99.97%) of the droplet nuclei before it is returned to the general circulation. If a HEPA filter is not used, the air should be exhausted directly to the outside away from air-intake vents, people and animals.

Air dilution should always be the favoured solution. If not possible, however, three different treatments for exhausted air are proposed here.

HEPA filter

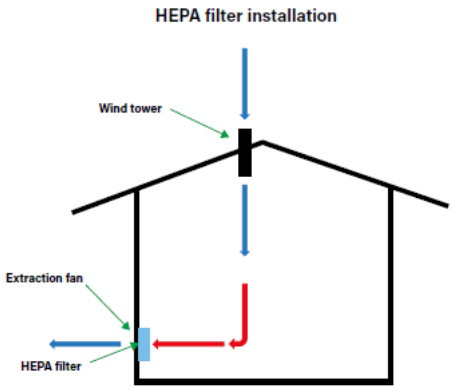
HEPA is a pleated mechanical air filter that theoretically removes at least 99.97% of dust, pollen, mould, bacteria and airborne particles with a size of 0.3 microns (µm). The diameter

specification of 0.3 microns responds to the worst case of the most penetrating particle size. Particles that are larger or smaller are trapped with higher efficiency. Using the worst-case particle size results in the worst-case efficiency rating (i.e. 99.97% or better for all particle sizes). All air cleaners require periodic cleaning and filter replacement to function properly; follow the manufacturer's recommendations on maintenance and replacement.

The minimum efficiency reporting value (MERV) is the ability of a filter to capture larger particles with a size between 0.3 and 10 microns (µm): the higher the rating, the better the filter is at trapping specific types of particles. This value is helpful in comparing the performance of different filters. The rating is derived from a test method developed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (www.ashrae.org).

Installing a HEPA filter after the air extractor could be a solution for exhausted air treatment (Figure 4), but availability and maintenance may be a problem.

Figure 4: HEPA filter arrangement



Ultraviolet germicidal irradiation

Because the clinical effectiveness of UV systems may vary, ultraviolet germicidal irradiation (UVGI) is not recommended for air management before air recirculation from airborne isolation rooms. It is not recommended as a substitute for HEPA filtration, local exhaust of air to the outside, or negative pressure, but it can be used as a complementary system (Figure 5).

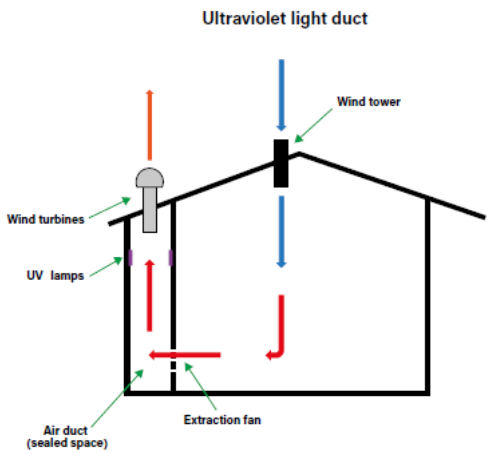
UVGI is electromagnetic radiation that can destroy the ability of microorganisms to reproduce by causing photochemical changes in nucleic acids. Wavelengths in the UVC range are especially damaging to cells because they are absorbed by nucleic acids. The spectrum of UV light includes wavelengths of about 100–400 nm. The subdivisions of most interest include UVC (200–280 nm) and UVB (280–320 nm). Microbes are uniquely vulnerable to light at wavelengths at or near 253.7 nm because the maximum absorption wavelength of a DNA molecule is 260 nm. Additionally, efficacy of far-UVC light inactivation has been proven on airborne viruses carried by aerosols. For example, a very low dose of 2 mJ/cm2 of 222-nm light inactivates more than 95% of airborne H1N1 virus, while virus-reduction factors of 3.4 or more for SARS-CoV have been achieved with the UVC-based system in platelet concentrates.

Effective room air disinfection depends on circulating maximal room air through the duct and the velocity at which it is circulated. For this reason, it is essential to define the size (volume) of the air duct (sealed space) according to the capacity of the air extractor. The higher the contact time, the more effective the disinfection.

UVC lamp requirements
The most important requirement is the UV wavelength, as it directly affects the disinfection efficiency of the lamp. Only use a lamp providing a wavelength of 254 nm (0.254 µm). There are three available UV sources that provide the required wavelength of 254 nm.

Electrical consumption should be taken into account, as this will drive the electrical supply choice. Another important aspect is the surface temperature. Bearing in mind the centre will be a temporary structure, lamps reaching high surface temperature may become a serious threat by increasing the likelihood of fire.

Figure 5: UV light arrangements



Space requirements
Space is required for equipment that is used intermittently at the bed space. This may include:
• electroencephalogram (EEG) machine
• ultrasound/echocardiography
• endoscopy (fibre-optic light source)
• defibrillators
• haemodialysis
• haemo-filtration.
Separate data and voice outlets may be used where structure cabling solutions are not available.

Components
• 1 x BOARD, marker, whiteboard, dry-wipe, with pen holder, wall mounted, 600H 900W
• 2 x HOOK, single, large, wall mounted
• 8 x SOCKET outlet, switched, 13 Amp, twin
• 1 x CLEANER'S SOCKET outlet, switched, 13 Amp, single
• 1 x LUMINAIRE, examination, wall, adjustable, 1000 lux (mobile exam lamp is a project option)
• 1 x TRUNKING, medical services, length as drawn
• 1 x DISPENSER, barrier cream, disposable single cartridge, wall mounted
• 1 x DISPENSER, paper towel, wall mounted

• 1 x DISPENSER, medical hand sanitiser, lever action, wall mounted
• 1 x DISPENSER, disposable gloves (set of three) and disposable apron, wall mounted
• 1 x BED, CCU/ITU, radio-translucent rising backrest, two-way tilt, height adjustable (685–860), on castors
• 2 x HOLDER, sack, with foot-operated lid, medium, free standing, 875H 430W 385D
• 1 x HOLDER, sharps box, up to 7 litre capacity, rail/trolley hang or wall mounted, 170H 125W 100D • 3 x INFUSION volumetric pump, 188H 110W 60D
• 1 x INFUSION enteral feeding pump, 365H 178W 178D (project option)
• 1 x LOCKER, bedside, four compartment with lockable section/drawer, towel rail at rear, on castors, 902H 485W 485D.
• 1 x MONITOR, vital signs, multi-parameter, with accessories, 280H 360W 215D
• 1 x TROLLEY, modular storage, single open frame, including handle and worktop, with up to five sets of runners for 600 facing inserts, 850H 730W 450D
• 2 x STAND, infusion, twin hook, breaks, mobile
• 6 x SYRINGE pump, battery operated, 170H 35W 75D
• 1 x TRANSPORTER ventilator, 370H 270W 85D (compatible with medical supply unit)
• 1 x VENTILATOR, portable, adjustable minute volume, 460H 470W 310D.

Ground characteristics
Ensure the site is flat and level. Ensure the site is geologically stable and consolidated, preferably without organic or stony material. Ensure the site is easy to dig, without the danger of landslides, and with the capacity for drainage. Avoid areas with a high groundwater table. Ensure the site is of sufficient size to extend the waiting room and triage area if necessary.

Meteorological characteristics
* consider regional rain fall. Sites should have elevated bases to account for flooding,
* Take into account sun orientation for improved shadow zones.

Recommended characteristics for selecting finishes and furniture
The recommended characteristics for selecting finishes and furniture are summarized in Table 3.

Table 3. Recommended characteristics for selecting finishes and furniture for a severe acute respiratory infection treatment centre

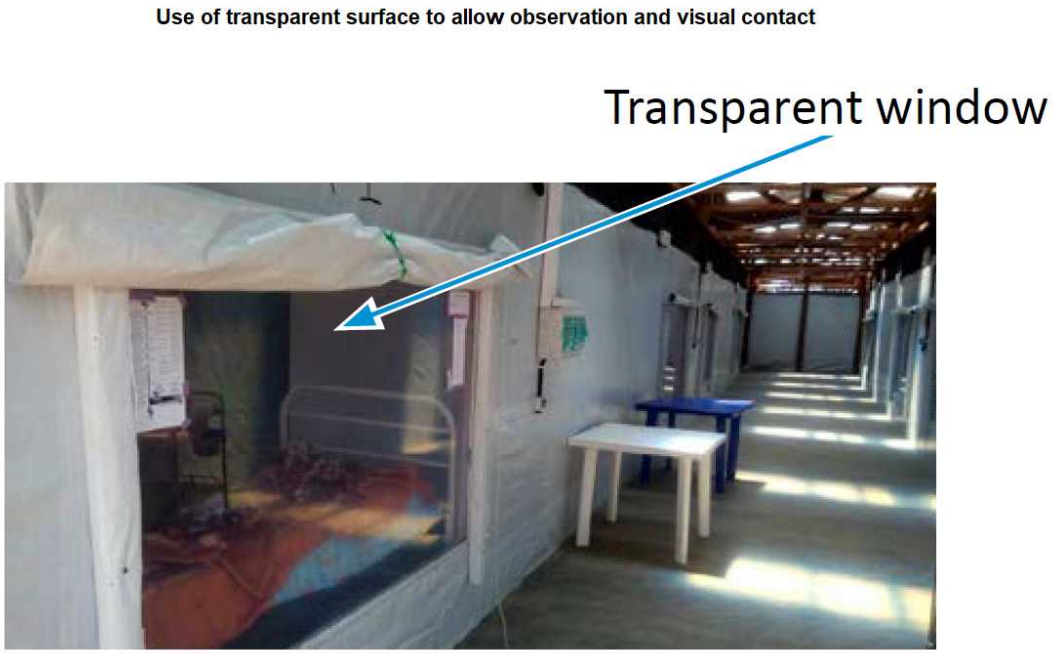
Characteristic	Selection guidance
Cleanable	Avoid items with hard-to-clean features, such as crevasses; Do not use carpets in patient care areas; Select material that can withstand repeated cleaning.
Easy to maintain and repair	Avoid materials prone to cracks, scratches or chips, and quickly patch or repair if they do occur; Select materials that are durable or easy to repair.
Resistant to microbial growth	Avoid materials that hold moisture, such as wood and cloth, as these facilitate microbial growth; Select metals and hard plastics.
Non-porous	Avoid items with porous surfaces, such as cotton, wood and nylon; Avoid porous plastics, such as polypropylene, in patient care areas.
Seamless	Avoid items with seams; Avoid upholstered furniture in patient care areas.

Fire risk assessment
The fire risk assessment for the area being converted should be reviewed in view of a higher life safety sleeping risk cohort and the additional issue of more oxygen being in use. This may increase staffing levels or require modified PHE. This review should be carried out by the trust fire safety advisor using their local knowledge of the site and training levels.

Use of transparent surfaces
The use of transparent surfaces or windows between the patients' rooms and the working area or nursing station (Figures 6) enables:

* visual contact with patients, strengthening the bedside relationship, the anthropological approach and community engagement;
* observation and monitoring, improving patient care through continuous patient observation and monitoring, and permitting a fast response;
* installation of an oxygen concentrator and ventilator, monitor and pulse oximeter in the working area rather than the patient's room, reducing the risk of nosocomial infections;
* reduced use of PPE, as many medical activities may be performed directly from the working area.

