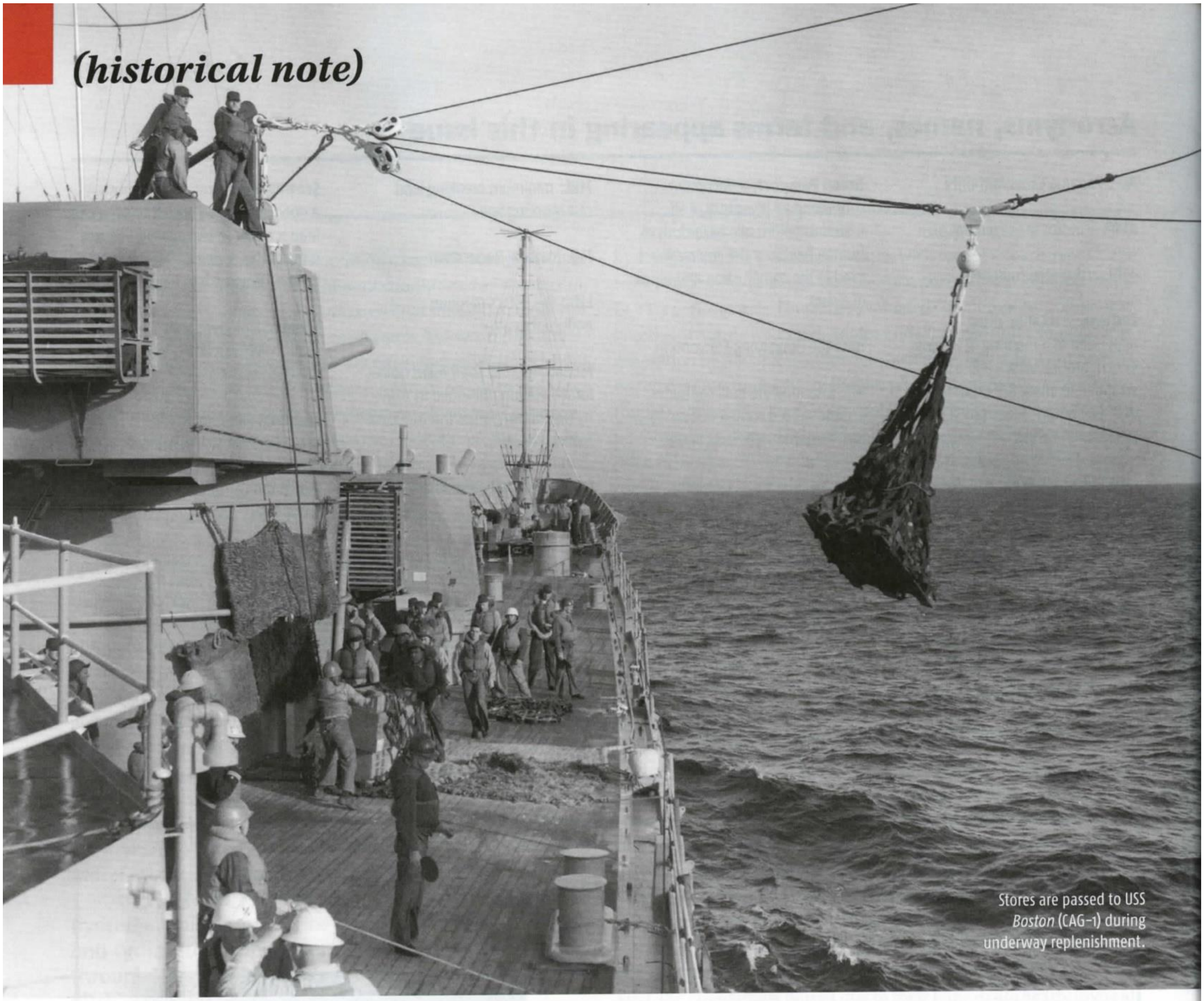


Stores are passed to USS *Boston* (CAG-1) during underway replenishment.

