



# Delta Explorer



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Pilot 2<sup>nd</sup> YR Elec Tech



CFO: Scott Precop, Safety  
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Supervisor, 2<sup>nd</sup> YR Elec Tech



Program Engineer: Mario  
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YR Comp. Science



Design: Ray Thompson,  
Tether Tech, 1<sup>st</sup> YR Elec Tech



Mentor: Professor Scott Fraser

## Delta Explorer

### Abstract

Smart, simple and robust—it belongs in the water. We didn't want to build just another remotely operated vehicle (ROV) that performs functions in any underwater environment; we wanted to create a small, compact, manageable working class ROV capable of enduring the harshest arctic conditions, to negotiate in or around any obstacle and to handle tasks normally associated with the larger working-class ROVs. Not only does our emphasis on being compact improve operational efficiency and safety, it drastically lowers the cost to our customers. Delta Explorer's lines are sleek, rounded, hydrodynamic, so that when it swims, it easily negotiates currents or waves coming from any direction without losing its heading. Every component is specifically manufactured to minimize current flow obstruction. We opened the frame to the maximum tolerance without reducing structural integrity or additional equipment options. VX Industries offers three payload configurations, each designed with mission specific tools for its industry intended purpose: science and exploration, specifically for under ice conditions, subsea pipeline inspection and repair, and offshore oilfield maintenance. The modular design creates unparalleled electronics options, while the tools, though designed with their specific purpose, are also multifunctional for a wide range of needs. As the name implies, the Delta Explorer's robust, compact, modular and omnidirectional design, will change the way we explore, change the way we engineer, and change the industry standard.



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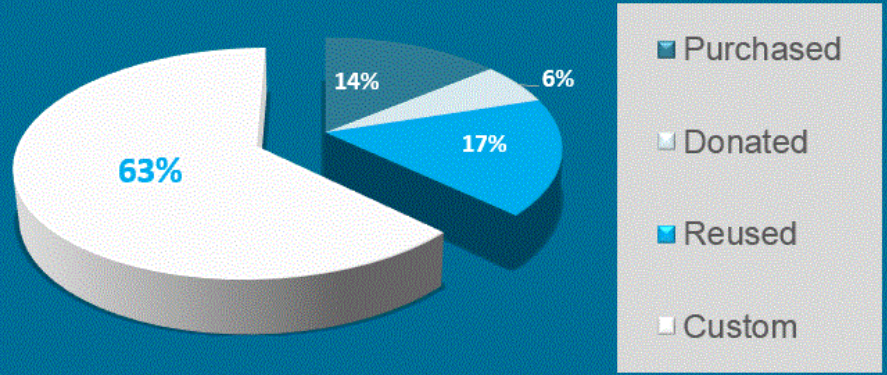


**OUR MISSION—TO DESIGN AND BUILD SIMPLE,  
INNOVATIVE REMOTELY OPERATED VEHICLES FOR  
TOMORROW'S UNDERWATER NEEDS**

# FINANCIAL REPORT



## ROV PARTS MAKE UP



### BUDGET

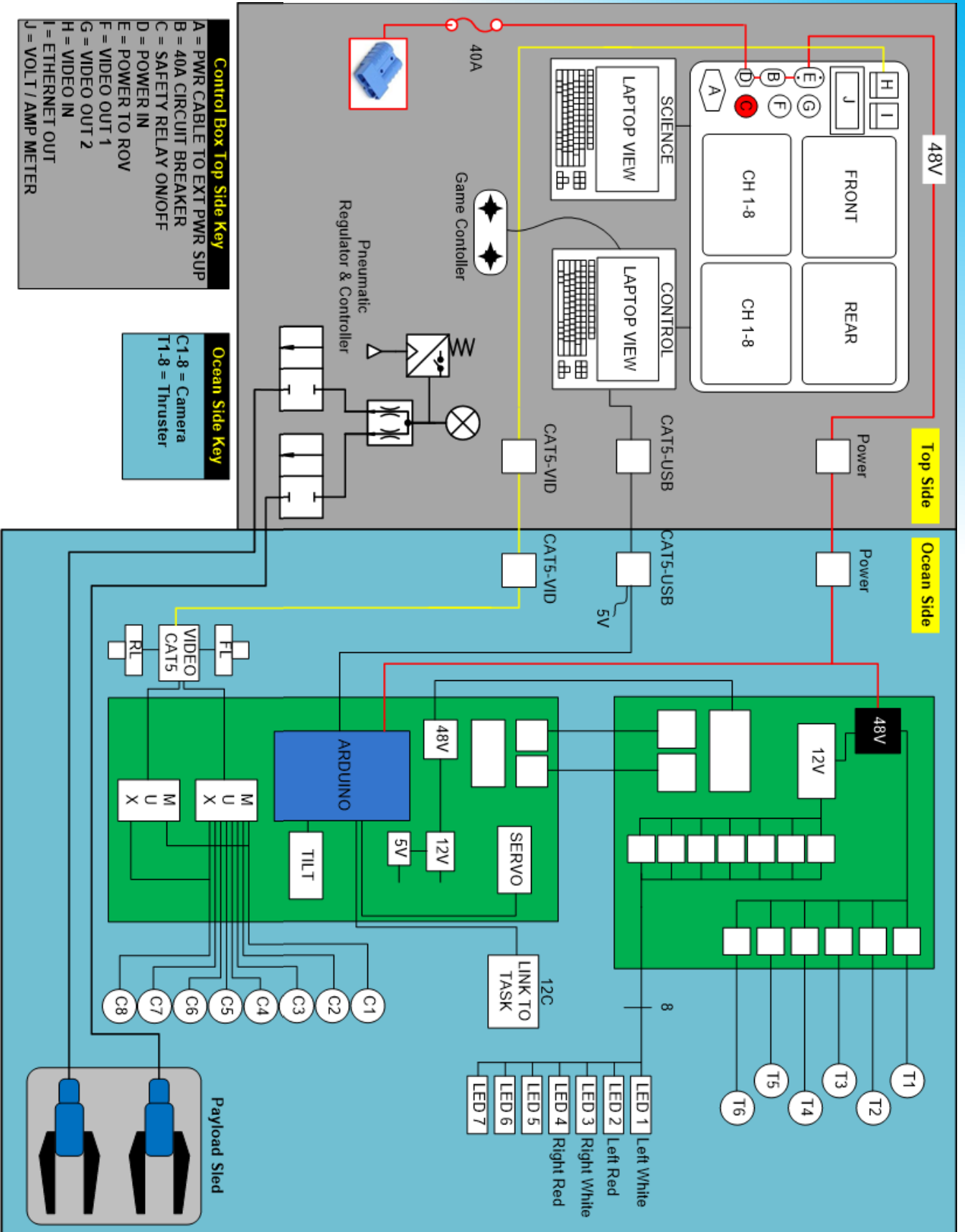
WORKING CAPITAL	
EIR Club*	\$ 2,700
Scholarship	\$ 10,000
Crowd Source	\$ 8,500
	<u>\$ 21,200</u>
Expenses	
Project	\$ 9,225
Shipping	\$ 1,100
Van	\$ 1,216
Airfare	\$ 5,246
Lodging	\$ 2,160
Meals	\$ 720
	<u>\$19,667</u>
<b>Net</b>	<u><b>\$ 1,533.10</b></u>

\* VX Industries Fundraises through the EIR Club.

### Delta Explorer Project Budget

	Item	QTY	Cost	Total Cost	
Purchased parts	Acrylic Dome	2	\$ 30.00	\$ 60.00	
	Lcd Monitor	4	\$140.00	\$ 560.00	
	Air Regulator	1	\$ 35.00	\$ 35.00	
	40A Fuse	1	\$ 12.76	\$ 12.76	
	LED light strip 4.9m	2	\$ 15.00	\$ 30.00	
	Acrylic Tube	1	\$ 80.00	\$ 80.00	
	Control Boards	1	\$350.00	\$ 350.00	
	Arduino Mega + Control Shield	1	\$275.00	\$ 275.00	
	<b>Subtotal</b>				<b>\$1,402.76</b>
	Donated	Seabotix BTD150 Thrusters	2	\$702.60	\$1,405.20
Dell Computer		2	\$700.00	\$1,400.00	
XBOX Controller		1	\$ 29.00	\$ 29.00	
<b>Subtotal</b>					<b>\$2,834.20</b>
Reused parts	Seabotix BTD150 Thrusters	4	\$750.00	\$3,000.00	
	Pneumatic Tubing, 23m	2	\$ 20.00	\$ 40.00	
	Camera Boards	4	\$181.92	\$ 727.68	
	Teledyne Connectors	2	\$ 95.00	\$ 190.00	
	Control Box	1	\$ 60.00	\$ 60.00	
	Industrial Control Box	1	\$ 39.00	\$ 39.00	
	<b>Subtotal</b>				<b>\$4,056.68</b>
Custom	High Density Foam, 4.5kg Sheet	1	\$547.76	\$ 547.76	
	Internal Status Meetings/Reports	1	\$325.00	\$ 325.00	
	Polypropylene Sheet	1	\$ 58.50	\$ 58.50	
	<b>Subtotal</b>				<b>\$ 931.26</b>
<b>PROJECT TOTAL</b>				<b>\$9,224.90</b>	

# SID SYSTEM INTERCONNECTION DIAGRAM



## OUR DEDICATION TO SAFETY

Safety has a negative connotation of slowing work down, frustrating employees and provides mountains of tedious paperwork. VX Industries doesn't care. If you work for us, you follow our guidelines or you're out, it's that simple. We deal with hazardous materials, high voltage, and dangerous working conditions all the time. Our people handle the same problems our products do, and like our products, their impacts have global effects. So we've adapted the "Slow is smooth, and smooth is fast" philosophy. Our methodical process and aggressive supervisors, systematically mitigate any possible safety hazards that are known and not known. Yet, we cannot wrap everything in bubble wrap, and most incidents are human neglect therefore if any employee regardless of position, conducts unsafe acts—they're fired.