Figure 6: transparent surface use



4. Unit design proposals

Ensuring triage, early recognition and source control

Clinical triage includes a system for assessing all patients at admission, allowing early recognition of possible 2019-nCoV infection and immediate isolation of people with suspected 2019 coronavirus disease (COVID-19) in an area separate from other patients (source control).

a. 20 Ft Container-triage/isolation rooms

A 20 ft container to be used as either 2 examination rooms. This design includes all finishing, fixtures, 2 doors, 2 windows, wall fans, one water air cooler, solar equipment partition and a small wash basin with associated plumping. It does not include full bathrooms and if used as Covid-19 isolation units an external bathroom will be needed or a shared bathroom can be installed. This however will make the room size smaller than the 40 ft container option.

Figure 7

Example of 2 beds isolation room

Figure 8

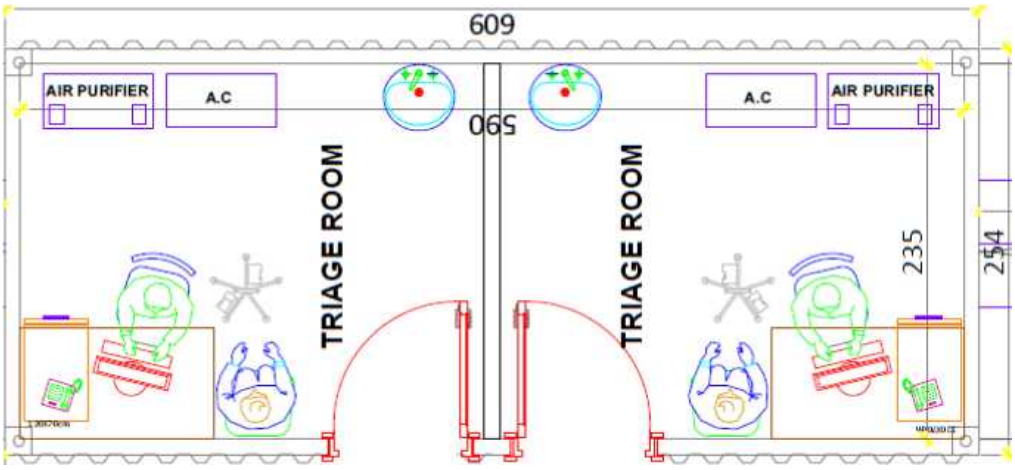


Figure 9–a (Alternative Triage Unit)

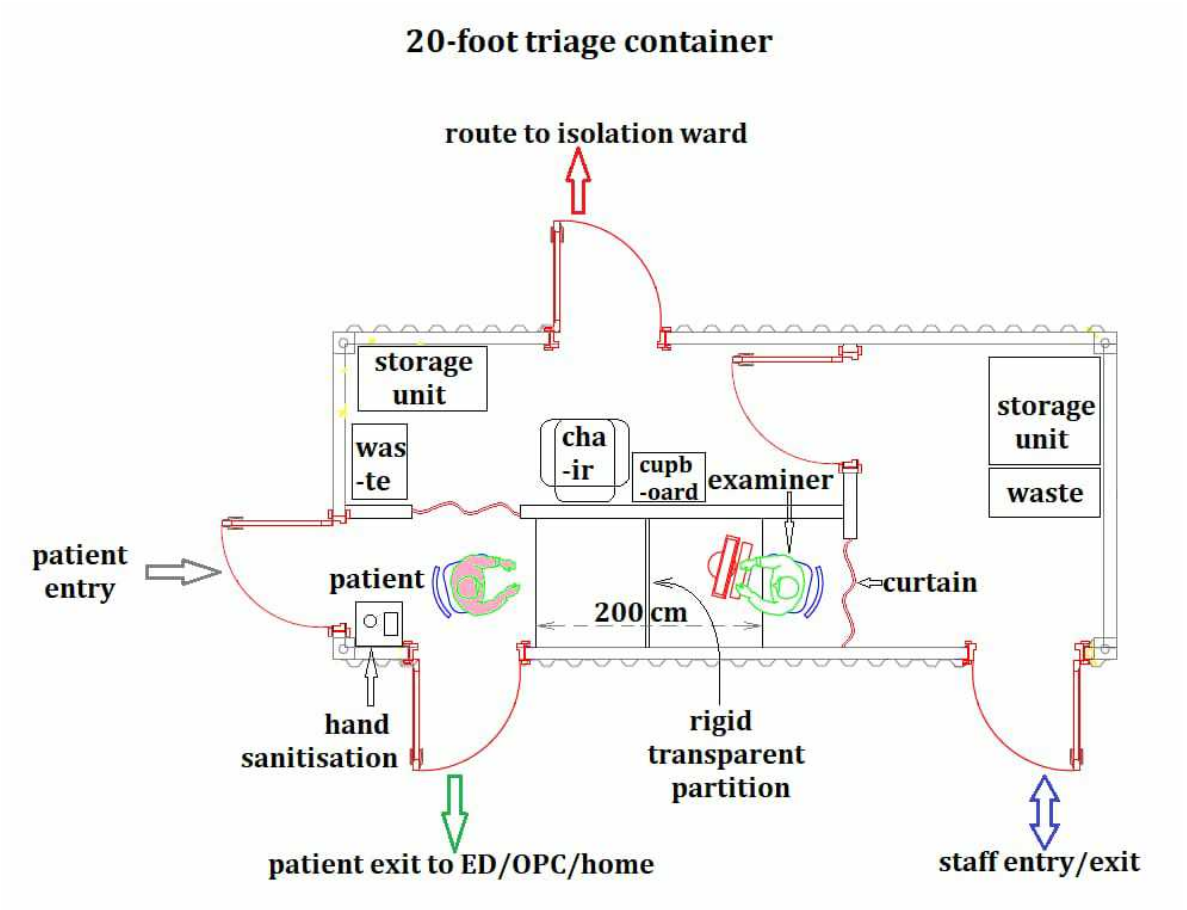
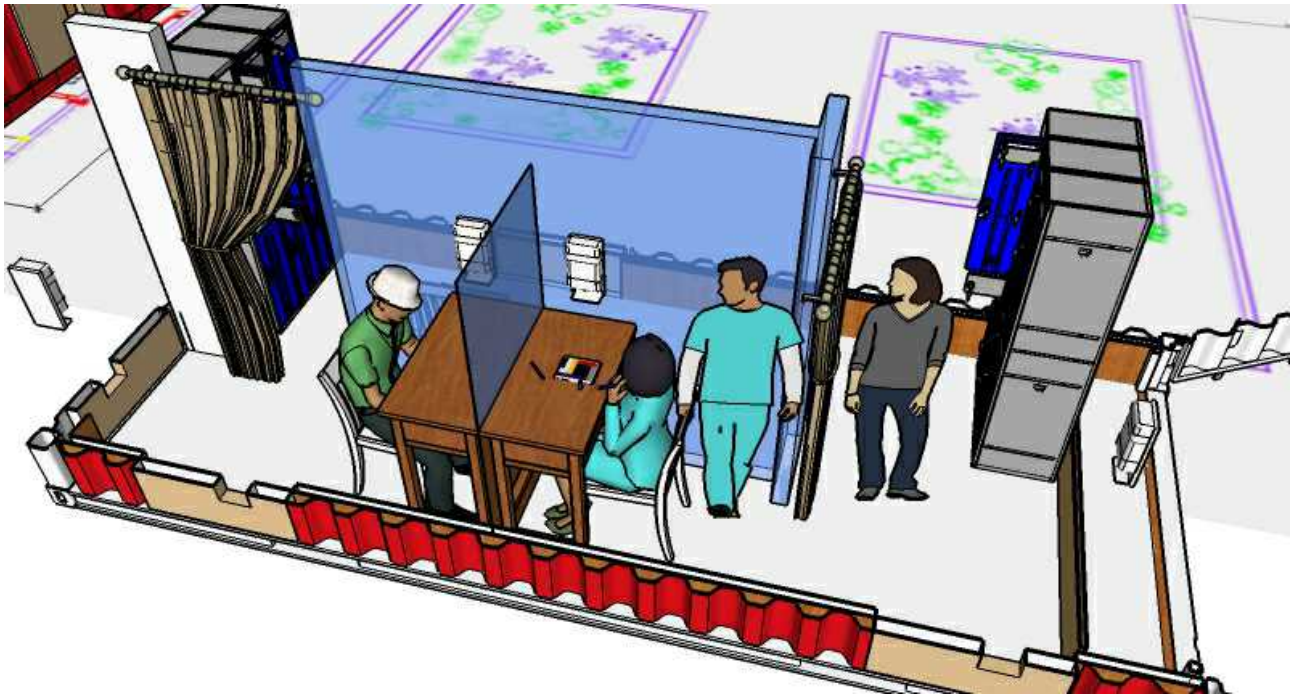
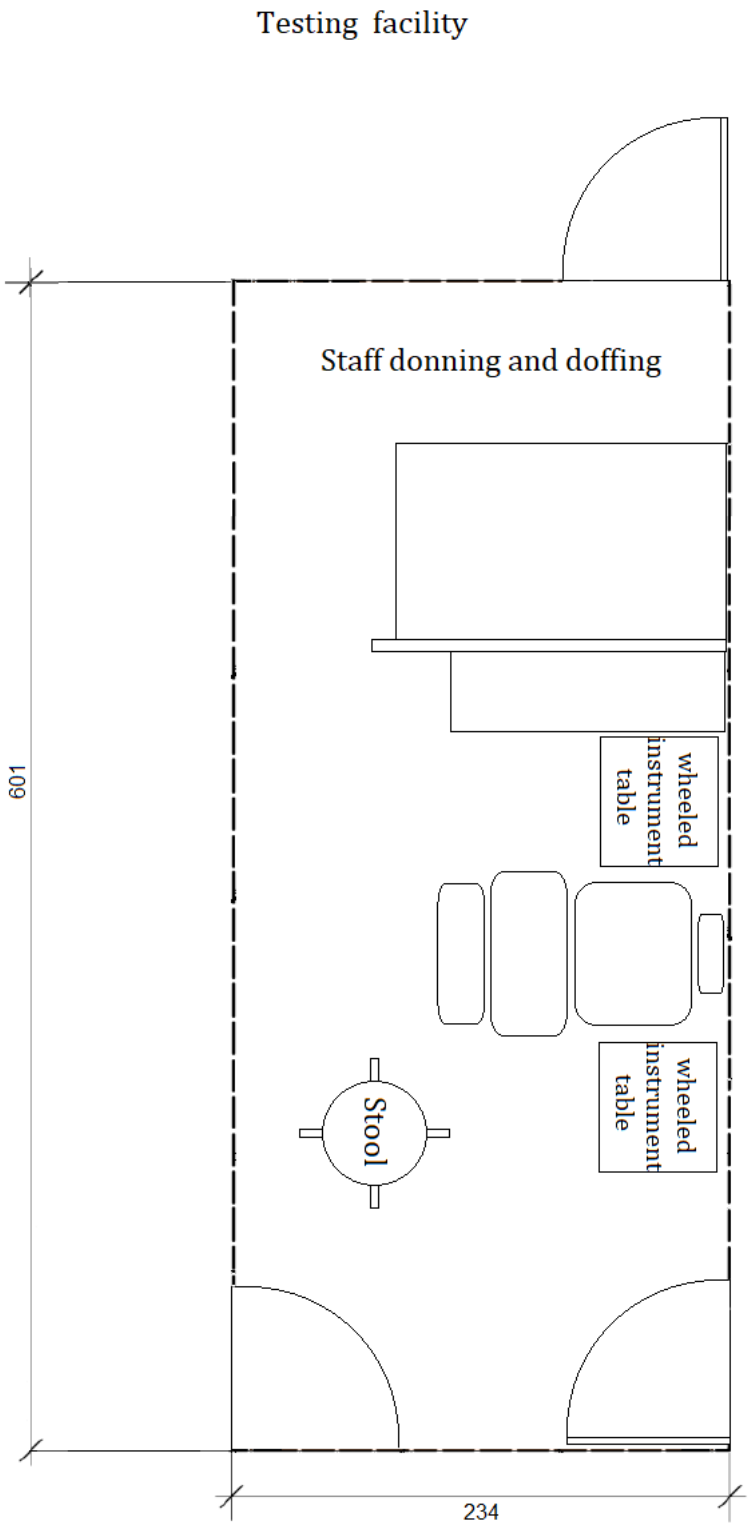


