

fathometers, gyro compasses, and Sea Area-3 Global Maritime Distress Safety and System consoles. It is the only deck that contains large, fixed windows on all sides, and is surrounded on all four sides by an open walkway, which measures approximately 3' in width.¹⁰

History:

In December 1976, NASA awarded the contract for the checkout and assembly of SRBs, at both KSC and MSFC, to USBI of Huntsville, Alabama.¹¹ A supplement to this parent contract gave USBI the responsibility for the location and retrieval of expended SRB casings, parachutes, and other flight elements from the Atlantic Ocean, and delivery to the Hangar AF SRB Disassembly Facility located on the eastern shore of the Banana River at CCAFS. On July 13, 1979, NASA signed a letter contract with USBI, allowing the company to establish and operate a two-vessel SRB recovery force; the contract was managed by KSC. The letter was formalized in June 1980, through a contract that amounted to \$7,230,976, and covered the period through February 28, 1982, with the option of extension through February 28, 1995.¹²

In 1977, the Naval Undersea Center, San Diego, and the U.S. Navy Supervisor of Salvage, under contract with NASA, formulated and developed the final operational scheme and retrieval vessel specifications for the SRB Retrieval System.¹³ NASA specified that the at-sea recovery operations be developed around using commercially available oilfield tug/supply vessels measuring at least 170 feet long. The design task was first to investigate the availability of such vessels suited to SRB recovery,

¹⁰ ACI, "Kennedy Space Center."

¹¹ USBI was a subsidiary of United Technologies Corporation (UTC) of Sunnyvale, California. Eleanor H. Ritchie, *Astronautics and Aeronautics, 1976, A Chronology* (Washington, DC: NASA, Office of Scientific and Technical Information, 1984), 300, <http://history.nasa.gov/AAchronologies/1976.pdf>.

¹² NASA KSC, "Alabama Firm To Conduct Shuttle Booster Retrieval Operations," News Release No: KSC 101-80, June 10, 1980, Sweetsir Collection, File No. ARCH00009097, Kennedy Space Center Archives Department, Florida. A third retrieval vessel, *Independence*, was built in 1985 by Halter Marine in Moss Point, Mississippi to support shuttle launch operations at Vandenberg Air Force Base in California. It was owned by the U.S. Air Force. After construction, she spent time at KSC getting ready for service. *Independence*, along with *Freedom Star* and *Liberty Star*, also was used in the salvage and recovery operations following the *Challenger* accident. On August 22, 1987, *Independence* left KSC for Port Hueneme, California, where the Air Force turned the vessel over to the Navy. "Photo caption," *Spaceport News*, September 11, 1987, 8; "KSC Welcomes VAFB's "Independence," *Spaceport News*, June 7, 1985, 3.

¹³ The Technical Report for the SRB Retrieval System Final Design Concept was prepared in 1977 by the Naval Undersea Center (NUC TN 1822). Anker M. Rasmussen, "Solid Rocket Booster Retrieval Operations," in *Space Shuttle Technical Conference, Part 1*, ed. Norman Chaffee (Springfield, VA: National Technical Information Service, U.S. Department of Commerce, 1985), 505.

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and then to adopt and modify them.¹⁴ David Fraine, Captain of the *Freedom Star* from 1992 until 2007, noted that USBI became involved in the recovery plan development process, and, using some of the Navy's recommendations, and "based on their own insight, developed some ideas and a plan for SRB recovery that wouldn't cost NASA as much money."¹⁵

In 1979, USBI hired Rudolph F. Matzer & Associates, Inc., of Jacksonville, Florida, to design the special retrieval vessels, based on the Naval Undersea Center specifications. The vessels, which were originally named *UTC Liberty* and *UTC Freedom*, were built at the Atlantic Marine Shipyard, Fort George Island, Florida.¹⁶ Since NASA did not have the money to buy or build their own vessels, UTC paid for the vessels' construction, and in turn, NASA paid the lease cost of the vessels. *UTC Liberty* was delivered to KSC in October 1980, and the *UTC Freedom* followed in January 1981.

In December 1980, several months prior to the first launch of the SSP (STS-1), *Liberty Star* underwent at-sea training (Figure No. 5) while *Freedom Star* was still at the Fort George Island shipyard. The tests of the final design concepts, conducted in an area located approximately thirty miles east of Cape Canaveral, utilized a full-scale Ocean Test Fixture simulating the booster stack, a full-scale model frustum, and full-sized parachutes.¹⁷

Beginning with STS-1, which launched April 12, 1981, the two booster stack retrieval vessels supported all 135 SSP missions (Figure Nos. 6, 7, 8). During STS-1 operations, the nozzle plug failed to operate satisfactorily. As a result, the Ballast Aerating Retrieval Boom (BARB), a device constructed from aluminum pipe and tubing, and divers were baselined for booster stack dewatering; an in-port Diver Operated Plug was developed and brought into service to provide final booster stack dewatering at Port Canaveral. Prior to STS-4, a recompression chamber obtained from the Navy was installed on-board one retrieval vessel, and

¹⁴ Robert L. Watts, "The SRB Retrieval Support Craft," in *Oceans '79, Fifth Annual Combined Conference* (New York, NY: The Institute of Electrical and Electronics Engineers, Inc., 1979), 691.

¹⁵ Fraine, interview, April 10, 2012, 18.

¹⁶ After Lockheed replaced USBI as the KSC base operations contractor, Lockheed changed the name of the vessels to *Liberty Star* and *Freedom Star* after their company symbol, the flying star. David S. Fraine, interview by Joan Deming and Patricia Slovinac, July 27, 2006, notes on file, ACI, Sarasota, Florida.

