TUG® Implementation Manual

September 2013

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Safety Information

Repairing TUG
Never attempt to repair or modify TUG yourself. Disassembling TUG may cause damage that is not covered under the warranty. TUG does not contain any user-serviceable parts.

Service should only be provided by an Aethon Authorized Service Provider. If TUG has been damaged in any way, do not use it until you contact the Aethon Helpdesk.

Battery Replacement
The rechargeable batteries in TUG should be replaced only by an Aethon Authorized Service Technician.

Certification and Compliance:
This device is Model AEC2

It contains modules certified under
FCCID: 2AA6CAEC2SOMENC1
IC ID: 10082A-AEC2SOMENC1
and
FCCID: 2AA6CWIFI6205PCIE
ICID: 11082A-WIFI6205PCI

The design of AEC2 complies with U.S. Federal Communications Commission (FCC) guidelines respecting safety levels of radio frequency (RF) exposure for Mobile devices.

RF Exposure
This device is only authorized for use in a mobile application. At least 20 cm of separation distance between the AEC2 SOM Enclosure device and the user's body must be maintained at all times.

CAUTION: Any changes or modifications not expressly approved by Aethon could void the user's authority to operate the equipment.

FCC Compliance Statement

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

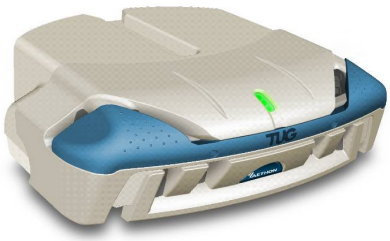
Canadian Compliance Statement
This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil est conforme avec Industrie Canada RSS exemptes de licence standard (s). Son fonctionnement est soumis aux deux conditions suivantes: (1) ce dispositif ne doit pas causer d'interférences, et (2) cet appareil doit accepter toute interférence, y compris celles pouvant causer un mauvais fonctionnement de l'appareil.

TUG Operations

How a TUG Works

Computer: The on-board computer contains the advanced TUG Operating System (TUGOS), which uses its detailed map of the hospital and sophisticated navigation software to plan routes, avoid obstacles, and constantly track its location.



Drive Train: Two independent electric motors

Power: 24VDC, four sealed lead acid maintenance-free batteries

Lift Mechanism: Mechanical

Drive Wheels: Patented, for ultra-high accurate odometry

Weight: TUG (w/batteries) 70 lbs; exchange platform 120 lbs

Travel Speed: 20 – 225 FPM

Battery Charging: Optimized opportunity charging with auto dock

Battery Run Time: Average 10 hours with intermittent opportunity charging

Interfaces:

Wireless – 802.11 AGN – 2.4GHz/5GHz

Mechanical – Elevators, Doors, Fire Alarms

Data – Pharmacy Information Systems (MedEx)

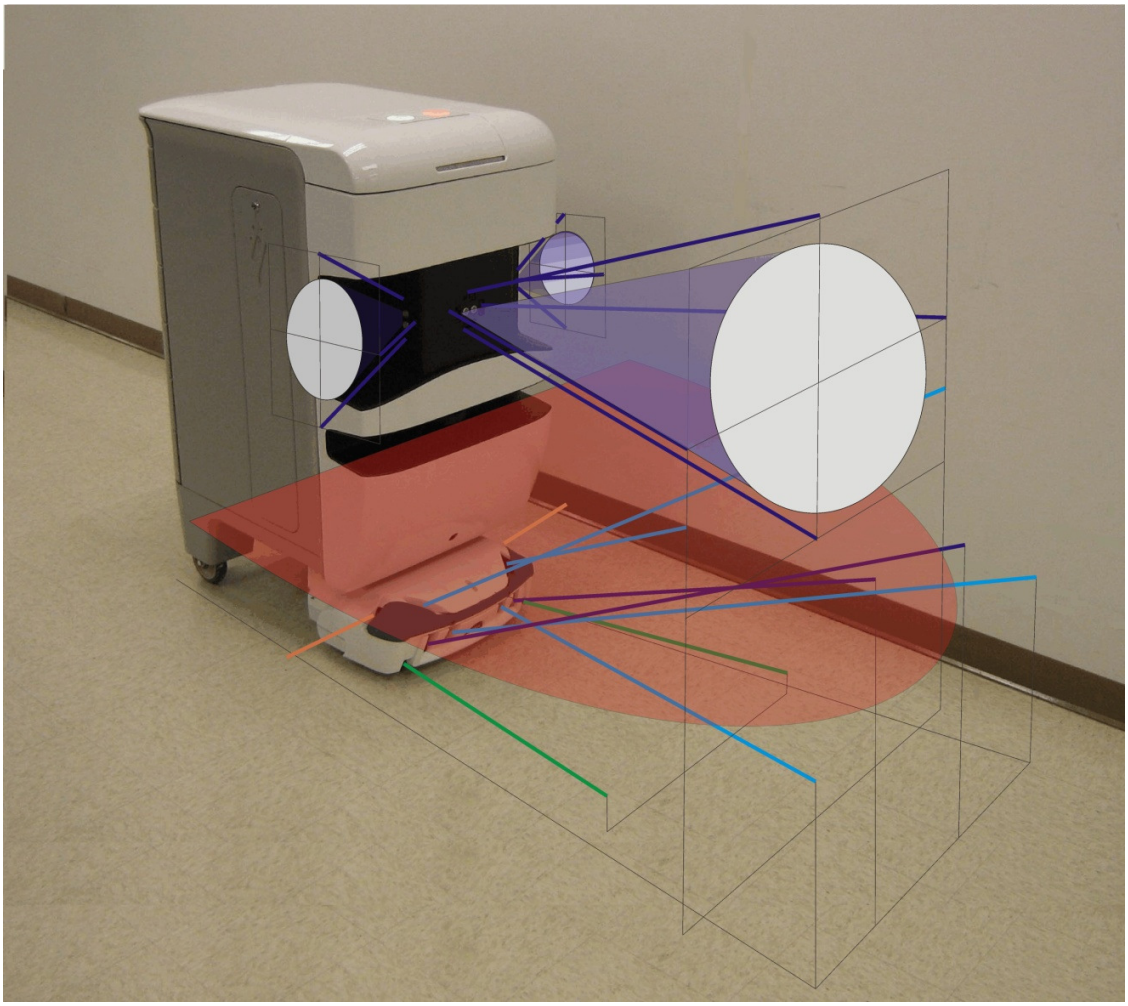
Communications – VOIP devices, smart phones, pagers