Figure 9-b (Alternative Triage Unit – 3D)



b. 20 ft container-testing facility

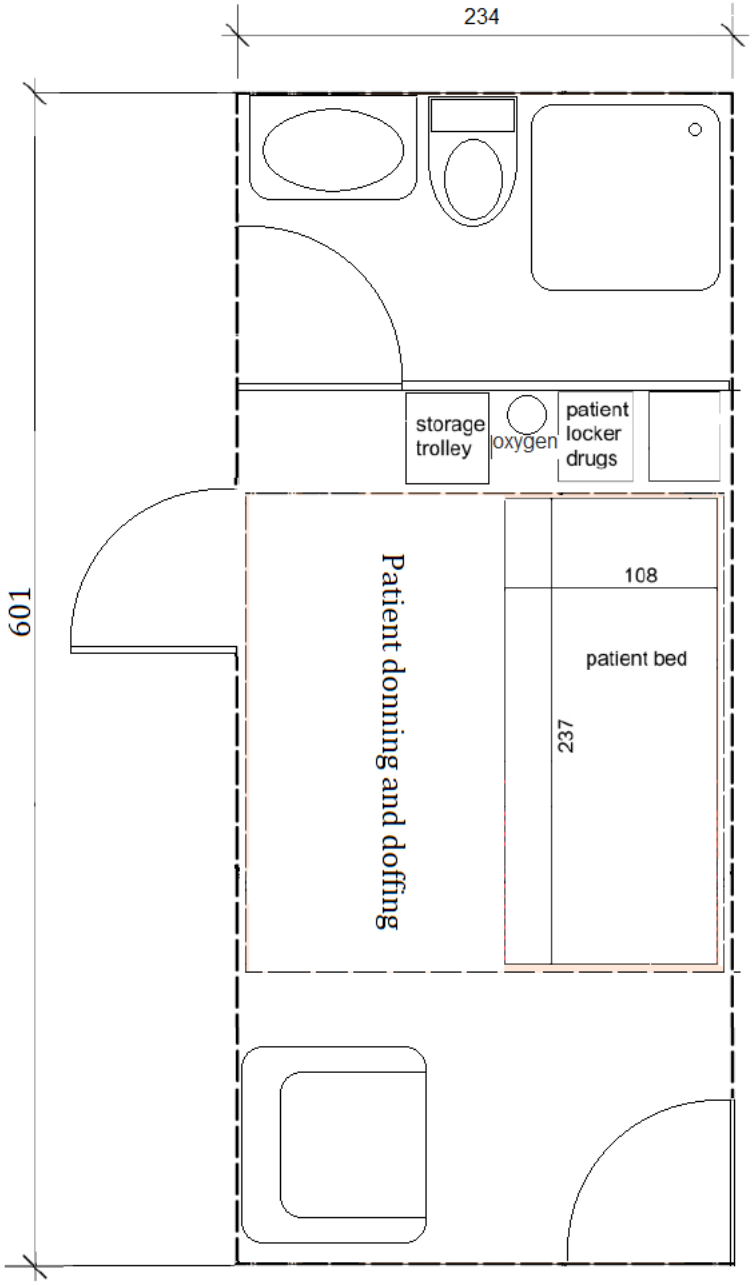
Figure 10



c. 20 ft container-isolation facility (in transit)

Figure 11

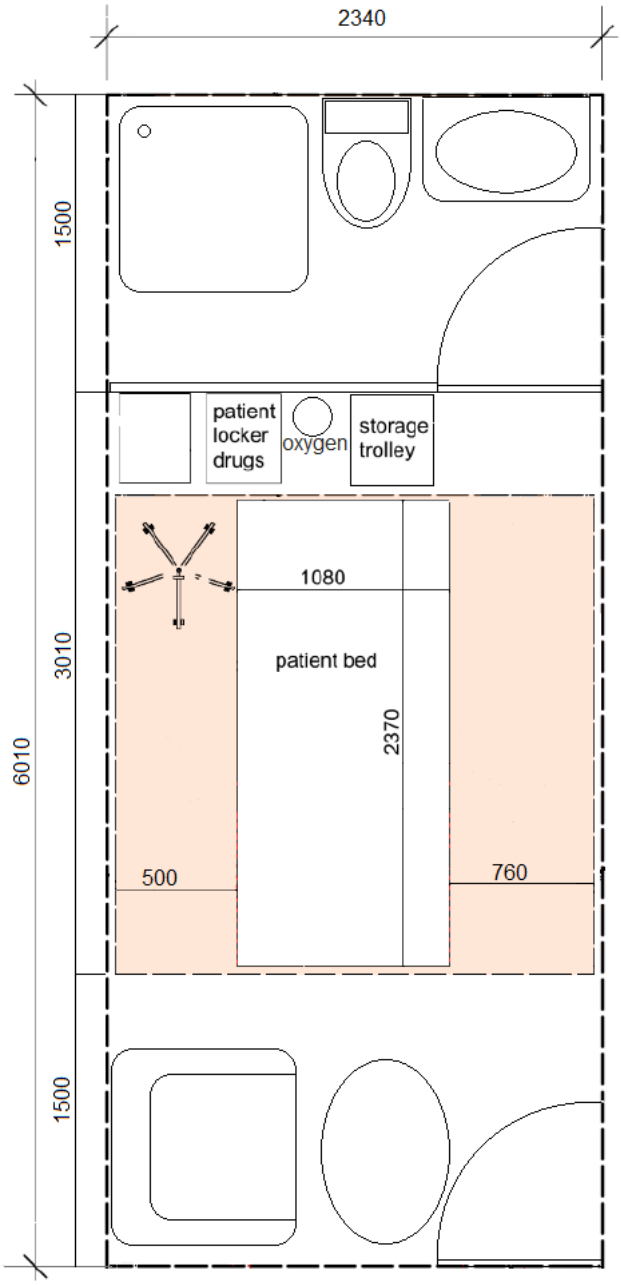
Temporary isolation facility



d. 20 ft container-isolation facility (14 days)

