



National Aeronautics and  
Space Administration

**SLS-PLAN-185**  
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# **SLS CORE STAGE STRUCTURAL TEST ARTICLE (STA) TRANSPORTATION PLAN**

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## REVISION AND HISTORY PAGE

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**NOTE: Updates to this document, as released by numbered changes (Change XXX), are identified by a black bar on the right margin.**

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## 1.0 INTRODUCTION

This document describes the required transportation planning for the delivery of the Space Launch System (SLS) core stage (CS) structural test articles (STAs), hereafter referred to as the test articles, and associated equipment from Michoud Assembly Facility (MAF), the manufacturing/assembly location, to Marshall Space Flight Center (MSFC), the testing location. This plan is developed in accordance with the goals and methodology put forth in the Logistics Support Infrastructure (LSI) developed for the Core Stage Element as detailed in SLS-PLAN-020, Space Launch System Program (SLSP) Concept of Operations, SLS-PLAN-025, Space Launch System Program (SLSP) Integrated Logistics Support Plan (ILSP), and SLS-SPEC-030-01, Space Launch System Program (SLSP) Support Equipment Specification, Volume I: Support Equipment Planning.

### 1.1 Purpose

The purpose of this document is to identify the transportation flow and describe the transportation functions and support equipment related to the shipment of the test articles and associated equipment from MAF to MSFC.

### 1.2 Scope

This document is applicable to the test articles and associated equipment shipped by NASA barge from MAF to MSFC. Specifically, this plan identifies the test article configurations for shipment, land movement at MAF and MSFC, loading and unloading the test articles onto/from a NASA barge, and water movement from MAF to MSFC. Site specific lifting and handling operations of the test articles are not included in this document.

This document is a data managed (Category 2) document used to describe Program Scope defined with SLS Baseline (Category 1) documentation. Work content and organizational responsibilities described within this documentation are provided to facilitate planning and to familiarize the reader with the interrelationship of activities within the SLS baseline. Specific SLS-PLAN-185 structural test article transportation agreements in the execution of this document's Program Scope description are defined in the SLS baseline documentation. In the event of an inconsistency of this document with SLS baseline documentation, the Baseline documentation is authoritative. See section 2.0 for guidance on the primary authoritative sources for this Plan.

### 1.3 Change Authority/Responsibility

The NASA Office of Primary Responsibility (OPR) for this document is AS42.

This document is maintained as a deliverable to the SLSP. This document will be submitted, and updated, as required, to reflect the maturation of the test articles' configurations and the refinement of the transportation functions.

Changes to this document shall be controlled at the OPR level using processes defined by the OPR.

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## 2.0 APPLICABLE DOCUMENTS

The agreements that guide and enable the planning content contained in this document are captured in the SLSP Program Agreements Document (PAD), SLSP-PLAN-186. The Structural Test Article Transportation Agreements across organizations within the SLS Program are captured in section 6.0 of the PAD and are mapped into the sections shown in Table 2.0-1.

**Table 2.0-1: Structural Test Article Transportation Agreements**

Agreement Area	Section
Organization	
SE&I	6.1
Multiple Elements	N/A
SPIO	N/A
Booster	N/A
Stages	6.5 (TBR-001)
Engines	N/A
Cross-Program	N/A

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

DD1149	Requisition and Invoice Shipping Document
MWI 6410.1	Packaging, Handling, and Moving Program Critical Hardware
NPR 6000.1	Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems Equipment and Associated Components
SLS-PLAN-020	Space Launch System Program (SLSP) Concept of Operations
SLS-PLAN-025	Space Launch System Program (SLSP) Integrated Logistics Support

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Plan (ILSP)

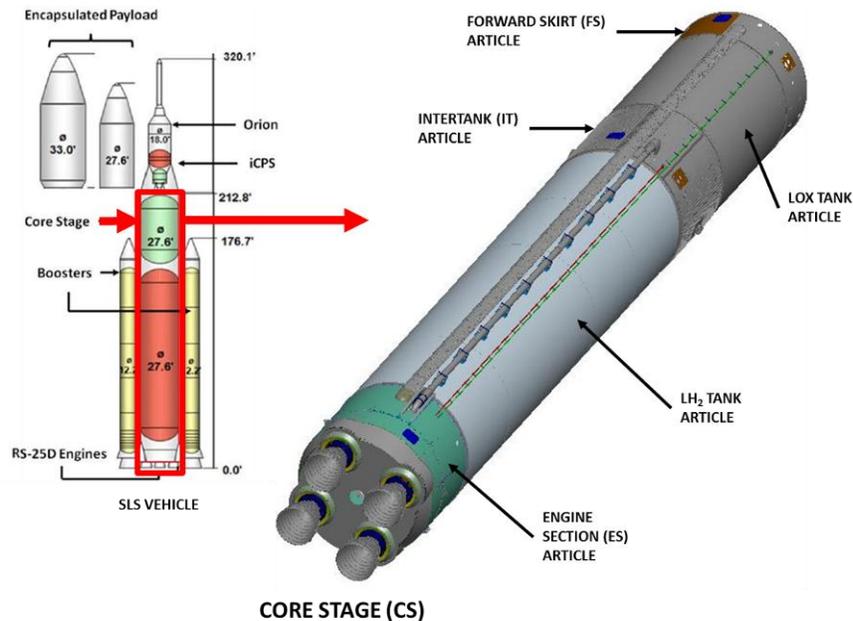
SLS-PLAN-030-01 Space Launch System Program (SLSP) Support Equipment Specification, Volume I: Support Equipment Planning

### 3.0 TRANSPORTATION – GENERAL

#### 3.1 Transportation Summary

The test articles are manufactured at MAF. A total of five test articles are required and represent the basic structural elements of the CS. The test articles are configured for shipment per specified drawings. The test articles are listed below and shown in Figure 3-1:

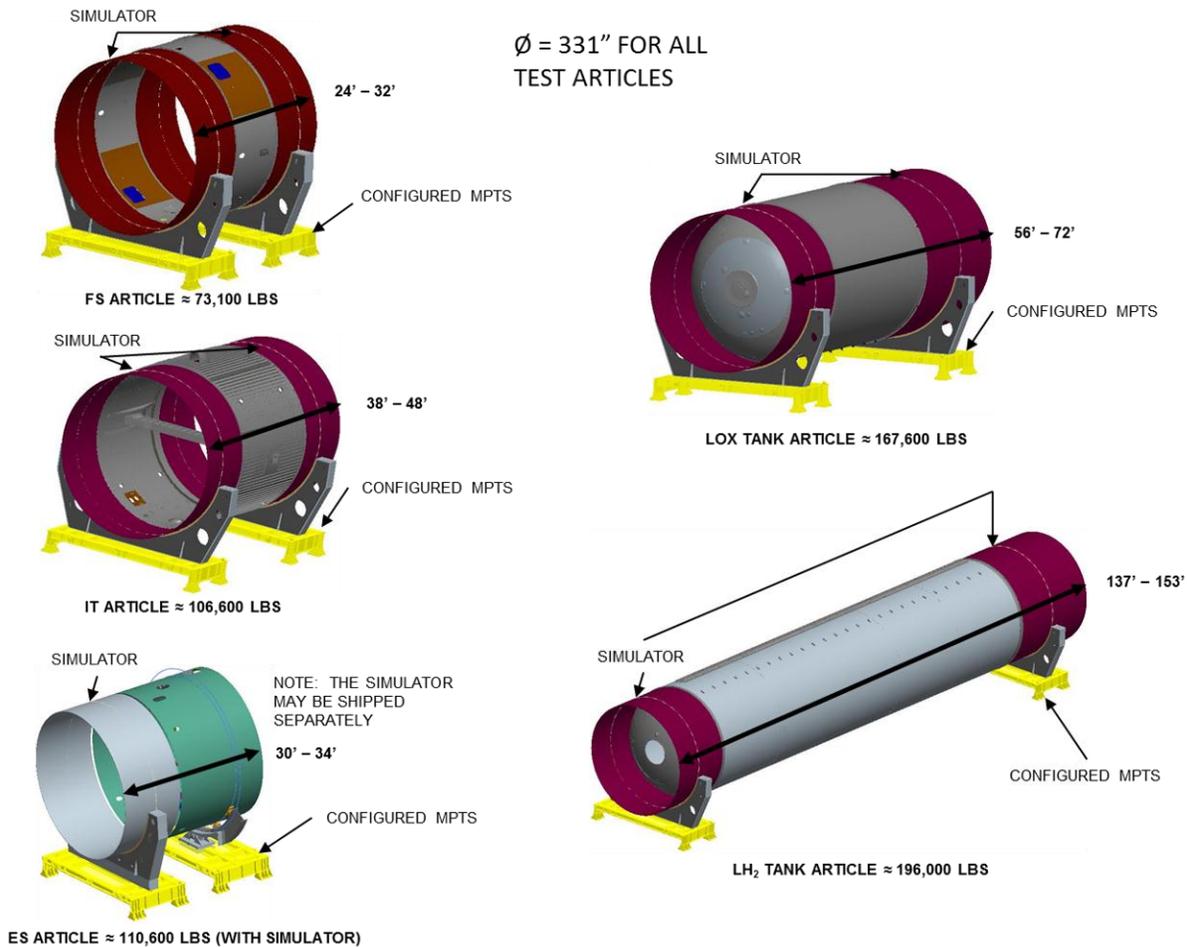
- Forward skirt (FS) article.
- Liquid oxygen (LOX) tank article.
- Intertank (IT) article.
- Liquid hydrogen (LH<sub>2</sub>) tank article.
- Engine section (ES) article.



