Pneumatics system*

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ABSTRACT

The Naiad AUV is capable of interacting with the environment using sensors and actuators. One of the short term goals of the prototype is to compete in the RoboSub[1], thus the current system is adapted according to the competition's mission requirements. There are two torpedo launchers, two markers, and two grippers. All the actuators are pneumatic-operated and are driven by separate and independent valves. The pneumatics system is controlled by a Generic CAN Controller, running the firmware written for this task.

1. INTRODUCTION

There are many benefits using pneumatics instead of an electric system; decreased power consumption, less electromagnetic interference and fewer electric components exposed to the water.

The mechanical parts of the pneumatic system were precisely engineered in such a way that they conform with Naiad's unique design, space and weight requirements. The pistons (and consequently the other components) were chosen to be as small as possible but still able to provide the required actuation characteristics (force, length, speed). Smaller components have the benefit of reduced gas consumption, which in turn equals to smaller gas tank and longer run time.

The pistons are driven by pneumatic valves that are controlled by a Generic CAN Controller. This controller receives commands from the CAN bus and activates the appropriate valve.

2. IMPLEMENTATION

Each component will be described in a dedicated section.

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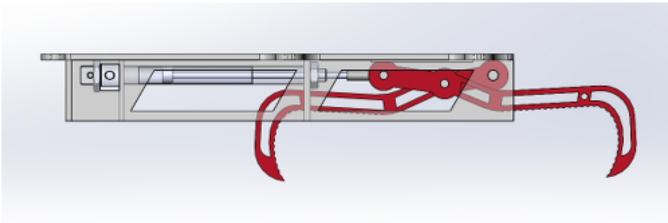

Figure 1: Gripper at open position

2.1 Gripper

The gripper have been designed in such a way that it is almost completely retracted in the tool compartment, providing a streamlined and hydrodynamic appearance of the robot. The gripper design can be seen in Figure 1.

In order to grip more effectively, the gripper closes with a very wide scooping motion, downwards and to the front. Moreover, the jaws are designed to interlock so they won't open accidentally. It is actuated by a single-acting naturally retracted cylinder, that in case of a power failure will open automatically (spring return), providing a "dead man's grip" mechanism. The Naiad AUV has two grippers installed on the underside of the hull.

2.2 Marker

The marker consists of a sphere attached to a tail ending in a conical shape pointing upwards. When inserted into the bay, this conical shape pushes and locks on a spring loaded latch. The latch is actuated by a single-acting, naturally retracted cylinder. There are two marker bays on the vessel. In Figure 2, the marker design is shown.

2.3 Torpedo launcher

There are two torpedo bays on the front. The torpedoes have been designed to fit precisely into the bays and are kept in place by a small spring loaded ball. The torpedo design can be seen in Figure 3.

The torpedoes have slightly positive buoyancy in order to follow a linear trajectory.

2.4 Pneumatic System

The system gas supply is a common 16gr CO_2 cartridge. This cartridge is very small and also allows a rapid "recharge" simply by replacing it with a new one. Also, a larger or

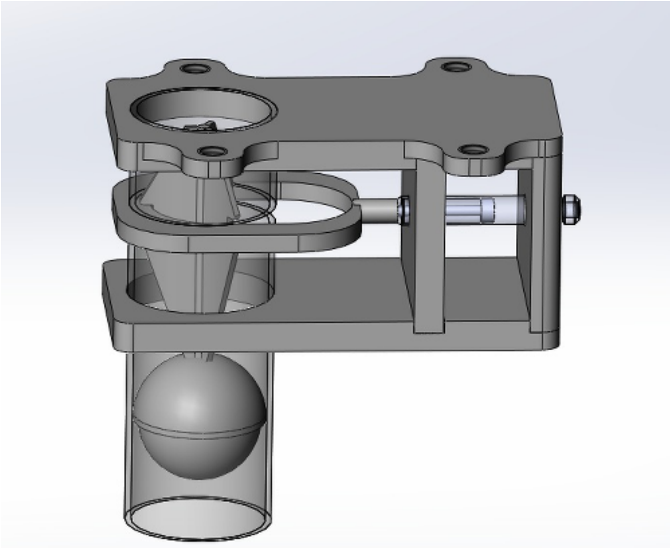

Figure 2: A loaded marker

smaller cartridge can be inserted if required. An additional benefit is that as long as there is liquid CO_2 evaporating inside the cartridge the output is relatively constant (depending on the gas temperature), whereas in a compressed air tank the pressure drops with every actuation in an exponential decaying manner.