Figure 12

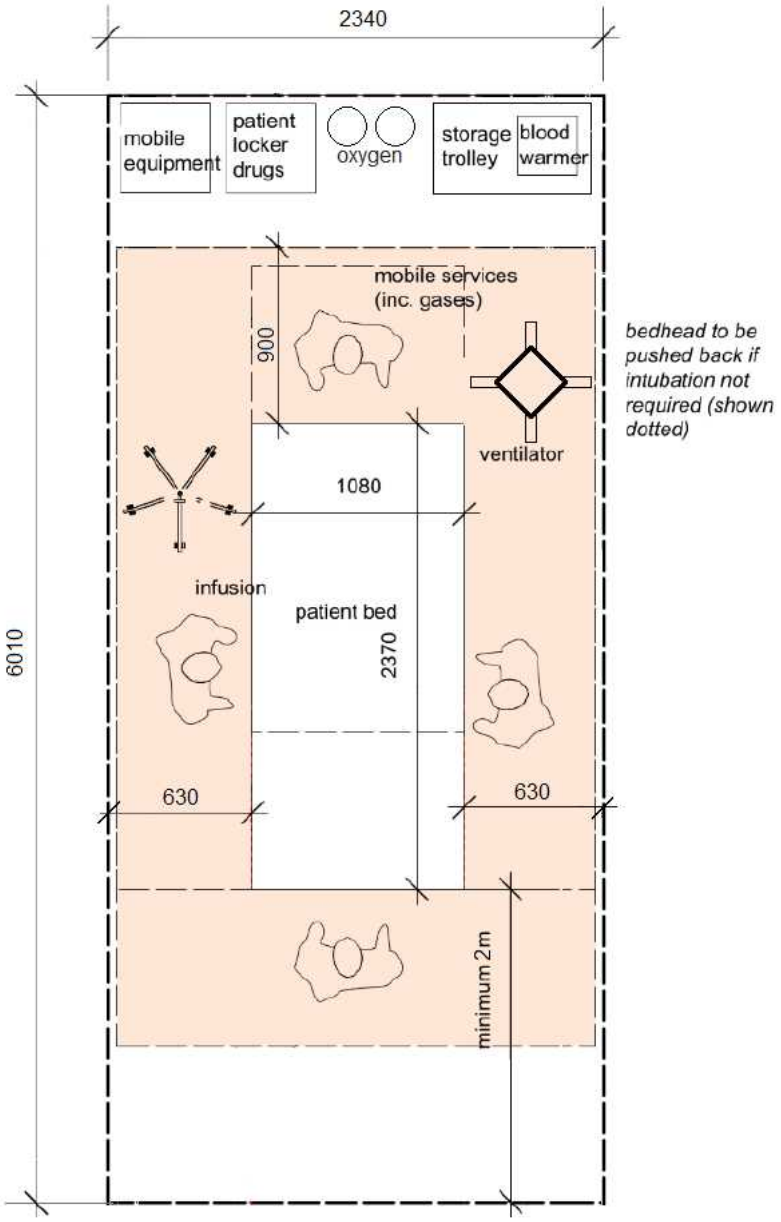
Figure: Isolation container unit



e. 20 ft container-intermediate and high level medical care facility

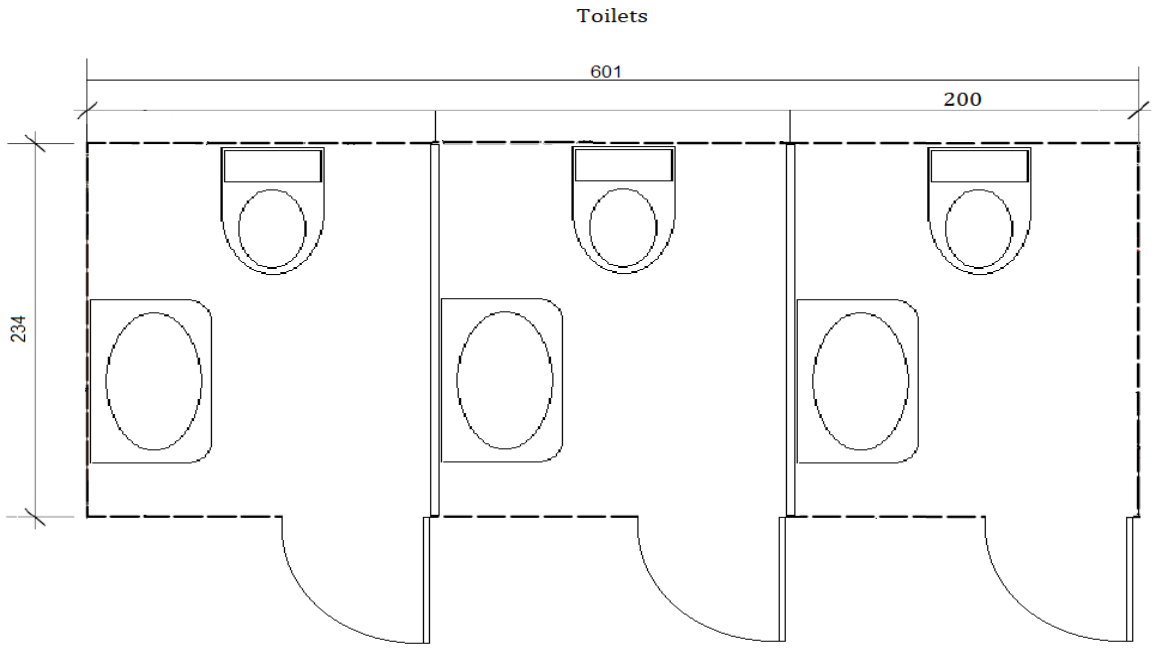
Figure 13

Figure: High level of care container unit



f. 20 ft container-toilet

figure 14

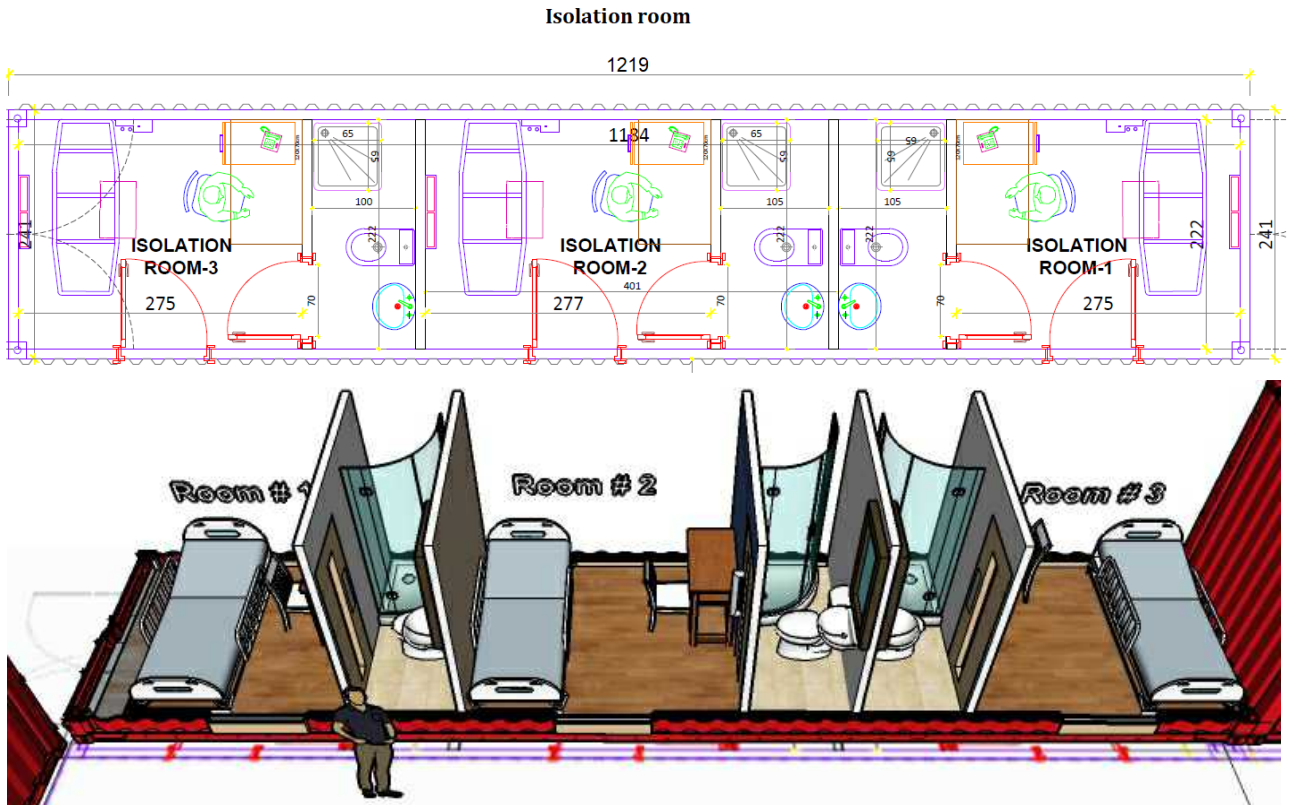


g. 40 ft

container-isolation facility

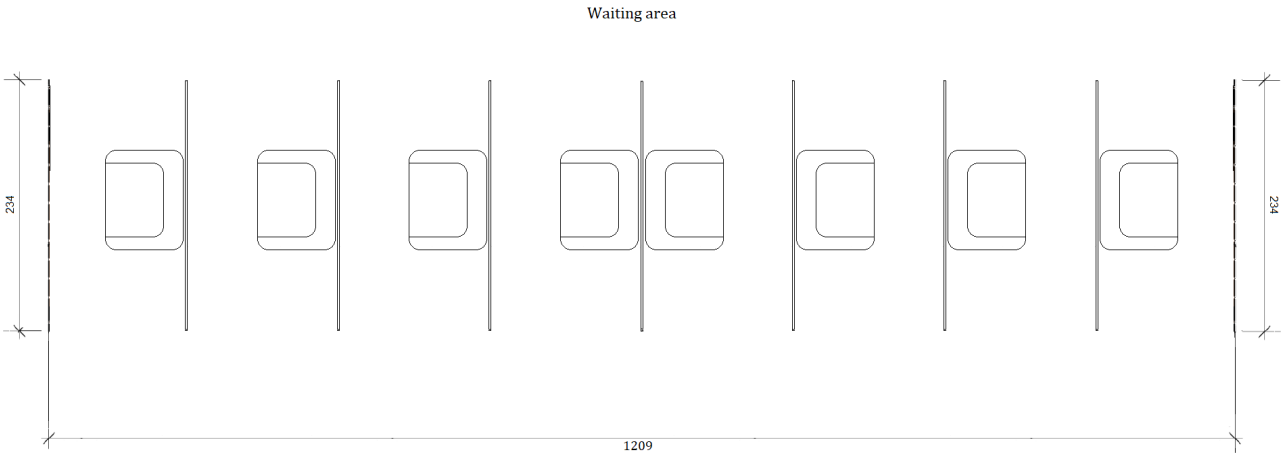
Our Second design is a 40 ft container to be used as 3 bedroom isolation units each with an en suite full bathroom. This design is modular and can be connected together to extend capacity and also versatile to be used for other applications. It can also be used for nursing and or doctors clinics. Other uses could be shared full bathrooms and changing rooms for medical staff. Each of the three rooms include a spacious area that could accommodate a bed, reading desk and an en suite full bathroom.