On Board Self-Diagnostics: Automatically connects with 24/7 help desk with full remote control capabilities

Infection Control: The TUG has a smooth surface, which can be disinfected by wiping with normal hospital disinfectants.

Navigation

Autonomous navigation using overlapping laser, sonar, and infrared sensors. TUG operates in a natural way – yielding right-of-way by stopping, slowing, or going around obstacles as appropriate – allowing it to co-exist with pedestrian traffic with no rules or training.



Operating the TUG

Sender

Users direct the TUG from a touch-screen monitor located at the home docking station where they simply choose a destination and press "go" to send it on its way. The on-board computer contains a map of the hospital.

On the touch screen, press the button(s) for your desired destination.

Press the **GO** button.

Receiver

Once the TUG reaches its destination, an individual removes the delivered item(s) and presses a green palm button on the top of the cart. The TUG continues to the next destination or returns to the home docking station.

Moving the TUG

In the event the TUG needs to be manually moved, simply press the red (pause) button and push the TUG out of the way. The TUG will automatically resume one its course after the pre-configured pause time (10 seconds default).

Continuing TUG

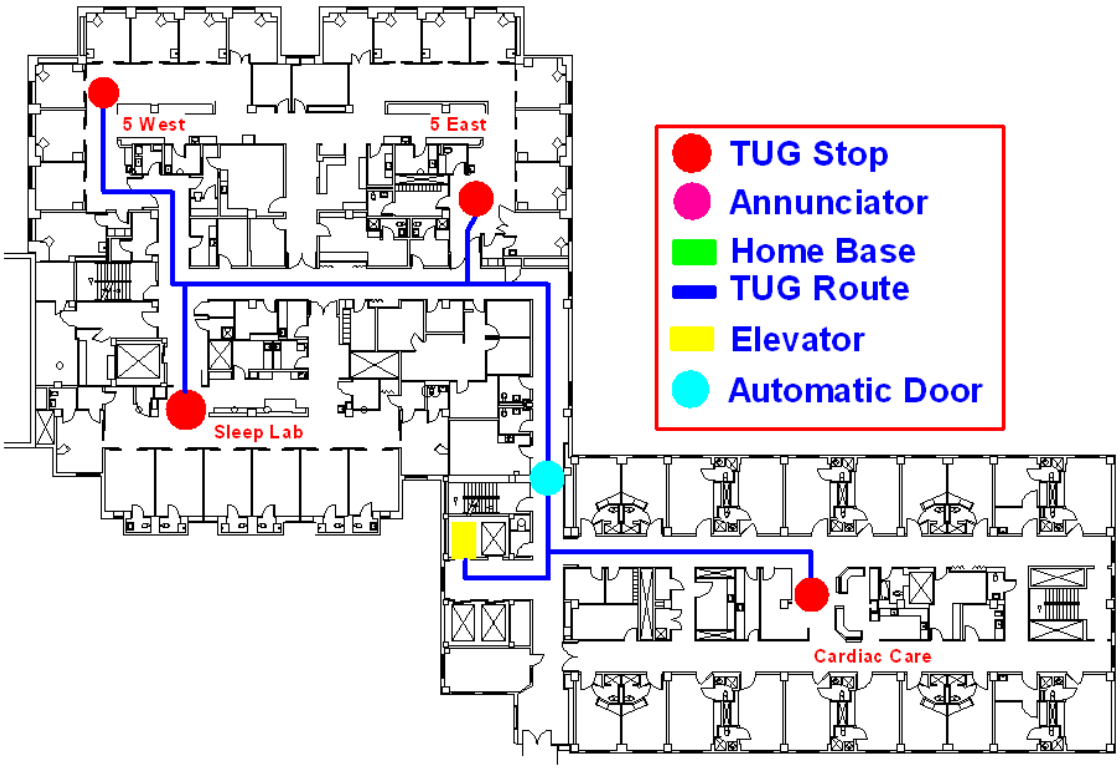
- Press the **RESUME** button.
- The TUG will continue on its path.
- If no button is pushed, the TUG will proceed on its own after 5 minutes.