**Figure 3-1. Test Articles**

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Each test article is considered program critical hardware (PCH) to be handled in accordance with Marshall Work Instruction (MWI) 6410.1, Packaging, Handling, and Moving Program Critical Hardware. Each test article is prepared individually for shipment with attached simulators configured atop the multipurpose transportation system (MPTS). This configuration is illustrated for each test article in Figure 3-2. Test articles may be shipped individually or, if space allows on the NASA barge (and as production dictates), shipped in multiples.



**Figure 3-2. Test Article Shipment Configurations**

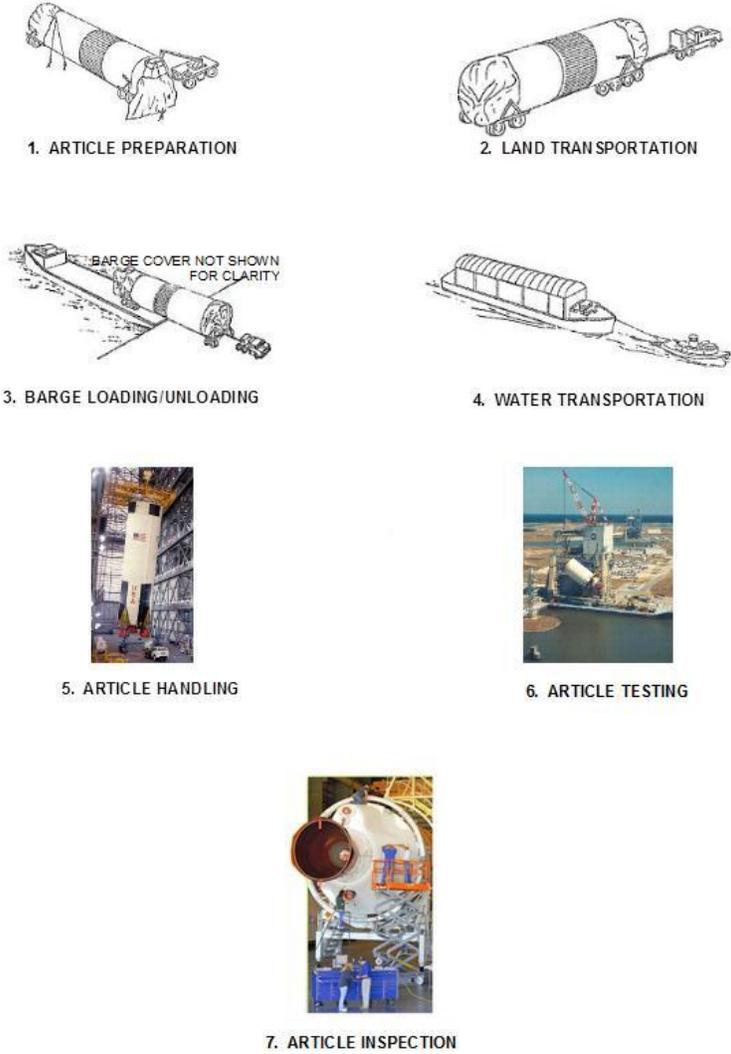
Test article transportation includes the following functions:

1. **Article Preparation** – Prior to test article movements, preparation includes installation of any test article protection equipment, securing the test article on the MPTS, and installation and checkout of any environmental control equipment and instrumentation required for transportation monitoring. Instrumentation, wiring, and other items required for qualification testing at MSFC may also be installed. Reference Section 5.1 for details.

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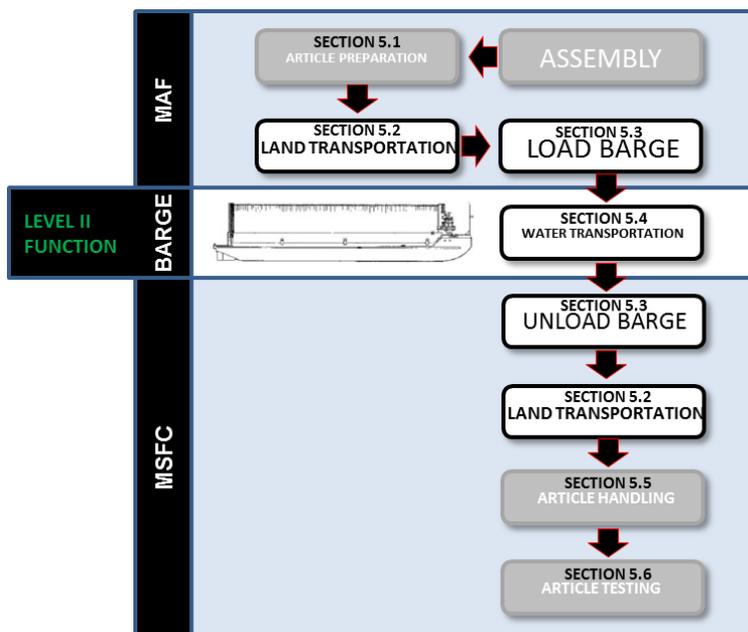
2. **Land Transportation** – Subsequent to article preparation, the movement of the test articles in the horizontal position by means of the MPTS. Land transportation is required from the manufacturing/checkout facility to the MAF dock and from the MSFC dock to the appropriate MSFC test facility. Reference Section 5.2 for details.
3. **Barge Loading/Unloading** – The process by which the test articles and MPTS are positioned and secured to the barge or unsecured and extracted from the barge. Associated equipment may also be positioned and secured. This is accomplished by a “roll-on/roll-off” technique at the dock. Reference Section 5.3 for details.
4. **Water Transportation** – The movement of the test articles, MPTS, and associated equipment by towing a NASA barge along a designated water route between the manufacturing facility, MAF and the test site, MSFC. The NASA covered barge *Pegasus* is designated as the primary transport vessel. Reference Section 5.4 for details.
5. **Article Handling** – Lifting of the test articles onto/from the MPTS and movement by crane and other lifting devices. Handling is required at MSFC for installation into the appropriate test facility after land transportation from the MSFC dock upon delivery of the test articles. Reference Section 5.5 for details.
6. **Article Testing** – Evaluation of the test articles for validation or certification of performance. Testing is required at MSFC. Reference Section 5.6 for details.
7. **Article Inspection** – Test article inspection occurs when custodial responsibility for the test articles is transferred from the sending organization to the receiving organization at identified points/times during test article transportation. Article inspection is performed by representatives of both the sending and receiving organizations to assess for appropriate test article shipping configuration and damage. Reference Section 5.7 for details.

These transportation functions are depicted in Figure 3-3. Each transportation function is specifically detailed for the test articles in Section 5.0.



**Figure 3-3. Test Article Transportation Functions**

The nominal sequence of transportation events for test articles is shown in Figure 3-4. This sequence begins with the test article assembly/integration at MAF and is completed with delivery to the appropriate test facility at MSFC.



**Figure 3-4. Sequence of Transportation Functions for Test Articles**

Transportation functions displayed in gray in Figure 3-4 are part of the overall sequence of transportation activities but are not included within the scope of this document.

### 3.2 Responsibilities

Test article transportation is the combined responsibility of NASA and the test article manufacturing/assembly contractor.

The test article transportation employs an “on-dock” responsibility transfer philosophy wherein operational responsibility for support equipment (SE), procedures, and personnel are transferred to the recipient upon delivery of the test articles.

