A Soft Mechanism for Regulating Pressure

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Abstract

Problem:

No drone that can deliver multiple inflatable devices to the victims which require them in large scale disasters such as floods.

Approach:

We developed a pneumatic regulator which functions as a one-way valve and deployment mechanism simultaneously. We then integrated this into a custom life-preserver for deployment from a drone.

Result:

If the input pressure Pin exceeds a total differential pressure of 30 kPa in relation to Pout, the device blocks air from passing through it, causing it to deploy. If pressure is applied to P_{out} or P_{in} reaches equilibrium with P_{out} the device blocks air from passing through it.

Significance:

This work has an impact on rescue operations of large-scale hydrological disasters, in which multiple people need to be saved from drowning at once.

Introduction

What is the problem?

- According to the World Health Organization 236,000 fatalities were estimated to occur by drowning per year, accounting for a full 7% of injury related deaths.[1]
- In floods it is estimated that 75% of all fatalities that occur are due to drowning, in 2020 1,922 people died in India alone due to seasonal floods.[5]

- Typically rescue teams search a flooded area which is very time consuming; in the time they reach people, they often have already died.
- To save the life of a drowning person, a lifeguard has as much time as it takes to cook a soft-boiled egg, or roughly three minutes.
- no drone that can deliver multiple inflatable devices to the victims which require them.

What did we do?

- We developed a pneumatic regulator that functions as a one-way valve and deployment mechanism at the same time.
- We integrated the pneumatic regulator into a custom-made life preserver.
- We deployed a life preserver from a drone.

Results / Significance

- Our device is very small (9.56 * 10^-6 m^3) and is lightweight (0.0258 kg).
- We can theoretically deploy up to 58 life preservers with a heavy payload drone (UAV systems, Tarot T650).
- This work has an impact on rescue operations of large-scale hydrological disasters, in which multiple people need to be saved from drowning at once.

Background

Drone based deployment

- The paper “Drones for Provision of Flotation Support in Simulated Drowning” reveals that the response time of a drone is twice as fast as the response time of a rescue swimmer when rescuing an active drowning victim. Another benefit of this approach is that the rescuer is not put at risk during the rescue.[4]

Deployable Structures

- The Bertoldi group developed a system to create large origami structures utilizing only air pressure in “, these structures have two configurations a “compact” configuration and an “expanded” configuration. The design methodology the Bertoldi group used can be applied at any scale.[3]

Why is it important?

- The Pneumatic Regulator can be used to combine the advantages of drone-based delivery of life preservers and deployable structures, allowing minimal delay in delivering needed structures and life-preservers to areas isolated by disaster.

Results and Discussion

Description of invented technology

Figure 1 (System Overview)