### **"Slow is smooth, and smooth is fast"**

The same applies to our manufacturing process and the products themselves. No short cuts or cheap quality material is used throughout our manufacturing process. Every design is scrutinized for possible safety hazards to the operators, in product maintenance and the environment the product works in. Every sharp corner, unless specifically designed for an indented purpose, is rounded off. The tools that have jagged edges are clearly marked and designed to mitigate worst case scenarios.

VX Industries wants to help preserve all life and planet Earth. We take every precaution using numerous checklists and strict adherence to company policy. No excuse qualifies for work related incidents or death.

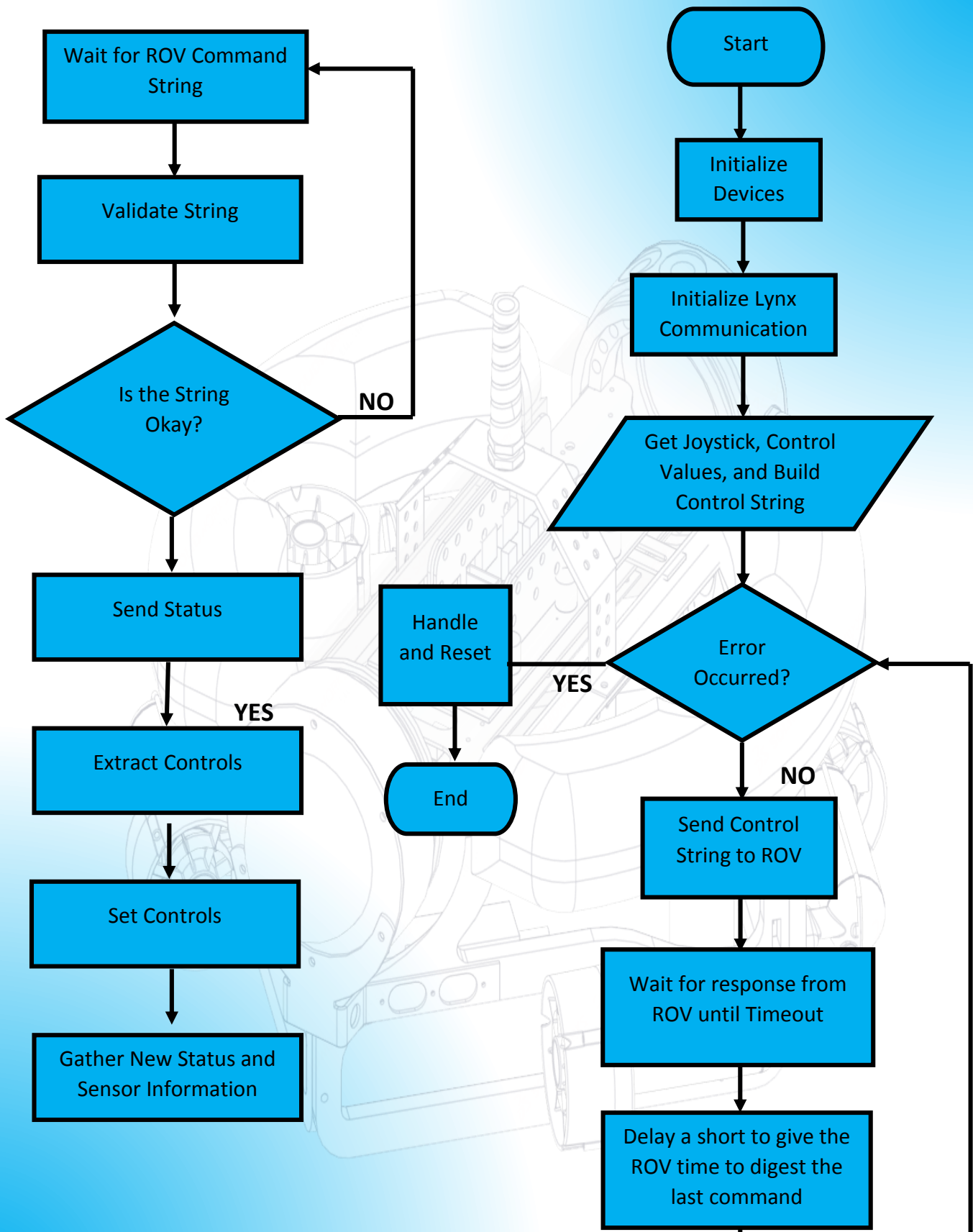


**Personal Protective Equipment**



**Safe practices while launching ROV for testing**

# SOFTWARE FLOW CHART



## DESIGN RATIONAL

### THE DELTA EXPLORER

Designed to be universal or specialized, the  $\Delta x$  fits every person at any level for any reason. Alone, the  $\Delta x$  is the pinnacle observation vessel. With four internal cameras and additional six more, which mount anywhere on the frame. Economical in design, sufficient for one person to handle, yet at its inner core, thrives a beastly industrial grade vessel capable of handling offshore oil rig maintenance, or even subsea pipeline repair.



$\Delta x$  SolidWorks Design

First deep water test, NOAA DAY  
NOV 15, 2014



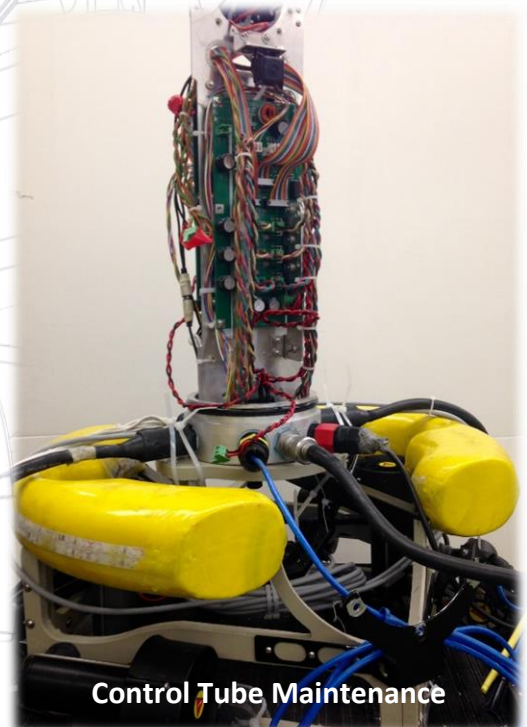
Depth:	11 m (tested)
Length:	570 mm
Width:	282 mm
Height:	700 mm
Weight in Air:	18kg
Thrusters:	6 BTD150
Input Voltage:	48V DC
Power Req:	750W

*“We wanted to create a fast agile, yet very precise vehicle, and since we wanted to reach a broad market, modularity is the best viable option.  $\Delta x$  needed to be ready for the National Oceanic and Atmospheric Administration day held on Nov 15 2014, so they crunched time, developed a stalwart vehicle that we could keep adding to over time.”*

*- CEO Marshall Dickey*

### Maintenance

Ease of adding, upgrading and maintaining the  $\Delta x$  was instrumental in the design process. Every component can quickly and easily detach. For onsite maintenance, we crafted a custom control tube holder that allows four technicians to work on the ROV.



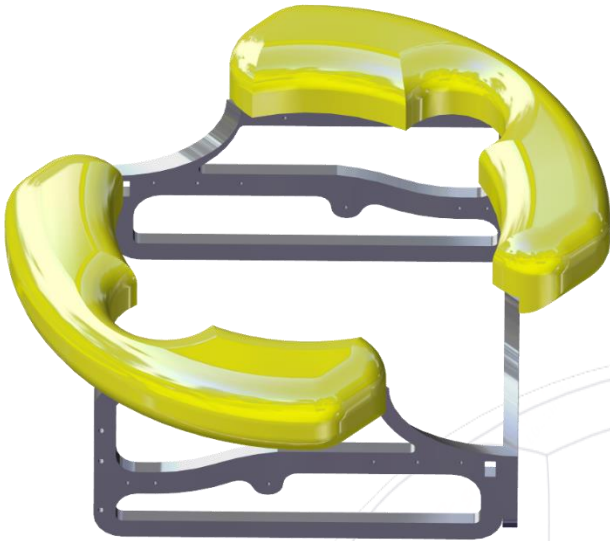
Control Tube Maintenance



OPS Mgr. and Assembler closing up the ROV



# DESIGN



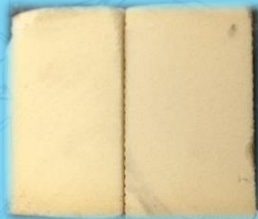
## FRAME

Positively buoyant, strong, yet flexible, the polypropylene frame design allows current to pass freely in both the sides and from underneath. To switch out payloads, the frames are designed slightly larger than the ROV frame, so that switching is simply releasing the cotter pins and setting  $\Delta x$  on top of whichever payload desired.