In general, the following applies:

#### **NASA/MSFC Office of Center Operations, Transportation & Logistics Engineering Office (AS42)**

- Prepare and maintain the Level II SLS Core Stage (CS) Structural Test Article (STA) Transportation Plan.
- Provide test article and associated equipment tie-down configurations, drawings, and marine transportation equipment (MTE).
- Provide NASA barge *Pegasus* for transport of test articles and associated equipment.
- Provide commercial tugs for barge movement.

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- Provide barge crew.
- Provide and conduct detailed ballasting and docking procedures for the barge.
- Verify proper barge configuration for water transportation.
- Operate and maintain MTE (including proof load testing).
- Acquire hazardous material transportation permits, if required.
- Prepare detailed move procedures for transport of the test articles and associated equipment from Building 110 at MAF to the barge.
- Prepare detailed procedures for loading and securing the test articles and associated equipment for transport aboard the barge at MAF.
- Prepare detailed procedures to unload test articles and associated equipment at MSFC.
- Prepare detailed move procedures for transport of the test articles and associated equipment from the MSFC dock to the appropriate MSFC test facility.
- Prepare detailed lift procedures and conduct STA lifting operations at Building 4619.
- Conduct barge loading and unloading operations including securing and de-securing operations at MAF and MSFC.
- Provide the MSFC kneel down transporter (KDT), as required, to support transport of the test articles and associated equipment at MSFC.
- Arrange for and provide return shipment of MPTS and SE.
- Install/remove land/water transportation monitoring/instrumentation (NASA required).

**NASA/MSFC Office of Center Operations, MAF Operations Office (AS60)**

- Configure the MPTS to interface with the chosen SPMTs.
- Perform land movement of CS flight article and associated equipment at MAF.
- Provide personnel and equipment to assist in loading and securing the CS flight article and associated equipment aboard the barge at MAF.
- Arrange shipment of associated equipment from MAF (reference Section 4.7).

**NASA/MSFC Mission Operations Laboratory, Ground Operations and Logistics Branch (EO40)**

- Prepare and maintain SLS-SPEC-030-01, Space Launch System Program (SLSP) Support Equipment Specification, Volume I: Support Equipment Planning.
- Provide the MPTS including multipurpose carriers (MPCs), hardware interface structures (HISs), and purchase self-propelled modular transporters (SPMTs).

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- Provide land/water transportation monitoring/instrumentation (NASA required).
- Perform the design, development, testing, and evaluation (DDT&E) for all lifting and handling ground support equipment (GSE) and associated SE for test article transportation, lifting, and handling operations.
- Provide lifting and handling SE, limited to the slings, spreaders, and leveling devices necessary to install/remove the test articles onto/from the MPTS (except at MAF).

#### **NASA/MSFC Test Laboratory, Propulsion Test Branch (ET10)**

- Prepare detailed lift procedures and conduct STA lifting operations for STA that are to be tested in the West Test Area.

#### **Manufacturing/Assembly Contractor**

- Develop detailed procedures for test articles and associated equipment preparation operations, which include loading the test articles onto the MPTS, installing simulators onto the test articles, and installing qualification test instrumentation at MAF.
- Perform preparation of test articles for transportation, which include loading the test articles onto the MPTS, installing simulators onto the test articles, and installing qualification test instrumentation at MAF.
- Provide, install, and checkout test articles and associated equipment protective equipment.
- Provide land/water transportation monitoring/instrumentation (contractor required).
- Install/remove land/water transportation monitoring/instrumentation (contractor required).
- Package associated equipment as needed for transport in support of transportation operations.

### **3.3 Transportation Safety and Contingency Planning**

Safety of the transportation crews, equipment, and of the test articles is a high priority. In general, the following safety measures will be captured in the detailed transportation procedures and apply to the activities included in this transportation plan.

#### **General**

- Detailed transportation procedures containing safety information and developed by the relevant facility or hardware custodian applicable to specific activities throughout the complete shipment cycle.

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- Trained and certified personnel provided for transportation operations per Program/Project established training requirements.
- Transportation hazard analysis performed applicable to specific activities throughout the complete shipment cycle.
- Adequate emergency and/or life-saving equipment provided and appropriately staged.

### **Land Movement**

- Weather briefing prior to movement with defined limitations.
- Physical security provided to inspect and secure transportation route and provide adequate buffer zone around convoy.
- Common communications system utilized by move crew.
- Equipment proof testing and checkout prior to movement.

### **Water Movement**

- Weather briefing prior to departure with defined limitations.
- Waterway conditions briefing prior to departure.
- Adequate provisions, communication, emergency, and firefighting equipment aboard the barge for personnel.
- NASA tug inspections and towing contractor crew and equipment certifications required by the classification and permitting organizations.
- Adherence to all maritime laws, standards, and navigational regulations.
- Exclusive and continuous barge tow.
- MTE checkout prior to movement.
- Minimize personnel required aboard the barge.

In general, the following contingency planning applies to the activities included in this transportation plan:

- Identification of “safe harbors” along the water movement route.
- Establishment of emergency plans applicable to specific activities/points within the complete shipment cycle.

## **3.4 Transportation Duration**

Delivery of the test articles is as follows:

### **MAF to MSFC (Up River)**

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Barge Loading/Test Article Secure	2 days
MAF to MSFC Dock (Mississippi (MS) River)	10 days
MSFC Dock to Test Facility	1 day
Test Article Secure at Test Facility	1 day
<hr/>	
<b><i>Nominal Transportation Time:</i></b>	14 – 15 days

**MSFC to MAF (Down River)**

Test Facility to MSFC Dock	1 day
Barge Loading/Return Hardware	1 day
MSFC to MAF Dock (MS River)	7 days
Barge Preparation	1 day
<hr/>	
<b><i>Nominal Transportation Time:</i></b>	10 – 11 days

The test article transportation delivery durations may vary depending on weather, waterway conditions, infrastructure issues, bridge operating restrictions, and marine services contractor availability.

**Note:** Bridge clearances prevent the use of the Tennessee-Tombigbee Waterway for *Pegasus*.

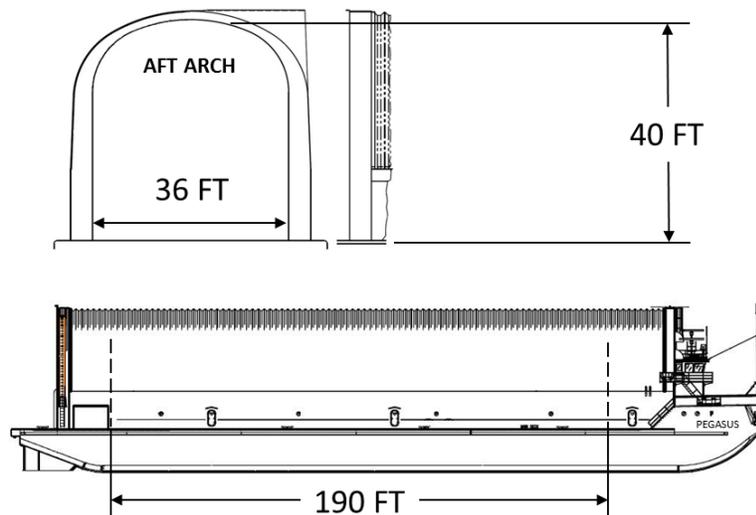
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## 4.0 TRANSPORTATION EQUIPMENT

Some transportation equipment is used for more than one of the transportation functions described in Section 3.1. The major items of equipment are listed in the following subsections with a brief description of their design and use.

### 4.1 Structural Test Article Barge

*Pegasus* is used for movements between MAF and MSFC for delivery of test articles from the manufacturing/assembly facility to the testing location. *Pegasus*, shown in Figure 4-1, accommodates the test articles, MPTS, and associated equipment. *Pegasus* is configured with an enclosed main deck (covered) that provides protection from salt spray and the weather, but does not provide a controlled environment.

