*Theo Estmond*

* works for Innovation focused on the navy
* big in the WW2 era
* addressed problems and finds solutions through new technologies or from historic data
* Changed coordinator, talks to the industry
* Takes others’ ideas to the department to create relations and have the problems solved
* Electrical engineer
* PEO
* 10 years in the navy

*John Faurbo*

* Theo’s boss
* Combat system engineer
* Similar role to theo
* Internal marketing in the organization to find problems and solve them
* 19 years in the navy
* Mechanical engineer
* Closer to comp sci or electrical
* Loves all things technical

<http://thor.angel-lm.com> - Thor arm

***Technology that wants to be contributed***

* Robot arm
* Large problem
* Halifax class is coming to an end, corrosion
* Remove it and paint over it to remove it
* Rust can be everywhere
* ‘how do we use robotics to solve this’
* Gave a co-op group to a product that can be 3d printable
* **Open source**
* Reasonable weight
* In a reasonable package
* Main problem: no inverse kinematics due to it being open source
* Main are is for the Halifax class: warships 150 m, carry 200 people, lots of steel and paint
* Flat wall ‘bulkheads’ what has the paint which is very intricate that must be painted in all corners
* Scan the space to plan the path for the sand/water blaster spray
* Take the paint and apply it
* Movement of the arm is key
* 3 degrees of rotation
* Build off of what is created
* If they find a solution they want, they will capitalize off it (co-op)