Stopping TUG

- Press the **PAUSE** button.
- Push cart and TUG forward or backward, as needed.
- TUG will wait 10 seconds and then resume travel.

TUG Route Planning

CAD drawings are imported into a graphical interface program to create maps which the TUG uses to navigate. We also use the CAD drawings (as seen below) to visually identify the TUG path for the customer and show the location of the power requirements.



Additionally, in the case of fleet implementations (multiple TUGs across multiple departments), the Field Engineer will also configure the Fleet Management module. This module contains features to control and prioritize TUG traffic, including:

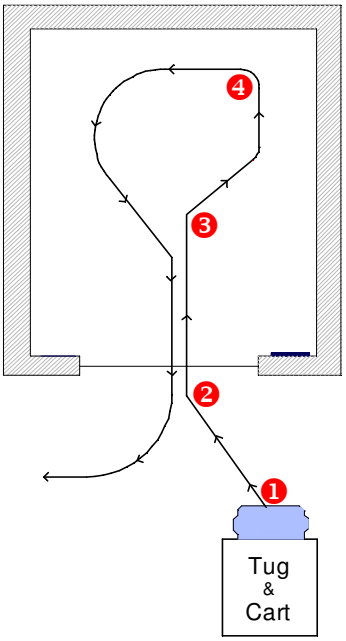
- Locking points –controls the ability of TUGs to pass in a particular hallway at the same time
- Buffering/Staging – controls the number of TUGs permitted to queue or pre-stage in selected areas of the pathway
- Elevator choice –controls TUG access to elevators based on cargo, time of day, availability, etc.
- Demand priority/proximity –controls the selection of vehicles and order in which requests for TUG service are met (assuming they cannot all be met simultaneously)

Elevator Operations

Elevator Selection

The TUG can use elevators with front and rear entrances. Your TUG implementation team will adjust the TUG's path based on the best mode for entry and exit.

Elevator interface development will require the assistance of your elevator manufacturer or your elevator service company. Aethon will work closely with your elevator service company contact to ensure a successful implementation and testing of your elevator interface.



Wait Location

The TUG waits in a location near the elevator as the cabin is being called❶. The TUG positions itself so beds can easily exit the elevator. In some situations, it may also be appropriate for the TUG to wait just outside the elevator lobby.

Emptying Cabin

The software proceeds to bring the cabin to the TUG floor empty. It accomplishes this by removing the cabin from the hall call button loop. It will then answer any remaining cabin call buttons. Once the last cabin call button is answered, the doors will close and the elevator will send Aethon a "no further demand" signal indicating that the cabin is now available for the TUG.

If a "no further demand" signal is not available, the TUG software will count a 10 second idle time and then assume the cabin is available for TUG use. The TUG will be announcing “Calling elevator” at this time.

Entering Cabin

Once the cabin has been emptied, the TUG will move toward the elevator. If people or obstacles are in the way, it will announce, "Waiting to proceed". Once the TUG is directly in front of the elevator door❷, it will call the cabin to its floor and open the door. The TUG will enter the cabin when the doors open and announce, “Entering elevator, please stand aside.”

Inside Cabin

The TUG will proceed to a point just inside the elevator❸ somewhat blocking the entrance. This is intended to discourage people from entering the elevator with the TUG and at least prohibit wheeled carts from entering. Once the doors close, the TUG will move to the back corner of the cabin❹. The intended TUG floor

button will be illuminated. If a person also enters the cabin, they will not be able to select a floor button and will be forced to ride with the TUG.

Alternatively, the TUG can move to position❹ and repeat the *emptying* cabin procedure to ensure no one is in the cabin before turning around. In this scenario, a person would be able to press a cabin button. This would be the preferred method but has the potential to double the TUG elevator travel time.

Exiting the Elevator Cabin

As the elevator cabin travels to the destination floor, the TUG is navigating through the elevator cabin and positioning itself to exit the elevator. When the cabin has arrived and the door is open, the TUG will hold the doors open while it exits. The TUG will be announcing “Exiting elevator, please stand aside” at this time. Once fully outside of the elevator cabin, the TUG will allow the doors to close and return the elevator to the hall call group.

TUG Elevator Emergency Mode

The Aethon system includes an elevator interface panel, mounted near the elevator controller cabinet, which allows the TUG to monitor various signals from the elevator controller. One of these signals is the Fire Service signal. By monitoring the Fire Service signal, the TUG is able to react immediately to a fire emergency situation by traveling to a predetermined safe parking location that is out of the direct path needed by emergency personnel.

The following process illustrates what happens when there is a fire emergency:

(1) The fire service signal from the elevator controller to Aethon's interface panel becomes active.

(2) The Aethon interface panel immediately sends the TUG a message placing it into emergency mode.

(3) If the TUG is already inside the car, the TUG will pull up to the door and wait for it to open. When the door opens, the TUG will drive to the emergency parking location.

