Enabling Secure Blood Delivery from Donor Centers to Battlefield Care Settings Through Extended Passive Cold Chain Capability

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Introduction

A significant percentage of deaths from trauma-associated hemorrhage and coagulopathy are potentially survivable if appropriate resuscitation products (whole blood or blood components) are available at the point-of-injury (POI), enroute, and during prolonged field care. However, transporting and maintaining blood inventory at far forward bases can be challenging. These products must be transported with proper cold chain maintenance in containers that can withstand arduous journeys and austere environments. The study aims to provide blood logistics stakeholders with a reliable, robust, cost-effective and flexible solution to deliver blood products from domestic and international donor centers to Role 2 and Role 3 settings, addressing critical gaps in battlefield medical logistics.

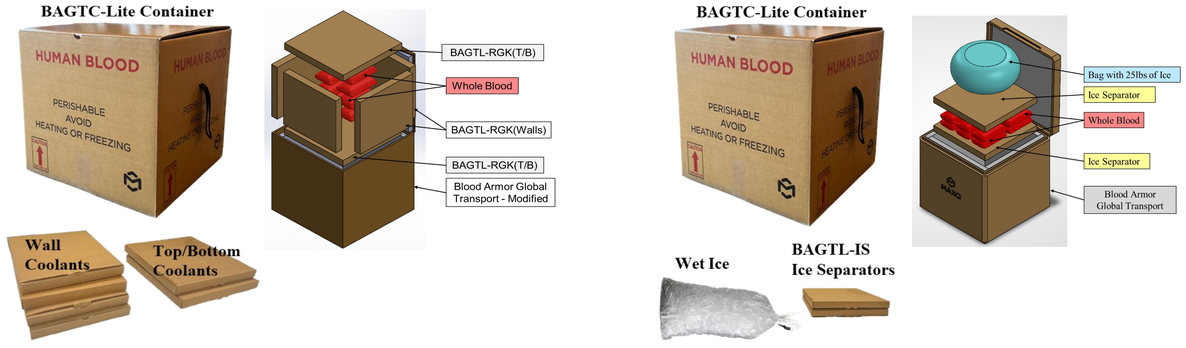
Methods and Materials

Design considerations: The desired container needs to maintain a minimum of 18 whole blood units for 7 days under extreme summer and winter conditions. The system needed to be optimized for expeditionary and prolonged field care operations, enabling reliable blood distribution from strategic logistics hubs to forward Roles of Care while minimizing weight, volume, power requirements, and logistical burden. The currently used Collins box, the primary container used to transport blood products from donor centers to the Armed Services Whole Blood Processing Laboratory (ASWBPL) and higher roles of care, has a limited validated transport duration, restricting its use in several critical operational scenarios.

Materials: High Performance insulation panels along with coolants enclosed in a double walled corrugated carboard box, were used to create a container sized **16.75" × 16.9" × 16.9" (12% smaller than Collins box).** The box has been designed to use either wet-ice or phase change materials to maintain the payload temperature. The proprietary phase change materials (PCM) coolants were carefully designed to be preconditioned in either a freezer or a refrigerator.

Thermal performance evaluation:

Laboratory testing: Blood Armor Global Transport (BAGT) containers were packed with both the wet-ice and PCM based configurations with simulated blood units and placed inside an environmental chamber and exposed to summer and winter ambient conditions, based on GMP/GDP compliant ISTA ambient profile for thermal transport for up to 7 days. For comparison, Collins box was also tested with wet-ice under the same ambient conditions. In addition, Blood Armor Global container was also tested under MIL-STD-810G Method 501.5 Basic Hot and Basic Cold ambient profiles for up to 48 hours. The simulated blood units were stored in conditions similar to cold stored blood products (1-6°C). NIST traceable calibrated digital temperature loggers were attached to the simulated blood units to measure its temperature during extreme ambient exposures.



7-days (168 hours) of temperature hold time for up to 24 whole blood units with the BAGT container using two different operationally-relevant Packing configurations (PCM/ Wet-Ice)