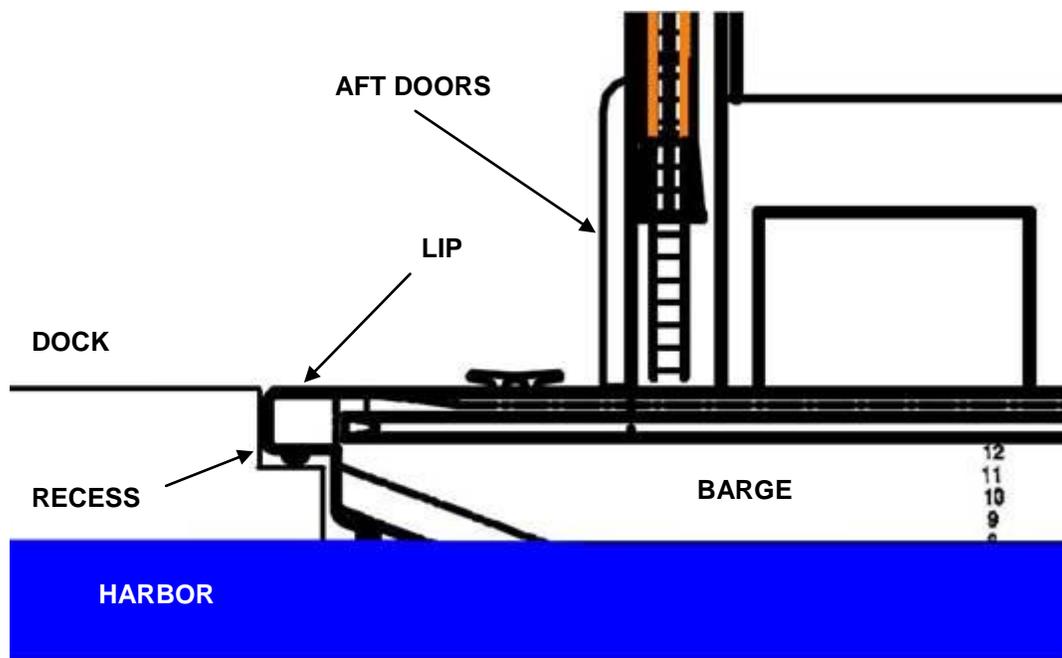


**Figure 4-1. NASA Barge *Pegasus***

Transfer of the test articles and the associated equipment is performed in a roll-on/roll-off manner. The stern of the barge is constructed with a lip which rests (upon ballasting) on a recess in the dock, depicted in Figure 4-2. This dock design is employed at the MAF and MSFC docking facilities. An array of D-rings, slotted pad eyes, and support pads installed onto the main deck provide capability to secure the test articles, MPTS, and associated equipment. The MPTS may be grounded to the barge structure during water shipment via a grounding strap. Adequate areas exist for storage of tie-down and maintenance equipment. The main deck area is 190 ft × 36 ft, with an interior cover height of 40 ft.

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**Note:** Structural flex of the main deck is expected during water transportation. Appropriate analysis should be considered to characterize and accommodate.



**Figure 4-2. Roll-On/Roll-Off Barge Docking Configuration**

*Pegasus* is a self-sustaining vessel except for propulsion. Movement of the barge is provided by tug(s). Power is generated by two 150 KW generators (or shore power). The main deck is lighted and can be secured. Six video cameras are installed on the main deck to allow complete and continuous monitoring/recording of the closed cargo area. Adequate berthing, messing, and sanitary provisions exist for up to four credentialed passengers.

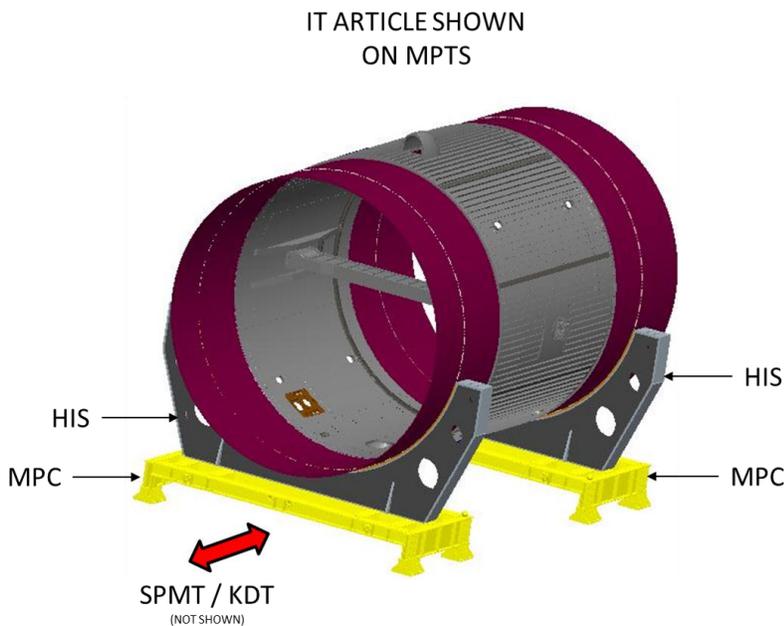
**Note:** Additional passengers may be accommodated during inland waterway transit. Also, though creating a higher risk with a unique asset, *Pegasus* may be configured for a dead ship tow without personnel aboard.

## 4.2 Multipurpose Transportation System

The MPTS consists of modular structural components assembled together as a single support structure system. This structural system interfaces with the test article GSE, as well as with the barge deck. Figure 4-3 illustrates the typical test article/MPTS configuration. The test articles interface with GSE hardware in the horizontal orientation for transportation via a uniquely designed forward HIS and aft HIS. This attachment methodology allows the test articles to be safely transported in the horizontal orientation. Each HIS manages the loads imparted to the test articles through the MPTS.

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Each MPC component of the MPTS also employs multiple load-bearing pedestals to provide clearance beneath the structure for the SPMTs (or the MSFC KDT with extensions) and to provide interfaces with the barge deck.



**Figure 4-3. Typical Test Article with MPTS**

### 4.3 Self-Propelled Modular Transporter

The SPMTs are government-furnished transporters configured as part of the MPTS. The SPMTs may consist of two or more SPMTs operated in unison. The SPMTs serve to provide propulsive power, steering, and braking for the test article and MPTS movement. The SPMTs lift the test article and MPTS from beneath to provide a means to transport from the manufacturing/assembly facility to the barge, to position the test article and MPTS onto the barge, to extract the test article and MPTS from the barge, and to position the test article and MPTS for lifting at the appropriate MSFC test facility. They are not required to supply air, fluids, or electrical power to the test article or the other components of the MPTS.

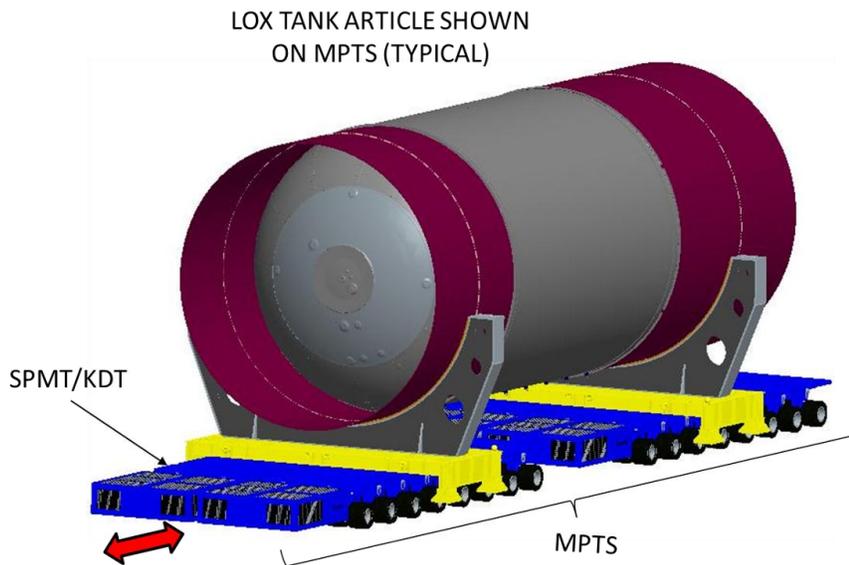
Government-furnished SPMTs are required at MAF for land movement of the test article and MPTS from the manufacturing/assembly facility to the MAF dock, and at MSFC for land movement of test articles and MPTS from the MSFC dock to the appropriate MSFC test facility. Figures 4-4 and 4-5 illustrate a typical SPMT.

**Note:** The MSFC KDT will also be used at MSFC in lieu of or in addition to a typical SPMT for land movement of some of the test articles.