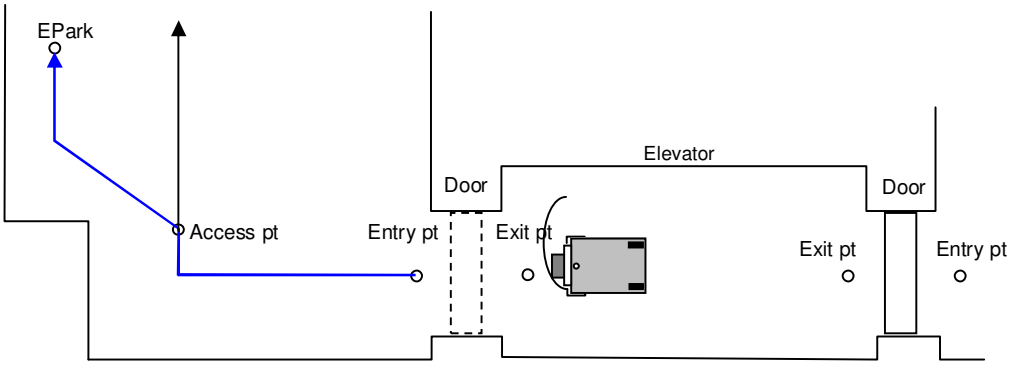
NOTE: The TUG will exit when the door opens whether it opens on the primary recall floor or an alternate recall floor.

(4) If the TUG is waiting to board the elevator, the TUG will simply drive to the emergency parking location.

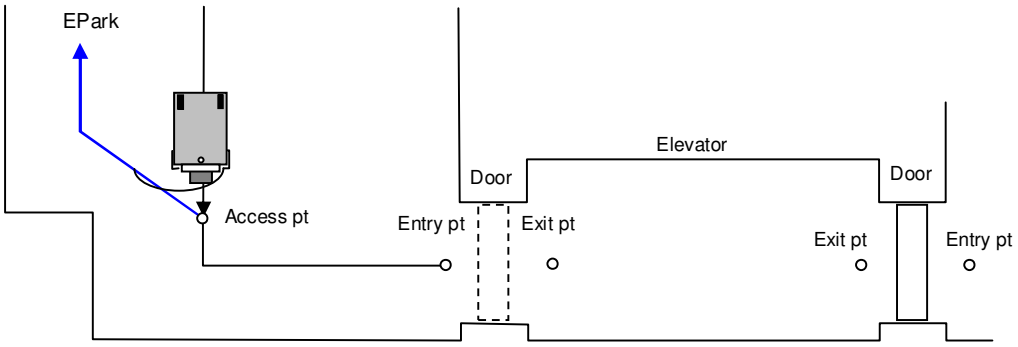
(5) When it reaches the parking location, the TUG will cancel its delivery and notify the Aethon helpdesk of the emergency situation.

The following diagrams depict example TUG paths (blue line) to the emergency parking location (EPark) when it is placed in emergency mode.

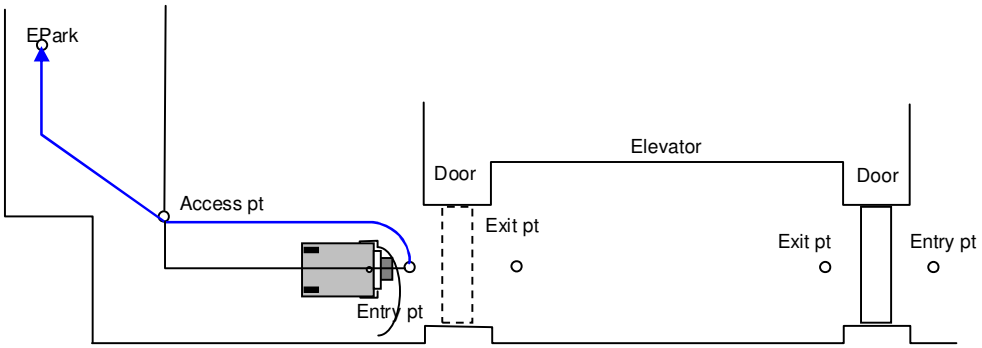
Path used to navigate to parking location when Emergency message is received while the TUG is in the Elevator.



Path used to navigate to parking location when Emergency message is received while the TUG is waiting for the Elevator.



Path used to navigate to parking location when Emergency message is received while the TUG is en route to the Elevator door, but prior to entering the car.



TUG Fire Emergency Mode

The Aethon system can monitor signals provided by building alarm equipment. Typically this includes a General Fire Alarm signal. This signal can be monitored by the Aethon elevator interface panel, mounted near the elevator controller cabinet, or by a remote IO panel installed where convenient to the building alarm equipment.

The General Fire Alarm signal can precede the release (closing) of fire doors up to 10 seconds. This delay is to allow the TUG to travel through a fire doorway zone that it might already be in when the signal is activated. By monitoring the General Fire Alarm signal, the TUG is able to react to a fire emergency situation by stopping at a predetermined safe location that is out of fire doorways or other emergency egress paths.