### SolidWorks Float Design



High density polyurethane cross sectional cut



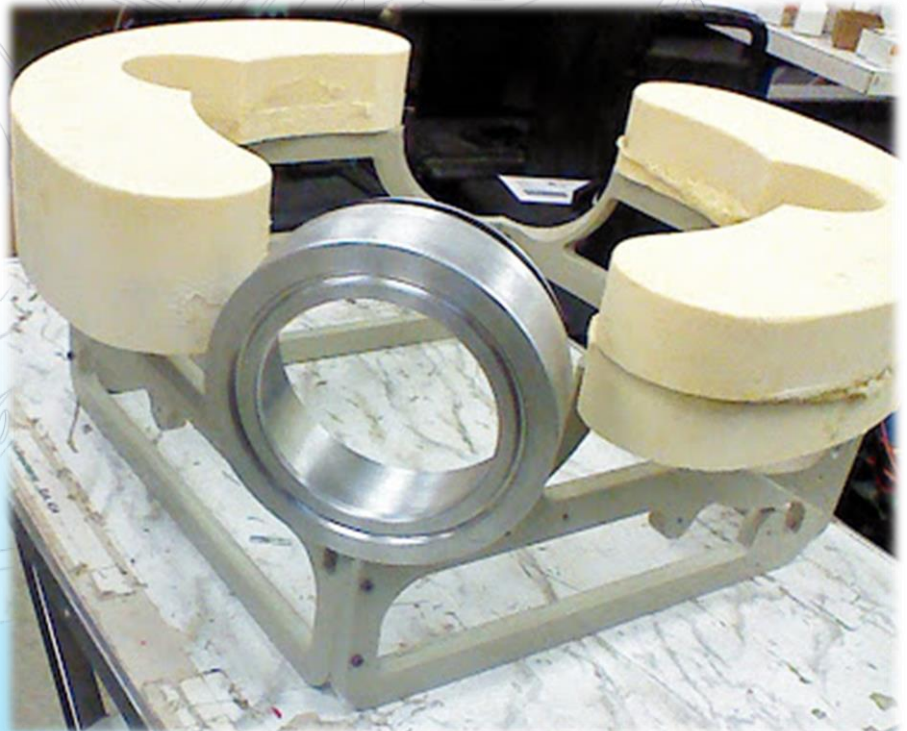
Two 51 mm pieces glued together



Shaped and coated with epoxy for CEO's review

## BUOYANCY

Our designers molded each polyurethane block into two crescent shapes that when fitted on the square polypropylene frame, provide superior structural integrity, and allow for the water current to easily pass over the ROV. Our circular float design and expansively open frame lets Delta X go anywhere, in any current relatively unhindered, proven by numerous test at California's Aquarium of the Pacific. They provided a current of 1.54 m/s, having no effect on the ROV.



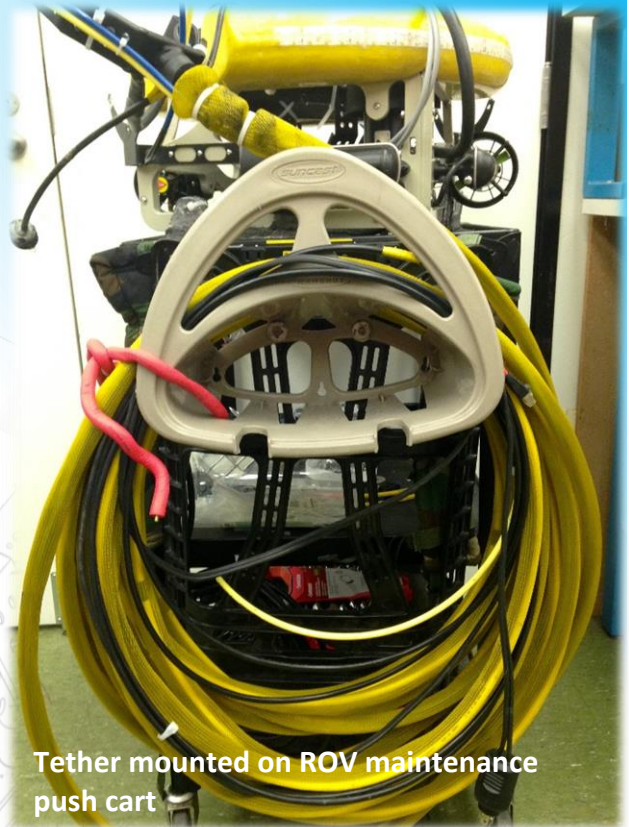
Float size test before finalization process

## VEHICLE SYSTEMS

### Tether

Following our design format, the tether too is highly adaptable. Built to customer specifications or factory design, the tether consists of an outer, highly visible yellow mesh tubing which doubles as a strength member. To handle the necessary voltage requirements, our power line combines 11 meters of CAROL stranded copper 12/2, direct burial wire from topside into 12 meters of 16/2 AWG stranded copper wire. Our combination decreases voltage drop and provides the most flexible power cable that can handle an input voltage variance of 30-48 volts.

Two Cat-5e cables transfer data, one for video output labeled in yellow, and the other Cat-5e cable labeled in red, that handles all the control inputs from the surface operator. The red cable utilized USB extenders for communication with the onboard ROV controller. Cat-5e is the current industry standard when sending data over extensive distances, though Cat-5e cable has a lesser transmission bandwidth of 100MHz, than Cat-6 with 200MHz, proving it's more cost effective to use Cat-5e and is more than sufficient for USB data transfer.



Tether mounted on ROV maintenance push cart



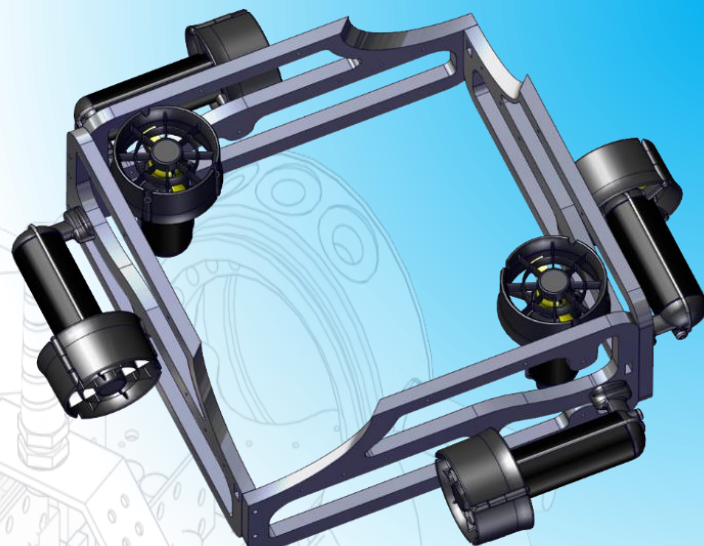
Tether Technician demonstrating backpack carrying option

### Tether Management

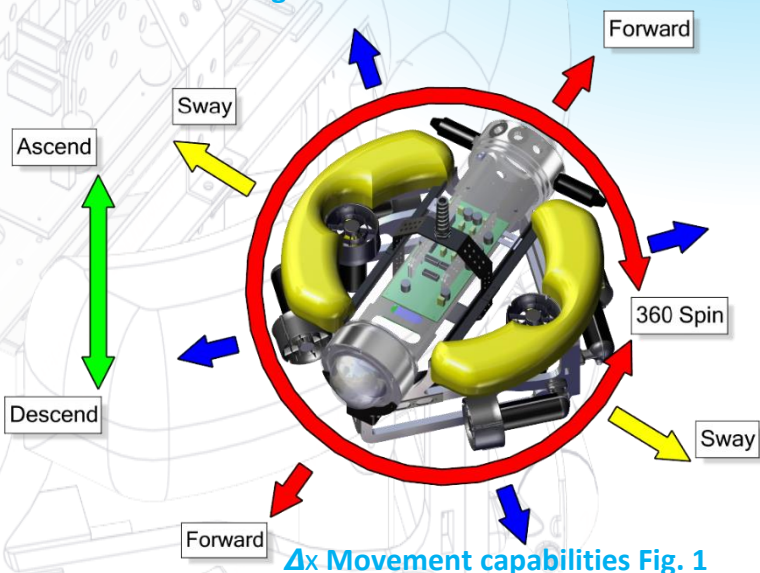
VX Industries uses a tried and true tether management system. We use an economical approach of simply winding the tether around the tether carrying station. Much like you would wind up your garden hose, making it easy to use. Due to its lightweight and mobile design, the tether can be effortlessly carried by the smallest person without encumbrance. Its light weight and compact design allows you to store it on any shelf or it can even hang on hooks mounted on a wall.

## Propulsion

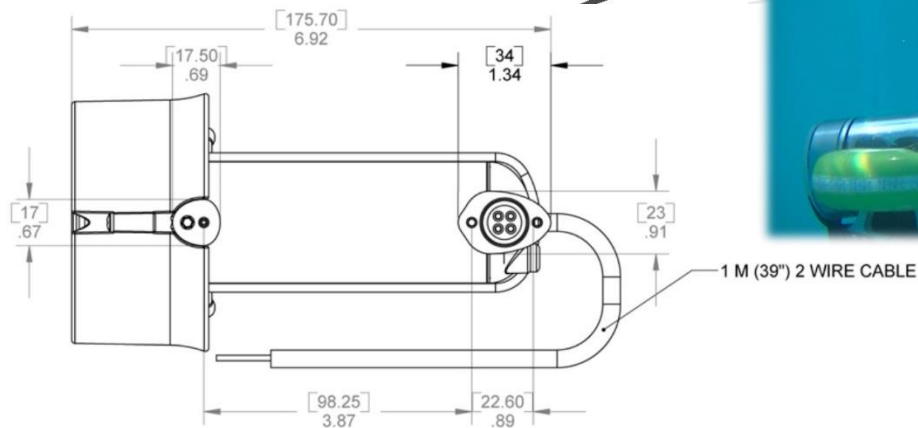
$\Delta$ x's immense maneuverability and astonishing 2 knot linear directional speed are indebted to the 6 powerhouse Seabotix BTD150 thrusters and design placement. The BTD150 brushless motors provide the needed thrust of "2.9kg f" to launch the  $\Delta$ x out of possible hazards, enough torque to lift heavy pipelines, or even turn rusted shutoff valves. Even more, the draw from each motor is so minute, we have an additional 18A for external tool options. Yet, the innovation and nimble agility comes from the four thruster vector configuration. Each thruster sits at 90° angles of each other, (Fig. 1), give the  $\Delta$ x: turn on a dime-dance in 360° circles, without tether interference, and even lateral sway direction. Each thruster is mounted to the outside of the frame allowing ease of maintenance, yet is hidden under the floats to provide protection for sea life and technician's fingers. All designed to allow the most novice pilot, look like a professional, nailing the Hotstab injection on the first go.