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**Figure 4-4. Typical SPMT**



**Figure 4-5. MPTS and Typical Test Article**

## 4.4 Protective Equipment

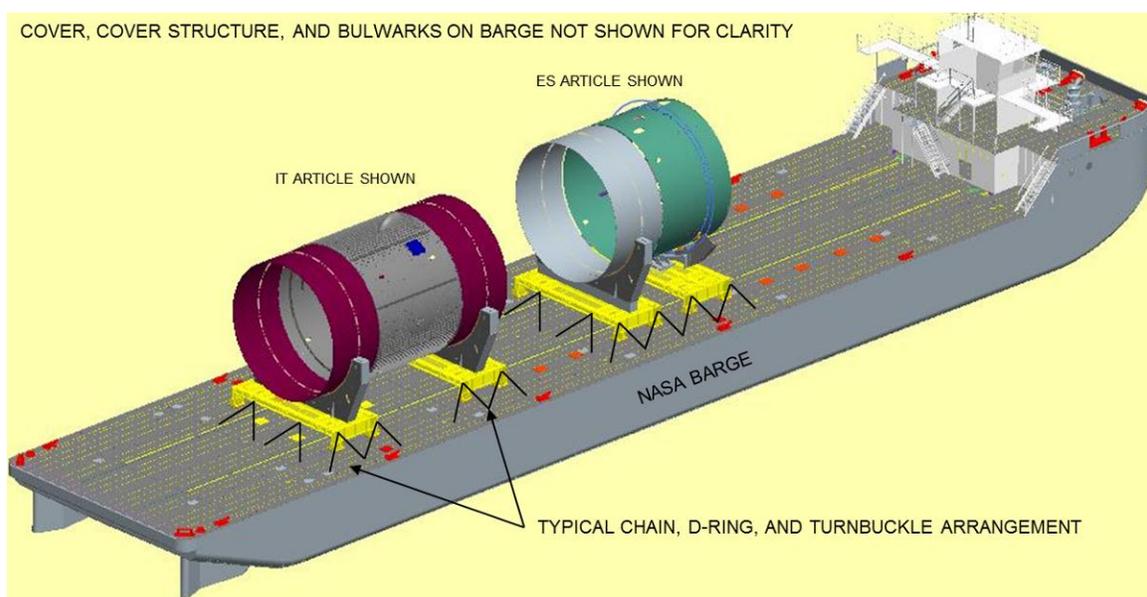
Protective equipment includes covers, plugs, temporary doors, desiccant bags, and other items used to preserve or to prevent unwanted environmental exposure for the test articles or certain defined areas of the test articles during land and water movements. Protective equipment may be installed during article preparation prior to land movement from the manufacturing/assembly facility at MAF to the MAF dock and during article handling at MSFC. Any and all protective equipment is provided and installed by the test article manufacturing/assembly contractor. No additional protective equipment is installed during land or water movement.

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## 4.5 Marine Transportation Equipment

The MTE is a system of hooks, blocks, turnbuckles, chains, cables, and other handling equipment which is used to secure the test articles, MPTS, and associated equipment to the barge during water transportation. This equipment is government furnished.

The MPTS tie-down configuration is based on a traditional, simple method utilizing chains, existing deck mounted and MPTS mounted D-rings, and turnbuckles to secure. The *Pegasus* will be modified, as required, to reinforce the deck structure to accommodate test article transportation loads. Figure 4-6 illustrates the test article and MPTS arrangement on the barge. Also reference Figure 5-7.



**Figure 4-6. Typical Test Articles and MPTS on the Barge**

One complete set of MTE, and its associated tooling and handling equipment, remains on the barge. Additional equipment is retained as spares.

## 4.6 Instrumentation and Environmental Control Equipment

During land and water movements, the test articles and MPTS may be instrumented to provide accurate records of the environments to which the test articles are subjected during the transportation. Instrumentation may also be installed on the barge to provide information to help evaluate the interaction between the barge and the test articles during water shipment.

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Instrumentation may include all devices, cables, and sensors required to adequately monitor transportation environments. The following types of measurements may be recorded or monitored during the transportation of the test articles.

#### **Test Article**

- Propellant tank pressures.
- Vibration.
- Acceleration.
- Strain.
- Interior temperature and humidity (within test article envelope).

#### **Barge**

- Pitch and roll.
- Ambient temperature and humidity on main deck.
- Acceleration/vibration.

The required number and types of measurements and their locations may be selected by the government and the manufacturing/assembly contractor.

Environmental control equipment may include “active” systems, such as dehumidifiers and air conditioning units, required to provide a specified environment to a specific area within the test articles.

It is the government’s intent to minimize personnel aboard the barge during water shipment. Both the instrumentation and the environmental control equipment should be designed and operated such that minimal or no personnel are required for proper function during transportation. Consequently, these items should be self-sustaining to the maximum extent reasonably possible. Electrical power and other provisions may, however, be provided by the barge, if required.

**Note:** Instrumentation, wiring, and other items installed for qualification testing purposes at MSFC are not included as Section 4.6 equipment.

### **4.7 Test Article Associated Equipment**

Test article associated equipment may include the following:

- Test ship loose articles.
- Test article “article specific” ship loose articles.
- Test article tooling and maintenance/emergency equipment.

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- MPTS tooling and maintenance/emergency equipment.
- SE or other equipment required to power or operate instrumentation, environmental control equipment, or protective equipment (example: gaseous nitrogen (GN<sub>2</sub>) bottles/hoses, power supplies, batteries, etc.).
- Handling equipment used to position or maneuver MTE.
- Other program or project hardware or equipment required to be transported between sites.

Established or “article specific” equipment is secured to the main deck or stored on the main deck or appropriate storage area per government-approved configurations. Proper grounding can be provided as required.

## 4.8 Lifting Equipment

Lifting equipment consists of linkages, slings, shackles, cranes, or other devices required to lift or to rotate the test articles from the MPTS. Lifting activities occur during article preparation prior to receipt of the test articles (for shipment) from the manufacturing/assembly facility at MAF, and prior to and subsequent to testing at the appropriate test facility at MSFC. No lifting equipment or operations are considered part of this transportation plan, but are included here to provide continuity.

**Note:** Lifting equipment may be required to position MTE aboard the barge. This lifting equipment, if required, is considered as associated MTE handling equipment, as discussed in Section 4.7.

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## 5.0 TRANSPORTATION FUNCTIONS

The following sections describe, in detail, the transportation functions as they relate to the test articles, depicted in Figure 3-3. All transportation functions are performed in a safe manner in accordance with safety requirements established at each facility or established by the custodian of the test article during specific phases of transportation. Detailed procedures for transportation functions will be developed and will contain the appropriate “WARNING” and “CAUTION” notations, and the appropriate safety information, to indicate where special care should be taken during the performance of the particular operation. For more detail on safety and contingency planning, reference Section 3.3.

### 5.1 Article Preparation

Test article preparation for delivery occurs at MAF by the test article manufacturing/assembly contractor after the fully assembled test article has been accepted for shipment to the test site (MSFC). Test article preparation is completed prior to land movement and includes the following activities:

- Provide and install simulators, as required.
- Secure test articles to the MPTS in a horizontal orientation.
- Provide, install, and checkout protective equipment, as required (reference Section 4.4).
- Provide, install, and checkout instrumentation, environmental control, and monitoring equipment, as required (reference Section 4.6).
- Package associated equipment, as required (reference Section 4.7).

Test articles and all associated equipment are packaged and prepared for shipment per NASA Procedural Requirements (NPR) 6000.1, Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems Equipment and Associated Components, and in accordance with U.S. Department of Transportation (USDOT) guidelines.

Test article preparations are performed within the manufacturing/assembly facility at MAF. Responsibilities related to this function are included in Section 3.2.

### 5.2 Land Transportation

Land transportation of the test articles and associated equipment occurs at MAF and MSFC utilizing the MPTS, as discussed in Section 4.2.

#### 5.2.1 MAF Land Movement

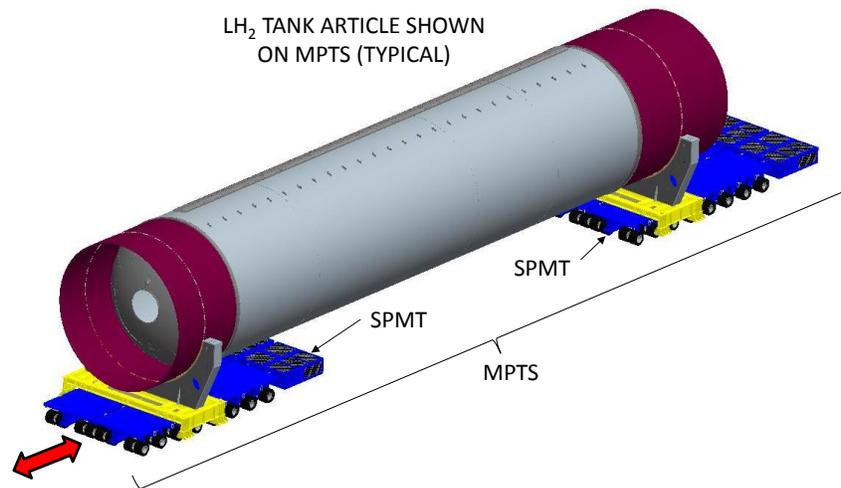
After all article preparation activities are complete and prior to movement, the following land movement activities at MAF are performed:

- Checkout of the MPTS.