Figure 15



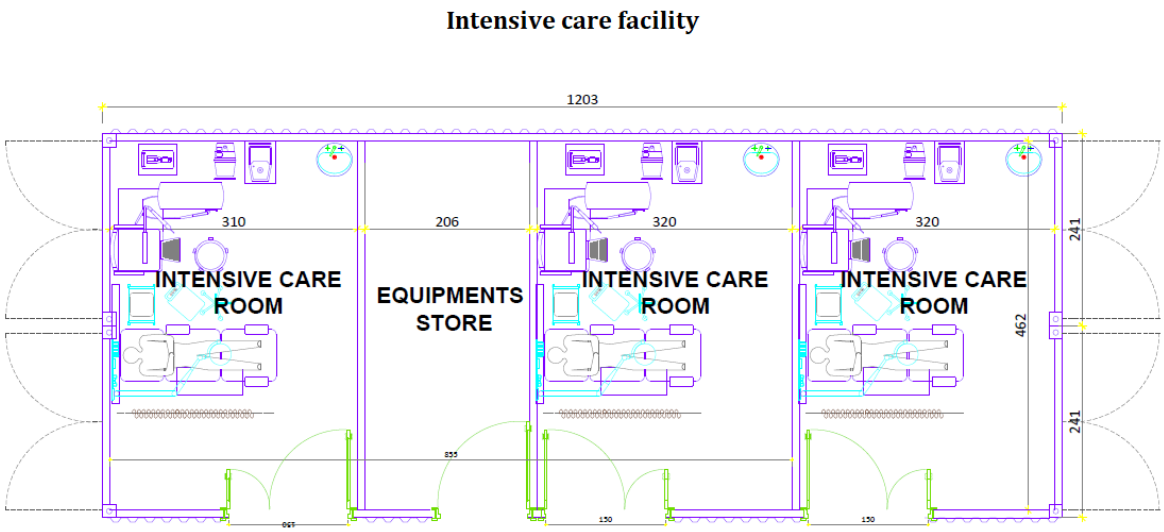
h. 40 ft container-waiting area

Figure 16



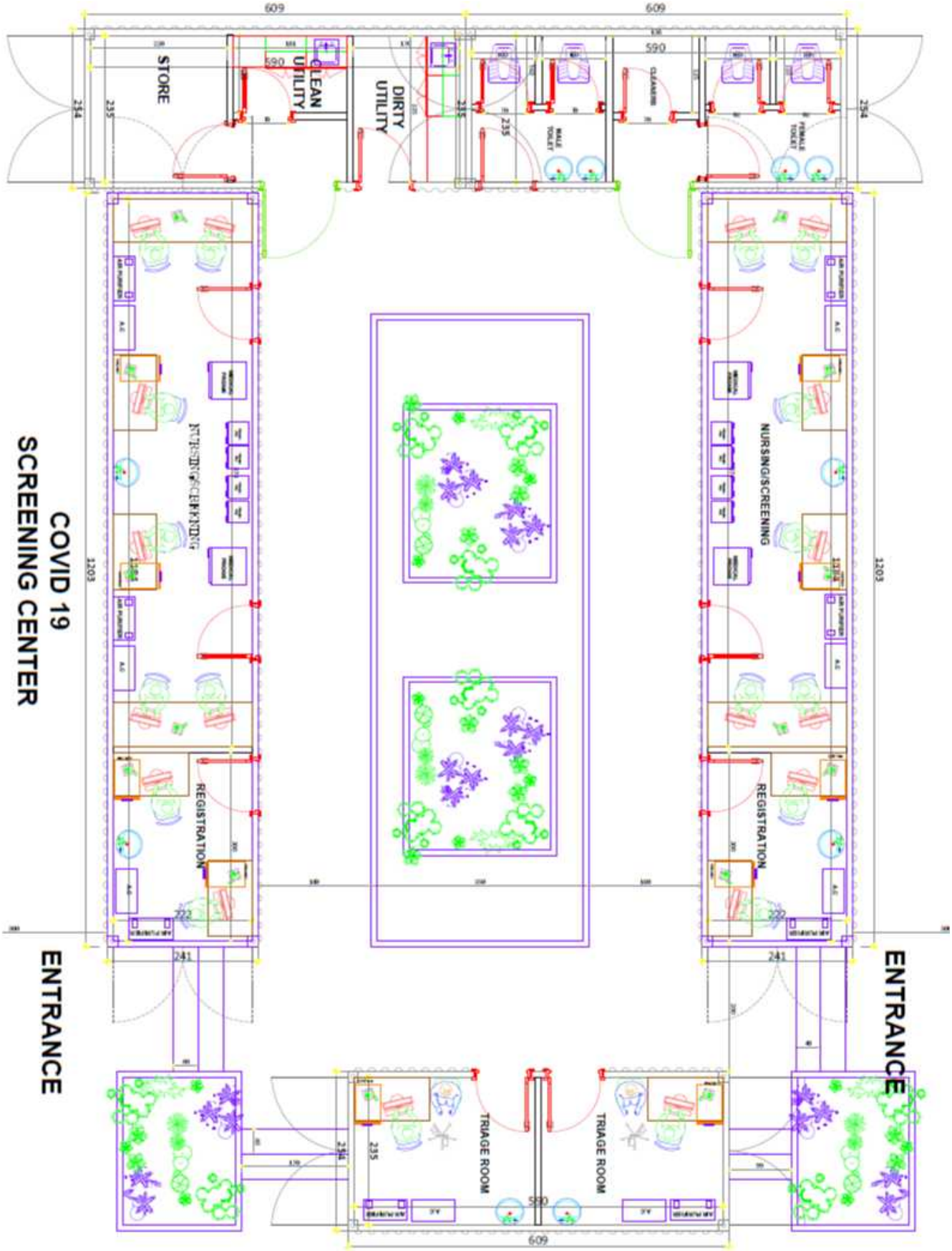
i. intensive care facility

Figure 17



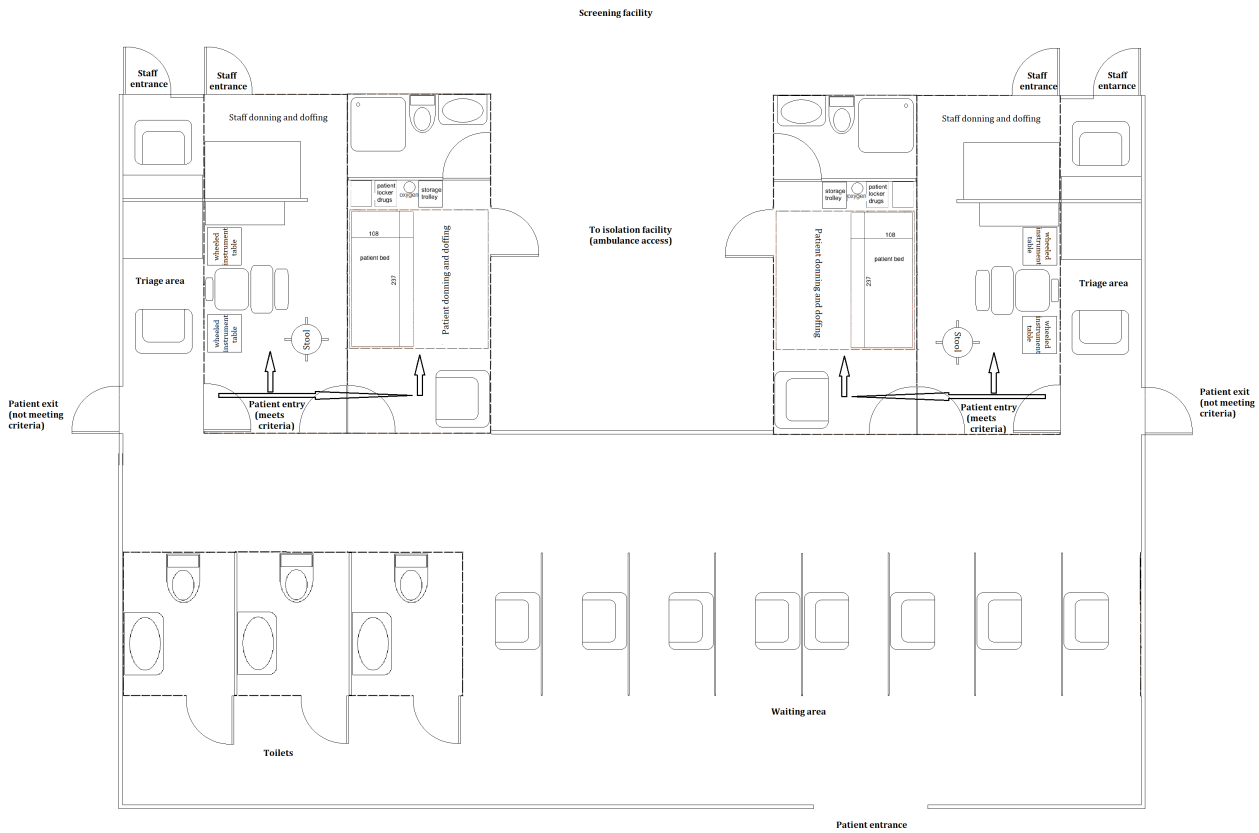
j. Screening facility

Figure 18



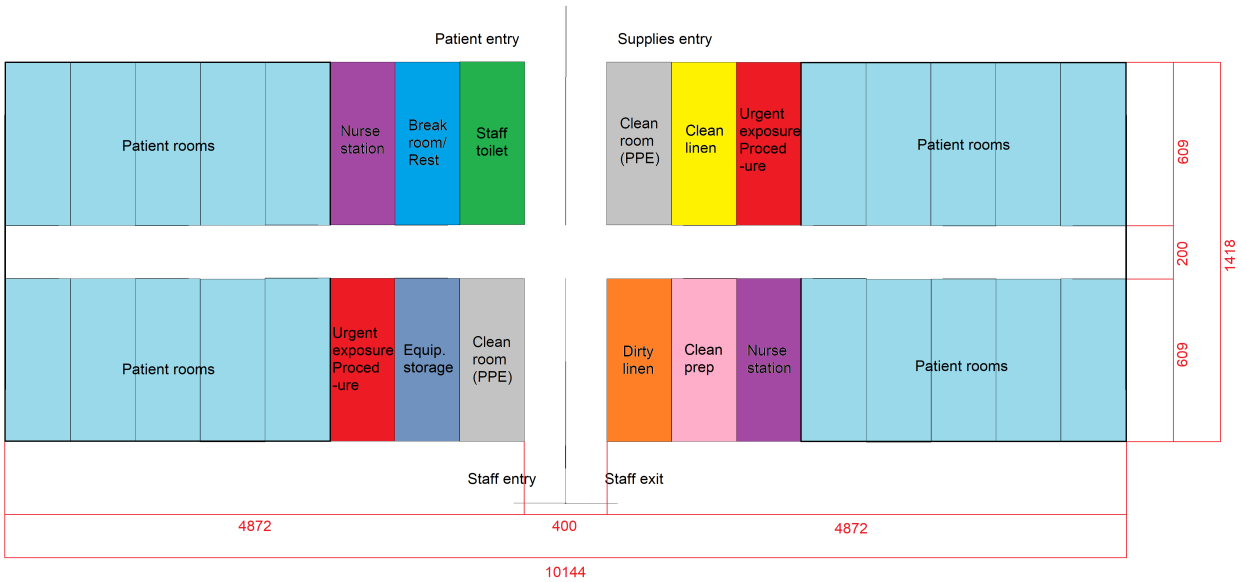
k. screening facility

figure 19



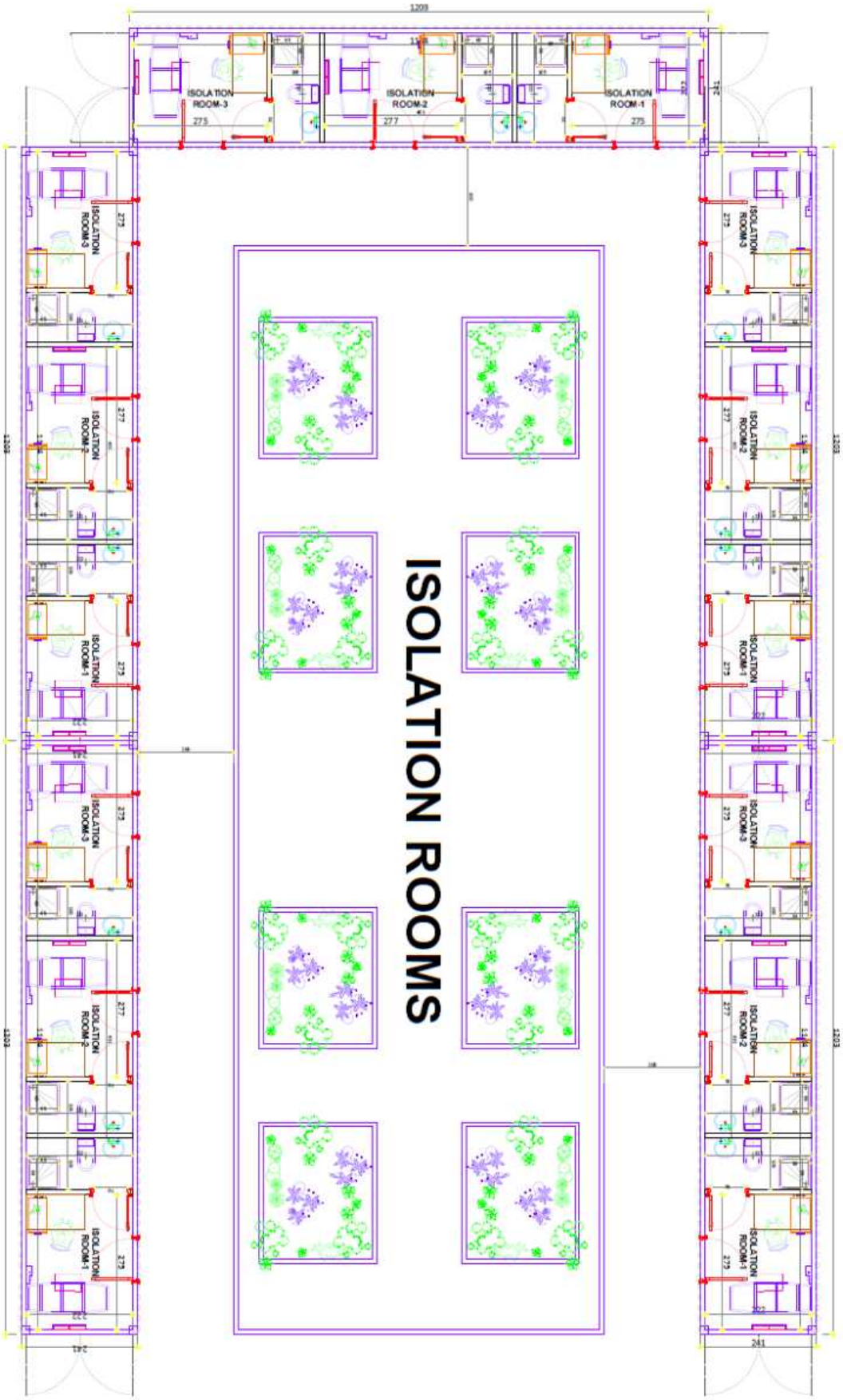
l. isolation facility

Figure 20



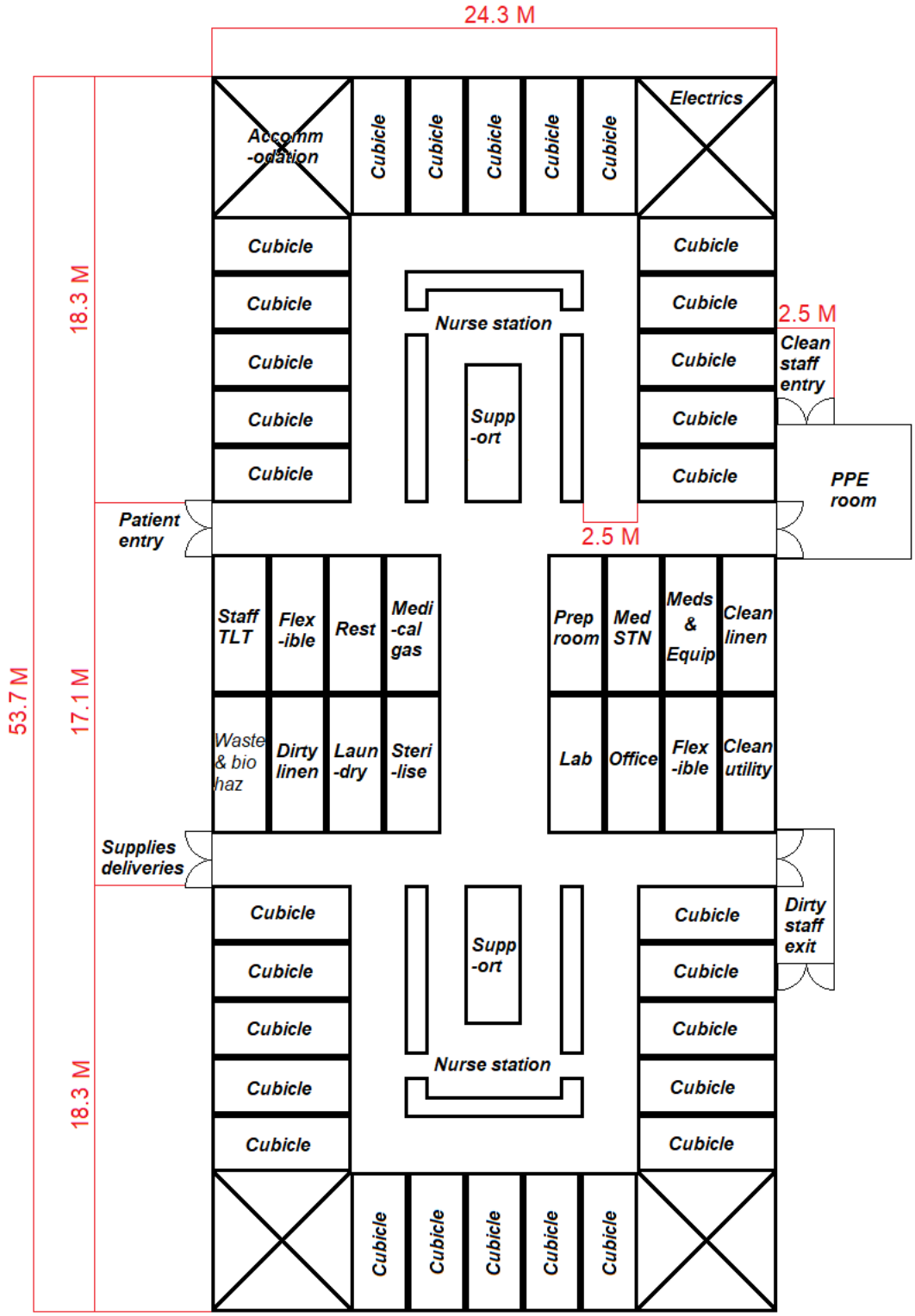
m. isolation facility

Figure 21



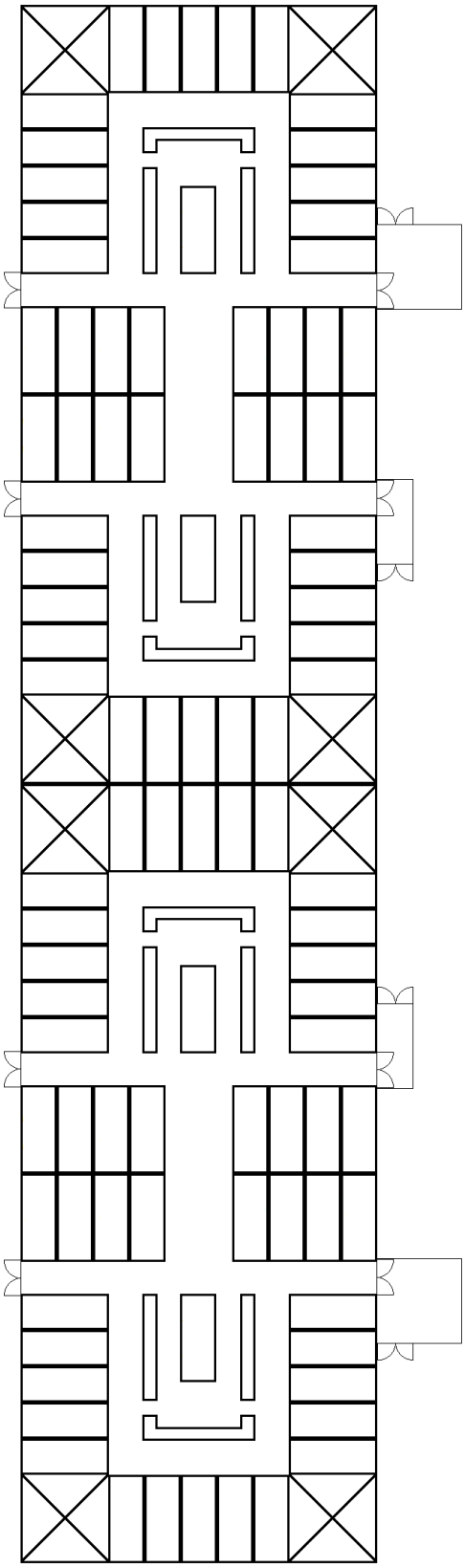
n. high level of care facility

Figure 22



o. high level of care facility

Figure 23



Cost estimates examples

a. The two configurations below for the Estimated costs have been calculated below. Other configurations will carry different cost

