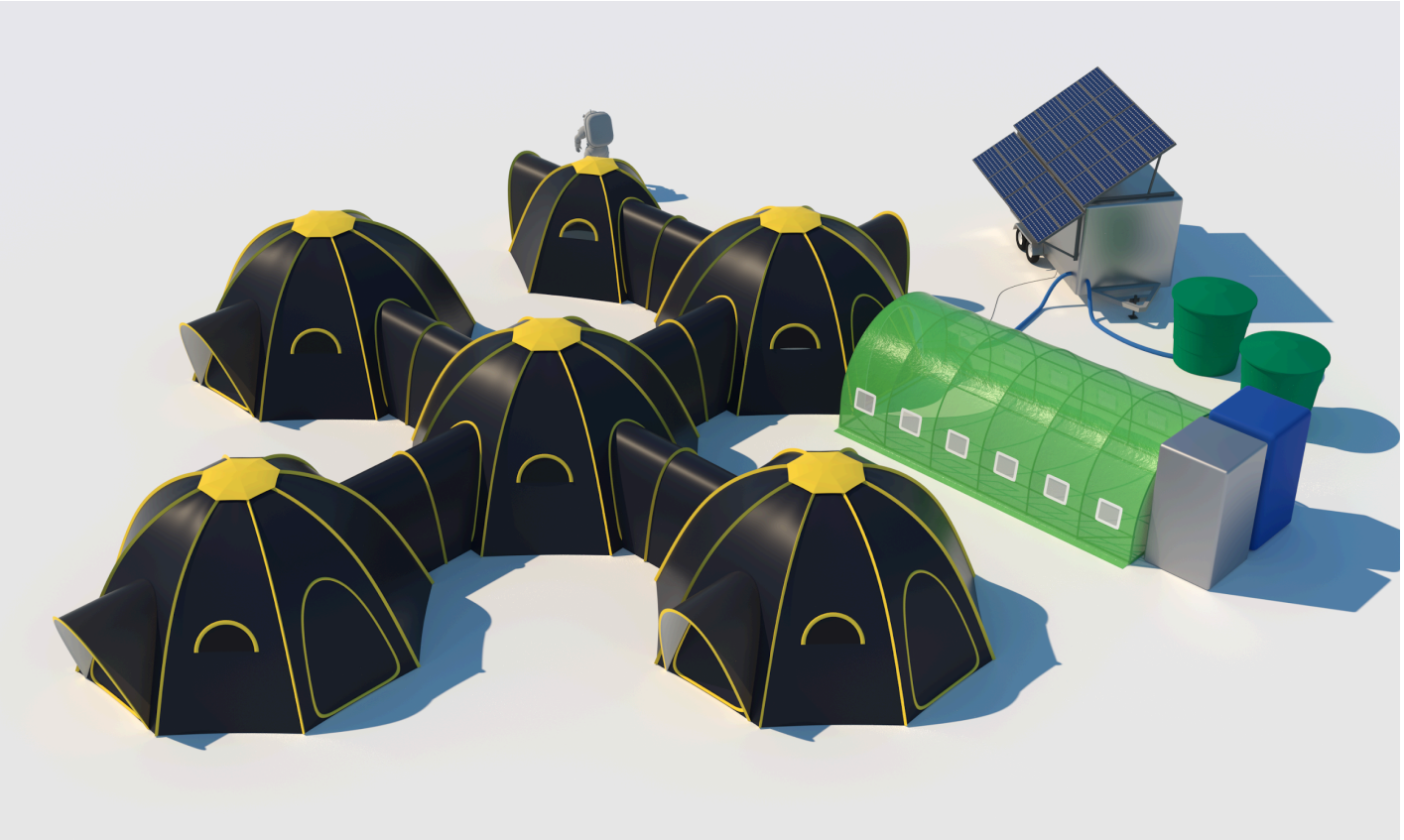
MARS-NZ

Mars Analogue Research Station NZ



Proposal for a low-cost habitat for planetary analogue research and education.

KiwiSpace Foundation

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Photo: Rosino/Flickr

New Zealand offers a wide range of rich locations for analogue research and education.

MARS-NZ

Mars Analogue Research Station NZ

1. Executive Summary

The Need

New Zealand is about to have its 'Apollo moment': Rocket Lab is planning to launch their first orbital rocket from Aotearoa later this year, and this will have a profound impact on our young people and the broader community. There is a real opportunity to leverage this growing excitement around spaceflight and exploration, and inspire our students to take up the all-important STEM subjects at school and university.

But there are limited space education opportunities in New Zealand, forcing individuals and groups to travel overseas to access research facilities, or education programmes such as SpaceCamp USA. But offshore opportunities are costly and introduce other challenges.

By example, KiwiSpace has organised several missions to the Mars Desert Research Station (MDRS) in Utah, USA. This fantastic facility is operated by the US Mars' Society, and supports crews of six for 2-week expeditions. Our missions were eagerly followed by NZ classrooms, but timezone differences meant most activities occurred outside of school hours, and a slow internet link with daily data caps made video linkups and file sharing difficult. International travel added over $15,000 in costs to each mission.

Why simulated environments?
Researchers use analogous locations to test equipment, processes and learn about the hazards of living and working in extreme environments. The benefits of such programmes benefit both off-world and terrestrial applications - such as Antarctica and the seafloor.

For example, the international Mars 500 mission placed six crew members inside a sealed habitat for 520 days for a psychosocial isolation experiment. It permitted the study of the technical challenges, work capability of crew, management of long-distance spaceflight, autonomy, resource rationing, health, conditions of isolation, and more.

New Zealand's terrain recently provided host to NASA for a teacher training field trip organised by the NZ Astrobiology Initiative. Robotic instruments, including a drone and rover, were used to image remote areas in volcanic regions that were out of reach to human visitors and practice remote identification of new terrain.

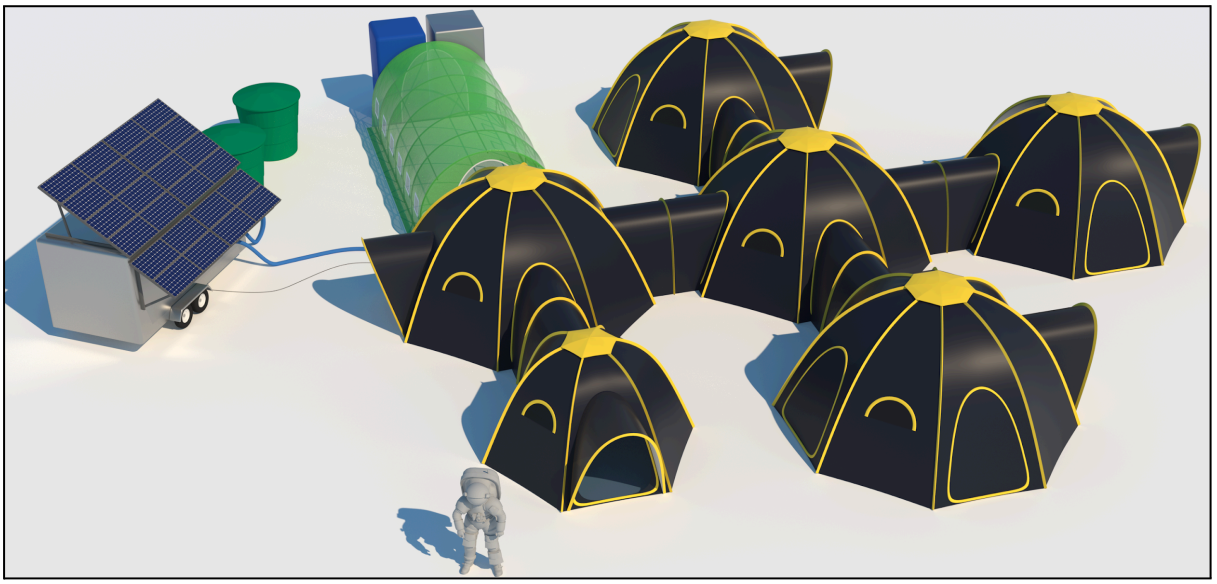
The Opportunity: Mars in NZ

We propose a two-pronged solution:

- A low-cost pathfinder habitat ("Mars base")
- Robust education, outreach and research programme

Firstly, we propose the development of a habitat that can be located for short-to-medium periods at different sites around New Zealand. This initial facility would be based on a modular tent system, providing a low-cost but functional base, which can be used for the research program. Crews would utilise the habitat for 1 or 2 week missions.

Render: Marcus Spranger



Secondly, we propose a strong research and education mission for the station - incorporating school programmes, university research, public outreach and international collaboration.

A scholarship programme is proposed to support bringing teachers and secondary students to participate in selected crew expeditions. Schools and the public would be able to follow along with all missions through a comprehensive web portal, including live video feeds, webcasts and mission data.

Preliminary discussions have also been conducted with NASA and other international space organisations, who have indicated a willingness to send scientists/educators to join a dedicated 'outreach expedition' each season.

It is envisaged this pathfinder project would operate over a three year period. The base would operate for a primary season each summer (Jan/Feb), and may include additional short-term public demonstrations at schools or during school holidays.

Outcomes

- Enable a large number of researchers, students and teachers to attend the facility, avoiding the high costs and difficulties with overseas options.
- Enable schools to easily follow along with the expeditions, including teacher and peer representation on some missions.
- Provide an exciting school field trip destination and access to quality researchers for remote regions, typically not exposed to space science.
- Development of an educational resource portal for schools, with content generated by and for the missions.
- Promotion of technologies and processes that can benefit us in space and on Earth (e.g. renewable energy and conservation, recycling, tele-robotics).
- Provide opportunities for local universities to develop space-age hardware (e.g. rovers, spacesuits) and test them in an analogue environment, under simulated mission scenarios.
- Bring international researchers to NZ (potentially including NASA), to participate in missions and perform public or school talks and outreach.
- Collection of important data to evaluate design elements and demand for a more permanent research station.
- Increase awareness of NZ's diverse landscapes, unique geology and biology.