The following process illustrates what happens when there is a fire emergency:

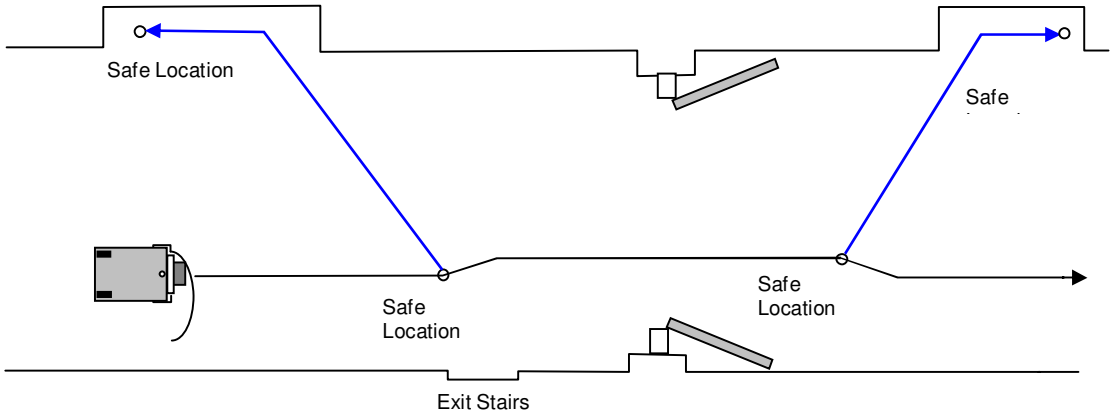
(1) The general fire alarm signal to Aethon's interface panel becomes active.

(2) The Aethon interface panel immediately sends the TUG a message placing it into fire emergency mode.

(3) The TUG will travel to the next predetermined safe location defined in its map.

(4) When the TUG reaches a safe location, the TUG will cancel its delivery and notify the Aethon helpdesk of the emergency situation.

The following diagram depicts an example TUG path through a fire door showing the safe location parking areas.

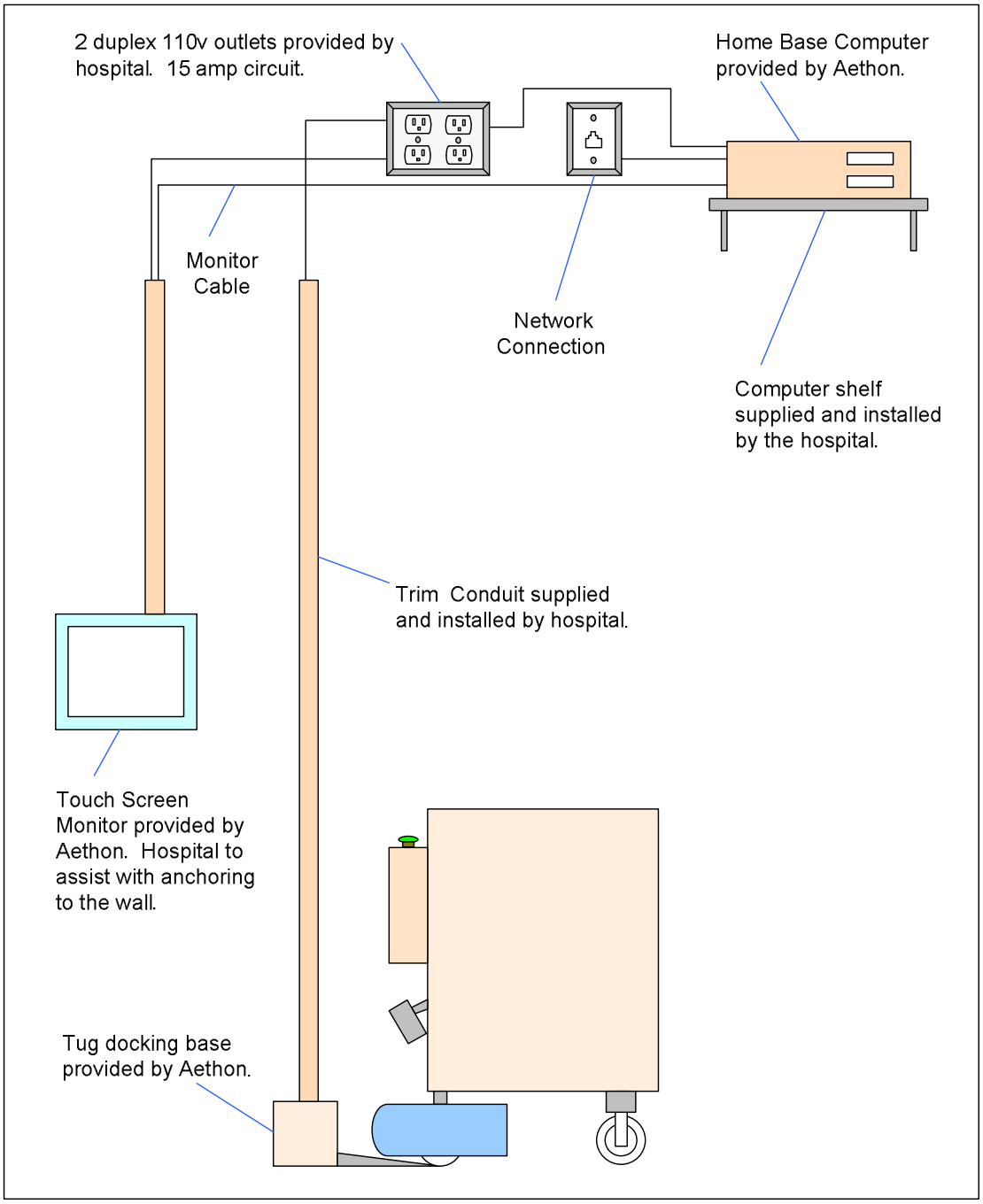


NOTE: The TUG, like all free-moving carts in a hospital, can easily be pushed/moved during an emergency.