Leaving from the tank, the gas passes through a regulator and supplied to a manifold, where it is distributed to the valves. A safety valve protects the system and personnel from overpressure. The markers and the grippers will be actuated by four 3-way valves (one for each cylinder). Each torpedo bay will be actuated by a 2-way valve. On the output of all valves an adjustable needle valve regulates the flow rate, allowing to control the actuation speed. Quick-connect connectors will be used because of their simplicity and ease of set up. Polyurethane tubing will be preferred over other materials (eg. nylon), because it allows tight radius bends, something important in limited spaces. An overview of the pneumatic system design can be seen in Figure 4.

2.5 Pneumatics Controller

A Generic CAN controller is used to control the pneumatic valves. The controller executes a control loop that starts by reading a received CAN message. This message can be a kill switch message, an execution mode message or a actuation message. Depending on the type, the appropriate dispatch procedure is called. The kill message dispatch procedure reads the payload of the message, and sets the controller to KILL state. Similarly, the mode message dispatch function sets the controller to the defined execution mode. Finally, the actuation message dispatch function energises the appropriate valve for the appropriate amount of time. Any message with undefined id or payload, is reject from the control loop. The actions of the controller for each can message can be seen at Table 1.

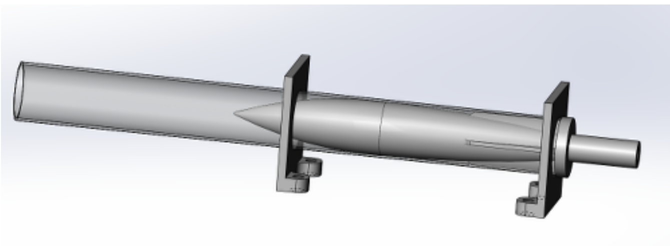

Figure 3: Torpedo in bay

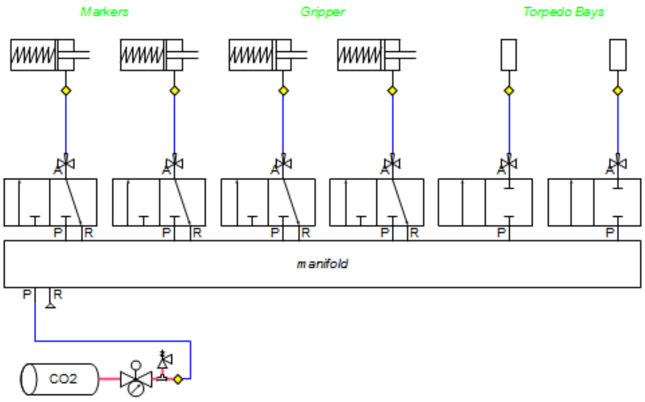

Figure 4: Pneumatics system design

3. RESULT

At the time of this writing none of the mechanics have been manufactured due to limited financial resources, and consequently not tested in real life. Since all the components have been designed and tested in SolidWorks, it is likely that the performance will be at least satisfactory and only small improvements (if any) will be needed. The Generic CAN Controller has been thoroughly tested through unit tests, but also in real life. The correct action was observed for any input value, and also undefined messages were rejected.

4. CONCLUSION

An actual system has to be build in order to further develop the pneumatics system. Problems might arise that can be only discovered through testing. For example the torpedo mechanism might require an unacceptably large amount of gas to operate, or it might disturb the balance of the robot during launching. In order to solve such unforeseen problems it might be necessary to partially or completely redesign the

Table 1: Pneumatic controller input-output

id	payload	action	out
KILL	KILL	kill enabled	n
KILL	not KILL	kill disabled	n
KILL	other	-	n
MODE	SIMULATE	sim enabled	n
MODE	not SIMULATE	sim disabled	n
MODE	other	-	n
ACTUATE	VALVE	actuate valve	y
ACTUATE	other	-	n
other	other	-	n

affected components.

5. REFERENCES

[1] Robosub. `http://www.auvsifoundation.org/foundation/competitions/robosub/`. Accessed 2014-01-10.