Funding/Support Needed

Preliminary investigations for this proposal suggest that it will require between $50,000-100,000 funding, sponsorship and in-kind services to establish the facility; and net operational funding of $20,000-50,000 per annum, largely to support the education/outreach programme.

*To view the full MARS-NZ proposal and supporting documentation, please visit the project website: **www.kiwispace.org.nz/mars-nz***

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2. Detailed Project Outline

Background

KiwiSpace is seeking funding and support to develop a portable research station, MARS-NZ. This low-cost habitat would be used for analogue research and a broad education and outreach programme with schools in New Zealand.

About KiwiSpace

KiwiSpace is a non-profit organisation aiming to bolster New Zealand's involvement in the global space sector, with a heavy focus on inspiring and educating New Zealand youth to pursue STEM subjects (Science, Technology, Engineering Mathematics) and promoting the opportunities available to them both domestically and abroad. We incorporated in 2011 as a Charitable Trust Board.

Lead by a passionate volunteer team, we have been working with schools and universities on a range of programmes and initiatives. Over the past four years we have organised or been a key member for a variety of successful projects, including:

Activity	*Description*
NZ Rocketry Challenge	An intermediate-level student model rocketry competition launched in 2012
Spaceward Bound	An 8-day planetary field trip for teachers and university students, around the central North Island area - featuring guests from NASA, Romania & Australia.
SpaceEd Workshop	Two-day teacher training supported by the Japanese Space Agency.
SpaceUp NZ	A two-day conference featuring over 30 participant-led talks and discussions.
School/Public Lectures	Our team has delivered presentations on a variety of topics at schools and public venues around the country.
Space Apps Challenge	Initiated by AUT University, KiwiSpace is part of the organising committee for this global space "hackathon."

Exploring 'Mars': The Mars Desert Research Station

KiwiSpace has sent or supported several crews at Mars Desert Research Station (MDRS). This desert-situated facility has been operated by the US Mars Society for the past 14-years, and supports crews of six people at a time, for two-week missions.

Defined protocols help maintain the illusion of living and working on Mars: when you leave the habitat you wear a spacesuit and exit via an 'airlock', astronaut food is eaten, and you have limited resources to manage (water, power, internet connectivity, etc).

Photo: _____

The Mars Desert Research Station (Utah, USA) provides an amazing, Mars-like analogue setting.

The facility is used by a wide number of groups from all around the world, including NASA and ESA (European Space Agency). The local environment provides a wealth of analogous environment which can be used to test equipment, human processes, and generally train for future space missions.

KIWIS ON MARS		
2011	ROMARS	KiwiSpace staff member participates in Romanian MDRS mission
2012	KiwiMars	KiwiSpace organises its first NZ crewed mission.
2013	TasMars	KiwiSpace organises a combined NZ-Australia mission.
2013	WSW-MDRS	KiwiSpace proposes and co-organises a mission for the International World Space Week youth inspiration program, and participates as one of the crew members.

However it is extremely expensive for New Zealanders to use this facility, mostly due to high travel costs. It costs up to $4,000 per crew member to attend (~$24,000 per expedition), including international flights and base fees. Crew members have each had to pay or fundraise their own way there - and the high price point has been a considerable barrier to participation.

Education & Outreach

With each expedition, KiwiSpace worked with crews to connect their mission to schools and organisations in New Zealand. In 2012 we ran a dedicated Mission Support centre at Carter Observatory in Wellington, where members of the public could come in and follow along with the mission. In other years this has been facilitated online, and combined with in-school and public lectures.

Photo: KiwiSpace

Members of the KiwiMars crew, outside the Mars Desert Research Station (Utah, 2012).

However there have been substantial issues with trying to coordinate outreach, due to three main factors:

- **Timezones**: Only a two-hour overlap exists with the school days.
- **Limited Internet:** The MDRS facility was not designed with outreach in mind, and has a slow satellite internet connection, with restrictive data caps. This makes streaming video, transfer of large photos and live mission data very difficult.
- **Volunteer, non-educator teams:** Crews will vary in makeup and may not contain the best science communicators. Time-pressures and lack of experience organising outreach can also result in substandard engagement pre- and post-mission.

The combination of these factors has substantially lowered the potential benefits of the outreach mission for each expedition - and is what this proposal attempts to address.

A new direction: Mars in New Zealand

We propose the creation of a low-cost analogue station in New Zealand, for use by researchers, educators and students. Importantly, unlike MDRS, we propose that **education and outreach is its primary goal.**

Photo: Podtents.com

Using modular tents to simulate a 'Mars Base' for use with education and science programmes.

High-Level Outline

- **Portable "Mars Base"** that can be easily established at different locations around New Zealand, with no dependence on host site infrastructure. The locations selected can be driven by research requirements (e.g. extremophiles, unique geology), to facilitate easy access for school field trips, or be in urban locations for public exhibitions.

- **Pre-Defined Protocols & Obligations:** The habitat will follow protocols similar to those of the US Mars Society's facilities, such as wearing a spacesuit outside the habitat, filing daily reports, and having their mission being broadcast live on the web. Crews will also be expected to participate in public lectures/webcasts after their mission.

- **Flexible Expedition Formats:** Students, researchers, professionals or enthusiasts can apply to participate in 1- or 2-week expeditions. Crews will bring their own food but other habitat resources will be provided in exchange for a weekly fee. Crews can set their own mission parameters and goals - such as testing engineering systems, human interaction (a la 'Mars 500'), promotion of NZ geology, etc.

- **Coordinated Education Programme:** A dedicated programme manager would be employed to manage the interaction between missions and schools, ensuring maximum engagement and removing the burden from crew members trying to juggle administration during an already busy field expedition.

- **Scholarship Programme** for teachers and students to removing cost-barriers for attendees from lower socioeconomic areas, and increasing student relatability by having their peers and mentors participating in missions.

- **Comprehensive Online Portal:** As prototyped with our past missions, we would develop an in-depth online “Mission Support” site where people can follow along with each mission’s progress. This would incorporate maps, webcams, daily reports, webcasts, and much more. It would also be the home for all the resources developed for and during the expeditions, to allow schools to incorporate this in their classroom learning.

- **International Guest Crew-members**: Our goal is to have personnel from organisations such as NASA AMES participate in one or two of ‘flagship’ expeditions each season. These international experts could also do talks at schools in the local area during their visit to New Zealand.

- **University Engagement:** Analogue environments are a fantastic place to test new technologies and equipment, and a key strategy of the programme would be to engage and partner with New Zealand universities. Student projects could be created to develop rovers technologies, aerial mapping, space suit demonstrators, computer vision, and much more. We also see an opportunity for university departments to use the base for department field/research trips.

- **Broader impact:** At MDRS we were in practice limited to a single crew of 6 each year, but with a NZ-based facility we can facilitate many more crews - and also support visits from nearby schools and the public. The education programme will also be optimised to maximise virtual participation by NZ schools.

A broader outreach programme

Terrestrial Themes

While the crew is undertaking a “Mars mission”, there are some very grounded principles that will be emphasised as part of the outreach message:

- Solar power/renewables
- Resource conservation and management
- Waste management & recycling
- Nutrition & food safety

Summer on Mars

It is envisaged that the base would primarily operate over the NZ summer (e.g. Jan/Feb) through to and including the first few weeks of school term. This is a convenient time of year for participants to take time off from work, and the weather is usually favourable.

The overlap with term time will allow schools to follow along in-class with several of the expeditions. We recommend having a teacher and/or student embedded with the missions, as well as the international (e.g. NASA) guest crewmember for maximum benefit.

Photo: NASA

The MARS-NZ habitat can be set up in city parks or school fields to provide engaging public demonstrations.

Urban Showcases

It would also be possible to establish the ‘Mars base’ in urban and regional centres at other times throughout the year -- making the programme accessible to areas without access to traditional science centres. This could form part of a school holiday education programme, or a partnership with school clusters to operate from school grounds.

These ‘urban missions’ would be a fantastic time to showcase the project partners/sponsors and key technologies being applied - solar power, water recycling, space suits, rovers, etc.

3 Year Programme

We propose architecting this project as a 2- or 3-year programme to ensure maximum benefits are realised:

- Allows programmatic engagement with universities and schools, over a multi-year period.
- A single season would be wasteful on the up-front investment, but it's very likely that a tent structure and other equipment will show wear after 3 seasons (18 weeks) of solid use.
- Data obtained during this initial 3-year programme can be used to develop a follow-on project proposal, which may include the development of a more permanent, rigid structure and host site.

The following is an example programme roadmap:

Year	*Theme(s)*	*Location*
Year 0	**Habitat Verification (2 weeks)** ● Set up in urban centre to verify configuration ● Testing of base systems ● Procedures development and documentation	Urban
Year 1	**Theme: Engineering for Mars** ● What it takes to travel to another planet ● Building a habitat - essential systems, etc. ● Non-Earth factors: Radiation, temperatures, etc.	Near-Urban
	Holiday programme (April) ● Technology demonstration - solar power, recycling, space suits, etc.	Urban centre
Year 2	**Theme: Planetary Science & Living on Mars** ● Geology, biology, atmosphere, etc ● Effects on human systems - gravity, radiation, isolation, etc	Analogue location i.e. Central Plateau
Year 3	**Theme: South Island Expedition**	South Island

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3. Project Team & Partners

KiwiSpace Foundation (Project Lead)

The proposer and lead for this project is KiwiSpace Foundation. Our key personnel for this project include:

Mark Mackay	Executive director of KiwiSpace, co-founder of Orcon Internet, staff member for four International Space University programmes, and board member for the World Space Week Association.
Haritina Mogosanu	Crew member for four MDRS missions (twice as commander), founder NZ Astrobiology Initiative & NZ Mars Society.
Julie Rowe	Independent technology and innovation strategist, previously managing partner for Touchcast NZ, head of operations at Propellerhead, and executive committee member of the UN-initiated Space Generation Advisory Council.
Jim Hefkey	Project team for NZ Rocketry Challenge, NZ Rocketry Association committee member, and tutor at Auckland University.
Marko Alach	Project manager for SpaceUp NZ unconference (2014) and KiwiSpace meetup series.
Janice Mackay	Teacher and former education manager for Kelly Tarltons Underwater World.

KiwiSpace team members with Japanese astronaut Akihiko Hoshide, at our SpaceUp conference, 2014.

Partners

Key partners currently include:

- **NZ Mars Society:** A local chapter of the International Mars Society.
- **NZ Astrobiology Initiative:** Organisers for the 2015 Spaceward Bound expedition in the central North Island, involving personnel from NASA, Australia and Romania.

Initial discussions are in progress with the following organisations, and we envisage some degree of collaboration with them on the project.

- **AUT University**
- **NASA AMES**

Further partnerships will be developed as this proposal matures and is put out for public consideration.

Advisors

In addition to direct partners, KiwiSpace is drawing on the expertise and experience from other individual organisations involved with analogue expeditions and related education programmes:

- **Victoria Space Science Education Centre (VSSEC):** who operate a student education programme incorporating a 'Mars room' in Melbourne, Australia.
- **Australian Mars Society:** organisers of multiple outback analogue expeditions.
- **US Mars Society:** operators of the Mars Desert Research Station.
- **OEWF (Austrian Space Forum)**: who have run expeditions at multiple sites all around the world.
- Past crew members of KiwiSpace' MDRS missions.

4. Notional Habitat Design

The following section outlines a broad design for the habitat, the design drivers and assertions made for budgetary purposes, and thoughts on operational approaches.

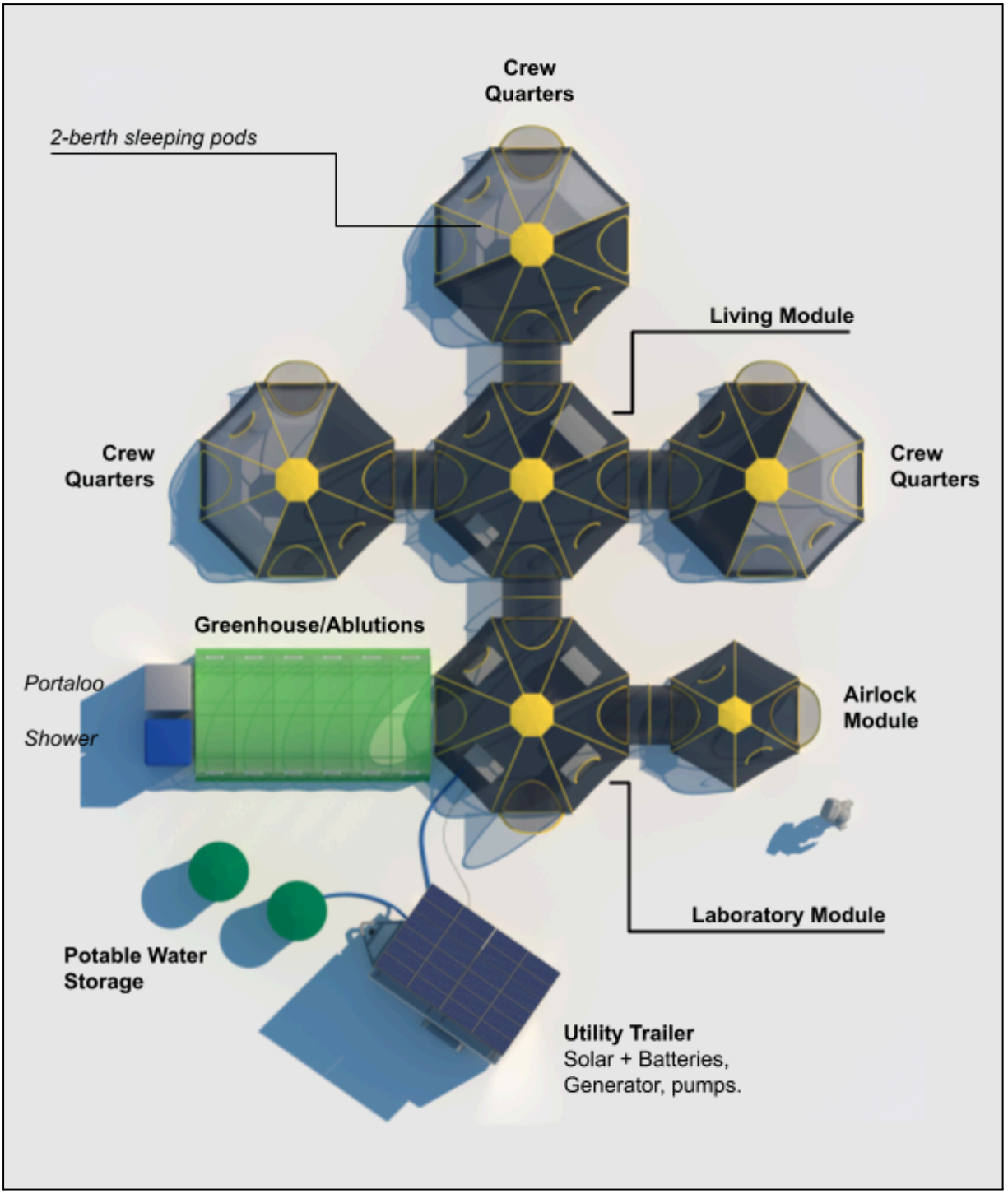
Best efforts have been made on estimating costs of major items, but the design may change and costs may vary - particularly for areas requiring compliance/certification.

Notes on Products/Pricing:

- *Any specific products referred to in this document are merely for determining credible price estimates for the proposed habitat design.*
- *Supplier estimates or recommended retail pricing has been used to determine budgetary figures. Formal, competitive quotes will be obtained for all major elements as this proposal progresses.*

Habitat Layout

A possible site layout, utilising modular tents and other facilities to create a convincing base simulation:



Features: At a glance

- Modular tent system
  - Low-cost, portable, and easily stored.
  - Flexible layout options to adapt to different deployment site constraints

- Medium-capacity Electrical System
  - Solar Panels + Batteries
  - Generator (Potentially just to charge batteries)
  - AC power distribution and LED lighting

- Potable water system, pressurised delivery and ideally with provision for hot water.

- Long-term campsite-style facilities
  - Indoor kitchen with fridge, microwave and cooktop
  - Wash-basin facilities and outdoor shower
  - Furniture
  - Serviced portaloo-style toilets

- Comprehensive Power Monitoring
  - Must provide detailed tracking of solar, battery and generator usage

- Robust Internet Connection
  - Satellite or 3G/4G internet uplink
  - Wifi distribution inside the habitat and nearby surrounds

- Remote monitoring capabilities for 'Mission Control' teams and habitat managers
  - Webcams providing live feeds of habitat
  - Power and water statistics available in real-time

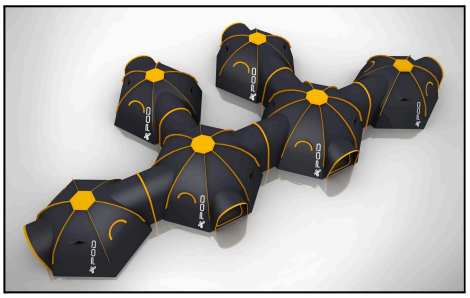
- Robust Surface Operations (EVA) capabilities
  - Space Suit simulators with local comms, ventilation, etc.
  - Medium-range field comms to allow habitat (and live-stream participants) to follow mission - e.g. hand-held radios, cellular links (if area supports), etc.
  - Emergency Tracker/Beacon for safety, ideally with online tracking map.

- Optional auxiliary infrastructure (if budgets or partnerships permit)
  - 3D Printer
  - Robotic Rover(s)
  - Quadcopter
  - Off-road buggy/Quad Bikes for longer excursions ("unpressurised rovers")

The Foundation: Modular Tents

Photos: Podtents.com

Podtents.com offers different-sized tents which can be interconnected with tunnels into various arrangements.



For the core habitat modules, it is proposed to use a modular tent system. These are low-cost compared with fixed-structures, portable, easy to erect and store.

For reference purposes we've used the tent modules available from www.podtents.com - a UK-based company, but any suitable system could be selected.

Using approximate currency conversions, the following table indicates the cost of the proposed tent combinations. In the ideal configuration this provides two large domes for working areas; 3 bedroom modules with capacity for 6 beds; and a smaller 'Mini' pod is used to store equipment and simulate an airlock.

INDICATIVE BUDGET: TENTS	*Basic*	*+ Improved*	*+ Ideal*
Crew Quarters 1: Maxi + Sleeping Pod + Tunnel	$1,200		
Crew Quarters 2: Maxi + Sleeping Pod + Tunnel	$1,200		
Crew Quarters 3: Maxi + Sleeping Pod + Tunnel		$1,200	
Living Module: Maxi + Tunnel	$1,200		
Laboratory Module: Maxi + Tunnel	$1,200		
Airlock Module: Mini		$650	
TOTAL	**$4,800**	**+ $1,850**	

Module: Crew Quarters

Photo: Podtents.com

Sufficient sleeping space is required for 4-6 crew members per expedition. The “Podtents” brand offers additional ‘Sleeping pods’ which can be inserted into their Maxi pods, providing private sleep areas and a storage area for personal belongings. If there are additional guests or logistics staff requiring temporary accommodation, they can use other empty modules such as the airlock.

Additional space inside the crew modules would be used for storage and thoroughfares. Basic camping beds should ideally be provided to keep crew off the ground. Crews would be expected to bring their own sleeping bags and pillows, and potentially face a weight/size allowance for personal items (like real astronauts).

INDICATIVE BUDGET: CREW MODULES	*Basic*	*+ Improved*	*+ Ideal*
Lighting (Battery Lanterns → LED Lighting strip)	$50	+ $150	
AC Distribution (RCD Extension lead & Power-strip)		$200	
Camping Beds (x2)		$150	
PER MODULE	**$50**	**$500**	
TOTAL (FOR 3 MODULES)	**$150**	**+ $1,500**	

Module: Laboratory

Photo: KiwiSpace

The MDRS lower level is used as the laboratory/work area.

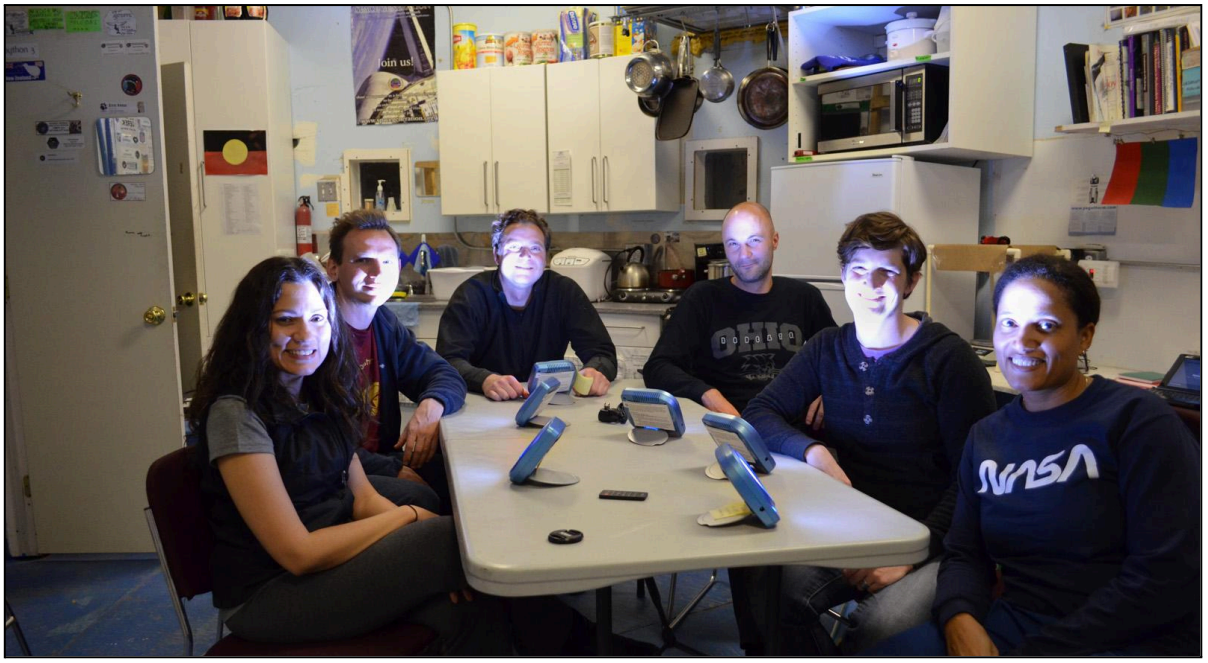
The Laboratory module is the main working area for the base. Requirements for this work area are likely to vary with each of each expedition, so it is anticipated that generic work areas and storage are provided.

It may be possible to source some standard equipment from a university for each season, with crews will be expected to bring anything else they need.

INDICATIVE BUDGET: LABORATORY MODULE	*Basic*	*+ Improved*	*+ Ideal*
Workstation Tables (Up to 3)	$50	$50	$50
Chairs x 3 (~$15 ea)		$45	
Storage			$150
Appliance Power draw tester/meter	$40		
AC distribution (e.g. NOMAD R15 2x15A, 4x10A)	$600		
Lighting (e.g. LED strip lights 300-1500 lumen)	$200		
First Aid Kit	$150		
Fire Extinguisher		$70	
Smoke Alarm			$60
Science Equipment (Borrow from university/school)	*Loaned*		
TOTAL	**$1,040**	**+ $165**	**+ $260**

Module: Living Area

Photo: Sian Proctor



The MDRS upper level is used as the living area and kitchen.

The living module is the social area of the habitat -- used for meetings, meal preparation, dining as well as core food storage. It needs to be lightly furnished with a table & chairs. Some heating/cooling control is desirable, as some locations will get quite cold overnight.

Food

Most most Mars analogue sites require crews to eat like astronauts: shelf-stable food, nothing perishable like salads, fruits, vegetables or the like unless they are dehydrated. Many crews undertake food studies during their mission.

Photo: Sian Proctor

Crew of the 120-day Hi-SEAS mission unpack and check their food stores.

For our habitat we propose providing a similar set of guidance to crews - but ultimately will let crews determine a food regime that best suits their mission goals, and the base capabilities. Limited refrigeration space is proposed, which will need to be shared by any science experiments, medicines, etc.

Design Assertion: Crews will be expected to bring their own food on a mission, alleviating the complexity for the base managers to cater to custom diets, food preferences, etc.

Kitchen facilities

The habitat will need kitchen facilities to support at six people, occasional visitors, and operate in all weather conditions. For a credible simulation it also should be indoors.

It is proposed that all cooking uses electric appliances, as it can be hazardous to use gas-burning stoves inside. This proposal provides for an electric cooktop (potentially induction for additional safety), and a microwave. These have high power loads, but are only used for short durations.

A backup gas camp cooker would be available for emergency use, should the electrical system fail. This would need to be used outside.

INDICATIVE BUDGET: LIVING MODULE	*Basic*	*+ Improved*	*+ Ideal*
Dining Table - Large	*$100*		
Chairs x 6 (~$15 ea)	$100		
Kitchen Bench & Cupboards (→ with sink)	$200	+ $100	
Storage (e.g. Shelving or stackable boxes)	*$150*		
Cutlery, Plates, Cookware, Sealed food storage	*$300*		
Water/Waste containers or Camp Kitchen Sink	*$150*		
Fridge 21L (→ upgrade to larger Fridge/Freezer 48L)		$360	+ $1,040
AC distribution with RCD (e.g. NOMAD R15 2x15A, 4x10A)	$600		
Lighting (e.g. LED strip lights 300-1500 lumen)	$200		
Microwave		$150	
Electric Stove (e.g. Hotplate or Induction cooktops)	$175		
Gas Cooktop (backup)		$100	
Electric Kettle	$25		
Fire Extinguisher	$100		
Smoke Alarm with Carbon Monoxide detection		$60	
Portable Air Conditioning (for overnight in cold locations)			$820
TOTAL	**$2,100**	**+ $770**	**+ $1,040**

Module: Airlock

Photo: Tim Serge

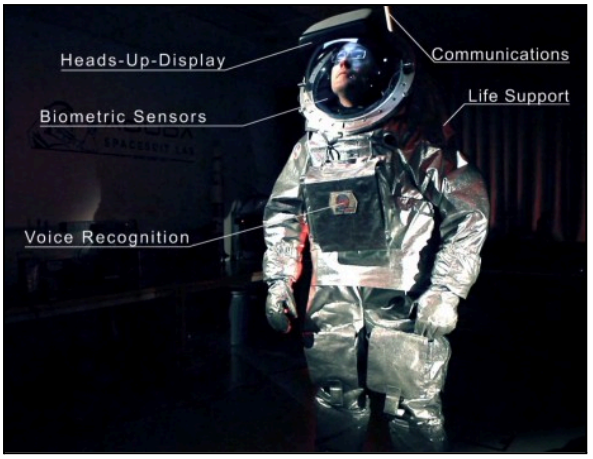
MDRS had a small airlock with an adjacent suit storage area.

Donning a space-suit is an important part of the simulation - and once the simulation commences are required whenever you leave the habitat. For our simple habitat concept, we are using a tent with two egresses - one to outside, one to the laboratory module. These doors are operated like a traditional airlock, with an artificial time-delay to simulate cycling the airlock before opening the outer hatch. For simplicity, we are proposing that the space suits are stored in our airlock.

INDICATIVE BUDGET: AIRLOCK MODULE	*Basic*	*+ Improved*	*+ Ideal*
Lighting (e.g. LED strip lights 300-1500 lumen)	$200		
Shelving or Table		$150	
TOTAL	**$200**	**+ $150**	

Surface Operations (EVA) Equipment

Photos: Judd Reid/Mars Society; Austrian Space Forum



Space Suits

When the crew leaves the habitat during the simulation, they are required to wear mock space suits. These can be incredibly simple (left) - effectively a ‘costume’, or a more elaborate prototype of a real suit (right - a german enthusiast/research suit prototype).

There is a lot of potential to engage university groups -- ranging from clothing design and science to engineering - to develop professional space suits as part of a collaboration or research project for a group of students. This is likely to take some time to come to fruition though -- at least a year.

So for the first-year space suit, we propose essentially a “functional costume”:

- Backpack
- Clear helmet
- Powered-ventilation
- Short-range radio
- Access/capabilities for providing hydration during a long mission.

The parts for this can be sourced relatively cheaply - but will require a reasonable amount of time to assemble 6 suits.

MDRS in Utah also provided several 4WD quad bikes, which were used as “unpressurised rovers” -- to assist with surface operations further from the habitat. These are relatively costly though, so not part of our proposal.