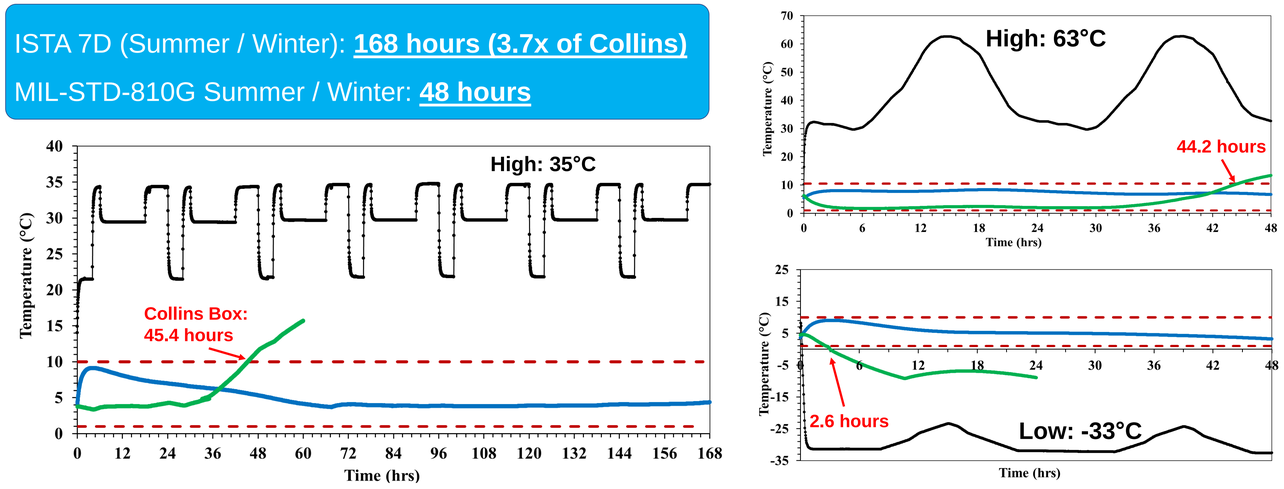
Results

BAGT Lite maintained Blood products at 1-10°C up to 7 days under operationally relevant ambient conditions.

Blood Armor Global Transport Lite - Performance Using Wet Ice

ISTA 7D (Summer / Winter): **168 hours (3.7x of Collins)**

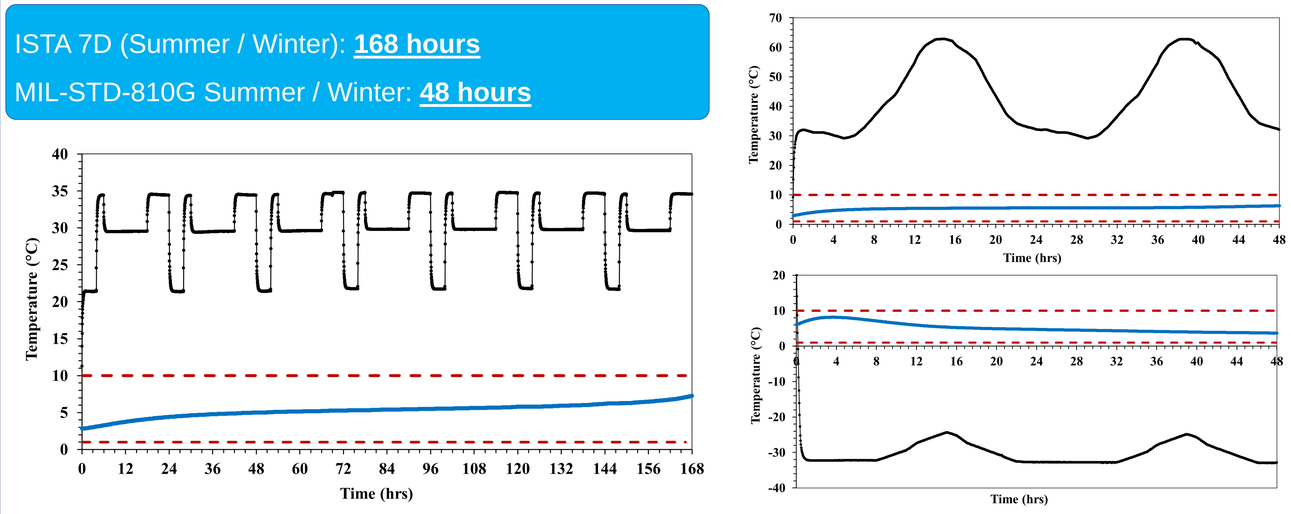
MIL-STD-810G Summer / Winter: **48 hours**



Blood Armor Global Transport Lite - Performance Using PCM

ISTA 7D (Summer / Winter): **168 hours**

MIL-STD-810G Summer / Winter: **48 hours**



● BAGT- Payload Temperature ● Collins Box- Payload Temperature —●— Ambient Temperature

Operational Significance: One container supports wet-ice or PCM pack-outs while protecting blood-product for extended durations – giving military blood logistics unmatched flexibility and reach.

Conclusions: The primary challenges in military blood product distribution is the limited validated transport duration of existing shipping solutions. The Collins box, which is currently the primary container used for blood transport, is validated for only 48 hours, requires re-icing every two days. This presents a significant operational limitation. In this study, MaxQ has successfully developed the Blood Armor Global Transport (BAGT) Lite container, which provides more than 3x the thermal performance of the Collins box. The BAGT Lite container has been qualified for using either wet-ice or PCM-based cooling configurations, providing flexibility to support a variety of operational scenarios. The BAGT Lite container is currently undergoing field evaluation by the 18th MEDCOM Area Joint Blood Program at the Tripler Army Medical Center in Hawaii, and by SOCAF at Camp Lemonnier, Djibouti.

Acknowledgement: This work was supported by the Office of US Army Medical Research Acquisition Activity through Defense Health Agency under Award No. W81XWH21P0115. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense.