

# Operation Manual

## Group 21

### New Housing Structure for Deep Sea Equipment



## Earth, Ocean and Atmospheric Science

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## ABSTRACT

The purpose of this design project was to design a new frame for Florida State University's tether-operated vehicle (TOV). The purpose for this vehicle is for surveying and exploring the ocean floor. Florida State's TOV consists of a galvanized steel frame with an array of surveying equipment and unistrut bars for attaching the equipment. The current TOV has too much empty space, is difficult to move around, and does not tow parallel to the ocean floor. The redesigned frame for FSU's TOV addresses these issues. This operation manual provides important information and instruction for how to operate the new frame. It functions by rigging up all the necessary components and dragging behind a cruise ship via a steel braided cable as the various surveying equipment collects data and transmits it back up to the boat by means of a fiber optic cable. In order to do this the equipment, bridle, and the side panels are attached to the frame. As with any design, there are some sources that could cause failure. These are addressed in the manual and recommendations on trouble shooting and proper maintenance are provided. Also listed in the manual are some recommendations on spare parts that will make the operation of the TOV more convenient for the user.

## Acknowledgements

We would like to thank the sponsors, Dr. Ian Macdonald and Eric Howarth, for giving this team the opportunity to help them with their project and providing the necessary guidance along the way. We would also like to thank Dr. Nikhil Gupta for making the time to meet with us at least twice a month and helping us on deciding on proper analysis techniques and vital design decisions. Additionally, we would like to thank our advisor, Dr. Camilo Ordoñez, for also providing advice on proper testing techniques and aiding during the analysis of the testing results. Finally, we would like to thank Dr. Patrick Hollis for helping the design team perform the stress analysis.

## I. Introduction

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Tether operated vehicles (TOVs) are utilized to survey and explore the ocean floor. This project was to design a new frame for Florida State University's TOV. This new frame is made from aluminum 6061 treated for corrosion resistance. An array of aluminum unistrut is used to attach the 17 pieces of data collecting equipment to the frame. A bridle made of steel cables attaches to the 3 connection points on the frame. The TOV will tow parallel to the ocean floor due to the specified lengths of the steel cables creating balanced the moments. Plastic side surfaces are utilized to create drag forces perpendicular to the flow, causing the vehicle to remain moving in a straight line. Feet have been incorporated to the frame to prevent the frame from settling on anything unfavorable (feet, equipment, etc.). The feet are attached so that they do not have any range of motion. They are also specialized so that the wheels provided are easily attachable and detachable. The TOV is launched off of cruise ships using an A-frame, and its altitude once in the water is controlled by a steel cable attached to a winch and pulley system. The entire system and electronics are wired back to the boat using a fiber optic cable.

This document is a guide to show how the TOV is assembled and operated, how to recognize and solve the potential problems associated with this product, how to perform regular maintenance, and provides an inventory of the components of this design.

## II. Functional analysis / Functional Diagram

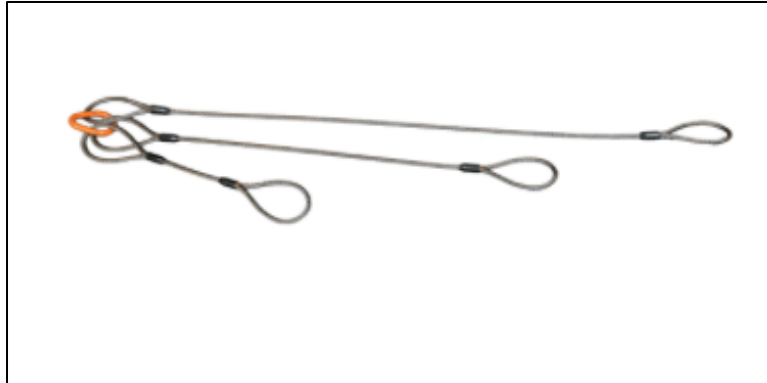
The frame and all of its connected equipment will function under the water as the cruise ship is dragging it. This is where it fulfills its purpose of surveying and exploring the ocean floor. Its function can be broken down into two main components, the towing and the data collecting and transmission. This section describes these components of the TOV's function

### a. Towing

The frame of the TOV has 3 connection points. These can be seen below in Figure (2) in section IV. At these connection points, the 3 ends of the 3-cable bridle that is included with the TOV are attached via a lifting shackle. This bridle is made of braided steel. The lengths of the 3 cables that make up this bridle are designed so that the TOV maintains a towing angle that is parallel to the ocean floor. This bridle was designed to constrain the pitch and roll of the structure. The 3 cables of the bridle converge at the top to an oblong master link. The oblong master link is the piece that attaches to the winch's towing cable. The bridle looks something like Figure (1). The ends of each cable are turned around and crimped around the shackle at the connection points on the frame. Surfaces attached to the side of the frame are utilized to create drag forces perpendicular to the flow, ensuring that the frame does not drift to the left or right, or move about the yaw



axis. These can also be seen in Figure (2). Once the vehicle is tethered, it is launched into the water and given time to sink to the desired depth. The altitude in the water is manually controlled on the boat using a winch and pulley system.



**Figure 1:** Image of the 3-cable bridle meeting at oblong master link, similar to the one utilized with the TOV. The yellow oblong master link attaches to the winch's towing cable and each of the 3 loops is crimped around a lifting shackle, which is attached to each of the TOV's three connection sites.

## b. Data Collecting and Transmission

Once the TOV is in the water at the desired depth and is being towed at the desired speed and orientation, the remaining function is of the components. Many pieces of equipment may be interchangeably utilized with this frame, but a list of the 17 pieces of equipment that this TOV was designed to hold and be used with can be seen in Table (1) below. This list consists of various lights, cameras, lasers, surveying and transmission devices, and electronics and their housings. The Nexus Sea Bottle is the device that collects the data from the components and transmits up to the boat by means of a fiber optic cable.

**Table 1:** List of the 17 pieces of equipment that this TOV was designed to be used with, though these are not the only equipment that may be utilized.

Component Name	Category	Number
Sub-Bottom Profiler	Surveying	1
Lantern Shark	Lights	2
LED Multi-Sea Light	Lights	4
Multi-Sea Cam	Camera	1
Navigator DVL	Surveying	1
SBE SeaCAT Profiler	Surveying	1
Sea Laser 100	Laser	2
Nexus Sea Bottle	Transmission	1
Track Link 500 Series	Surveying	1
Release Mechanism	Surveying	1
Still Camera	Camera	1
Linear Power Converter	Electronics	1

### III. Project/Product Specification

Below is a list of the key components for the TOV and their specifications.

#### a. Frame

The frame dimensions can be seen in Figure (BLANK). It was machined from Aluminum 6061 piping with a 2-3/8 inch outer diameter at a 0.218 inch wall thickness. Its mechanical properties can be seen in Table (2).

**Table 2:** Table showing some mechanical properties of the aluminum used for the frame

Brinell Hardness	95
Tensile Strength	45,000 psi
Yield Strength	40,000 psi

#### b. Lifting Shackle

The three lifting shackles provided with this TOV are Lehigh's galvanized steel anchor shackles. They are 3/8 of an inch, weigh a third of a pound each, and have a loading capacity of 2000 pounds. A more complete specification chart can be seen in Appendix (A).

#### c. Oblong Master Link

The oblong master link that this TOV is designed to be used with is Peerless Chain's Double grade 100 model. It is made of steel and has a coating in

plastic to prevent corrosion. It has a length of 4-15/16 inches and a width of 2-11/32 inches. It weighs 7400 pounds and has a load limit of 7400 pounds.

#### d. Unistrut

Various lengths of slotted Aluminum 6061 unistrut are utilized on this TOV to attach the equipment to the frame. See Appendix (A) for the CAD drawings of the unistrut.

#### e. Wheels

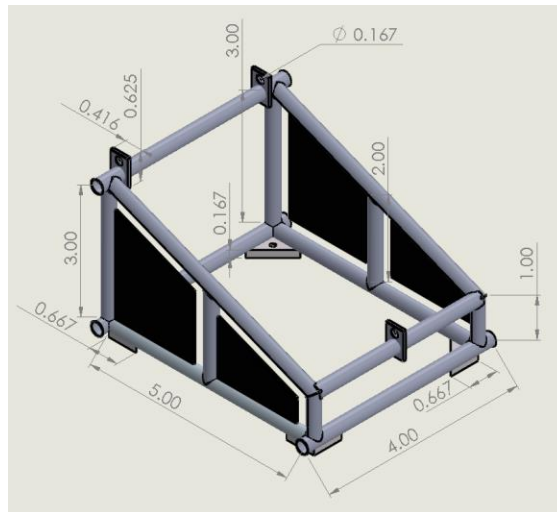
The wheels that are supplied with this TOV are the Focus FTC34105HD models. There are 4 of them. They are polyurethane wheels with braking mechanisms. Each wheel has a load capacity of 250 pounds and have a  $\frac{3}{4}$  inch by 1 inch #10 threaded stem. They have a height of 7.1 inches, width of 1.5 inches, and a weight of 9.1 pounds.

#### f. Side Panels

The side panels were laser cut to specific lengths using half inch ABS plastic which has yield strength of 8790 psi.

### IV. Product assembly

This section shows the assembled TOV with the key components attached. The arrangement of the unistrut array and equipment varies by user and by their needs, so the inside has been left empty. A list of the parts can be seen in Table (3). (The bridle has not yet been designed in the actual project so the assembled drawing does not include the bridle. The wheels have also been omitted because they have not been ordered or been drawn in CAD.)



**Figure 2:** CAD drawing of the final TOV design. This model incorporated the frame, the side panels, and the feet. Dimensions shown are in feet.

**Table 3:** Part list corresponding to the assembly of the TOV seen in Figure (3)

Part #	Name	Quantity
1	Frame	1
2	Side Panel	4
3	Feet	4
4	Wheel	4
5	Shackle	3
6	Bridle	1
7	Master Link	1

## V. Operation Instructions

This TOV is designed so that it can be rigged to most towing systems for universal usage. These operations instructions will tell the user how to prepare the TOV so that it will be ready to attach to any towing cable and launched off of most boats.

### a. Attaching Equipment to Frame

The unistrut attaches to the frame using U-bolts. Depending upon the user's needs, you may want to set up 1-2 layers for equipment. Each components attaches differently. You must refer to that components user manual to read how to mount it. Unistrut it attached to the frame length wise, and more unistrut is attached to those widthwise, depending up where the component needs to be placed. A nut a bolt connects the pieces of unistrut to each other. The assembly of the internal array is entirely up to the user and depends on their needs.

### b. Attaching Bridle to Frame

The bridle is attached to the frame by means of lifting shackles. To attach, remove the pin of the shackle so that the cross bar can be opened. Hook the shackle around the connection points on the TOV, close the cross bar, and reinsert the pin. Once this is attached, the TOV is ready to be attached to a towing cable in preparation to be launched.

### c. Attaching Side Panels

The side panels come attached to the frame, but if for any reason they become detached, they are simple to reattach. They attach to the frame using simple hose clamps. Attach each side loosely to the corresponding area of the frame. Tighten each hose clamp a little bit at a time so that the load will be applied equally to all of the clamps, minimizing malfunction. These must be tide tight enough so that the panel does not have the freedom to move, this will make the side panels most effective.

## VI. Troubleshooting

Although this TOV is designed for high reliability, it is possible that you may experience some troubleshooting. Below is a list of some possible problems you may encounter and suggested solutions. Reference this section if you experience problems operating the TOV.

### a. Potential Problems

- i. Not Towing Straight – If the vehicle experiences problematic pitch yaw or roll during towing, refer to solution i below.
- ii. Wheels not rolling – If the wheels are jammed into place or the locking mechanism is not functioning, attempt solution ii below.
- iii. Failure of Hose Clamp – The side panels are attached to the frame via hose clamps. While these side panels do not experience very high forces, there is always a chance that these hose clamps will experience failure. If this occurs refer to section VII. Regular maintenance subsection d. Component replacement.
- iv. Failure of Lifting Shackle – The lifting shackle is rated for a weight significantly higher than it is designed to experience. Though if failure occurs, refer to section VII. Regular maintenance subsection d. Component replacement.
- v. Fracture of Frame – If a fracture in the frame occurs, the TOV must be taken to a shop to be repaired. It is not recommended to attempt to repair the frame by oneself due to the danger that is caused by welding equipment. Also, one should make sure that most of the full integrity is restored before using the frame again. Professional welding services are recommended.
- vi. Failure of Oblong Master Link – The oblong master link is rated for a weight significantly higher than it is designed to experience though if failure occurs refer to section VII. Regular maintenance subsection d. Component replacement.
- vii. Failure of Unistrut – The Aluminum unistrut is rated for loads higher than what they are expected to experience during towing. If failure still occurs, refer to section VII. Regular maintenance subsection d. Component replacement.

### b. Potential Solutions

- i. Visually inspect the bridle and ensure that no twisting or tangling has occurred. If a problematic pitch continues and the vehicle is lower in the front, it is recommended to shorten the front cable of the bridle. If it is lower in the back, it is recommended to shorten the back two cables of the bridle.

- ii. Visually inspect the wheels for debris and attempt to remove any debris found. If the debris has caused damage to the component, refer to section VII. Regular maintenance subsection d. Component replacement.

## VII. Regular Maintenance

Although this TOV is more than capable of holding the 17 pieces of equipment it was designed for, plus much more, it is always important to perform regular maintenance in order to ensure prevent failure and ensure safety.

### a. Pre-Cruise Inspection

Before using the TOV, the user should perform a visual inspection to make sure there are no obvious points of weakness that could be subject to failure.

- i. Check the welds to make sure that their integrity remains in-tact and there are no obvious points of weakness or fracture. If a weld does not look in-tact, do not proceed with use in a cruise.
- ii. Make sure all of the feet are tightly fastened to the frame and none are wiggling or loose. This will ensure safety during deployment and retrieval.
- iii. Make sure all the unistrut that has been bolted on are tightly fastened to the frame and there is no room for movement. This will prevent parts from coming loose underwater.
- iv. Make sure that the lock on the wheels remains effective before attaching them to the feet. This will ensure safety when the wheels are attached to the vehicle.

### b. Proper Cleaning

The vehicle should be thoroughly cleaned after each use. The vehicle is subjected to marine plant and wild life while cruising under the water and this can dry and cause damage to the waterproofing of the frame or compromise the integrity of the material.

### c. Proper Storage

The user should ensure that the TOV is stored in a safe, clean, and dry environment while not in use. Prolonged exposure to harsh environments could compromise the integrity of the waterproofing techniques that were applied to the aluminum or cause corrosion. The user should also not store the TOV with all of the equipment attached. After cruises, the equipment should be detached until the next cruise.

### d. Component Replacement

This TOV utilizes mostly off the shelf items.

- i. Unistrut Fracture – The aluminum unistrut used on this TOV is easily available off of most metals websites. It is not recommended to repair a failed piece of unistrut, but instead to replace it with a new piece.
- ii. Lifting shackle and oblong master link – Both of these components are also universally available at many home improvement stores and websites. If failure or corrosion occurs in either of these pieces, it is recommended to replace with a piece of equal or greater loading value.
- iii. Hose Clamps – Hose clamps are also universally available at any home improvement stores. If failure occurs in these components, it is recommended to replace with a piece of equal or greater loading value.
- iv. Wheels – Many kinds of lockable wheels are commercially available. If failure occurs in one of the wheels, it is recommended to replace the wheel with the exact model so that there will not be discrepancies among the 4 wheels. If that specific model is not available, it is recommended to replace all of the wheels.

## VIII. Required Spare Parts

This TOV does not require any spare parts, though it would be convenient to have a few just in case a component experiences failure. Some of the components, which you may want to keep a back-up of, are listed below.

- Various lengths of Aluminum unistrut
- Lifting shackles of equal or greater load ratings
- Oblong master links of equal or greater load ratings
- Hose clamps of equal or greater load ratings with similar size ranges
- Individual or sets of wheels

## IX. Conclusion

In conclusion, proper maintenance and storage will prevent most issues. It is important to perform regular inspections of the TOV especially before use. This is a large product with much weight that could prove hazardous, so it is important to always practice safety procedures and caution while handling and interacting with it. This TOV is designed to support the weight of more than 900 pounds of loading, which is significantly more than the expected loading (SEE IF YOU CAN FIND ACTUAL NUMBER). If the user identifies a problem on the frame, it is recommended that a professional be hired to fix the issue in order to maintain as much of the TOV's structural integrity as possible. Most of the components not including the frame are commercially available in many home improvement stores and need only be replaced if necessary.

## X. References

- [1] <https://www.metalsdepot.com/products/alum2.phtml?page=pipe&LimAcc=%20&aident=>
- [2] <http://www.mcmaster.com/#3230t26/=11sdux0>
- [3] <http://www.homedepot.com/p/Lehigh-2000-lb-x-3-8-in-Galvanized-Steel-Anchoring-Shackle-7202S-6/100315094>
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- [5] <https://www.fastenal.com/products/details/0523403?term=oblong+link&r=~|category11:%22601922%20Lifting%20and%20Rigging%22|~%20~|category12:%22601933%20Lifting%20Hooks%20and%20Attachments%22|~%20~|category13:%22609107%20Master%20Links%22|~>



# XI. Appendix

The first figure shows the CAD drawing for the unistrut used to mount the equipment in the structure. The second figure shows the specification sheet of the lifting shackle.

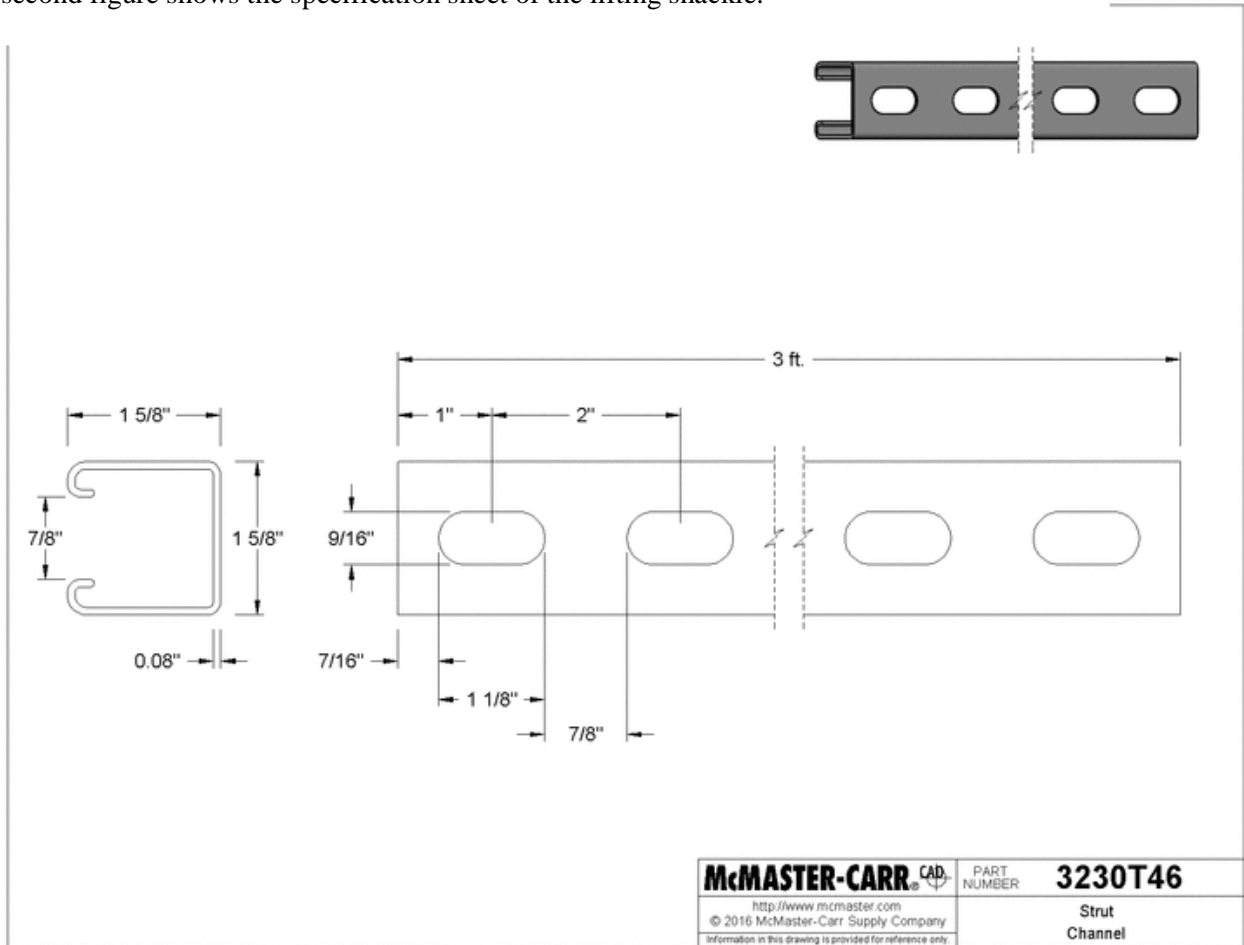


Figure 1: CAD drawing of the unistrut used for mounting equipment to the frame

**DIMENSIONS**

Assembled Depth (in.)	.25 in	Hook length (in.)	0.875
Assembled Height (in.)	5.75 in	Hook opening (in.)	1.0
Assembled Width (in.)	2.75 in	Projection (in.)	2.5
Hook diameter (in.)	0.375		

**DETAILS**

Fastener Type	Other Hook	Maximum Weight Capacity (lb.)	2000.0
Finish Family	Metallic	Package Quantity	1
Magnetic	No	Product Weight (lb.)	0.33 lb
Material	Galvanized Steel	Self-adhesive	No

**Figure 2:** Specification Sheet for the lifting shackle