Field Safety

Crews may travel a fair distance from the habitat for field expeditions, over all sorts of terrain, so it is recommended that we provide some form of emergency beacon/tracker. It is desirable to be able to provide real-time tracking of any field crews: This would allow their position to be plotted for schools following a mission remotely and any “Earth base” roles. Similarly, it is desirable to have basic two-way communication. While handheld radios should be available, these are affected by terrain.

For example, an InReach Explorer provides internet-based tracking website with updates at 10-minute intervals (or as low as 2-minutes with the right rate plan), emergency SOS functions, and the ability to compose and receive SMS-style messages. Waypoints and detailed tracking as low as every minute can be stored on the device - making a system like this perfect for during-EVA requirements, and then post-EVA analysis.

Field Communications

It would be desirable and improve the simulation if there was two-way audio communication is required with field crews. Handheld UHF radios are recommended for simplicity (or possibly suit-integrated systems in the future). These have reasonable range, and are fairly low-cost - but do not satisfy the emergency/tracking requirements on their own.

INDICATIVE BUDGET: SURFACE OPS EQUIPMENT	*Basic*	*+ Improved*	*+ Ideal*
Space Suit (4 essential, 6 desired, 1st-year budget: $200 ea)	$800	$400	
First Aid Kit	$100		
Stretcher (for simulated and real emergencies)			$300
Medium-range radio - portable 3W handset	$150		
Medium-range radio - base station (handset + antenna)	$250		
Satellite Tracker/Emergency Beacon (e.g. InReach Explorer)	$550		
Quad Bikes/Buggy for longer-distance EVAs			*Not in budget*
TOTAL	**$1,850**	**+ $400**	**+ $300**

Habitat Exterior & Surrounds

Photo: KiwiSpace

MDRS external view: Greenhouse (left) and main module connected by a simulated 'pressurised tunnel'.

Some equipment such as generators and fuel needs to be stored/operate in an open air environment. In a real Mars base this would likely be inside a dedicated engineering module, thus for the simulation purposes we treat access to these areas as "in-simulation." Ideally the pathway and area would be fenced or enclosed by a tunnel to maintain this illusion.

Beyond the engineering and ablutions areas, the requirements for the exterior of the habitat are fairly basic -- mainly safety and functionality. Outdoor lighting is desired to facilitate any safe near-base nighttime operations, with battery-powered torches being used beyond the range of this.

Good signage is desired to support branding in promotional images, funder/sponsor recognition, and labelling of base elements.

INDICATIVE BUDGET: EXTERIOR	*Basic*	*+ Improved*	*+ Ideal*
Simple tunnel/Greenhouse for Ablutions area			$320
Ablutions area lighting (possibly flood-lights)	$200		
General-purpose Outdoor LED Light Stand (Desired → x2)	$500	$500	
Fencing (50m Orange Safety Mesh)		$50	
Fencing stakes		$100	
Signage	$800	+ $600	
TOTAL	**$1,500**	**+ $1,250**	**+ $320**

Utilities: Power Systems

Photo: Ross Lockwood

Unlike camping, an active research habitat will have significant power demands. Each crew member is likely to bring a laptop/tablet which will be used extensively, it is proposed to use electric cooking systems (to support indoor use), greater lighting requirements than recreational camping, and scientific instruments which all may be powered on at once.

The goal is to simulate realistic Mars-base operations - not to require people to use battery lanterns or revert to pen-and-paper.

The first human missions to Mars are likely to use solar power in some form, and we propose the same for our analogue base. While a solar/battery system large enough to satisfy the full habitat requirements will be large and expensive, it should be possible to create the illusion of a fully-solar system for simulation purposes.

It is proposed that the habitat have a large battery bank -- which utilises solar charging when available, but is supplemented by generator power. With sufficient funding, the generator may simply be used as a backup for cloudy days -- but unless we can find a suitable sponsor/partner, it is envisaged that the generator will run for a substantial portion of the day.

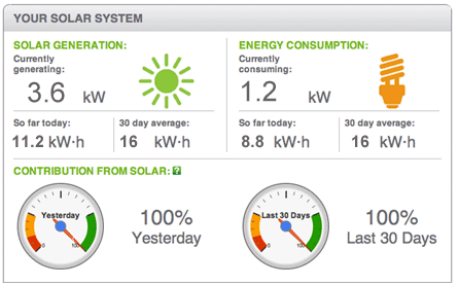
Design Assertion: All "in-simulation" power should be taken from the batteries, with the generator charging the batteries as needed. This allows us to measure all power consumption at one point, and simplifies wiring requirements.

The generator can be used directly in the event of Solar/DC equipment failure or for out-of-simulation requirements. In the event of a generator failure, the crew can conserve remaining battery power, continue to use solar generation (if available), and utilise gas cooking and battery-powered torches until the system can be restored.

Power Monitoring

Power should be treated as a finite resource, and carefully managed. To facilitate this it is important that the crew has detailed statistics about their power generation, storage and utilisation.

Battery lifetime will be limited, and different loads in the habitat will deplete this more quickly. Certain devices will also have high load requirements, and may not be able to operate concurrently (e.g. induction cooktop cannot be on at same time as the microwave oven). A crew will need to juggle these constraints and their mission goals, but will need the tools to do this.



Most solar systems already have some form of basic tracking -- but for analysis purposes, it is desired to maintain an accurate historical log of metrics. Some systems provide for remote-monitoring and storage of this data via the internet -- which would be extremely useful if the expedition crew are also simulating an 'Earth Mission Support' role as well. The habitat administration and support team will also find this information useful.

An online monitoring system would be beneficial for site management and education goals.

Discussions in progress with suppliers to develop a more accurate budget.
Figures below are early estimates which are likely to change.

INDICATIVE BUDGET: POWER SYSTEMS	*Basic*	*+ Improved*	*+ Ideal*
Generator	$7,000		
Solar power + battery system (e.g. like this one)	*$10,000*		
Power management system	*$1,000*		
Detailed Power monitoring capabilities (→ extra monitors)	$200	+ $200	
Master Power distribution board - 230V AC	*$1,000*		
Labour for power system integration & certification	*$1,000*		
TOTAL	**$20,200**	**+ $200**	

Placeholder for power system dimensioning analysis.

Utilities: Water

Most sites selected for the habitat will not have ready access to mains water supply or waste facilities - thus the habitat will need to be self-sufficient for a reasonable period (1-2 weeks minimum).

The water system should support an operational mode that would reasonably mimic that of a Mars base or the International Space Station. Water would be treated as a finite resource and need to be carefully managed, and efficient use of water would be essential.

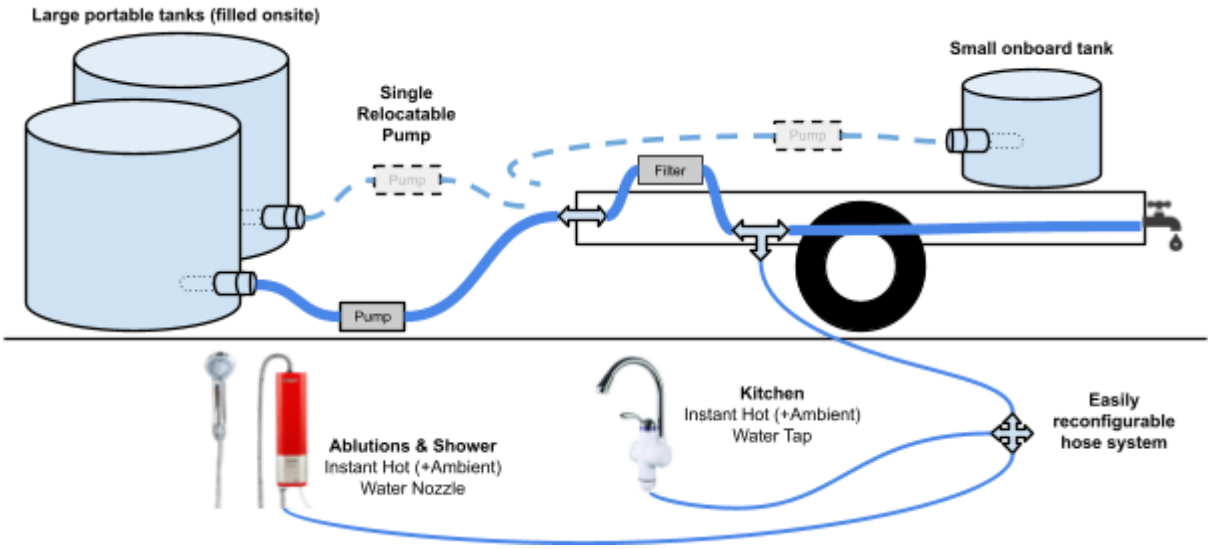
Proposed capabilities

- Potable water delivered by a contractor (ideally once per season)
- Large portable water storage tanks (or bladder for small storage/transport footprint)
- Semi-pressurised water delivery for:
    - Shower
    - Ablutions hand-basin
    - Kitchen
    - Cleaning hose
- Hot/warm water capability
- All-electric systems - pumps, heating, etc (e.g. no gas water heating).
- Water usage monitoring capabilities.
- Use of a serviced, self-contained portaloo for toileting and to reduce water needs.

Notional design

The diagram below shows a basic design that provides:

- Support for a trailer-mounted water tank, or connections to large external tanks.
- Standardised connectors (filter, non-return valve, shut-off valve) on each tank.
- Single water pump, which can be connected to the current water tank source.
- Piping system similar in concept to garden hoses, for easy site plumbing.
- On-demand hot water systems at tap, to simplify plumbing and low power use.



Water Consumption

The habitat needs to support six crew members - but should also provide support for occasional short term guests, and drinking water for visiting field trips.