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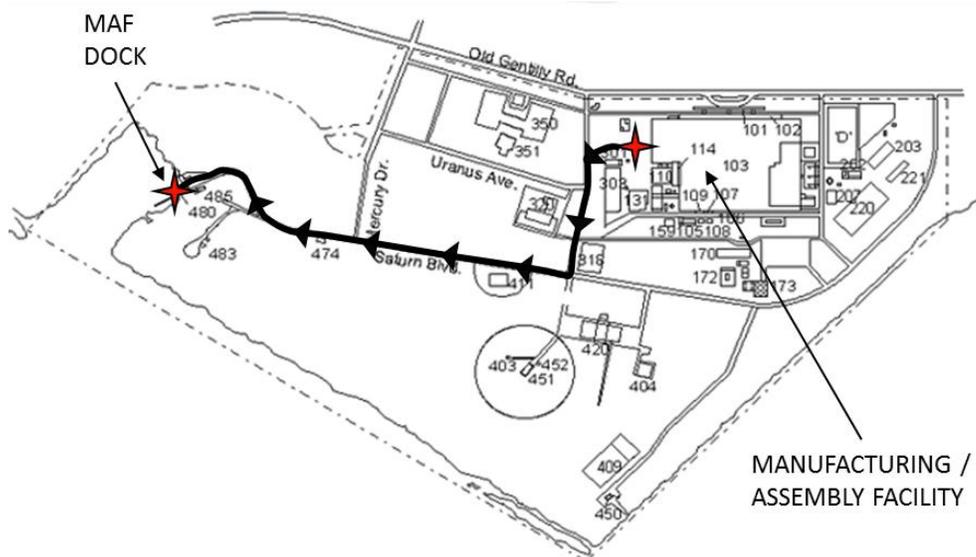
- Activation of instrumentation, environmental control, and/or monitoring equipment.

Movement of the test articles is provided by the MPTS, shown in Figure 5-1.



**Figure 5-1. Land Movement of Test Articles and MPTS at MAF**

Synchronized steering and braking are provided by an operator positioned to simultaneously operate the SPMTs. The test articles and MPTS are lifted and transported by the SPMTs over existing facility roads at very low speeds from the manufacturing/assembly facility to the MAF dock. Figure 5-2 illustrates the route.



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### Figure 5-2. Land Movement of Test Articles and MPTS at MAF

The land movement is accomplished by the following minimal personnel under direction of a move director:

- SPMT operator(s).
- Lookouts.
- Technicians.

All personnel are in continuous contact via a common communications system. The technicians monitor and record necessary information required to properly utilize the MPTS.

Associated equipment packaged for water movement may be transported to the MAF dock via truck, forklift, or other conventional method, as required.

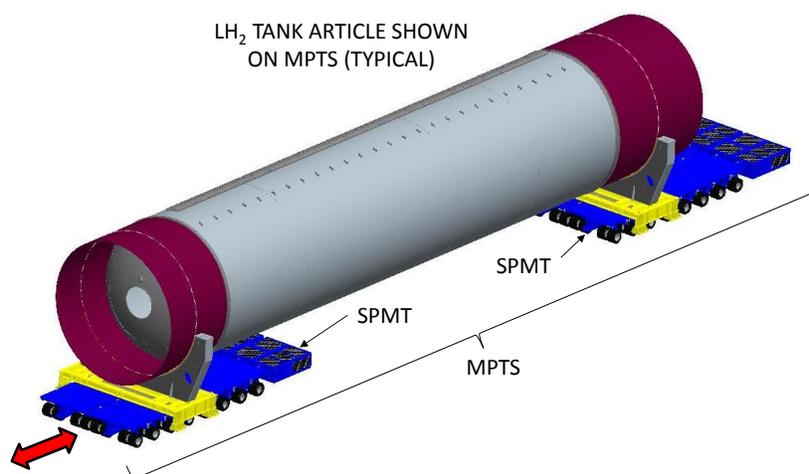
Responsibilities related to this function are included in Section 3.2.

### 5.2.2 MSFC Land Movement

After barge unloading at the MSFC dock, the following land movement activities at MSFC are performed:

- Checkout of the MPTS.
- Activation of instrumentation, environmental control, and/or monitoring equipment.

Movement of the test articles is provided by the MPTS, shown in Figure 5-3.



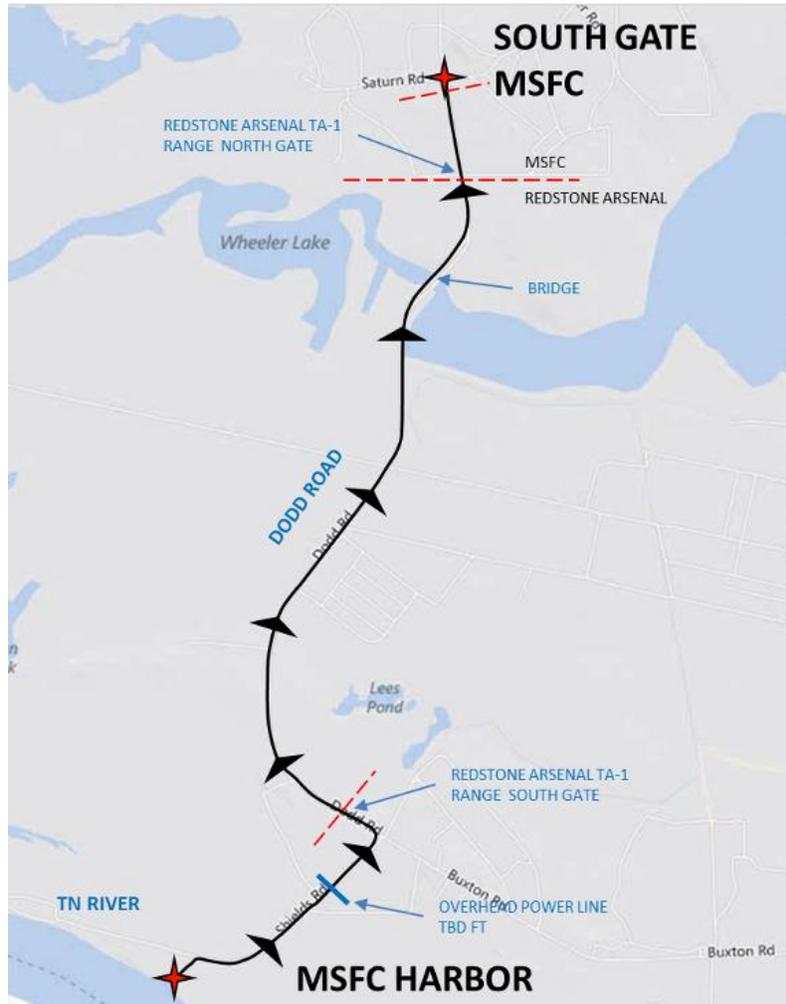
**Figure 5-3. Typical Test Article and MPTS Land Movement Configuration at MSFC**

Synchronized steering and braking are provided by an operator positioned to simultaneously operate the SPMTs. The test articles are lifted and transported by the MPTS at very low speeds

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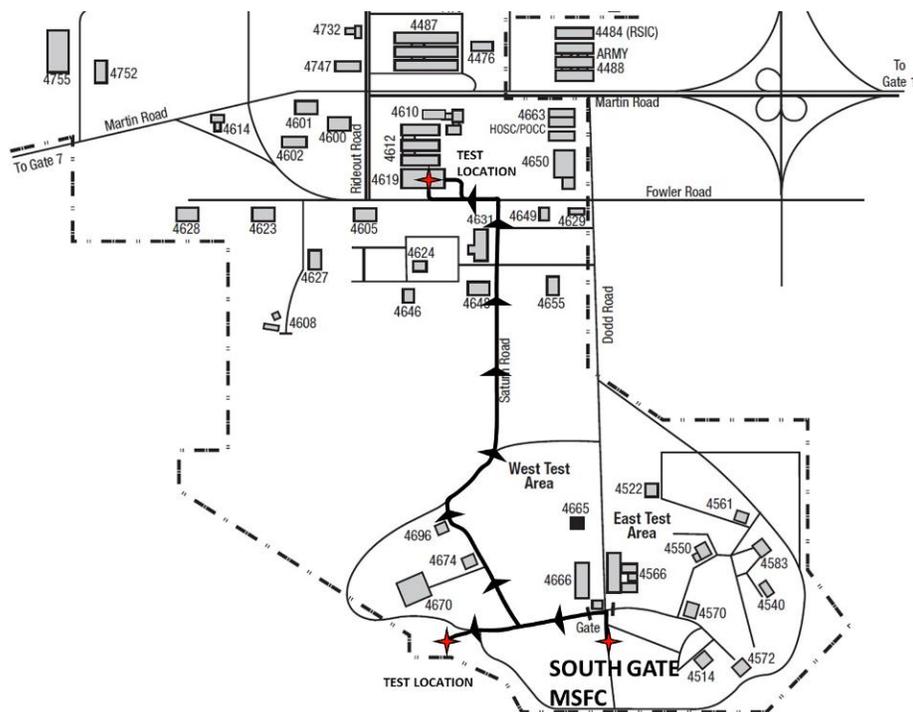
from the MSFC dock to the appropriate MSFC test facility. Figures 5-4 and 5-5 illustrate the route.