Figure 24: 20 Ft - 2 Triage Container Unit

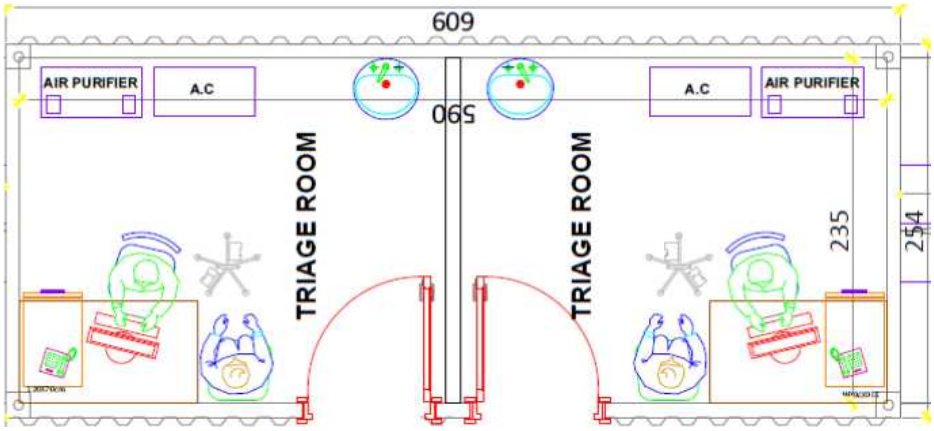


Table 4

BILL OF MATERIALS 20 ft Container framing + Finishing

PRODUCT NAME	20 Ft Container / 2 room partition
PART NUMBER	**20 Ft Container - USD**
Container	
Container + Handling	1440
Finishing Material	
Drywall Flooring Metal Studs & Partitioning Rigid Insulation paint & Compound	1380
Doors and Windows	
windows PVC door	1242
Electrical	
Electrical wiring Electrical Panel board LED Fluorescent lamps double Plugs / Boxes Light switch / box Miscellaneous	288
Plumping	
Shower Toilet Wash Basin Fixtures	0
Water Air Cooler & Ducting	600
Workmanship	
Metal Welders Electricians Plumpers Finishing	924
TOTAL PARTS + Labor	**$5,874.00**

