T-Minus: A Micro-Timer System for the Delayed Release of Chemicals

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Introduction

T-Minus' goal is to provide a small discrete package with delayed release functionality of a variety of semi-viscous formulations (volatile, active, corrosive, etc.) using minimal battery power to provide an ejection distance between one to two feet from the device. This project focuses on shrinking the timing and discharge systems while increasing efficiencies in energy consumption.

Our end goal is to fit the system inside of the volume of a soda can while being able to discharge a compound months after set to do so. We are also looking at both hardware and software securities to ensure that the device is virtually tamper-proof and can only be disarmed by the individual/ group that armed the device.

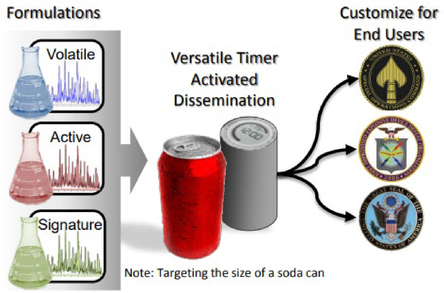


Figure 1: Mission concepts of the T-Minus system

Planning Phase

Requirements:

Device must be small enough to fit in a soda can, have minimal power consumption, and dispense medium-viscosity fluids (~100 Cst) at a target placed up to two feet from the device.

Proposed solutions:

Dissemination method: In the case of T-Minus, fluid motion can only when a pressure differential is created. To generate/release a pressurized fluid on demand, different methods of pressurization were considered. These methods included: micro air pump, inert gas cylinder, electronically-activated gas generator, motorized screw, pre-pressurized environment, or a compressed spring. The pressurization methods could then be paired with various geometries such as a syringe or a suspended membrane. Given the space premium, bulky components (pumps, springs, motors, etc.) were eliminated. The current T-Minus prototype utilizes syringe with pressurization coming from a gas generator.

Electronics: A low power Micro Controller Unit **(MCU)** or Real Time Clock (**RTC)** module will be used to set either a traditional countdown timer or a calendar alarm depending on requirements for delay duration and any needed security. Once the point is time is reached a signal pin will set its output, triggering the dissemination device. The **MCU** allows for a suit of sensors and security features allowing for an advance and intelligent device capable of immediate release based on environmental condition, lockout, destruction and other modes of tamper prevention.

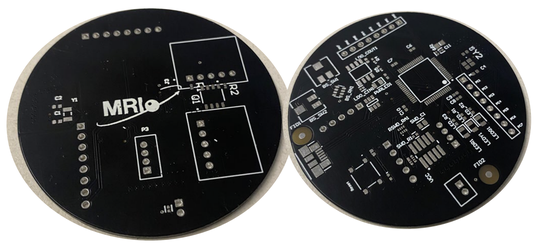


Figure 2: Custom T-Minus PCB design

Initial Design Phase

The TMINUS system was modeled in CAD to facilitate easy design changes while prototyping different iterations using additive manufacturing. Early designs involved prototyping different component configurations to optimize the size of the device while still providing functionality and adequate fluid spray. The preliminary design consists of an internal syringe that houses the gas generator, piston, and fluid chamber, a battery bank, control board, nozzle, and an external housing and cover. The syringe mechanism and housing were fabricated using an additive manufactured high strength carbon fiber-nylon material and tested for functionality via an external compressed air system. The control board was designed in CAD and layout optimized to minimize space.