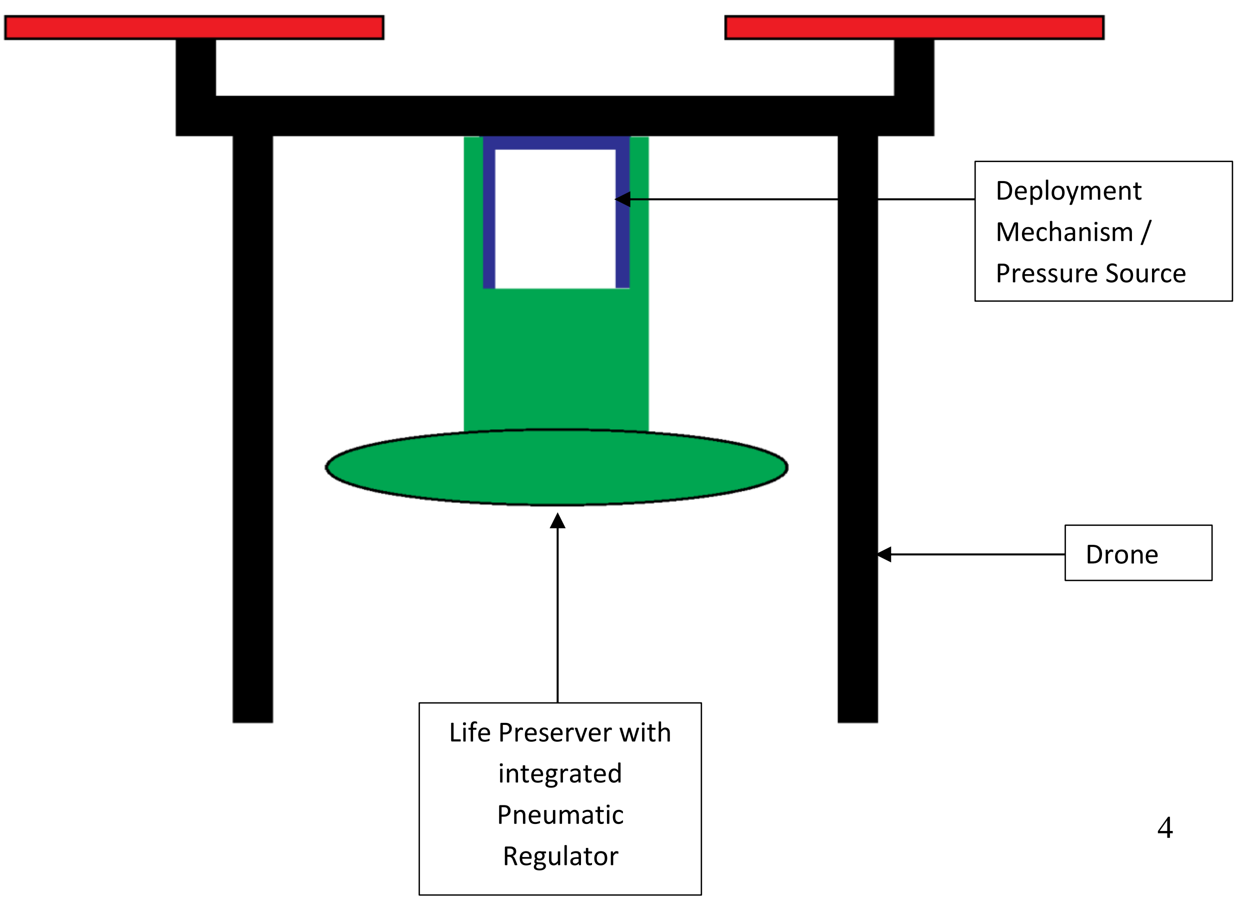
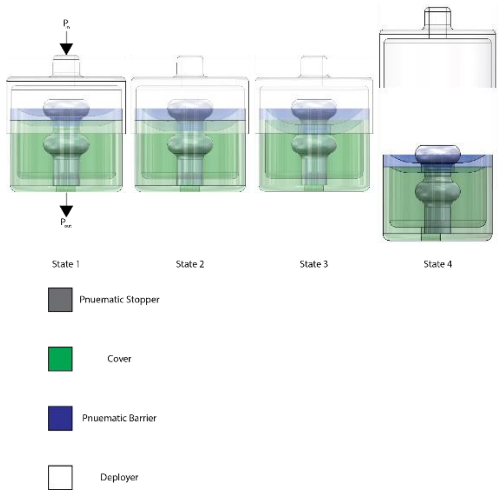