b. example cost of 40 Ft - 3 bedrooms with ensuite isolation container unit

Figure 25

Isolation room

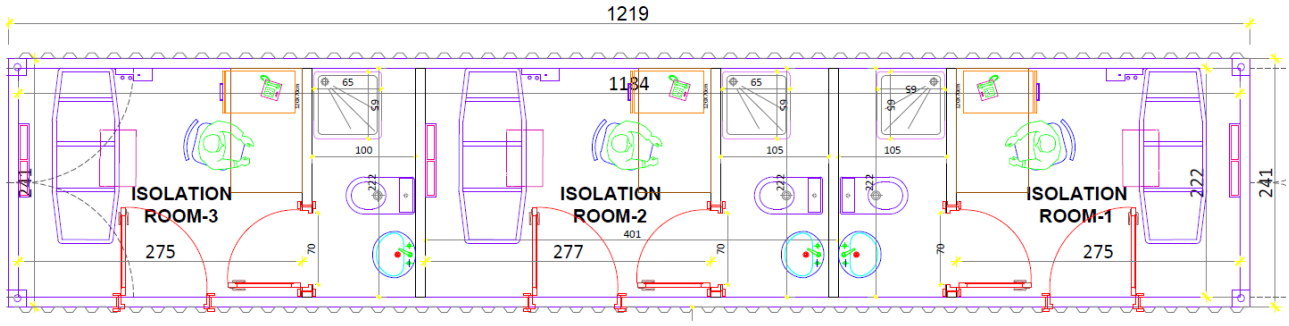


Table 5

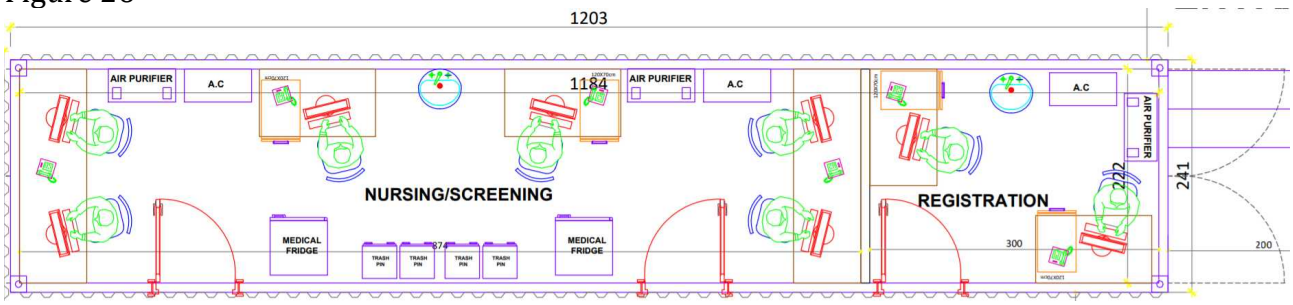
BILL OF MATERIALS 40 ft Container framing + Finishing

PRODUCT NAME	40 Ft Container / 3 room partitions + 3 insuit Bathrooms
PART NUMBER	**40 Ft Container - USD**
Container	
Container + Handling	2880
Finishing Material	
Drywall Flooring Metal Studs & Partitioning Rigid Insulation paint & Compound	3240
Doors and Windows	
windows PVC door	2772
Electrical	
Electrical wiring Electrical Panel board LED Fluorescent lamps double Plugs / Boxes Light switch / box Miscellaneous	696
Plumping	
Shower Toilet Wash Basin Fixtures	3600
Water Air Cooler & Ducting	600
Workmanship	
Metal Welders Electricians Plumpers Finishing	2100
TOTAL PARTS + Labor	**$15,888.00**

c. Other Container Configuration Cost

1. Registration/screening facility

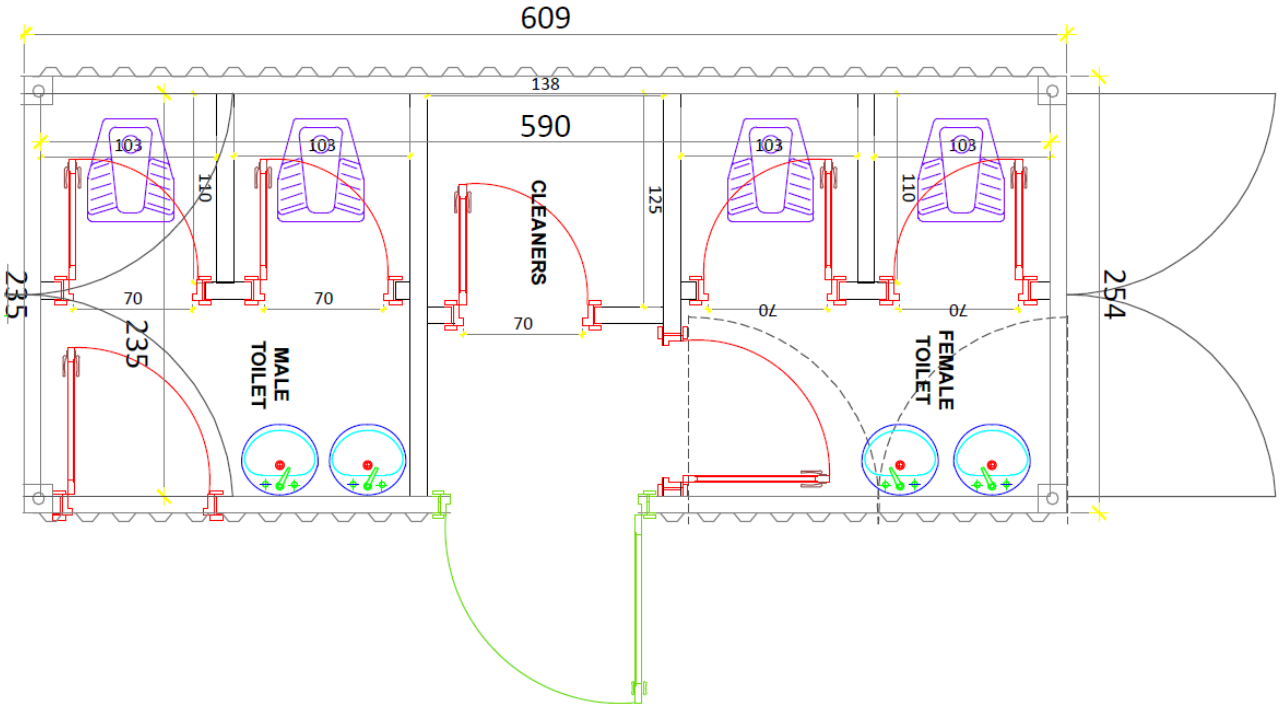
Figure 26



This unit has basic configuration and no bathrooms. The cost as shown below is significantly less.

2. 20 ft Container - Male/Female Toilets

Figure 27



3. 20 ft Container – Clean/Dirty Room - Store

Figure 28

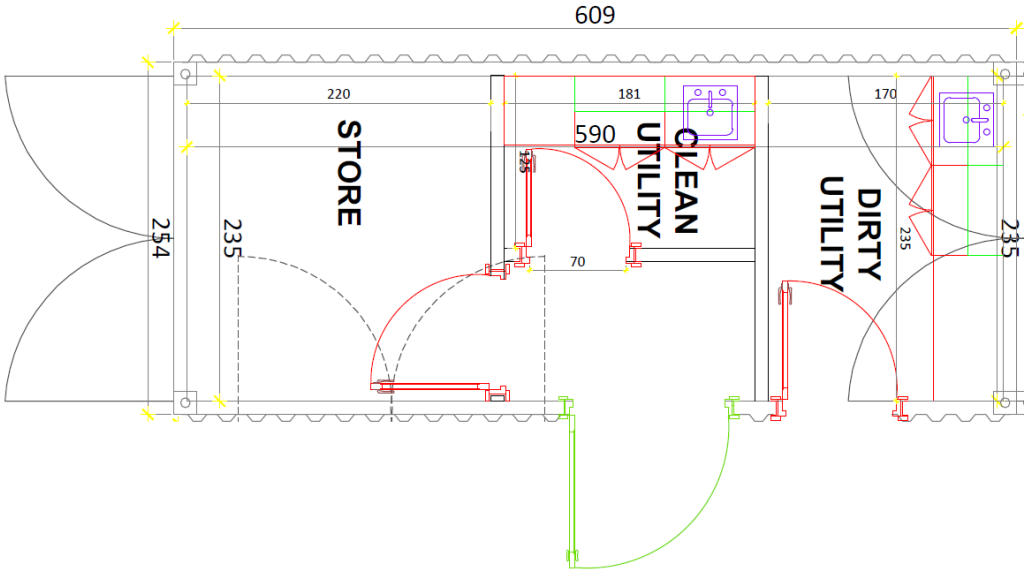


Table 6

cost estimates for 3 facilities

PRODUCT NAME	20 Ft Container / 2 Male/Female Toilets + utility Room	20 Ft Container / 3 room partitions	40 Ft Container / 2 room partitions
PART NUMBER	20 Ft Container M/F Toilets - USD	20 Ft Container Utility/Store - USD	40 Ft Container nursing- USD
TOTAL PARTS + Labor	$9,090.00	$5,970.00	$8,580.00

Other cost examples

Project Details: Please refer to the proposed site schematics

- Cost of 1 X 20 ft Finished Containers-2 Triage Rooms: $5,874
- Cost of 1 X 20 ft Finished Containers-2 Utility and Storerooms: $5,970
- Cost of 1 X 20 ft Finished Containers-Male/Female Toilets: $9,090
- Cost of 1 X 40 ft Finished Containers-Nursing/Screening Rooms: $8,580
- Cost of 1 X 40 ft Finished Containers-Isolation Rooms with en-suite bathrooms: $15,888

Solar: Optional - Depending load and needed power consumption

- Cost of 6 KW solar power system with battery storage installation-Fits 40 Ft Container $9,500 each,
- Cost of 6 KW solar power system with battery storage installation-Fits 20 Ft Container $5,000 each
- Proposed starting date: 20/04/2020
- Proposed completion date: 20/05/2020

Total cost of project as configured on pages 7 & 8: $199 K

Solar Systems cost estimates

Table 7

S.No	Item	Description	Price
1	6 KW Solar System	including 22Kwh batteries	$9,500
2	3 KW Solar System	including 11 Kwh batteries	$5,000

Figure 29: 6 KW Solar Power System for 40 ft Container Unit

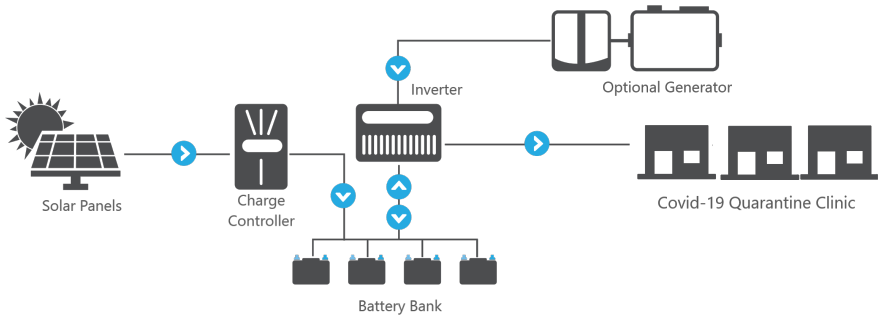
Figure 30: 3 KW Solar Power System for 20 ft Container Unit

Offered Solar System Solution for 20 ft & 40 ft Container Options

a. **Option 1: 3 KW Solar and Battery Storage system - Off / On Grid**
This option will cater for the 20 ft container. It can power all lighting, electrical outlets for light use (Cell phone charging, laptop charging, LED TV, and wall fan). This system is also able to power a small water air cooler for both quarters.

b. **Option 2: 6 KW Solar and Battery Storage system - Off / On Grid**
This option will cater for the 40 ft container. It can power all lighting, electrical outlets for light use (Cell phone charging, laptop charging, LED TV, and wall fan), small fridge. This system is also able to power a larger water air cooler for the three quarters as well as medical equipment that uses less than 3 KWh.