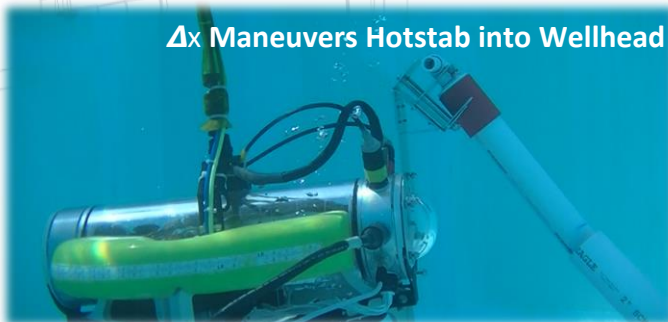
$\Delta$ x Thruster Configuration



$\Delta$ x Movement capabilities Fig. 1



Thruster Dimension Diagram



$\Delta$ x Maneuvers Hotstab into Wellhead



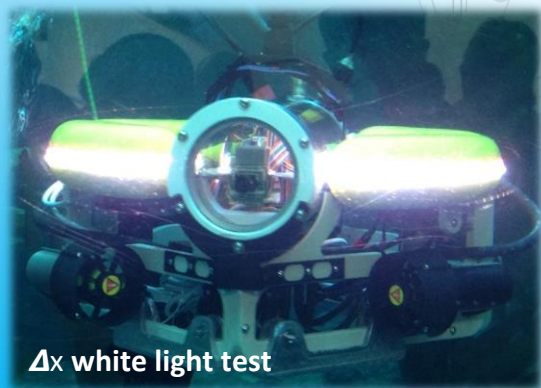
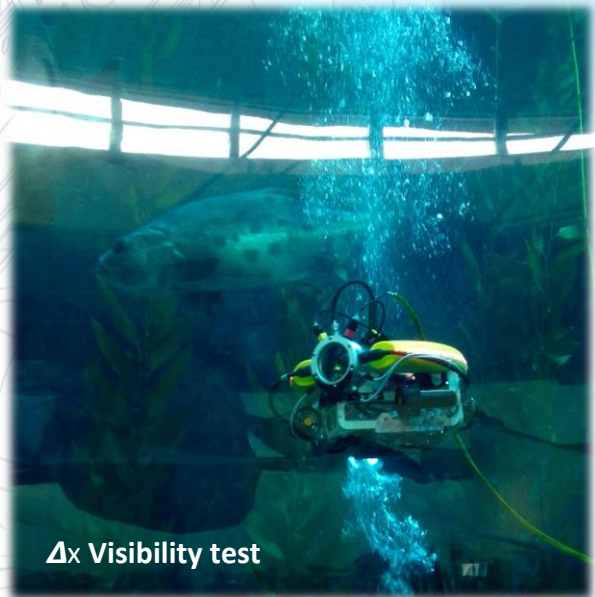
## Lights, Camera, Sensors

Researchers, engineers, or the curious observer can experience the underwater world through four primary internal high-definition, wide-angle cameras. The two used mostly for piloting, sit on servo motors for angle adjustments giving a maximum range of 170° view out of water, 150° view in the water. Add a secondary camera for perspective, and highly technical piloting becomes a breeze. However, many eyes, make light work, and  $\Delta x$  provides an additional six external cameras which can mount anywhere on the frame. Ten eyes create countless possible configurations and an essential design addition.

### 4 primary cameras and 6 additional cameras that can mount anywhere

The murky deep poses no problem for  $\Delta x$ ; with its built-in red and white LED light ring and optional four externally mounted high-powered Mini Eagle Eye lights. Though visibility is still limited, the red light cuts through more so, compared to any other color in the spectrum and the high powered white light provides truest color for identification and visual inspection.

$\Delta x$  control boards come equipped with sensor upgrade modification. Though not “plug-and-play,” connectors are provided to power any additional sensors.



*“Originally, numerous sensors were planned, but were later cut from final production because, they just weren’t needed. Yet, we wanted to keep the option open for our customers, so we provide those options, plus outstanding technical support services.”*

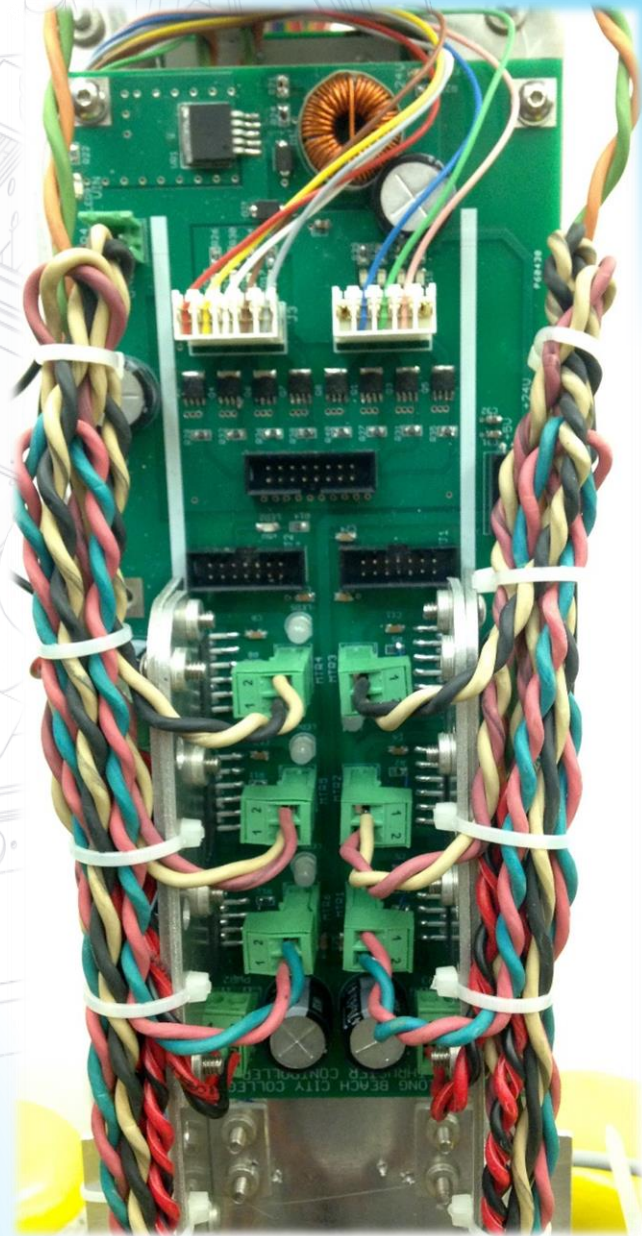
*-Program Engineer Mario Bermudez*

## ROV Control Boards

For the past year and a half, our research and development team have been developing a universal control system that will decrease production time and costs.  $\Delta x$  proudly integrates this new system which, provides customization that can be added at any given time. Using Eagle CAD, our designers constructed two dual layer circuit boards with over 100 components each. VX Industries contracts all its board manufacturing through *Advanced Circuits* out of Aurora Colorado for their high quality end product. The bare printed circuit boards return to VX Industries where they are fabricated and assembled by our highly proficient staff.



Arduino Mega Shield for Sensors & Cameras



H-Bridge for power to thrusters and lighting

# OPERATOR CONTROL STATION



Four Channel Supervisor Station

## OPERATOR CONTROL STATION

For large scale operations, the Task Supervisor has a designated viewing station allowing for real time observation and control implementation. Furthermore, the station can be used by the Pilot or Science officer for multi-angle camera views for precision piloting or observation.

### Control Station

#### Specifications

- 4x 180mm screen
- 4 Channel Balun
- 35A Circuit breaker
- 48V backup power supply
- Multimeter
- Safety Shut-off switch