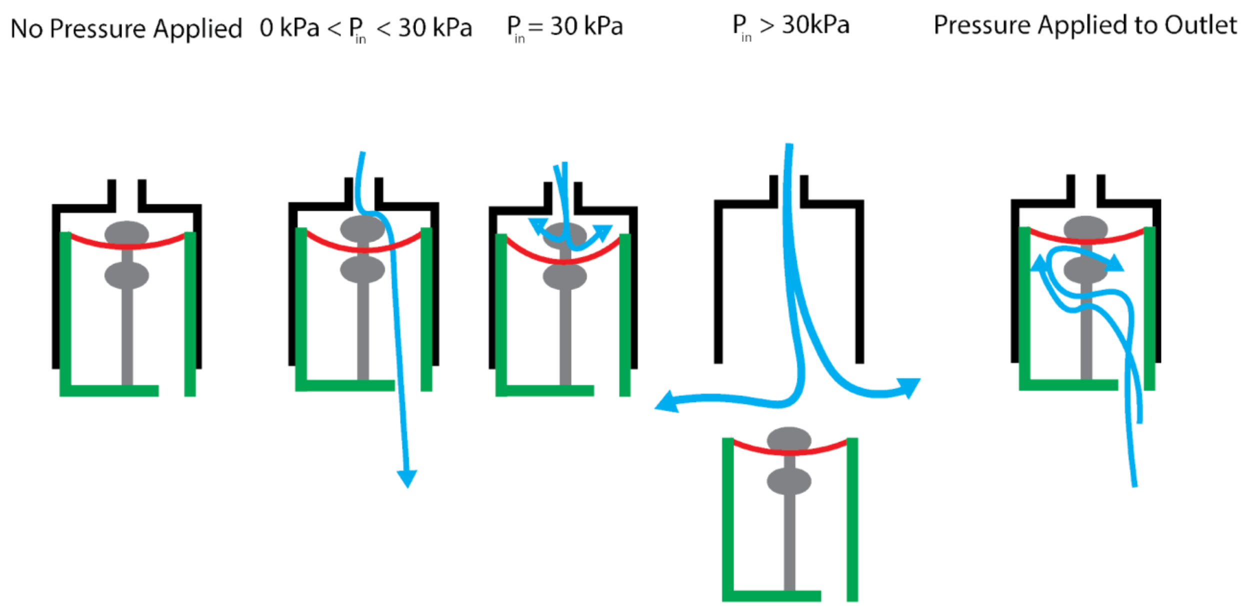
Figure 2 (Pneumatic Regulator)

A) Device Schematic



B) Device Implementation

C) Operational States



D) Characteristics

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- The pneumatic regulator serves as a one-way valve. When a pressure is applied to the input $\mathbf{P_{in}}$, the membrane passes air to the output $\mathbf{P_{out}}$ (Figure 2, Part A, State 2). When a pressure is applied to the output $\mathbf{P_{out}}$, the membrane will block air from passing to input $\mathbf{P_{in}}$ (Figure 2, Part A, State 1).
- If the input pressure Pin exceeds a total differential pressure of 30 kPa in relation to Pout, the device also blocks air from passing, the membrane will push against the upper stopper. This feature allows for constraining the maximum speed of inflation (Figure 2, Part A, State 3). The previously mentioned feature will lead to the exit of the regulator from the deployer. (Figure 2, Part A, State 4).
- At any given time, when the input and output pressure equivalate, the inflation stops (Figure 2, Part A, State 1).

Figure 3 (Life Preserver)

Inflation and Deployment Time

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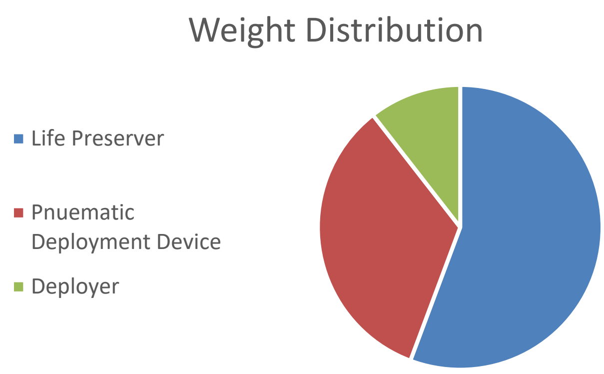
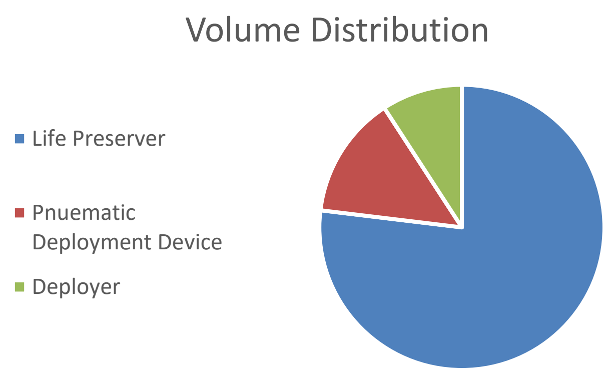
Figure 4 (Weight and Volume Distribution Pie Charts)





Demonstration

Figure 5 (Demonstration)

A) Situation Overview

B) Drone Approaches Person

C) Life Preserver Deployed

Conclusions

[To be added once the story is confirmed]

Acknowledgements

[To be added later]

References

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Supporting Information