Figure 31



All solar systems will include battery storage devices that will be able to further extend power usage into the night. all containers can be connected to each other using AC-coupling method. This will extend the solar capacity to cater for much larger medical devices that require more power draw. The table below shows typical appliance and electrical equipment that can be used with a 3 KW and 6 kW systems

Table 8: Appliances consumption

6 KW Battery Storage system				22 KWh
3 KW Battery Storage System				**11 KWh**
Appliance	**Quantity**	**Watt**	**Hours/Day**	**Kw/Day**
LED TVs 32 inch	3	18	12	0.65
LED Lights	6	8	6	0.3
Outdoor Lights	2	8	6	0.096
Refrigerator	3	50	12	1.8
Water Heater	1	1250	2	2.5
Wall Fan	3	75	8	1.8
Air Cooler	1	250	8	2.0
Excess 6 kw system				10

Activity Schedule for the project

- 5 x 40 ft container for isolation units
- 2 X 40 ft container for registration and nursing rooms.
- 3 x 20 triage rooms, toilets and cleaning facility.

Table 9

	Duration / Days	Status / Start Date
Site Survey	2	TBD
Design of Quarantine Clinic	4	Complete
Material Estimate	2	Complete
Required load Calculation	2	Complete
Supply of required material	4-14	TBD
Supply of solar power system	35	TBD
Implementation	30	TBD

Challenges

Some challenges outlined below are to be expected:

1. Containers availability:
   Although there is an abundance of empty containers in Sudan, they may not always be readily available for purchase. One way to overcome this is to hold a social media campaign asking for people to donate their unused containers for this cause. This could reduce the cost of the build significantly by up to 1000 USD per 20 Ft container and 2500 USD for a 40 Ft container.

2. Raw material availability in Sudan's market:
   This is typical in countries with fragmented markets like Sudan. To overcome this challenge Siraj Energy will import in advance any material that will pause a long lead item or could be scarce in the market. The main objective of Siraj Renewable Energy is to balance between socio-economic development of the market in Sudan and the pressing need for these medical facilities.

3. Initial high cost of converting shipping containers:
   Although the initial investment on converting these shipping containers might seem high at first it will be offset by the versatility of its future use when the epidemic is over. These converted medical containers could serve as mobile or semi-permanent clinics in the future.

4. Cost Reduction:
   One way to cut cost is to have 4 beds containers with curtain partitions and one shared bathroom for nonacute cases. This will bring down the 40 ft container price to $9 k US.

5. Electrical power cuts:
   To avoid delay and manufacturing disruption, a generator needs to be provided at the production line with sufficient diesel supply by the government to overcome the electrical cuts from the National Power Grid.

Advantages & Conclusion

There are many advantages and expected opportunities that could benefit many communities in Sudan as;

1. These converted medical containers could serve as mobile or semi-permanent clinics in the future where the need is great in areas where medical facilities are not available. This will have a huge positive impact on remote areas' health needs.

2. The conversion process of shipping containers into useful units is straightforward from design, construction and implementation. We manufacture units made from shipping containers in-house, ensuring superior production and activation times, high-quality products, and a timely completion–all while thinking green.

3. The implementation period of the project is moderately short as long as required materials are available within the market. The production of one unit takes 7 days, but the approach Siraj is taking is a production line approach will enable us producing one container every 2 days after the first week of production start.

4. The Logistic standardization when transporting shipping containers ((ISO standard) makes it quite convenient and easy to handle when transporting the medical units. The Medical Units can be handled anywhere in Sudan through specialized transportation modes:
    a. Trains and trucks can transport to accessible areas such as cities and villages within close proximity to the main rail and road networks.
    b. Heavy duty military trucks and freights can be used for off road and remote areas.

5. Crane loaders, light and heavy-duty equipment will be required to lift and download during the logistics process and the assembling of the Medical Units.

We conclude that the construction and assembling of the Quarantine-Mobile Clinic will be straightforward on site. However, it requires collaborative work between the assigned engineers, health care officers, infrastructure teams and security forces to handle the medical units on site. Also, we recommend building a security fence around the quarantine to avoid direct contact between the COVID-19 patients and other members of the community as this is the protocol that is recommended by health organizations during dangerous diseases outbreaks such as Ebola.

5. Long-term containers facilities utilisation

The newly converted health facilities can play a similar role in the case of COVID-19 pandemic recurrence which is strongly advised. Furthermore, our group had put together a proposal for the use of the multi-container health facilities in the delivery of primary healthcare services in underserved rural areas (figures 32 & 33).

Figure 32

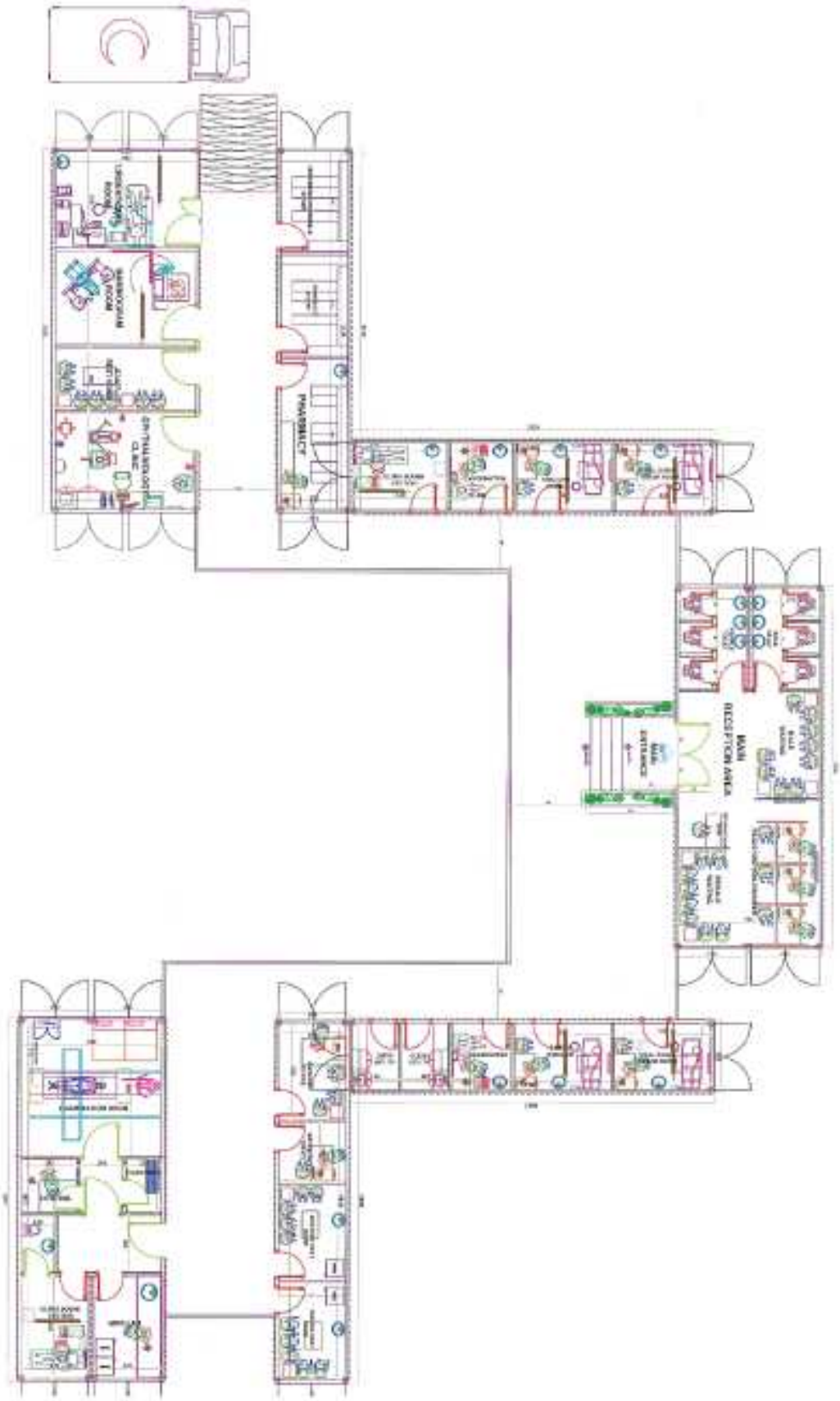
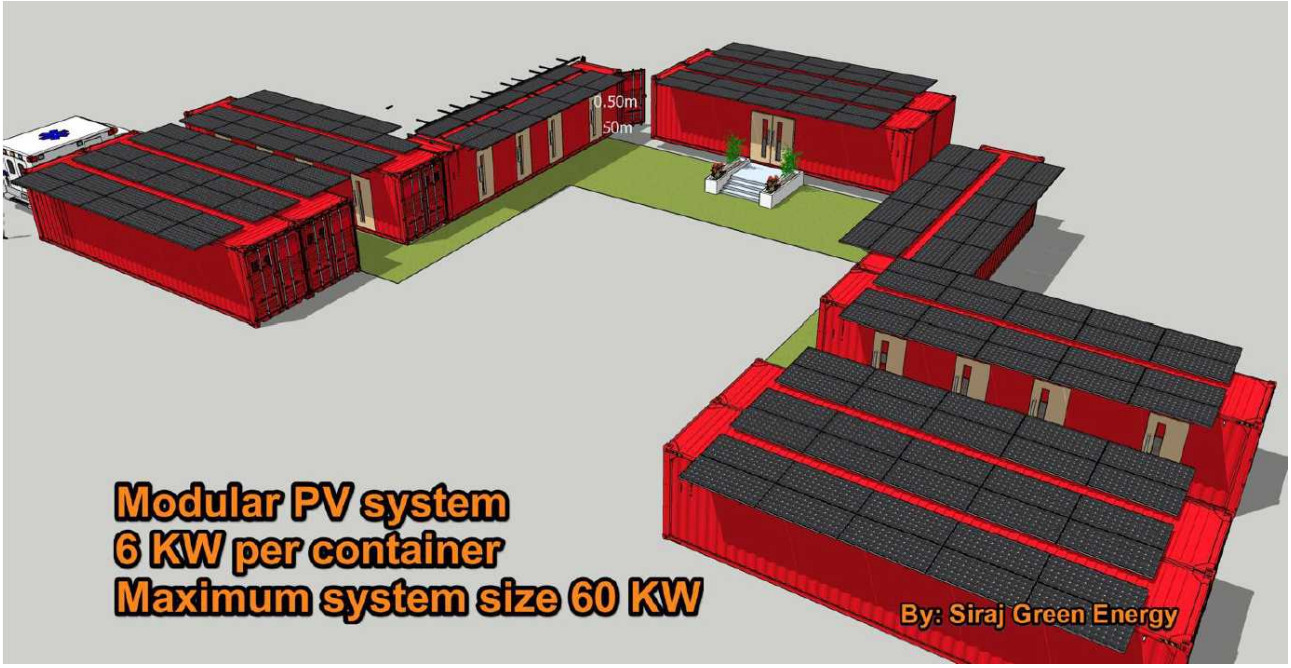


Figure 33


0.50m
50m
Modular PV system
6 KW per container
Maximum system size 60 KW
By: Siraj Green Energy