Average residential water consumption in Auckland is around 180 litres per person per day, during summer. With water "readily on tap" people tend to use more, and by example, a water delivery company contacted allocates 100L per person per day for rural users, who tend to be more conservative with water consumption over dry summers.

Crew 137 at MDRS reported use of approximately 40 litres per person per day, but this is a plumbed system so people people tend to behave more like they're at home/work. FMARS in the Canadian arctic is also plumbed, but the crews are responsible for collecting their own water from a nearby lake or snowmelt. A water usage study there reported 11.7 L/person/day, with disciplined water management.

Considering the MARS-NZ design and imposing a mantra of water conservation - we propose the following water budget:

Purpose	*Use (L)*	*Frequency*	*Usage per person*	*Daily per person (L)*
Shower	10.0	Per-Shower	0.5 per day	5.0
Body Wash	2.0	Per-Wash	0.5 per day	1.0
Toilet	6.0	Per-Flush	3-4 per day	*Self-contained system (Ex-SIM)*
Meals	1.0	Per-Day-Per-Person	per day	1.0
Drinking	2.0	Per-Day-Per-Person	per day	2.0
Dishwashing	0.5	Per-Day-Per-Person	per day	0.5
Teeth/Face-wash	0.5	Per-Wash	2 per day	1.0
Hand Washing	0.5	Per-Wash	3 per day	1.5
Laundry	5.0	Per-Wash	1 per week	0.8
TOTAL (Per-person, Per-Day)				**12.8 Litres**

Providing some contingency (~20%) results in the following dimensioning:

Per-Day, Per-Person	*Per-Week (6 crew)*	*Per-Season (6 weeks)*
15 Litres	640 Litres	**3,780 Litres**

These figures are a significant drop from MDRS normal usage, but comfortably exceed those of freedom camping or desert expeditions. Water usage and storage requirements will need to be carefully reviewed during the first season, and contingency funding available for refilling water tanks, if it proves necessary.

In practice, it would be reasonably inexpensive to dimension slightly larger (or additional) tanks - and most water carriers charge the same price for delivery up to around 12,000 litres of water.

INDICATIVE BUDGET: WATER SYSTEMS	*Basic*	*+ Improved*	*+ Ideal*
Water pump with flow-control	$500		
2 x Stackable Water tanks (2000L - $620, 3000L - $780)	$1,240		
Low-volume water tank, for utility trailer (e.g. 100L)			$330
Tank fittings (Non-Return Valve, Particle filter, Tap, etc)	$300		
Inline Carbon Filter	$70		
Kitchen Taps (Instant Hot/Ambient Water Tap)	$120		
Ablutions Taps/Shower (Heated)	$120		
Food-grade hoses (40m @ ~$10/m)	$400		
Food-safe hose fittings, junctions & taps (~20 @ $15/each)	$300		
Shower Tent		$130	
Hand-operated Washing Machine		$100	
Water flow meters (feed-line only → feed line + 2 x taps)		$170	$340
Flow monitoring electronics (to integrate with portal)			*$300*
Labour for water system integration (~2 days @ $55/hr)	$880		
TOTAL	**$3,930**	**$400**	**$970**

Utilities: Waste & Ablutions

Human Waste

For simplicity, sanitation is proposed using hired portaloo-style toilets, refreshed every 1-2 weeks by a contractor. This will be far easier than dealing with chemical toilets, and keeps the main sanitation system outside of the habitat. While unclogging the toilet will be an operational requirement on Mars, it's an unnecessary distraction for our primary goals.

Greywater

The crew will generate greywater from dishwashing, cleaning, clothes washing, etc -- and this will need to be managed. It is proposed to use a portable greywater tank, and where possible, have sinks drain directly into this. Most backcountry camping rules allow disposal of limited quantities of greywater (provided well away from water sources). If we are near a conventional campsite, then it may be appropriate to temporarily interrupt the simulation and dispose at the nearby facilities. Consideration will need to be given to using environmentally biodegradable and non-toxic cleaning products, etc.

Toxic/Dangerous Waste

Provision should be made for storage and offsite disposal of liquid waste that is toxic to the environment (such as chemical used by experiments, etc), as well as sharps, broken glassware, biomedical materials, etc.

General Waste/Recycling

The general rule of camping is that you "Leave No Trace" -- and with the exception of benign waste water, this would be the recommended approach for the habitat. Crews would be expected to take away and dispose of all their rubbish, food waste, etc when they depart. It is also recommended that crews adopt waste-minimisation strategies and account for (weigh) their waste and recyclables.

INDICATIVE BUDGET: ABLUTIONS/WASTEWATER	*Basic*	*+ Improved*	*+ Ideal*
Toilet (e.g. Chemical toilet or rent Portaloo)	*Rented*		
Wash-basin (Basic containers → with camping sink & table)	$50	+ $80	
Wastewater Storage Tank (40L)	$200		
TOTAL	**$200**	**+ $80**	

Utilities: Mobile Utility Platform

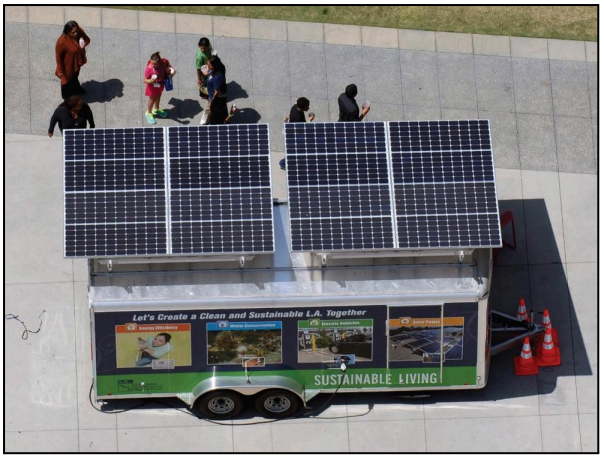
A pre-configured trailer would provide robustness, mobility, and significantly reduce site setup time.

It would be advantageous to house the key utility equipment on some form of mobile trailer/platform. Electrical and water systems could be wired and firmly fixed in place, and potentially caged/sheltered. With careful design, both water (e.g. water pumps & heater) and electric systems may be able to co-exist and meet regulations, simply requiring hoses and electrical wiring run to the various tanks and outlets. Solar panels could be mounted on the trailer roof, along with other electronics such as wifi base stations, satellite dish, pole-mounted flood lights, etc.

While not a mandatory design requirement, this make site setup significantly easier, improve reliability of the core systems, and reduce risks from inexperienced operators meddling with the system design (*see state of MDRS engineering area, right*).

The trailer-based 'mobile utility system' would also be very useful for other activities KiwiSpace supports - providing a mobile hub for events requiring power, wifi hotspot and low-volume water supplies where a grid-based hookup is more difficult (e.g. NZ Rocketry Challenge).

An enclosed trailer would provide reasonably secure storage areas for some habitat components, providing convenience and potentially reducing off-season storage costs.



The utility trailer is a prime candidate for finding a matching partner/sponsor interested in sustainability education.

Proposed Trailer Capabilities

- Electrical Systems:
  - Solar Panels (on roof, fold-up doors - ideally tiltable for max. sunlight)
  - Generator (Ideally mounted inside, else stored inside for transport)
  - Deep-cycle Batteries
  - Internal Sockets (10A) for in-trailer appliance use
  - External Sockets (16A) for distribution nodes - e.g. NOMAD R10 or R16
  - Wifi & Satellite/3G Routers
- Water Systems:
  - Water Pump
  - Water filtration system
  - On-demand or Conventional/stored water heater
  - Small potable water container (for urban off-grid events)
  - Water distribution Outlets (to connect to external taps, hoses, etc.)
  - Built-in Water Taps
- Fold-up, extendable or installable Mast
  - Wifi Antenna
  - 3G/Satellite Antenna
  - Outdoor Floodlights
- Fuel Tank
- Cooking facilities
  - Electric cooktop and/or Gas cooker
  - Fridge (Inside when in 'trailer mode' but removable to place in habitat)
- General storage (for electrical gear, water hoses, etc).

INDICATIVE BUDGET: MOBILE UTILITY TRAILER	*Basic*	*+ Improved*	*+ Ideal*
Trailer (Simple/Caged → Enclosed)		$5,000	+ $5,000
Fit-out and additional components		*$2,000*	
TOTAL		**+ $7,000**	**+ $5,000**

Technology

An important goal of the habitat is to **provide information about what is occurring during simulations** to schools, the general public, simulated 'Mission Controls' and site support/maintenance staff. This will drive significant bandwidth and technology requirements.

The crew, as with any real Mars mission, also needs to get a lot of work done -- and so they need to tools to do this -- including access to "Earth" resources/information, local networking, data from the various habitat and EVA systems, etc.

Internet

A reliable, well-sized internet uplink is extremely important. Dimensioning will need to be planned out closer to implementation, but broadly we're after the ability to stream the following simultaneously: HD video conferencing, surveillance cameras, low-level internet traffic (e.g. email) and habitat data (e.g. power consumption).

Satellite internet uplinks would provide the most flexibility on where to locate the habitat each season, but are costly, slow, have high-latency and usually offer quite restrictive data caps. Consumer 3G/4G or Rural Broadband (Fixed 3G) coverage would be ideal.

Local Network

Due to the non-rigid nature of the habitat, where possible we suggest avoiding the use of wires for connectivity -- and using Wifi wherever possible. This provides flexibility to position equipment, will be required by all smartphones/tablets/computers the crew bring along -- and can facilitate activities inside and outside the habitat, within a certain range.

Long-distance outdoor connectivity would prove incredibly useful -- allowing the use of Wifi-controlled rovers, space-suit telemetry, etc. Most Wifi systems do not have good coverage - but there are some devices that work better, and we recommend the use of these if the budget provides (e.g. Ruckus Wireless outdoor access points use beamforming to boost range to active clients).