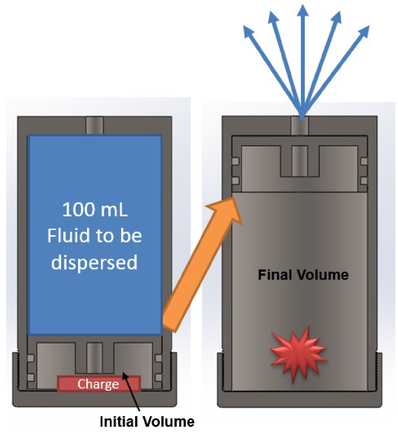


Figure 3: Syringe actuation example

Test Design Concepts

The gas generator system was tested inside a chamber that represented the syringe when full and when empty to determine the proper amount of fuel to be used in the TMINUS prototype system. A functional standalone system was created and tested at various pressures with water and 100 cSt silicone fluid. Figure 4 illustrates the fan spray pattern of the TMINUS device when activated, reaching a height of 4ft from the nozzle. Issues that arose during testing were related to the additive manufactured pressure vessel, including imperfect threading and piston movement that was not as smooth as desired. These 3D printed parts were used to enable quick design changes. Moving forward, the pressure vessel would be fabricated from a more robust material such as stainless steel, which would also provide resistance to corrosive materials if required.

To accurate design the syringe to withstand the pressure of the gas generation, a cast iron facsimile was built to represent the initial or final volume of the syringe mechanism. A 2 g and 5 g sample was installed and actuated. Figure 5 shows the resulting pressure data.

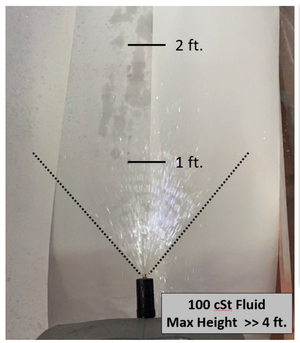


Figure 4: Syringe testing with 100 cSt fluid

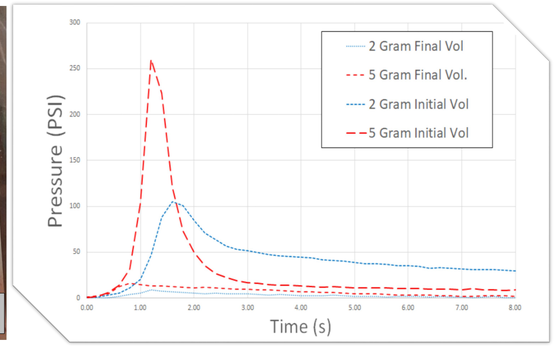


Figure 5: Pressure data from gas generation tests

Build and Test Prototype

At the current phase of the TMINUS system, the user interface is an external wired switch box connected to the device. The switch box enables push button ignition of the piston. To maintain the small form factor for the TMINUS system, an external user interface would be desirable. Options include a device-mounted interface with screen programming, external USB interface tablet, or a storage case with integrated programming of individual TMINUS devices.

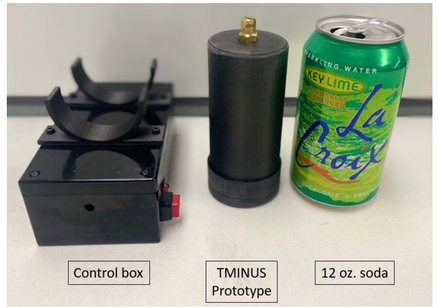
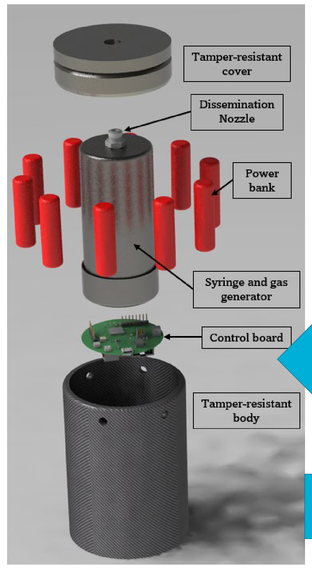


Figure 6: Current T-Minus stand-alone prototype

Refine and Deliver Device



Future improvements with take the current T-Minus form factor and further reduce the exterior dimensions. The threshold goal was stated to be the size of a soda can. Creating multifunctional structures, the T-Minus design can fit in the volume of an 8.4 oz Red Bull can while still holding 100 mL of fluid.

The T-Minus project has submitted a white paper to the target client is awaiting the continued development.

Current

Next-Gen

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