Resupply on the Run

The development of underway replenishment

BY NORBERT DOERRY

In 1916, anticipating the entry of the United States Navy into World War One, the officers onboard USS *Maumee* (Fuel Ship No. 14) recognized that the older destroyers with insufficient range to cross the Atlantic Ocean would need to be refueled at sea in less than perfect weather. At that time, ships were traditionally refueled in protected harbors. Occasionally, refueling at sea would be accomplished in calm water using the astern refueling method where the fuel ship would trail a hose behind it, the receiving ship would then retrieve the hose, and once the hose was inserted into the fuel tank, pumping commenced. The *Maumee* officers, including then-Lieutenant Chester Nimitz, quickly realized that the astern refueling method would be too slow and restricted to calm water; another way would have to be found.

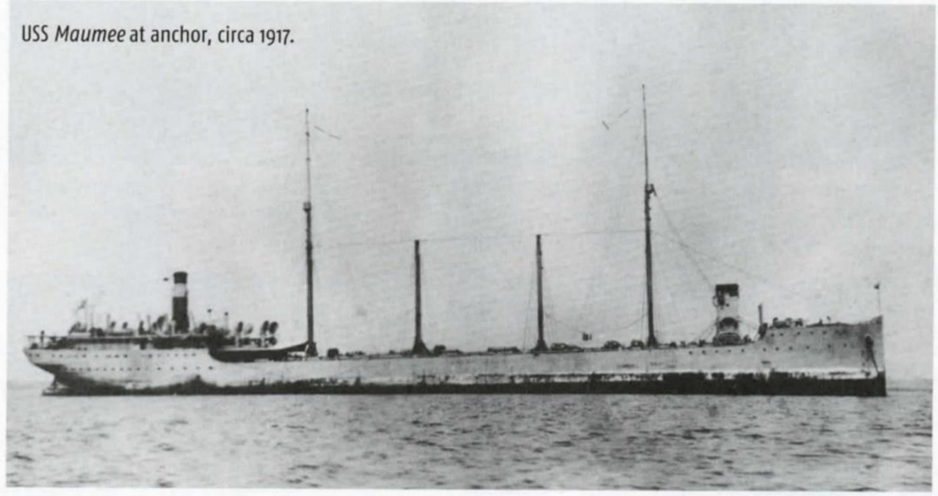
Their answer, alongside refueling, continues with refinement to the present. The *Maumee* solution was for the receiving ship to maintain position alongside the fuel ship, which suspended from a cargo boom a cradle that supported the fuel hose. Initially, a towline was used to assist the ships maintain position relative to one another. When the U.S. entered World War One in April 2017, *Maumee* was ready. Over three months, she refueled 34 destroyers transiting the Atlantic using alongside refueling, enabling those ships to contribute to the Allied victory.

Further refinement and adoption of alongside refueling resulted from the "fortification clause" of the 1922 Washington Naval Treaty. In order to gain Japan's agreement, the U.S. agreed not to build any new fortifications or bases in the Western Pacific. This provision forced the navy to alter its war plan with Japan (War Plan Orange) to recognize that the existing bases would likely be lost early in a conflict. The navy would have to be able to project power at sea, without pre-established bases, over a distance approaching 5,000 nautical miles. Underway replenishment would become an instrumental part of meeting this logistics challenge. During the inter-war period, the methods pioneered by *Maumee* would be evolved and adopted fleetwide.

As expected, underway replenishment played a key role in the Pacific theater in World War Two. Following Pearl Harbor, Admirals Mitscher and Halsey concluded that, in the age of naval air warfare, aircraft carrier task forces were safer at sea than in port. Underway replenishment was expanded to include resupplying ammunition and stores in addition to fuel. A ship could be completely provisioned in three underway replenishments. Ships would first come alongside an oiler for fuel; then an ammunition ship to refill magazines; and finally a stores ship for food, consumables, and repair parts. By 1945, a task force typically expended its ordnance in three days; with underway replenishment, the task force could be back on station (or on its way to its next destination) after only 2 nights and 1 day to resupply. Previously, task forces required 10 to 12 days to resupply after 3 days of combat. It was this increase in combat effectiveness that led Fleet Admiral Nimitz to proclaim, "Underway replenishment was the United States Navy's secret weapon of World War Two."

Adapting the gear

During World War Two, normal deck gear was adapted to support underway replenishment. Fuel transfers were accomplished using the "close-in" method, which was a refinement of the system used by *Maumee* in World War One. Instead of a cradle, multiple saddles were used to support the fuel line between the two ships. Most of the



USS *Maumee* at anchor, circa 1917.

deck gear needed to implement the close-in method was located on the delivering ship (typically an oiler). Transfers of stores and ammunition employed the Burton method, in which the load is suspended by lines (called whips) attached to points on both the delivering and receiving ships. A successful transfer required close coordination of winches for both lines to avoid the cargo from hitting the water or overstressing the cables if the cargo was kept too high. At times, a fairlead on the receiving ship was used to enable the delivering ship to control both lines.