At other analogue facilities, some crews have used balloon-mounted radio systems to provide even greater range -- but we suggest that this is left to possible research projects. A

real Mars base would most definitely provide near-distance communication to crews on the surface.

Webcams

It is envisaged that webcams would be installed in all common areas of the facility, streaming continuously to the web for 'mission control' sites to access. Crews will need to accept this as a condition of access to the facility. These cameras may also be useful for webcasts/videoconferencing.

Ideally all the video feeds would be 1080p, but this will depend on available bandwidth. The mission control systems would ideally provide an interface to select HD streaming for special events, on on-demand viewing.

Audio Conferencing

Communicating with schools is one of the primary goals, and equipment to support effective two-way conferencing with schools should be provided.

Remote-Administration

We envisage installing a small server at the habitat which will aggregate the various data sources (webcams, telemetry, etc) and manage the uplink to the internet repository. This server can also then be used for the site administrators/support staff to remotely connect in and manage certain functions. This may also be useful for storing video archives, providing basic file services, and scheduled (overnight) uploads.

INDICATIVE BUDGET: TECHNOLOGY	*Basic*	*+ Improved*	*+ Ideal*
Satellite / Cellular Uplink (Installation + hardware)	*$2,000*		
Wifi Distribution (→ Ruckus Outdoor for performance)	$500	$1,500	
Server for webcams and remote monitoring (e.g. Mac Mini)	$1,000		
Cameras (Outside, Living, Laboratory, Airlock)	$1,000		
Conference microphone & speaker	$200		
TOTAL	**$4,700**	**+ $1,500**	

Website

The website would act as a virtual 'Mission Control,' and a hub for all the project resources.

The website is one of the most critical parts of the base infrastructure. It is the public face of the project and will need to satisfy a number of requirements:

- About the Base: Explain the various components and systems, operational requirements, and how a real Mars base would differ.
- Sponsor/partner recognition
- Support handbook for crews and site managers
- Application forms and scheduling for expeditions.
- Per-expedition mini-sites, providing reports, photo/video galleries, etc.
- Forms/automation for crew reporting obligations

It would also form the live 'Mission Control' portal to provide schools and the public a real-time view of base operations:

- Webcams
- Consumables (power consumption, water use, waste, etc)
- Webcasts / audio-conferences with crews
- Interactive chat / Q&A
- Maps
- Schedules

A professional website/UI designer should be engaged at the outset to ensure maximum usability and a well thought out design to handle three years of data. It is envisaged that ongoing edits would be managed by crews and the base administrator.

INDICATIVE BUDGET: WEBSITE	*Basic*	*+ Improved*	*+ Ideal*
Website Design & Establishment	$2,500	$2,500	
TOTAL	**$2,500**	**+ $2,500**	

Operational Requirements

Photo: Paul Graham/Mars Society

Even a simple design like MARS-NZ will have significant assembly and operational requirements.

To ensure that maximum value is realised from the habitat and related resources, the programme needs effective operational oversight, and a structured approach to how crews interface with the habitat.

Habitat Operations Manager

The operations manager would broadly be responsible for the efficient, reliable operation of the habitat, and ensuring crews understand and follow operational requirements.

The job description would include:

- Managing crew bookings, documentation and payment for each operating season.
- Maintenance/On-call support for habitat crews, and managing urgent repairs.
- Organising host locations and coordination with site owners/representatives.
- Coordinating volunteers to facilitate habitat set up, pack-out and other operations
- Organise crew training weekend.
- Managing suppliers/contractors to ensure habitat operates smoothly with all required consumables.
- Collection of mission/operations data from crews and habitat telemetry, and subsequent summary reporting.
- Development and maintenance of the operations handbook/support website.
- Development and review of health & safety procedures.
- Financial reporting and management of grant/funding obligations.
- Off-season maintenance and testing of habitat components.
- Technical management of programme website and base IT systems.

Multiple sources with experience of the MDRS and F-MARS facilities have advised that this should be a dedicated, full-time role when the habitat is in operation. Off-season activities are estimated to require an average of one day per week effort.

Project Manager - Site Establishment

Significant logistics management will be required once the project is approved, and base component assembly and integration begins. If funding permits, it is proposed to employ a project manager for a 2 month period to act as liaison with suppliers, coordinate volunteers and manage the initial assembly of the habitat.

If possible, this should be the same person employed as the Habitat Operations Manager, to maximise their familiarity with the base systems and supply chain.

Support Site/Wiki

As outlined in this proposal, there are a large number of systems which make up the broader habitat -- and additional operating protocols, reporting obligations, etc. As such we propose using an online website to develop and iteratively refine an operating/support handbook for all crews to use. This would also serve as a reference tool for habitat support staff, with equipment manuals, blueprints, maintenance logs, etc - ensuring knowledge is not lost if volunteers/employees move on.

Crew Training Session

Preceding each season it is proposed to have a crew training day/weekend approximately a month before the season starts. This would be mandatory attendance for at least two people from each crew. The training would provide hands-on familiarity with base systems, space suits, communications gear, etc - and may include the crews setting up the habitat at a test location.

Volunteers

It is envisaged that members of KiwiSpace, related organisations and potential users of this habitat will be willing to contribute their own time to help make this programme a success -- supporting the initial habitat development, website content development, and promoting the programme within local communities.

A budget is proposed to cover volunteer expenses and travel costs for any formal in-school activities, holiday programmes, and installing/removing the habitat each season.

5. Education/Outreach Programme

The MARS-NZ facility and missions being undertaken will provide an engaging context for a wide range of educational activities. In its simplest form, schools are able to follow along with the missions in progress, interact with the crew using online chat and video, and learn more about how a real Mars mission would unfold. But far greater value will be realised by providing deeper linkages to the New Zealand curriculum and Te Marautanga o Aotearoa.

Education/Media Coordinator

A short-term contract position is proposed to maximise the media-exposure and educational benefits of the habitat.

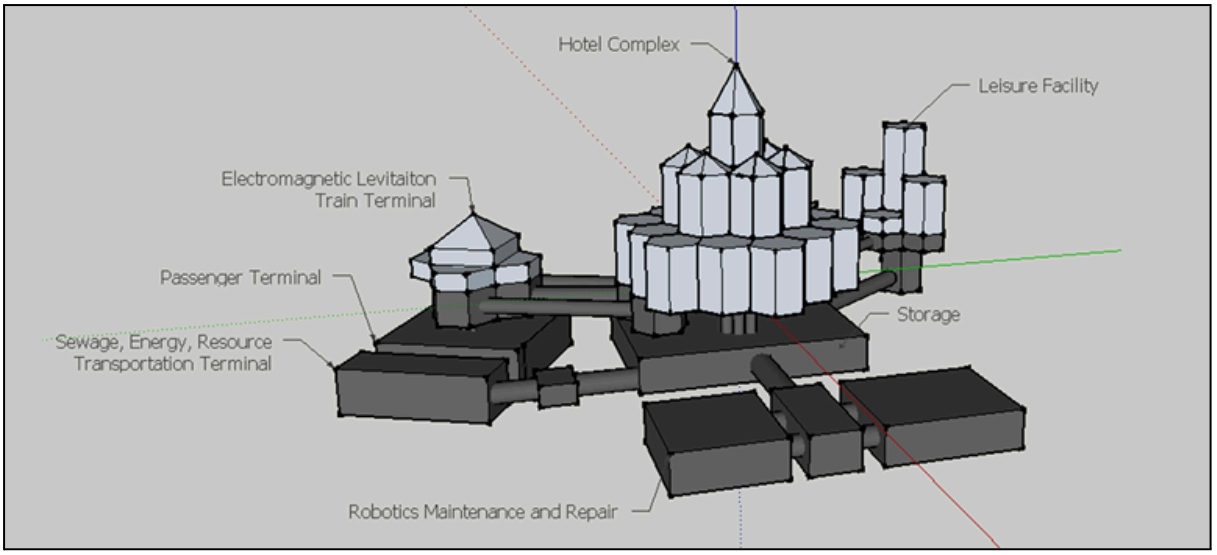
The job description would include:

- Developing guidelines and resources to assist schools to integrate the education programme into their curriculum and schedule.
- Issue press releases and liaise with national and local media, to profile the habitat, education programmes, and special events.
- Work with crews utilising the habitat during the beginning of school term to incorporate the education programme elements.
- Organise online web conferences between crews, schools and the general public.
- Identify venues and coordinate public talks by crews around the country.
- Gather statistics on programme reach and participation, particularly on secondary in-classroom activities.
- Consider a longitudinal study to track effect of this (and related) programmes.

It is proposed to operate this as a project-based contract, to deliver the initial education material, establish initial relationships with schools, and manage the outreach and media programme for the first season. Effective effort is anticipated to be around 4 months work.

This role may be well-suited to a science-savvy part-time/relief teacher, as the beginning of the school year is usually a quiet time for them.

Image: uksdc.org



A Lunar Hotel designed by students from Pate's Grammar School, Cheltenham, UK.

6. Budgets & Funding Strategy

Preliminary budgets are included on the following pages. These have been prepared using a combination of estimates from suppliers, and recommended retail pricing for products. Competitive quotes will be obtained for all major items as the project progresses.

Funding Strategy

Cost-reduction through sponsorship

Many of the capital costs of this programme are prime candidates for finding supportive partners/sponsors. This is why the education programme is so important, particularly the focus on Earth-based uses of the technology and conservation approaches:

Item	*Example outreach messages*
Solar Panels	EECA Energywise linkages, teaching efficiency, how solar systems work, low-energy appliances, ...
Water systems	How clean water is produced for your home, power consumption of hot water systems, ...
Waste	Recycling, waste minimisation, classification of waste, ...
Internet systems	Promoting sponsor's plans, and particularly rural/mobile internet technologies.
Food safety/cooking	Safe cooking in tents, shelf-stable foods - and relevance for emergency kits, ...

Startup Grants

Complete sponsorship is unlikely, so it will be necessary to find one or more grants for the initial capital investment required.

Operational Grants/Funding Required

Direct revenue from crews attending the facility is likely to cover the base habitat's direct operating costs (e.g. water, fuel, basic administration) - however it is insufficient to run the more broad outreach and education programme.

A volunteer-led/best-effort outreach programme, and fewer scholarships could be adopted to reduce costs. But as the real value from the programme is from its outreach/education mission, care should be taken when adjusting the operating strategy.

Preliminary Budget: Site Establishment

NOTE: The amounts are currently manually aggregated from preceding pages.
This document is being revised daily as quotes are obtained and other information becomes available.
FIGURES MAY NOT ALWAYS TOTAL CORRECTLY/CARRY FORWARD.
This will be triple-checked for the final revision.

AGGREGATE SITE ESTABLISHMENT COSTS	*Basic*	*+ Improved*	*+ Ideal*
Tents	4,800	1,850	
Crew Modules (x 3)	150	1,500	
Laboratory Module	1,040	165	260
Living Module	2,100	770	1,040
Airlock Module	200	150	
Surface Operations (EVA) Equipment	1,850	400	300
Exterior	1,500	1,250	320
Power Systems	20,200	200	
Water Systems	3,930	400	970
Ablutions & Wastewater	250	80	
Mobile Utility Trailer		7,000	5,000
Technology	4,700	1,500	
Website	2,500	2,500	
TOTAL		**+ $17,765**	**+ $7,890**
CUMULATIVE TOTAL	**$43,220**	**$60,985**	**$68,875**
TOTAL CAPEX FUNDING REQUIRED *(with **20% contingency** for costs missed in budget)*	**$51,864**	**$73,182**	**$82,650**

Estimated Funding Requirements

Exact costings will vary as a final design is formulated based on equipment choices, partnerships, available budget and negotiations with suppliers.

As a guide, we suggest the upfront investment in establishing the habitat will require:

$40,000	**Cash/Finance**
$40,000	**Sponsorship, discounts and in-kind contributions**

Preliminary Budget: Operations

INCOME	Notes/Math	Annual	Subtotal	Totals
Notional charge per crew member (see notes)	$500			
Income per expedition-week (Average 5-person crew)	5 x $500 = $2,500/wk			
Income per season (6 weeks)	6 x $2,500	15,000		
TOTAL OPERATING REVENUE (PER-ANNUM)				**$ 15,000**
EXPENSES				
Per-Expedition Expenses				
Fuel for generator (estimate $1/hour)	14h x 7d x $1/hr = $100	~600		
Portaloo hire (weekly average)	~$180	1,080		
Potable Water Delivery (up to 14,000L, e.g. to Desert Rd)	~$70/week	400		
Internet data (weekly)	~$100/week	~600		
Subtotal (Costs per Expedition-Week)	**~$450/week**		2,680	
Seasonal Costs				
Off-season storage costs (excluding utility trailer)	11 mo @ $100/mo	1,100		
Base installation/pack-up costs (e.g. truck hire)	Estimate	2,000		
Per-season consumables	Estimate	1,000		
Repairs and maintenance	Estimate	2,000		
Satellite Beacon/Tracker subscription (Freedom Plan)	2 mo @ $99/mo	200		
Volunteer expenses budget		2,000		
			8,300	
CORE OPERATING EXPENSES			**$10,980**	
CORE OPERATIONAL SURPLUS				**$4,020**
Administration Costs				
Project management for site establishment	2 months @ $60k	10,000		
Habitat Operations Mgr (Avg 1 day per week, 10 months)	10/12 x 0.2 x $60k	10,000		
Habitat Operations Mgr (Full time for 2 mo, during season)	2 months x $60k	10,000		
			30,000	
Education/Outreach Programme Costs				
Education/Media Coordinator ($50k per annum effective)	4 mo @ $50k	12,500		
Education/Media Coordinator expenses & travel costs	Estimate	1,000		
Scholarship expedition placements (4 places per annum)	4 x $500	2,000		
			15,500	
International Education Exchange				
Intl. Flights for international guest (e.g. NASA)	Estimate	3,000		
Domestic flights + transportation	Estimate	400		
Guest accommodation/transportation	4 nights @ $150	600		
			4,000	
TOTAL OPERATING EXPENSES			$49,500	
YEAR 1 OPERATIONAL FUNDING REQUIRED				**$45,480**

Notes to the budget:

- The budgets use example products in an attempt to provide credible costs. These are examples only and costs will vary based on the final design/product choices.

- The operating budget provides an estimate for year-one operations costs only. It is likely this can be reduced in subsequent years.

- Discounted/second-hand purchasing is an option to reduce costs in some areas, but reliability and lack of warranty trade-offs will need to be considered.

- The budget does not attempt to factor in any discounts which may be obtained from friendly suppliers. But it's also worth noting that if discounts are available, at times it may be worthwhile choosing more capable equipment at a similar budgetary level.

- Electrical compliance is a significant unknown, as the initial author of this document was not qualified in this area. Broad estimates have been made based on casual review of available literature and online resources. The author strongly suggests putting the key electrical and water distribution systems on a platform/trailer, so that these are assembled to code, and are then less prone to damage and misuse by less-experienced habitat users.

- Primary revenue is expected to come from fees charged to the crews using the facility. For the purposes of budgeting **a fee of $500 per week per crewmember** has been used, which matches the rate charged by the Mars' Society to use the Mars Desert Research Station. This figure can be reviewed to find the optimal figure to balance maximum utilisation and revenue to cover habitat costs.

- Depending on final design and the habitat will be capable of housing between 4-6 people, so an average crew size of 5 people has been chosen for revenue estimates.

- **Capex vs Opex:** It may be possible to rent some items (e.g. walkie-talkies), but the hire costs over three years (18 weeks hire) are likely to be significant, negating any savings.

Appendix: Example Mission Schedules

The following table indicates how the habitat might operate over Summer 2016:

Week	*Dates (2016)*	*Example Expedition Schedule*
T-1 Month		Pre-season check of all equipment
Week 0	6 - 9 Jan	Site setup & verification
Week 1	10 - 16 Jan	**Expedition 1a** (week 1 of 2)
Week 2	18 - 23 Jan	**Expedition 1b** (week 2 of 2)
Week 3	24 - 30 Jan	**Expedition 2a** (week 1 of 2)
Week 4	31 Jan - 6 Feb	**Expedition 2b** (week 2 of 2)
Week 5	7 - 13 Feb	**Expedition 3** (Incorporating school outreach)
Week 6	14 - 20 Feb	**Expedition 4** (Incorporating school outreach)
	21 Feb	Site closeout

One-week and two-week mission periods would be offered:

- The shorter (and cheaper) 1-week format would be good for teams who can spend time doing mission preparation in their home city, before departing for the habitat.
- The longer two-week format is suited for teams with a more in-depth science/mission plan, or that is made up of individuals from around the country/world.

	Notional 1-Week Mission Plan	*Notional 2-Week Mission Plan*
Pre-Exp.	Detailed mission planning and preparation	General pre-mission planning
Sun	Arrival and handover from previous expedition	Arrival and handover from previous expedition
Mon	Familiarisation and mission preparation	Site familiarisation and mission preparation
Tue	**Mission Simulation**	Site familiarisation and mission preparation
Wed	**Mission Simulation**	Site familiarisation and mission preparation
Thu	**Mission Simulation**	**Mission Simulation**
Fri	**Mission Simulation**	**Mission Simulation**
Sat	Post-sim activities	**Mission Simulation**
Sun	Handover to new crew; Departure	**Mission Simulation**
Mon		**Mission Simulation**
Tue		**Mission Simulation**
Wed		**Mission Simulation**
Thu		**Mission Simulation**
Fri		Post-sim activities
Sat		Post-sim debrief
Sun		Handover to new crew; Departure

The above plans are a suggestion only - crews are free to set their own schedule. But especially for missions operating during the school term we propose a Tue-Friday mission cadence. This provides for a briefing day to students on Monday, before the crew simulation commences the following day. The simulation then ends before the weekend reducing impact on the following week's lesson plans.

Appendix: Power requirements analysis

The following is an early-stage analysis of the power-loads expected at the facility, to assist with dimensioning of power systems.

Device	*Average Load (W)*	*Qty*	*Time (h)*	*Total (WattHr)*
Laptops	60W(Ref)	6	24h	10,080
Smartphone chargers	12W(Ref)	6	3h	216
Refrigerator/Freezer 48L ($1400)	17W Avg (Ref)	1	24h	408
Internal LED Lighting	14W (Ref)	5	20h	1,400
Battery chargers (for habitat gear)	22W (Ref)	2	12h	528
Outdoor Lighting	50W (Ref)	1	6h	300
Server	6W Idle, 85 Max = ~40W	1	24h	960
Webcams	1.2 W (Ref)	4	24h	115
Wifi Hotspot	10W	1	24h	240
3G/Satellite Router	60W (Ref)	1	24h	1440
Constant Peak	750W			(15,687 WH)
Sporadic Use Devices				
*Microwave	1000W	1	0.5h	500
*Electric Cooktop	2000W	1	1h	2000
Electric Kettle	2000W (Ref)	1	0.5h	1000
*Water Pumps	400W	1	2h	800
*On-demand electric water heater	2000-3000W	1	1h	3000
Hair Dryer	1000W	1	0.25h	250
Heat Pump Aircon/Heater	1300W (Ref)	1	4h	5200
TOTAL				**~28.4 kWH**
TOTAL PEAK (Constant + Starred items)	**7,150 Watts**			