### Pilot & Science Station

#### Specifications

- Dell Optiplex 960 All-In-One
- Windows 7
- 64bit OS
- 3.0GHz Core2Duo



Control Station Wiring



Science Computer Station

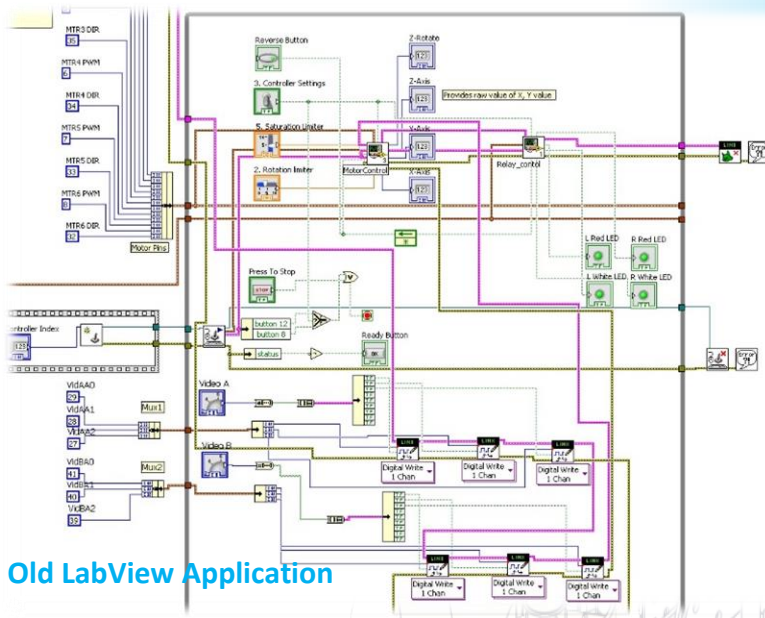


Sequence Start-up



Piloting Control Station

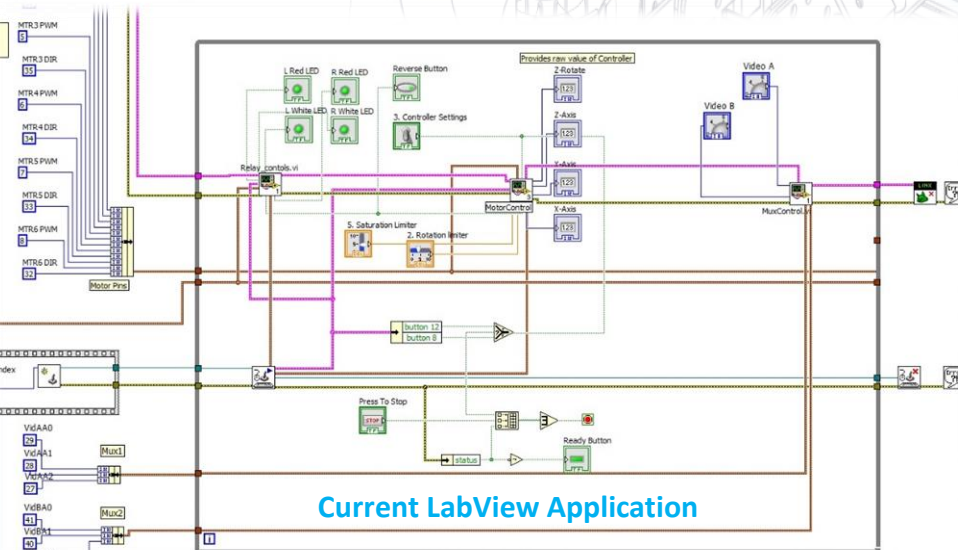
# SOFTWARE



Old LabView Application

## LabView

LabView provides a powerful programming medium that allows us to actively control an Arduino, in a manner that can't be done through other programs. The visual aspect, cuts down on debugging, and makes future upgrades a seamless expeditious transition.



Current LabView Application

```

ServoAddedArduinoFirmware //LINX.h
#define SERVOMAX //TODO: find the 'maximum' pulse length for our se

void setup() {
  //Setup LINX Device (Serial Interface Only)
  setupLINX();
  //Setup an array to store the pwn's for easy access later.
  Adafruit_PWM_Servo_Driver pwns[3] = {pwn0, pwn1, pwn2};
  //Setup the pwn's with values using a loop
  for(int i = 0; i < 3; i++)
  {
    pwns[i].begin();
    pwns[i].setPWMFreq(60);
  }
  uint8_t subbackup = TWBR;
  TWBR = 12;
}

void loop() {
  //Check For A LINX Packet
  #ifdef LINX_SERIAL_INTERFACE_ENABLED
  checkForLINXSerialPacket();
  #endif
  #ifdef LINX_ETHERNET_INTERFACE_ENABLED
  checkForLINXethernetPacket();
  #endif
  #ifdef LINX_WIFI_INTERFACE_ENABLED
  checkForLINXwifiPacket();
  #endif
}
    
```

Arduino Firmware

## Arduino

One of the most versatile programmable hardware on the market, the Arduino is the heart of  $\Delta x$ .

With the powerful processing capabilities of Labview and the superior responsive and manipulative behavior of the Arduino,  $\Delta x$  can power through any obstacle or meticulously calculate a strategic solution.

**1. Arduino USB port**  
COM4

**2. Rotation limiter**  
75

X-Axis: 0  
Y-Axis: 0  
Z-Axis: 0  
Z-Rotate: 0

L Red LED, R Red LED, L White LED, R White LED

**3. Controller Settings**  
Joystick (0)  
Controller Index: 0  
Game Controller (1)

**5. Saturation Limiter**  
255, 200, 150, 100, 50, 0  
191

**Order of Operations**  
1. Set Arduino USB port  
2. Set Rotation Value (Default 75)  
3. Set Controller Index/Settings  
4. Start Program  
5. Set Saturation Limiter (Default 191)

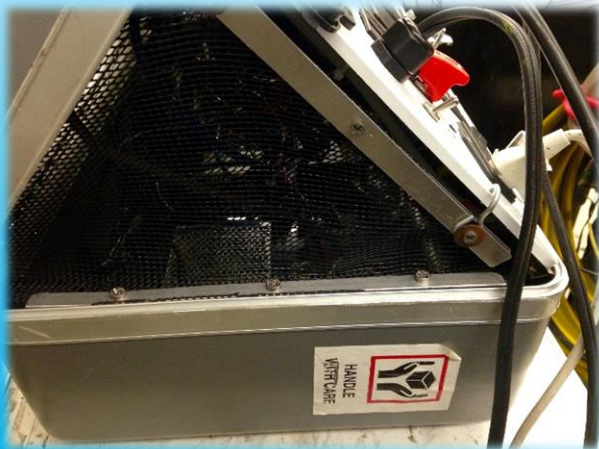
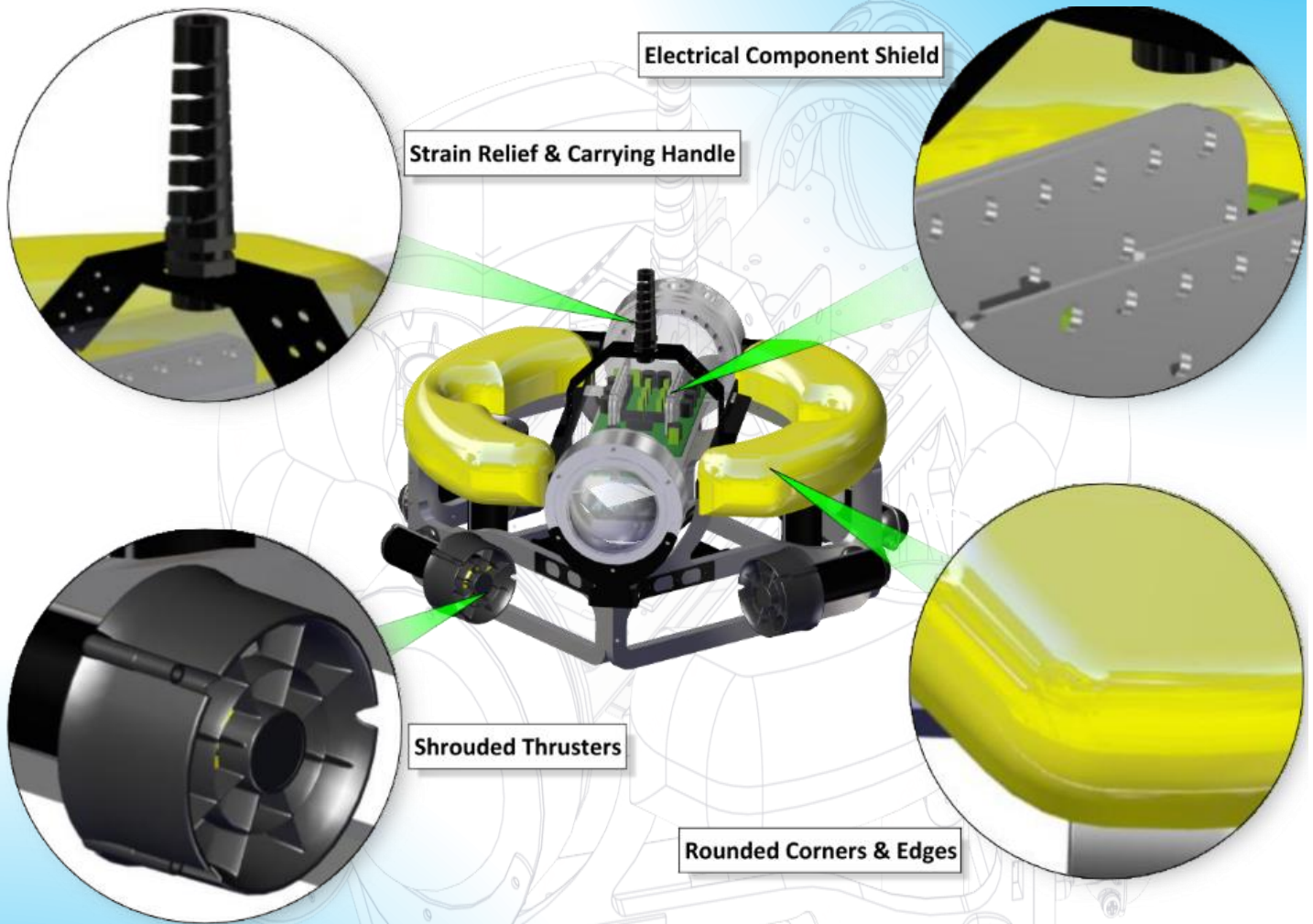
Reverse Button, Video A, Video B

Pilot Control Interface

# VEHICLE SAFETY

## Δx Safety Features

VX Industries wants to help preserve all life and planet Earth. We take every precaution using numerous checklists and strict adherence to company policy. No excuse qualifies for work related incidents or death.



Overspray and electrical shock prevention safety feature

The same applies to our manufacturing process and the products themselves. No short cuts or cheap quality material is used throughout our manufacturing process. Every design is scrutinized for possible safety hazards to the operators, in product maintenance and the environment the product works in. Every sharp corner, unless specifically designed for an indented purpose, is rounded off. The tools that have jagged edges are clearly marked and designed to mitigate worst case scenarios.

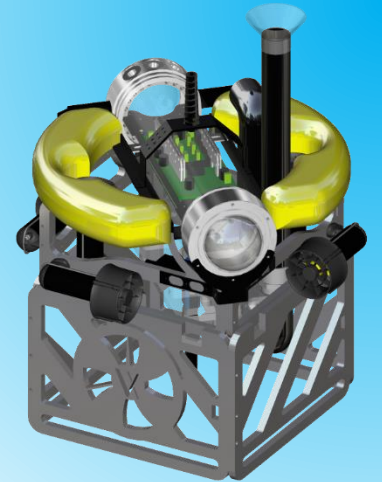


# SCIENCE & RESEARCH PAYLOAD (S&RP)

All tool-inclusive, the S&RP provides the largest payload option available. Tall enough to carry a passive acoustic sensor, this frame comes equipped with a unique claw that doubles as a multipurpose claw for animal collection, cutting edge harmless algae collector, and numerous camera mount options for identifying various sea life.

*“One of the most unique aspect of this payload is the option for personalized logo. We cut it into the frame for esthetic design, but having the design doesn’t impede the hydrodynamic flow.”*

- Engineer Aaron Durst



Δx S&RP SolidWorks Design

## Specifications

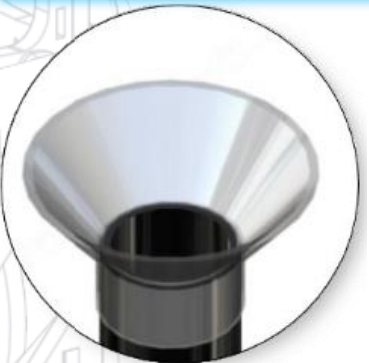
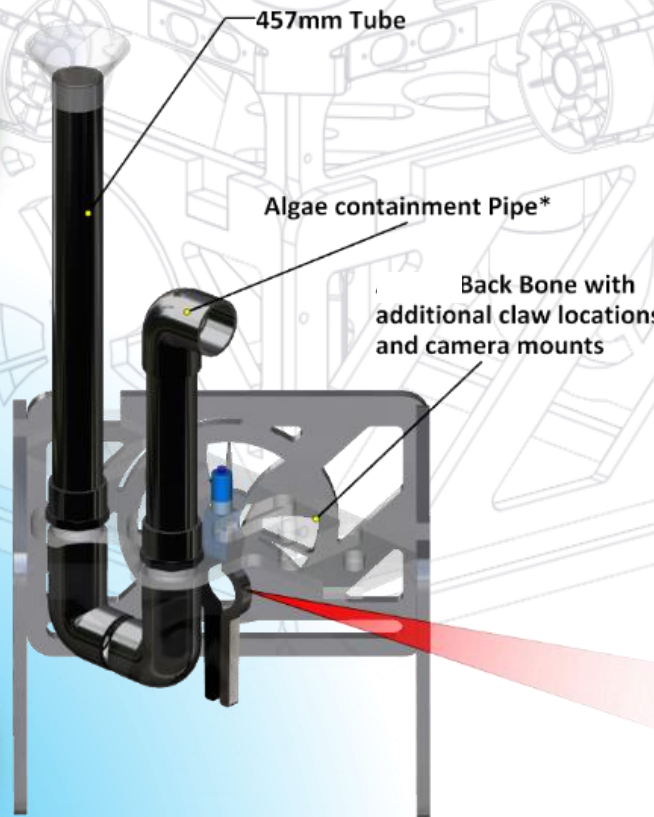
Height:	267 mm
Width:	394 mm
Length:	560 mm
Weight:	5 kg



High impact & bullet camera



Custom Logo Options



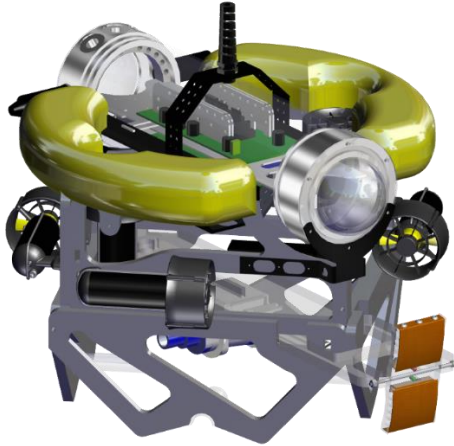
Harmless Algae Collector

Passive Acoustic Sensor - Multipurpose Claw



\* Actual Container not shown

# OFFSHORE OILFIELD MAINTENANCE PAYLOAD (OOM)



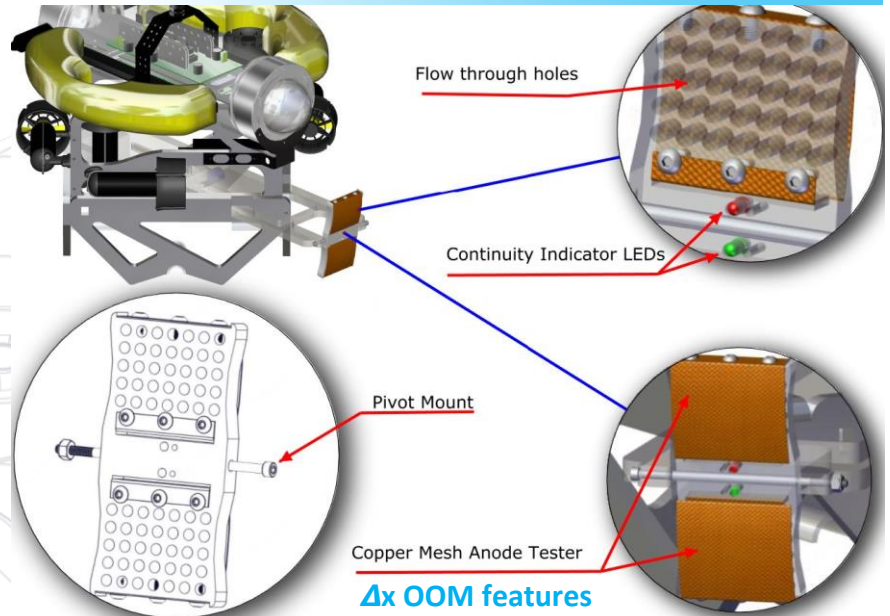
Δx OOM SolidWorks Design

## Specifications

Height:	267 mm
Width:	394 mm
Length:	560 mm
Weight:	5 kg

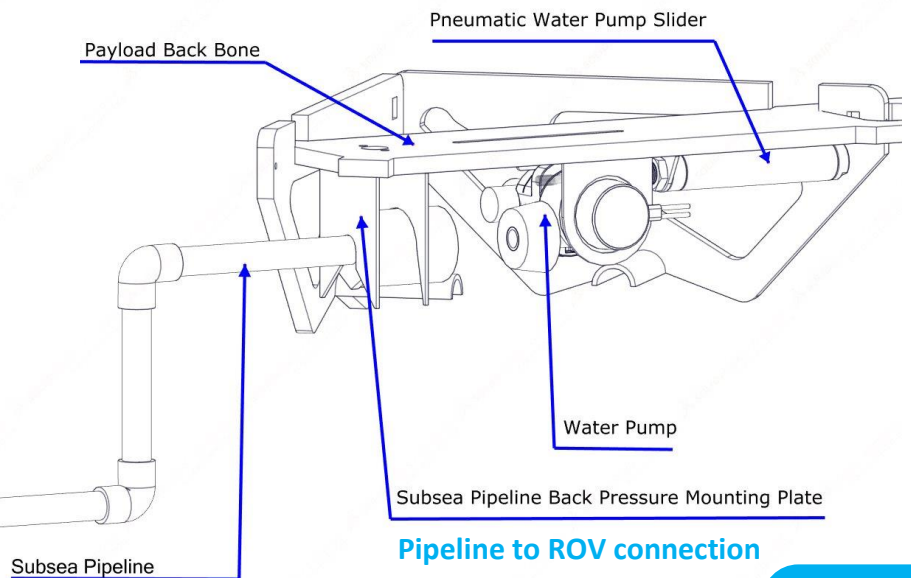
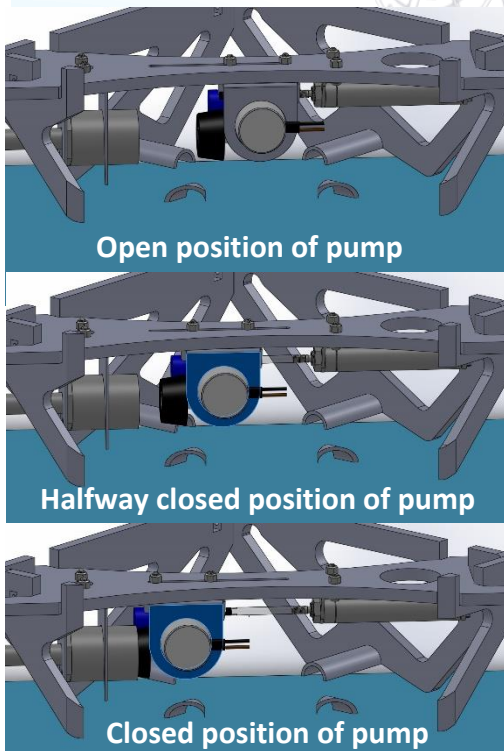
Inspecting platform legs for galvanic corrosion is ridiculously easy with our simple, streamlined pivot mounted tester.

Unlike any working ROV in the industry, Δx's maintenance payloads have capitalized on their size and design to perform all the necessary functions with as little moving pieces possible. Able to turn the most corroded valves just by sitting on top, and using Δx's powerful thrusters to provide the torque to turn.



Δx OOM features

With the multi-angle camera views and superior thruster configuration, Δx maneuvers easily through tumultuous currents and delicately attaches to subsea pipelines. The pneumatic sliding pump with tapered rubber gasket and back pressure mount plate ensure a perfect seal and minimal chance for potential oil leaks.



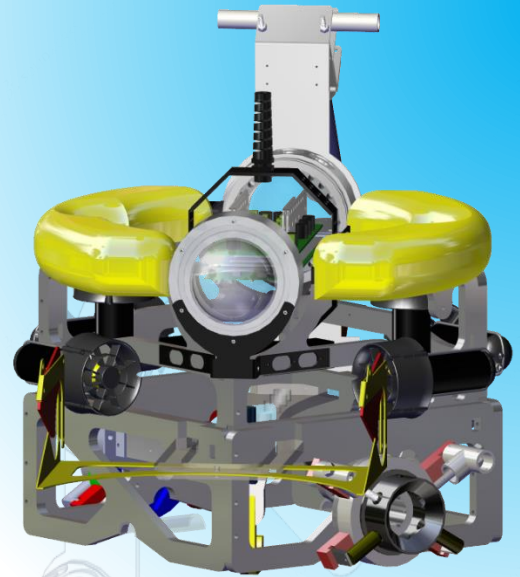
# SUBSEA PIPELINE INSPECT & REPAIR (SPIR)

The SPIR payload metamorphoses the  $\Delta x$  from a carefree swimmer, into a pint-sized behemoth. Our front-mounted gravity latch pipeline carrier safely and securely extracts corroded sections of pipe and doubles as a known distance for measurements. The dual-mounted flange and pin can installer caps pipelines in seconds while the multi-camera angled perception makes injecting the hotstab the simplest of maintenance tasks. Our designers went all out designing the most aggressive and versatile ROV's, redefining "working class ROV."

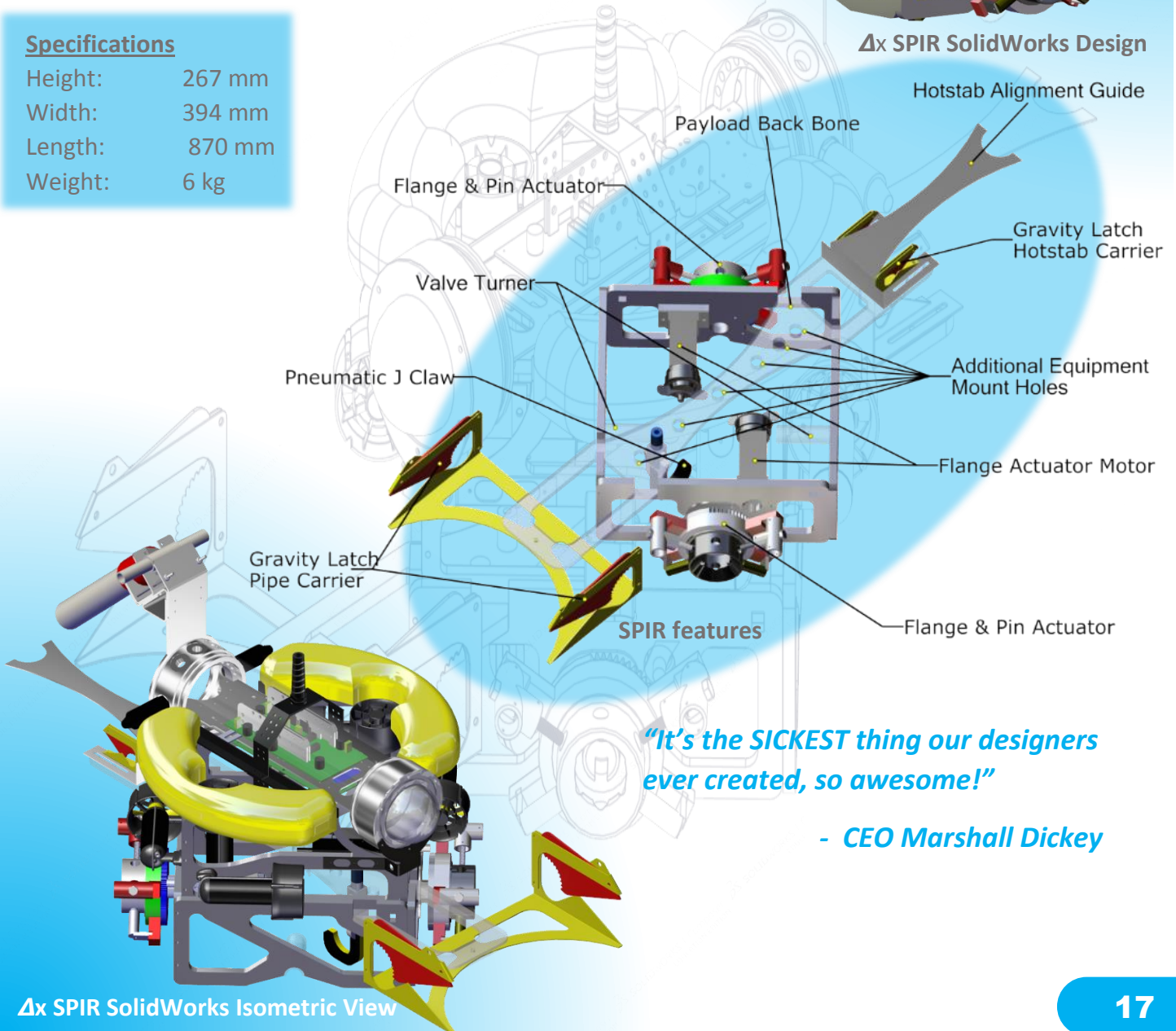
## "REDEFINING THE WORKING CLASS ROV"

### Specifications

Height:	267 mm
Width:	394 mm
Length:	870 mm
Weight:	6 kg



$\Delta x$  SPIR SolidWorks Design



*"It's the SICKEST thing our designers ever created, so awesome!"*

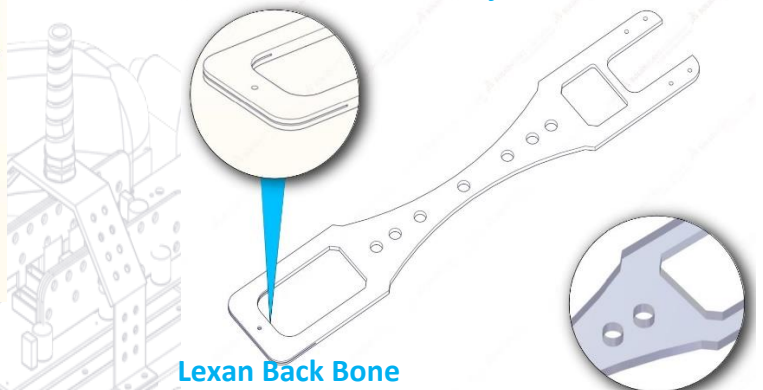
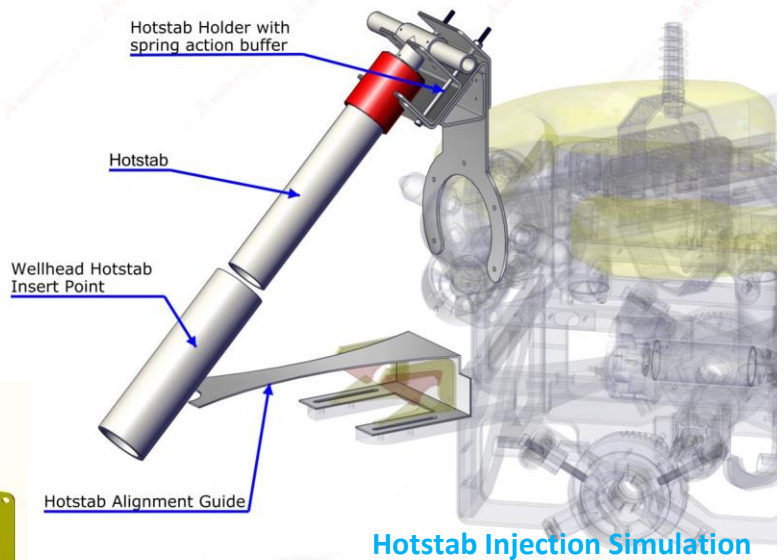
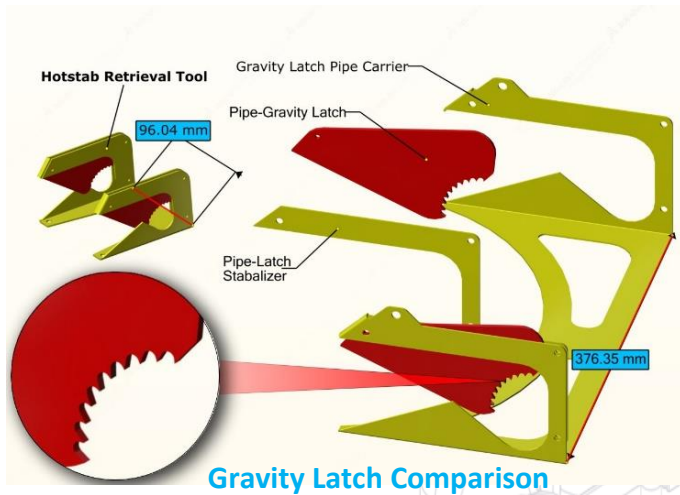
*- CEO Marshall Dickey*

$\Delta x$  SPIR SolidWorks Isometric View

# SUBSEA PIPELINE INSPECT & REPAIR (SPIR)

## Special Tooling

Each tool specifically, designed to simplify maintenance procedures, maximizes work productivity. The spring-action hotstab buffer cushions recoil during piloting mishaps and the wellhead injection hotstab alignment guide further decreases piloting errors and potential equipment collisions.