**Note:** The MSFC KDT will be utilized for land transportation at MSFC in lieu of or in addition to typical SPMTs for the FS article, the ES article, and the IT article.



**Figure 5-4. Land Movement of Test Articles and MPTS at MSFC**

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**Figure 5-5. Land Movement of Test Articles and MPTS within MSFC**

The land movement is accomplished by the following minimal personnel under direction of a move director:

- SPMT operator(s).
- Lookouts.
- Technicians.

All personnel are in continuous contact via a common communications system. The technicians monitor and record necessary information required to properly utilize the MPTS.

Associated equipment packaged for water movement may be transported to the appropriate MSFC test facility via truck, forklift, or other conventional method, as required.

Responsibilities related to this function are included in Section 3.2.

### 5.3 Barge Loading/Unloading

The barge loading and unloading function is the roll-on/roll-off operation by which the test articles, MPTS, and associated equipment are positioned on the barge or extracted from the barge. Prior to these activities, the barge is prepared by a government-furnished barge crew by ballasting the stern (lip) to rest on the dock recess and securing the barge to mooring locations,

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depicted in Figure 4-2. This provides and maintains a safe and appropriate interface for roll-on/roll-off operations. The MAF and MSFC docks are configured as such. The barge monitoring instrumentation may also be installed by the barge crew to measure desired parameters referenced in Section 4.6, if required.

Barge loading and unloading is accomplished by the following minimal personnel under direction of a move director:

- SPMT operator(s).
- Lookouts.
- Technicians.

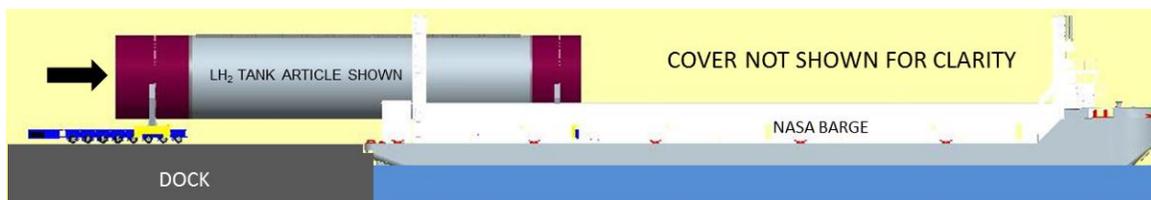
All personnel are in continuous contact via a common communications system. The technicians monitor and record necessary information required to properly utilize the MPTS.

During the loading process at MAF, this function includes securing the cargo via the government-furnished MTE, discussed in Section 4.5. During the unloading process at MSFC, this function includes removing and stowing the MTE and a general inspection of the cargo prior to preparation for land movement.

Responsibilities related to this function are included in Section 3.2.

### 5.3.1 Barge Loading at MAF

Barge loading occurs at the MAF dock upon land movement of the test articles and MPTS from the manufacturing/assembly facility. SPMTs remain positioned beneath the MPCs in the lowered, non-load carrying position available to lift and transport the test articles and MPTS onto the barge, as shown in Figure 5-6. Markings on the main deck of the barge indicate correct positioning. Associated equipment may be positioned aboard the barge by conventional methods as required.

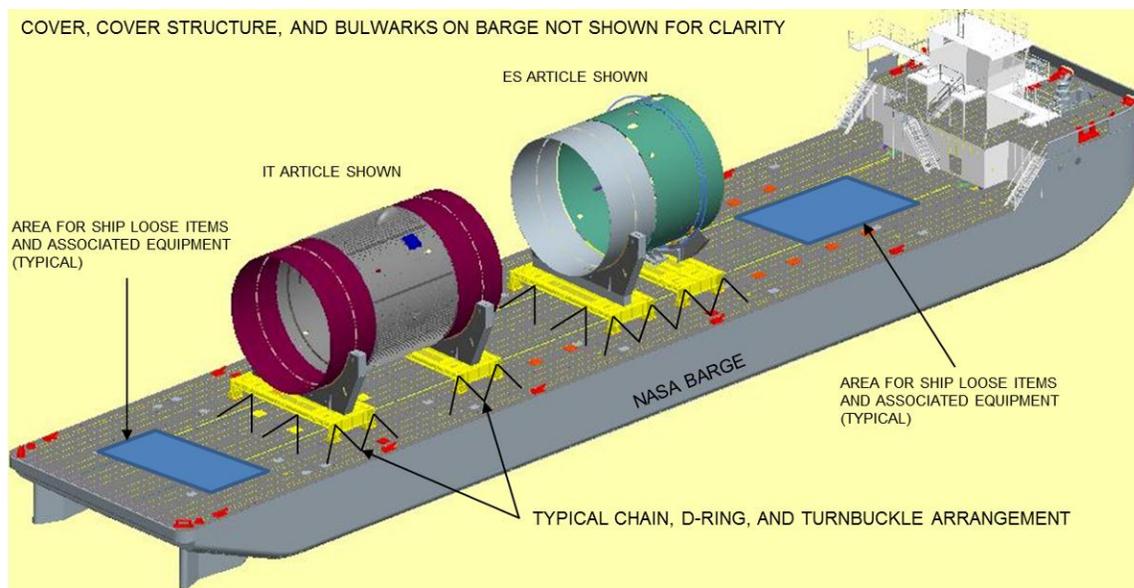


**Figure 5-6. Barge Loading at MAF**

After the test articles, MPTS, and associated equipment are loaded, those items are grounded, as required, and secured to the barge using MTE. The test articles and MPTS are secured to the main deck via multiple pedestals attached to the MPCs. To further retard potential movement,

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turnbuckles and other linkages are secured to D-rings, in a specified pattern, to fully constrain the MPCs. This configuration is illustrated in Figure 5-7. Associated equipment is secured, as required, by conventional methods.



**Figure 5-7. Barge Loading/Tie-Down Arrangement**

The aft doors of the barge are closed and secured, and the aft curtain is drawn by the barge crew. Upon verification of the shipment configuration, the barge crew de-ballasts the barge to release it from the dock and to provide the proper draft for water transportation.

**Note:** The government, the test article manufacturing/assembly contractor, and/or others may desire personnel aboard to accompany the test article shipments. Though this is not the operational intent, additional personnel may be accommodated. These personnel should be minimized due to safety concerns, as discussed in Section 3.3.

Responsibilities related to this function are included in Section 3.2.

### 5.3.2 Barge Unloading at MSFC

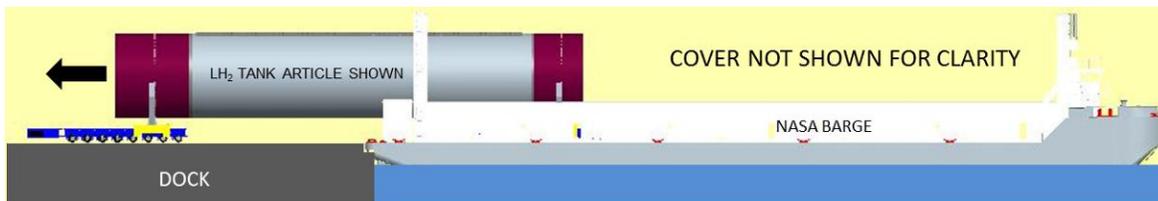
Barge unloading occurs at the MSFC dock after water transportation of the test articles, MPTS, and associated equipment from MAF. Prior to beginning operations, a general inspection is performed by the barge crew and by the unloading crew to verify grounding, and to verify no damage has occurred to the barge, test articles, MPTS, and associated equipment during water transportation. All or part of the instrumentation, environmental control, and monitoring equipment, as discussed in Section 4.6, may be removed by the barge or unloading crew. The MTE, discussed in Section 4.5, is then removed and stowed aboard the barge.

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After all tie-down removal activities are complete, the following unloading activities are performed:

- Checkout of MPTS.
- Verify barge secure.