*Questions*

* Other problems with the arm?
* Built open standard, only working for one sensor
* Robot itself has future applications
* Interacting with confined space, gas tank
* Key: robot arm becomes a tool that can be used in different places
* Does it need to be water resistant?
* No, water integrity would be a benefit but no necessary
* Is the piping generally spaced out?
* The arm itself is not a bit deal would want to come to a mid point to the arm/camera
* Not going to be putting the arm in it, but should pivot around
* Can typically only mat 3d plains or parabolic plains
* Spray patter of paint or the system should be able to get in the areas
* What are the general expectations?
* Open source, built off of common language: python, c++, easily understood
* Tend to like open source inverse kinematics that could be translated to gerbal or is better to gerbal
* Describe ideal scenario, looking for a file to upload it?
* Somebody would bring down the robot
* Camera would turn on, to idenfity the free space, co-ordinate based
* Scan the area to make sure it understands the geometry from the camera
* Then take off the camera system to remove any of the paint, sprayed down
* Make sure the spray system applied going forward is in the same area
* Want the head to be taken off very easily
* Why is it better to have robots than people?
* Robots are cheaper, can employ as many robots as possible
* Could have people that could control multiple robots
* Economy scale savings compared to people
* What kind of technical experience would the user have?
* User would likely be people who aren’t very capable, little to no technical experience
* 12th grade math is the minimum bar
* Nice interface for where the robot needs to work on
* Camera system is more complex
* How many people were involved in the old process, in the new one how many people are involved in using the system?
* Want it to be operable by a single person, function for one person
* With more than one person, the value of the robot becomes diminished
* ‘point, set, walk away from it’
* How long would be ideal for the painting process?
* 4m^2 2 by 2 in 4h, 1^2 m per hour, also important to wait for the paint to dry
* What did you mean by degree of freedom?
* Articulation
* Different direction of movement = extra direction of freedom
* 3 or 6 are common
* Benefit of 3 degree over 6?
* Way easier to code, and easier proof of concept
* Matrix calculations will be less difficult
* Any hindrances with the co-op group?
* Problem came with the open source
* The sensors bought didn’t fit and so it had to be adjusted
* Will run into a problem where the fact that the arm works off of G code
* Is meant to move one motor at a time, all the motors moving together will be complex
* Understanding G code was troublesome
* 2 options: build inverse kinematics with g code, which can be expanded to 6 degrees
* Open source software that can be designed for x,y,z axis which will be easier to code the inverse kinematics: mathematical calculations to go from point a to point b
* What is the ideal lifespan of the arm?
* Due to thor being open sourced, its okay for it to break
* Mainly wanted maintainability
* Has to be able to work for 24h without working
* Better for longer, Minor repairs every 3 months, major every 6 months would be ideal
* There are 3d printers on the ship?
* Yes, there are, old school mills and plasma cutters
* Is there a preferred file format?
* No preference, since they are early on
* Is a reasonable explanation is given, it will be okay
* Wants it to be input translated to output/motion
* Why are you not buying an industry robotic arm?
* Its cheap, industry robot arms are minimum 20-30k on a small scale
* Locked into ecosystem
* Wants to go by repair by replacement
* What are other examples that would want to be painted?
* Small crevices that could be tedious for someone to work on
* Are you planning on doing the exterior?
* Yes, you could hang the robot over the edge with cables in place
* Have paint scaffolding
* Or suction cup build (requires extra degree of freedom)
* How would you secure the robot?
* Open to suggestions, part of it has remote wheels with batteries that can just go down a corridor
* If it doesn’t work/goes through a major technical issue, they would move on
* The corrosion removal is the important thing
* Did you have any objects to robot operating systems?
* Ros.org with a gazebo simulation (gazeboim.org)
* What would be the range of motion be like?
* Around 1m, general robot dimensions (bs)
* Around .5m to 1-2m
* Do we need to think about interacting with other people?
* It would be an added bonus where it could sense that someone interacted with the space in case individuals would walk into the robot’s workspace
* Not a requirement but its nice to have
* In terms of priorities, what would be important and what are the outcomes youre looking for?
* Kinematic system
* End defector
* Any modifications from the original robot
* How do you want to degrees to be laid out like?
* Functional robot where the defector can be connected
* Up to professor’s
* What are new people most surprised?
* How small everything is crammed
* The doors are small, pipes in the way, light fixtures, very small space
* Very dense
* Smallest object?
* More importantly is lifting capacity, 20lb, either the whole thing is 20, or can be broken down into multiple parts of 20lb
* Smallest major doorway for moving is between 1m^2 area want to be able to be carried on a ladder
* So then 3 points of contact is important
* Who would be fixing the robot?
* Likely have technical background in technology
* Eng tech, electronics technician background from colleges
* Have basic understanding of electric wiring, electric systems, soldering, schematics
* Have a full machine shop in order to reproduce parts for the robot, very skilled people
* How much weight does the arm need to support?
* Thor has 750 grams of functional load at full extension
* About 1 kg end defector weight
* Will the robot have to be robust, or is it okay to be fragile?
* 98% certain if the robot ran into something it wouldn’t break something inside
* Collisions would be bad with the robot for maintainability
* When water blasting the area, what is the water source looking like?
* Have a compressor or pool of water, they have water reservoirs/fire hose
* Lots of pressure from them, take a feed from that so when hitting the surface, it can do what it should do (8 bars of pressure)
* A hose that can be pointed there, which should be able to withstand high pressure nozzle
* Is there an inspection element?
* Yes, but more important how you can detect the corrosion is detected
* It would be worth to get data from the robot for inspection, would be very important for the organization
* Would be great if the data could be extracted and sent to them
* Being able to capture water off the deck would be nice, so not much will be wasted
* Could use vacuums into waste disposable containers to get back the water
* Moving away from sand because it can create contaminants, either water or co2 would be better
* What did the co-op students not understand when partaking in the project?
* Mainly the G code and Gerbal
* Not actually too complex, were able to get basic results from it
* It was limited due to their lack of skill
* You had to assemble it backwards
* The robot arm was meant to be built in reverse, which was complicated
* Design order is there, and documentation is also important
* End goals is to be able to be shipped to other places.
* Is it for the purpose of workers not being there?
* Because its painting in confined spaces with low o2
* Only one entry area, so depleted o2 environment
* Key thing will be inspection, so rust removal will be important
* Will be dark places, must be able to perform in all lighting areas
* Would kinda prefer having lights on the robot
* Assume there is florescent lighting
* Would it be preferrable to have a flashlight mounted on the robot?
* Design/engineering wise, would be a good choice
* How will it be powered?
* Expect to be plug it into an outlet to recharge
* 120v power outlet, longevity is not a priority at the moment
* Lower greenhouse gas emissions, if it was more efficient, it would be better
* Power is coming from the grid; shore cables
* Not required for working at sea
* How much processing power should be required? Does it need to be really optimized?
* Typically, Auridon’s and raspberry pies
* 100-dollar budget
* Smaller processing powers
* *YOU DON’T HAVE TO REINVENT THE WHEEL, OPEN-SOURCE SOFTWARE CAN BE FOUND ONLINE*