Innovations in underway replenishment were introduced into the fleet following World War Two. Recognizing the importance of underway replenishment, specialized deck gear was developed. The first major improvement was attaching the fuel hose saddles or cargo to a trolley riding on a tensioned line, called the highline or spanwire, between the two ships. While the highline/spanwire supported the weight of the load via a padeye on the receiving ship and a winch on the delivering ship, inhauls and outhauls were used either to move the cargo between the ships, or to adjust the location of the saddles for the fuel hose. Manual labor or winches were found to be inadequate to keep the highline/spanwire taut as the two ships moved about. To solve this problem, anti-slack devices and ram tensioners were installed on the delivering ship.

For transferring fuel, specialized connectors called probes and probe receivers were developed to enable quick connections and disconnections. For cargo transfer, sliding padeyes enabled raising or lowering the connection of the spanwire. With the padeye high, the load could be brought over the ship's deck and then lowered to the deck by lowering the padeye. Alternately, a cargo drop reel in the trolley can be used to lower the load to the deck. These new methods were refined and perfected until they were incorporated into the Standard Tensioned Replenishment Alongside Method (STREAM) and implemented in the U.S. fleet in the 1970s and 1980s. Ships can now routinely conduct underway replenishment operations day or night while holding station with between 140 and 200 ft. of separation in up through sea state 5.

Three in one

Another innovation was the development of multi-product supply ships. Instead of three separate supply ships to provide fuel, ammunition, and stores, a single supply

Resupply on the Run *continued*

The fast combat support ship USNS *Arctic* (T-AOE 8), right, transfers fuel while sending supplies and other stores to the Nimitz-class carrier USS *Harry S. Truman* (CKN 75) via cable during underway replenishment in the Persian Gulf in 2004. United States Navy photo by Photographer's Mate Airman Kristopher Wilson.

Pakistani naval frigate *Tippu Sultan* (D 185) receives fuel from the fast combat support ship USNS *Supply* (T-AOE 6) during an underway replenishment in the Arabian Sea in 2006. United States Navy photo by Mass Communication Specialist 2nd Class Kitt Amaritnant.

The aircraft carrier USS *Enterprise* (CVN 65) conducts an underway replenishment with the fleet replenishment oiler USNS *Kanawha* (T-AO 196) in the Atlantic Ocean in 2010. United States Navy photo by Mass Communication Specialist 3rd Class Stacy D. Laseter.

ship would provide all three. With multiple STREAM stations, all three types of products could be transferred at the same time. These fast combat support ships and replenishment oilers could operate with the battle fleet. More recently, ammunition cargo ships are able to fulfill this role, albeit with a limited fuel oil capacity. The introduction of helicopters on replenishment ships for transferring stores and ammunition using vertical replenishment also has increased the speed of replenishment.

In the first decade of the 21st century, the increased sortie generation rate requirements for the Gerald R. Ford-class aircraft carriers and supportability issues with STREAM components necessitated improvements to STREAM. These improvements are part of "electric STREAM" or E-STREAM. For example, E-STREAM replaces the hydrostatic transmissions in the winches of STREAM with variable frequency drive (VFD) electric motors and modern programmable logic controllers. The VFD controlled motors enable a doubling of the transfer rate. Higher loads (up to 12,000 lbs. versus 5,700 lbs. for STREAM) are accommodated with thicker highline wire rope. Overall, E-STREAM employs technologically mature components and methods to increase reliability and reduce total ownership cost. E-STREAM is planned for installation in all new underway replenishment ships starting with *John Lewis* (T-AO 205), currently under construction at NASSCO in San Diego, CA.

For more than 100 years, the United States Navy's ability to project power thousands of miles from our shores has depended on our capability to replenish warships at sea. With the changing geopolitical climate the U.S. is currently facing, this need continues and will require continuous advances in underway replenishment technologies. In the same way that STREAM provided the foundation for our underway replenishment capability over the last 40 years, E-STREAM promises to serve as the foundation for the next 40 years. Fleet Admiral Nimitz would be proud. **MT**

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