¹⁷ NASA KSC, "Flight Simulations Conducted as Shuttle Interface Test Nears End," KSC News Release No. 268-80, 1980, Sweetsir Collection, File No. ARCH 00009192, Kennedy Space Center Archives Department, Florida; Rasmussen, "Solid Rocket Booster Retrieval Operations," 506.

before STS-5, an at-sea prototype Diver Operated Plug was designed and constructed. Other equipment changes followed in parallel with the evolution of retrieval techniques.¹⁸

Beginning on January 28, 1986, immediately following the *Challenger* accident (STS-51-L), and ending on August 28, 1986, both *Freedom Star* and *Liberty Star* were among thirty-eight surface vessels and approximately 6,000 NASA, Air Force, Navy, Coast Guard, and contractor personnel participating in marine search and salvage operations.¹⁹ As a result, about forty-five percent of the orbiter, fifty percent of the ET and booster stacks, and other flight systems were recovered.²⁰ This effort was characterized as the largest ocean recovery operation in history.

In 1993, NASA officially purchased *Freedom Star* and *Liberty Star* from USBI. As a result, at this time, the vessels went from being privately-owned and operated commercial vessels to government-owned and contractor-operated.²¹ To commemorate NASA's purchase of the two vessels, four aluminum "meatball" emblems fabricated by EG&G were attached to the smoke stack port and starboard sides of both vessels.²²

Permanent structural changes were made to the vessels ca. 1997 and 1998 by Dentyen's Shipyard in Charleston, South Carolina, in order to tow the NASA ET barge from MAF to KSC (Figure No. 9). These modifications were designed by Rodney E. Lay & Associates, Naval Architects, in Jacksonville. Changes included strengthening of the stern with reinforced plating, as well as installation of new bulwark fairings and a new H-bit on the back deck through which cabling will be threaded to keep it centered during towing operations. In addition, the hydraulic tow winch was replaced with a stronger and more powerful double-drum waterfall tow winch. One reel of the winch was dedicated to booster stack towing; the other supported ET towing operations.²³

¹⁸ Rasmussen, "Solid Rocket Booster Retrieval Operations," 507.

¹⁹ Joel W. Powell, "Challenger search and salvage," *Spaceflight* (29), April 1987, 154-159.

²⁰ "51-L salvage operation ends," *Space News Roundup*, September 5, 1986, 1.

²¹ Fraine, interview, April 10, 2012, 19.

²² "Retrieval vessels exhibit NASA emblem," *Spaceport News*, January 15, 1993, 8. Previously, in 1992, the NASA "meatball" insignia had been painted on the stack of each vessel. NASA KSC, *Space Shuttle Solid Rocket Booster Retrieval Vessels*, NASA Facts (Florida: Kennedy Space Center, 1994), Sweetsir Collection, File No. ARCH00019061, Kennedy Space Center Archives Department, Florida.

²³ "SRB retrieval vessels to begin towing external tank," *Spaceport News*, August 29, 1997, 1 and 8.

Other vessel improvements included Differential and WAAS GPS navigational equipment, a flume tank system for increased stability, state-of-the-art communication systems, and man-rated boat davits. The Welin davit system, installed circa 2001, was a safety enhancement that, in addition to new Ambar boats, made it possible to work under rougher conditions.²⁴ The new dive boats, unlike their predecessors, were safer and more efficient, and could be hoisted fully loaded over the side of the retrieval vessels. Previously, equipment had to be handed down to the divers.²⁵

The dynamic positioning system was installed in 2002. A Genset Seachest, designed by Rodney E. Lay & Associates, was installed on each vessel in 2003. The following year, each vessel received a new emergency generator. In 2006, both retrieval vessels were modified with the installation of a mount on the back deck to support the power supply for the debris detecting Doppler radar system.²⁶ The same year, Weibel Continuous Pulse Doppler X-band radar was installed on both vessels to support radar tracking operations.²⁷

Twice every five years, the vessels were placed in drydock at a vesselyard for scheduled repairs and modifications. Both *Liberty Star* and *Freedom Star* were taken out of service at the same time, and were down for three to six weeks.²⁸

Functions:

SRB Recovery at Sea

Both *Liberty Star* and *Freedom Star* were used for every Shuttle mission; each vessel retrieved one booster stack, as well as its corresponding frustum, three main parachutes, drogue parachute, and if found, its pilot parachute.²⁹ Twenty-four hours prior to launch, the two vessels departed

²⁴ Fraine, interview, April 10, 2012, 22.

²⁵ "New dive boats for SRB vessels," *Spaceport News*, September 26, 1997, 7.

²⁶ Joseph P. Chaput, interview by Rebecca Wright, *STS Recordation Oral History Project*, July 13, 2011, 12.

²⁷ Cheryl L. Mansfield, "Freedom and Liberty Go to Sea," April 26, 2006, accessed at http://www.nasa.gov/mission_pages/shuttle/behindscenes/recovery_vessels.html. Working with the land-based C-band radar, the X-band radar provided velocity and differential shuttle/debris motion information during launch. The radar data were sent from the vessels via a satellite link and analyzed at the C-band radar site located on north KSC. NASA, KSC, "Media Detail," Photo No: KSC-06PD-2648, Released December 1, 2006, accessed at <http://mediaarchive.ksc.nasa.gov/detail.cfm?mediaid=30622>.

²⁸ Fraine, interview, July 27, 2006.

²⁹ *Liberty Star* typically retrieved the right-hand booster and *Freedom Star* the left-hand booster as part of two independent operations. Chaput, interview, 20. Features on the exterior of the SRB, such as the ET attach struts, required that the right-hand SRB be hipped on the starboard side of the towing vessel, and the left-hand SRB on the