Facility and Information Systems Requirements

TUG Home Base Station

The Home Base PC is equipped with a network card and is wired to the hospital network. The TUG communicates to the hospital's wireless network with an onboard wireless network card.



TUG Home Base Station (example)

TUG Batteries

Type: Sealed Lead Acid Battery (commonly VRLA, “valve regulated lead acid”)

- Power-Sonic PS-12120
- Recombinant oxygen cycle; no out-gassing during normal operation or charging
- Absorbent Glass Matt (AGM) technology (immobilized electrolyte)
- Spill-proof design and construction allows safe operation in any position
- U.L. recognized under file number MH 20845

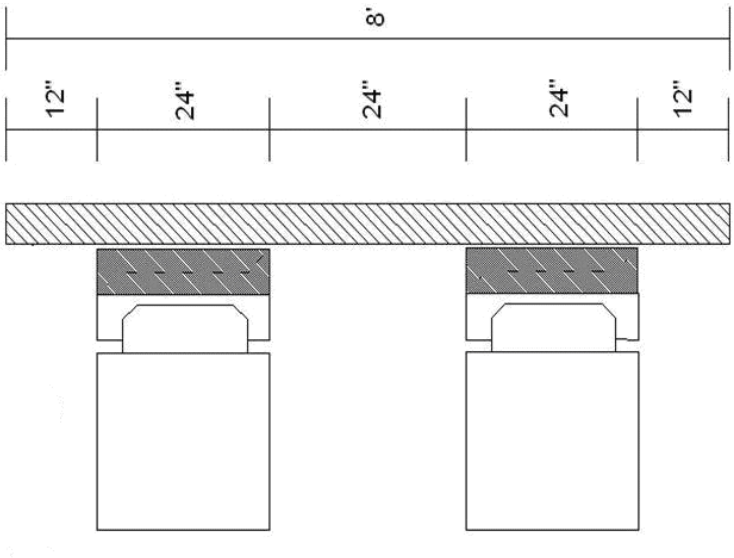
Capacity: Qty 4 – 2 series batteries stacked in parallel

- Each with 12VDC @ 12A-Hr
- Total 24VDC @ 24A-Hr

Weight: 9.0 lbs, 3.86"W x 5.95"L x 3.94"H

Transportation: Approved for air transport by DOT, IATA, FAA

TUG Charging Station(s)



Primary Power Input

85-264VAC +/- 10% at <3.2A / 1.6A RMS at full load

Fused at 6.3A, inrush (coldstart) <25A (peak)

Max. 85-132VAC @ 47-63Hz

Output Power on Skids

29VDC @ 5.5A nominal, 6.5A peak

Reverse voltage protection

Thermal shutdown built-in

Charging Current Limit

Square (voltage drops as current peaks)

Isolation

>20Mohms at 100VDC, outputs to chassis Ground

24V Ground tied to chassis ground (3rd prong of AC input)

Dock height is 27". Width is 12". Power drop needs to be placed to the right or to the left of the dock. If placed above the dock, the power drop needs to be higher than 27" above the floor.

Charging Base and TUG Electrical Safety Considerations

Charging Base

The TUG Charging Base is a Class I power supply and, as such, requires an Earth safety ground connection provided by the AC power cable. The output of the Charging Base is +29VDC +/- 1V which meets the definition of IEC Extra-low Voltage (<50VAC and <120VDC).

TUG on Charging Base

When the TUG is on the Charging Base. it is classified as a Class III PELV (Protected Extra-low Voltage) system, as an Earth ground connection is made through the Charging Base. The maximum voltage in the TUG is the Charging Base output in this configuration (nom 29V).

TUG Standalone

When the TUG is not on the Charging Base, it is classified as a Class III SELV (Safety Extra-low Voltage) system, without an Earth ground connection. The maximum voltage in the TUG is the battery voltage in this configuration (nom 24V, max 29V).

IEC 61140 definitions:

- ELV is classified as <50Vac rms and <120Vdc.
- SELV is classified as "an electrical system in which the voltage cannot exceed ELV under normal conditions, and under single-fault conditions, *including* earth faults in other circuits".
- PELV is classified as "an electrical system in which the voltage cannot exceed ELV under normal conditions, and under single-fault conditions, *except* earth faults in other circuits".

Home Base PC

Manufacturer/Model

Dell OptiPlex 780 Minitower

Dimensions

14.2"H x 6.9"W x 16.4"D

Input Power Requirements

90-264VAC 47-63Hz, 300W Max

Departure Monitor

At each TUG Home Base Station there is a wall-mounted, touch-screen monitor which allows the user to select the destination(s) for the TUG. It will also display the location of the TUG as it is traveling to a destination. An announcement will be heard through speakers on the monitor when a delivery has been made.

Manufacturer/Model

Elo 1529L Touch Monitor

Dimensions

11.27”H x 13.99”W x 10.44”D

Input Power Requirements

90-265VAC 50/60Hz, 50W Max

Annunciator

When the TUG is making a delivery to a location that is behind a closed door, an Annunciator can be mounted on a desk or wall inside the room. As the TUG approaches the room, it sends a radio frequency signal to the Annunciator which beeps and lights to indicate the TUG has arrived outside the door. The radio frequency is 433MHz, similar to a garage door remote control.

Power Requirements

Input power: 90-264VAC 47-63Hz, 0.5A Max

Power supply UL/CUL: File E245587, UL 1310

Automatic Door Interface

The Automatic Door Interface allows the TUG to remotely control the switch for an automatic door. This is necessary since the TUG is unable to physically press the wall-mounted switch when it wants to pass through the doorway.

Aethon will provide a wireless relay and cabling (see photos below) for each automatic door to be opened along the TUG's path. Coming out of the relay is a 4-wire cable terminated with a male disconnect. The female disconnect (also provided by Aethon) is to be mounted through a hole (pre-existing or newly drilled) on the door control box. The hole size should be approximately ½" to allow for the female disconnect and included hex nut to be secured. The hole is wired and drilled by the company who services the doors.

The relay uses a frequency of 433MHz (same as a garage door opener).

Power Requirements

Input power: 24VDC or 24VAC, 3W Max

The 4 wires are to be connected to the door control box as follows:

Power to TUG Interface Box

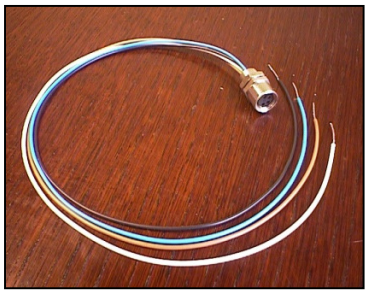
(1) Black Wire – ground
(2) Brown Wire – +24VDC or 24VAC

TUG Interface Box to Door Control Box

(1) White Wire to Hallway door button switch – N/O contact switch
(2) Blue Wire to Hallway door button switch – N/O contact switch

NOTE: White and Blue wires simply provide a closed circuit to activate the door controller. Typically these two wires connect to the hallway door button switch. However, depending on your door control box you may chose an alternate location.

Automatic Door Relay

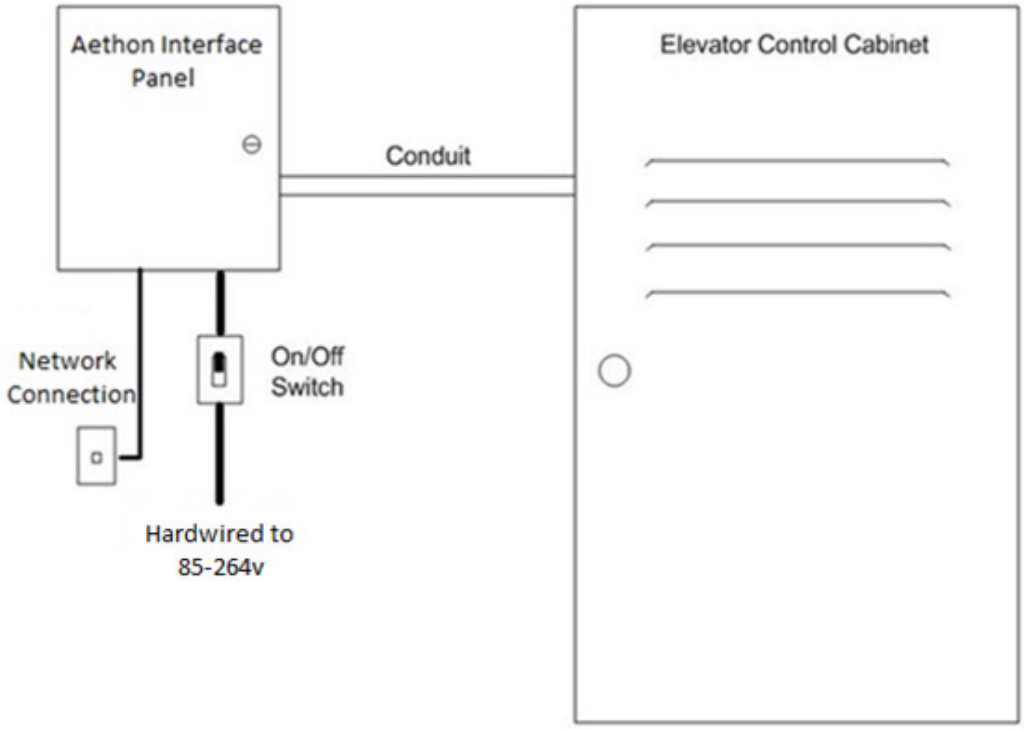


Female Quick Disconnect

The hospital can choose whether the relay will be located on top of the door control box or hidden above the ceiling tile. The weight of the relay is 7 ounces.

Elevator Interface

The Aethon Elevator Interface enables the TUG to interact with the elevator much like a person (call the elevator, send to desired floor, enter, and exit). The TUGs uses wireless Ethernet to communicate to a PC mounted in the Aethon Elevator Interface panel which is connected to the elevator controller. Inside the box, there are relays that close or open according to the requests received from the TUGs. The interface also informs the TUG of the current elevator cabin location and direction of travel.



The Aethon Elevator Interface panel meets NEMA 1 requirements and is 20"H x 16"W x 6-5/8"D. It should be mounted on the wall near the location of the elevator controller.

Typically a 37 conductor, 18AWG numbered wire cable is used to connect the Aethon panel to the Elevator Controller cabinet. This requires a minimum of a 1¼" pipe.

A hospital network outlet is required near the Aethon Elevator Interface panel. Aethon will supply a 6' patch cable from the outlet to the Interface panel.

Power Requirements

Input power: 85-264VAC, 47-440Hz, 0.5A Max

Summary of Electrical Requirements

Equipment	Total # of Receptacles Needed	VAC	Max Amps
Charging Dock	1	85-264	3.2/1.6A
Home Base / User Interface PC & Monitor	2	90-264	3/1.5A
Elevator Interface Panel	*See note	85-264	0.5A
Annunciator	1	90-264	0.5A

* The Elevator panel will be hard wired into an electrical circuit using a disconnect box supplied by Aethon.

TUG Wireless Communication

The TUG requires wireless network access for communication at the docking stations, the elevators and elevator lobbies, load/unload destinations, and areas where multiple TUGs may cross each other's paths. Wireless network coverage is strongly recommended along the TUG routes.

Network Settings

Wired LAN ports and Static IP Addresses are assigned by the hospital for each Home Base PC, User Interface PC, and Elevator Interface Panel.

Static or DHCP-Reserved IP addresses are assigned by the hospital for each TUG. An additional IP address is needed during installation for the Aethon implementation specialist laptop.

Device	Location	LAN/WIFI	MAC Address	IP Address	Netmask	Gateway
HomeBase PC		LAN		<192.168.0.99>	<255.255.255.0>	<192.168.0.1>
User Interface PC		LAN				
Elevator Panel 1		LAN				
Elevator Panel 2		LAN				
Tug 1	Roaming	WIFI				
Tug 2	Roaming	WIFI				
Installer Laptop1	Roaming	WIFI				
Extra IP Range	Future TUGs					

Wireless Authentication

TUGs will include either Intel PRO/Wireless 2200BG or Intel Centrino Advanced-N (ABGN).

Currently supported wireless authentication methods: WEP, WPA-PSK, WPA-EAP, WPA2, EAP-Fast, IEEE8021X, LEAP, PEAP.

Preferred methods: WPA-PSK or WPA2-PSK

Protocol: <EXAMPLE: WPA2-PSK>
Encryption Method: <EXAMPLE: AES>
SSID: <EXAMPLE: TUGNET>
Key: <EXAMPLE: ABCDEF4126140235>

Remote support from Aethon's help desk to the hospital's TUG network uses the secure socket layer protocol as an added security measure. In addition, each host in the TUG networked infrastructure uses a firewall and only allows specific IP addresses and ports to access the network.

Virtual Private Network (VPN) and Email Account (SMTP)

VPN – Remote access to the TUG Home Base PC is accomplished with a VPN tunnel, which provides an encrypted and secure way of transmitting data between the hospital and Aethon via the Internet. The hospital is required to provide an IP address and network connection at the home base computer for this purpose.

Aethon currently supports two options for the remote access.

Option 1: Hospital provides Internet access to the Home Base PC, or two specific paths out of the firewall.
SSH = Helpdesk connection server (38.107.149.254 port 22).
Home Base PC establishes outbound Secure Shell tunnel to the Helpdesk server.

Option 2: Hospital establishes a persistent B2B VPN.
VPN = Aethon Cisco ASA
The VPN is handled by the VPN/Firewall appliances on both sides.
The Aethon VPN setup form will also need to be filled out.

Due to the Real Time nature of the Aethon Robotics System and to provide 24x7 help desk service and support, Aethon does not support Web Based, Token Based, Client Base or Terminal Server application based virtual private networks.

SMTP – The SMTP Address will be used by the Homebase to send outbound messages to tugmessage@aethon.com. Aethon maintains its own SMTP server for this purpose and the site need only allow SMTP traffic through its firewall. If SMTP traffic is not allowed through the firewall our software allows for the use of a site provided SMTP relay. If necessary, the Home Base PC can authenticate with a username and password to said relay. As a third option our software can be configured to use site provide email account and credentials.

Aethon currently supports the following options for SMTP access

Option 1: Hospital allows access through the firewall to Aethon Exchange server
SMTP = Aethon Exchange server (66.192.107.205 port 25).

Option 2: Hospital provides an SMTP relay and credentials, if necessary, for email traffic to Aethon.

Option 3: Hospital provides email address on its email server with credentials to send email traffic to Aethon.

Virus Protection

Aethon uses Norton Anti-Virus software on all Windows-based internal and external PCs and Server machines. In addition, the TUG network's embedded system is based on a read-only version of Linux.

The Aethon Home Base Server is designed to provide the highest level of network security so that sensitive data is kept secure and protected from all internal and external threats. Its Linux-based operating system is inherently secure, as all application-level processes are executed within a sandboxed environment that does not allow administrative actions to be taken. The server utilizes a strict IP tables-based firewall policy that blocks all inbound and outbound traffic except that which originates from Aethon-approved devices, such as the TUG robot, the MedEx™ workstation and servers via a secure connection from our data center. All non-essential services, such as email and FTP, are disabled to prevent malicious use.

Paging

When the TUG is making a delivery to a location that is behind a closed door, or to a destination that is not supported by an FTE, the TUG can send an email to a Text-Based Pager alerting the staff of the delivery. These messages can be customized per delivery.

It is important to note that the pager must have an associated email address, (for example: 4125551111@aethon.com).

Campbells Run Business Center
100 Business Center Drive
Pittsburgh, PA 15205
Help Desk: 1-888-201-9522
www.AETHON.com