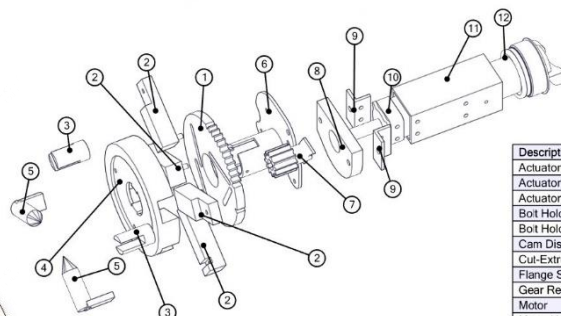
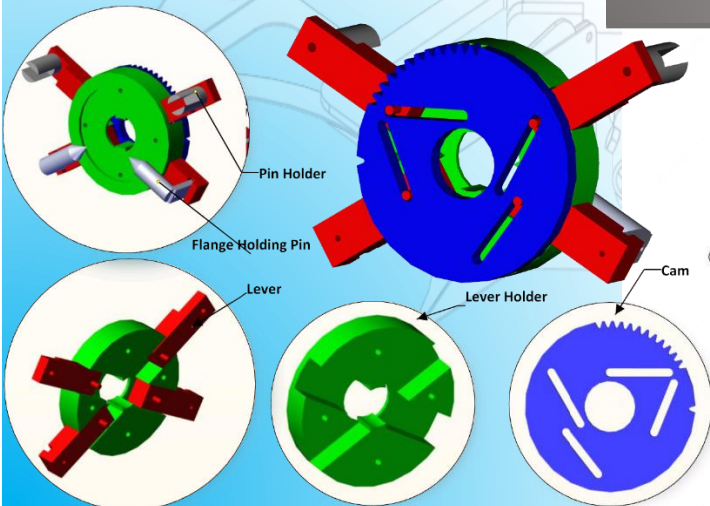


The Gravity Latched retrieval system falls into place as the pipe actuates the hinge teeth. Though its menacing appearance might cause concern, virtually no part of this tool can cause harm when used correctly.

Inspired by the sci-fi adventure, *Interstellar*, the Flange and Pin cam actuator is the only tool with moving parts



### Flange & Pin Actuator



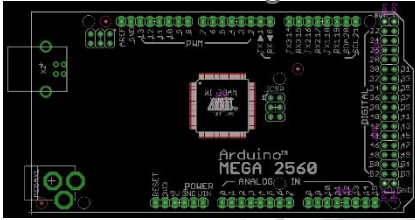
Description	BOM ID	Qty
Actuator Axle	6	1
Actuator Gear	7	1
Actuator Holder	4	1
Bot Holder	3	2
Bot Holder Mount	2	4
Cam Disc	1	1
Cut-Extrude4	9	2
Flange Stabilizer	5	2
Gear Reducer	10	1
Motor	12	1
Motor Housing	11	1
Motor Spacer	8	1

Cam Actuator parts breakdown

# MANUFACTURING PROCESS

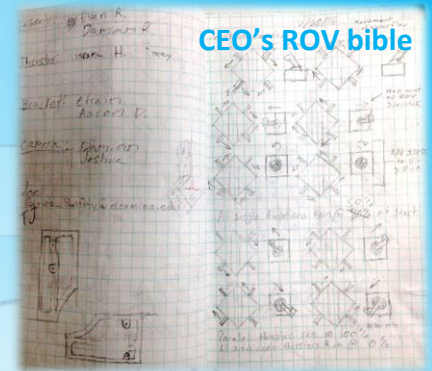
## Project Management

### Arduino Board Design



### $\Delta x$ Phase I

- PCB boards design
- Think-tank on ROV design
- PCB assembly
- Research & Development



### $\Delta x$ Phase II

- Marketing campaign
- ROV build
- Software development
- ROV quality control test
- Deep sea test



Wiring Diagram for ROV



ROV construction

### $\Delta x$ Phase III

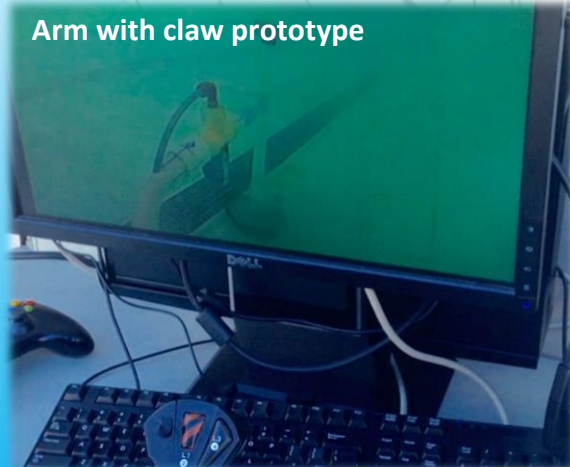
- Payload tool design
- Software debugging
- Technical Documentations
- Tool prototypes tested
- Tool re-engineered
- Quality control tests
- Final product to ship

Often, we started with one idea, that would get cut, but, lead to the development of a simpler more profound tool.

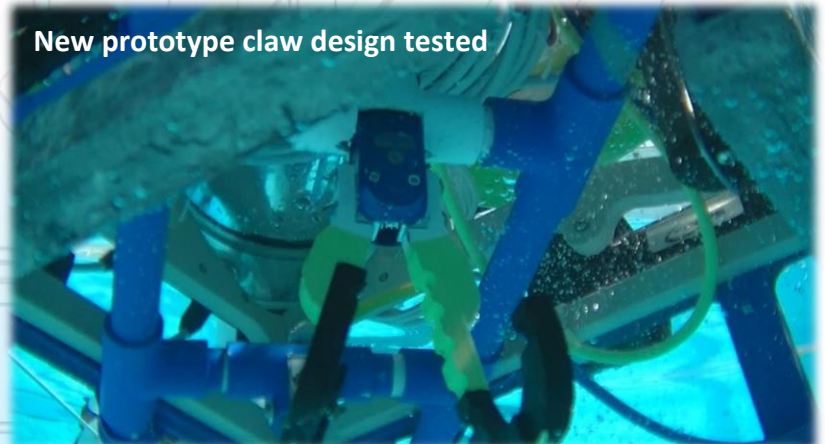
## Troubleshooting

The design of our first arm was disastrous. A great concept, but piloting with the arm was too problematic, so it was scrapped and all components would stay virtually inside the payload, or extremely close to the ROV.

### Arm with claw prototype



### New prototype claw design tested



# OUR STORY, OUR FUTURE

## Challenges

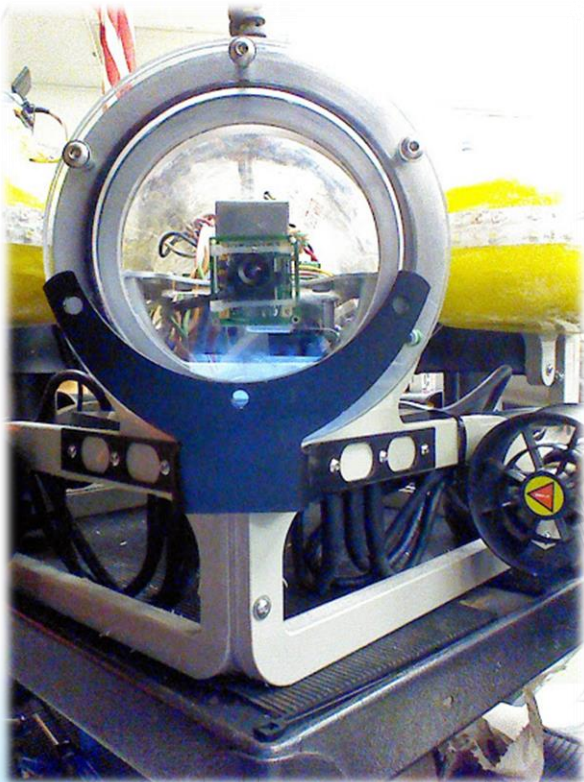
There was no time for long debates over design issues. Once we had a solid design that met the criteria we assigned, we ran full steam;  $\Delta x$  had to be in the water by November 15 2014—and it was.



Building a flume tank

## Problem solving strategy

Testing equipment was fabricated in order to verify the effectiveness of all the tools and components on the ROV.



$\Delta x$ , prepped before first deep sea test



Troubleshooting the Harmless Algae collector

## Lessons Learned

Electromagnetic interference not contained, distorts any hope of visual acuity within our control station. Every time the thrusters would engage, rippling distortion waves plagued the viewing stations. Connections were checked, programming scrutinized, systemically we traced the culprit to a simple ammeter shunt.

## Our Future

VX Industries continues to seek out new revenue streams by advancing our current products, creating new advanced products and securing grants for research and development. Our goals push us towards knowledge of the unknown and to take complicated tasks, break them down and solve them with simple solutions, fast efficient and cost effective.

## Our Team

*Passion fuels innovation, plows over hurdles, and through obstacles; pushing you to the limits of creativity—that's VX Industries.* **Reflections**

When you're a kid, you draw robots, play with Legos, they seem real and move and with a little help from your hand and quirky sound effect produced by your mouth it comes to life. Now, I'm here, doing the same thing, but on a scale I'd thought was only for high paid professionals. I drew a robot, built it from scratch, and even gave it personality. We've accomplished so much in so little time, that at times, I had no idea how we got to this point.



CEO designing on SolidWorks

-Marshall Dickey

Talk, Design, build, test, rebuild, repeat  
-Ray Thompson



Two curious entities...

This was a daunting task. We had a good team that had passion for the project. Each of us can identify key components on the Delta Explorer and say, "I built that." We stayed under budget, which was my goal, and have a strong footing to leverage this project for future projects.

-Scott Precop



Everyone who had a hand in the project

Robotics design and engineering is a blast, and I am thrilled to be working with a team that also loves robotics.

-Aaron



Brainstorming payload tools

Even knowing programming, I never knew what the capabilities of an Arduino could be.

-Mario Bermudez



Vacuum sealing 6 video cables

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**SAS Automation:** With one video we had your support, and a donation of three pneumatic claws!

**Long Beach City College foundation and donors:** Without your generous donations we would have never made it to this competition, thank you for the chance to let us "Change the industry standard."

**NOAA and The Aquarium of the Pacific:** Without your request to have us at NOAA Day in November, We would not be as far as we are today. Thank you for giving us something to work towards early on.

**Significant others and Family:** Thank you for your support over the past year and allowing us to dedicate our time away from you to accomplish something great.

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