Movement of the test articles, MPTS, and associated equipment from the barge is provided by the MPTS. SPMTs are positioned beneath the MPCs in the lowered, non-load carrying position available to lift and transport the test articles and MPTS from the barge. Markings on the main deck indicate correct positioning, as shown in Figure 5-8.



**Figure 5-8. Barge Unloading at MSFC**

The SPMTs position the test article and MPTS on the dock pavement in preparation for land movement to the staging area at the appropriate MSFC test facility. The associated equipment may be extracted from the barge, as required, by conventional methods.

**Note:** The MSFC KDT will be utilized for land transportation at MSFC in lieu of or in addition to typical SPMTs for the FS article, the ES article, and the IT article.

Responsibilities related to this function are included in Section 3.2.

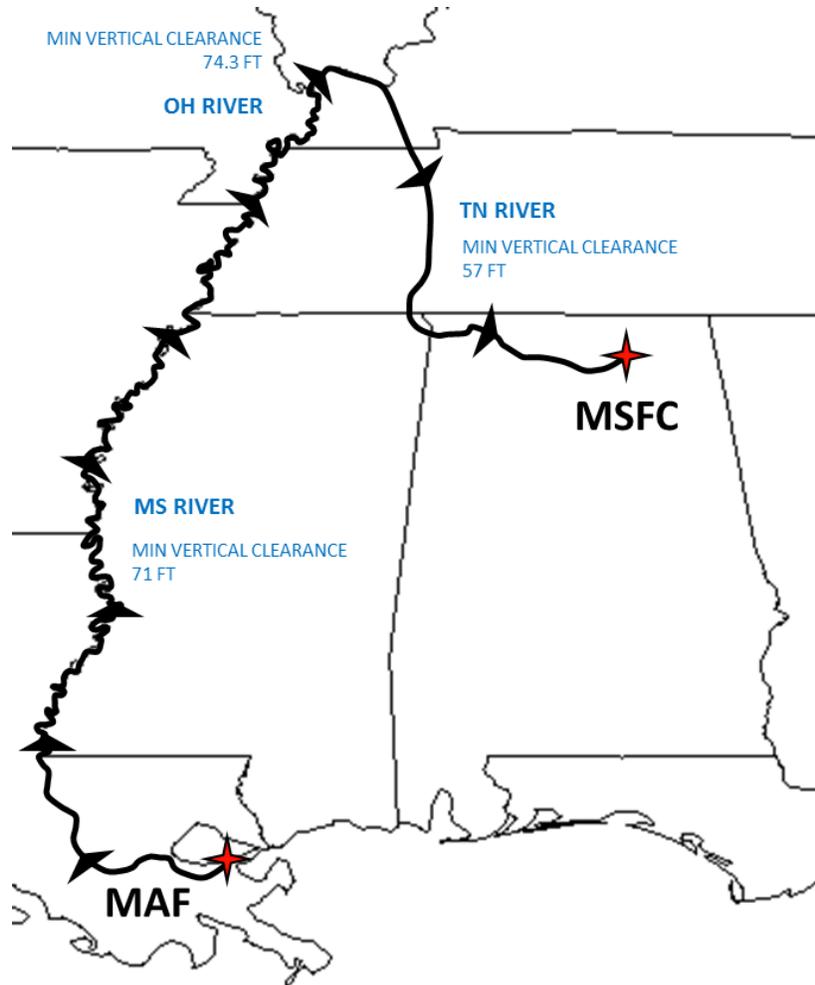
## 5.4 Water Transportation

Water transportation is accomplished by NASA, utilizing *Pegasus*, discussed in Section 4.1, on inland waterways between MAF and MSFC. Along the route, the barge is towed by commercial tugs (a push tug and possible assist tug ahead of the barge) via the Gulf Intracoastal Waterway (GIWW), the Mississippi River, the Ohio River, and the Tennessee River. This route is approximately 1240 miles in length and is illustrated in Figure 5-9 below.

Waterway restrictions include navigation through several locks, a 70 ft horizontal clearance through the Inner Harbor Navigational Canal in New Orleans, Louisiana, and a height restriction of 57 ft at several bridge locations along the Tennessee River. This height restriction could impact navigability of the barge if local water levels are significantly higher than standard pools. Operational planning must account for possible delays.

**Note:** Bridge clearances prevent the use of the Tennessee-Tombigbee Waterway for *Pegasus*.

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**Figure 5-9. Test Article Water Movement Route – MAF to MSFC**

Responsibilities related to this function are included in Section 3.2.

## 5.5 Article Handling

Test article handling occurs at MSFC prior to testing and after land movement from the MSFC dock to the appropriate MSFC test facility. Article handling includes activities required to lift the test articles or move the test articles by means other than the MPTS. Specifically, this includes lifting, by crane and lifting devices, the test articles from the MPTS at the appropriate MSFC test facility to bring the test articles to a vertical position for further processing at the appropriate MSFC test facility. Article handling, and the lifting devices required to perform handling activities, is not considered part of this transportation plan, but is included here for continuity.

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## 5.6 Article Testing

Test article qualification testing occurs at the appropriate MSFC test facility after land movement of the test articles from the MSFC dock and integration into the test stand. Other instrumentation or component testing with the test articles may occur at various defined locations/times as required. Article testing, and associated activities, is not considered part of this transportation plan, but is included here for continuity.

## 5.7 Article Inspection

Visual inspection from walk-up access on *Pegasus* is performed by representatives of both the sending and receiving organizations to document configuration and condition of the test articles. Due to inspection limitations on the barge, only the visible areas of test articles are inspected. Inspection satisfies the DD1149, Requisition and Invoice Shipping Document, hardware transfer process. The DD1149 is signed by both sending and receiving organizations, and the hardware is transferred to a location where a follow-on visual inspection of the previously inaccessible areas is performed. Issues identified by the follow-on inspection that result in a “return-to-sender” decision would require another DD1149 signoff by the sending and receiving organizations for ship-back to MAF.

**Note:** Defining specific points and locations for transfers of accountability of property is an SLS Element function and is not included in this document. Reference SLS-PLAN-025 Section 6.4.

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## 6.0 TRANSPORTATION DATA AND DOCUMENTATION

The transportation data and documentation methodology is structured to support a verification process established to validate the test articles have not been exposed to transportation loads or environments beyond the design limits during all transportation functions from the manufacturing/assembly facility, MAF, to the test site, MSFC. This process is described below.

Two methods are utilized to provide this verification: documentation and data. Each is used to establish the test articles have not been exposed to transportation environments outside of the design limits.

### 6.1 Documentation

The “AS RUN” procedures will provide documentation that all transportation activities were performed in accordance with the pre-approved procedures.

### 6.2 Data

The “AS RUN” data collected from any instrumentation and environmental control systems or other instrumentation, as discussed in Section 4.6, are evaluated to verify the test articles were not exposed to transportation environments outside the design limits. A comprehensive report will be prepared to accompany the test article end-item delivery, as required.

All relevant documentation and data, and other supporting information, will be submitted to the SLSP as quality records to support the CS and SLS flight verification processes.

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## APPENDIX A ACRONYMS AND ABBREVIATIONS

CS	Core Stage
DD	Department of Defense
DDT&E	Design, Development, Test, and Evaluation
ES	Engine Section
FS	Forward Skirt
FT	Feet
GIWW	Gulf Intracoastal Waterway
GN <sub>2</sub>	Gaseous Nitrogen
GSE	Ground Support Equipment
HIS	Hardware Interface Structure
ICPS	Interim Cryogenic Propulsion Stage
ILSP	Integrated Logistics Support Plan
IT	Intertank
KDT	Kneel Down Transporter
KW	Kilowatts
LBS	Pounds
LH <sub>2</sub>	Liquid Hydrogen
LOX	Liquid Oxygen
LSI	Logistics Support Infrastructure
MAF	Michoud Assembly Facility
MIN	Minimum
MPC	Multipurpose Carrier
MPTS	Multipurpose Transportation System
MS	Mississippi
MSFC	Marshall Space Flight Center
MTE	Marine Transportation Equipment
MWI	Marshall Work Instruction
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirements
OH	Ohio
OPR	Office of Primary Responsibility
PCH	Program Critical Hardware
SE	Support Equipment

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SLS                   Space Launch System  
 SLSP                 Space Launch System Program  
 SPEC                 Specification  
 SPMT                Self-Propelled Modular Transporter  
 STA                  Structural Test Article  
 TN                    Tennessee  
 USDOT               United States Department of Transportation

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## APPENDIX B OPEN WORK

All resolved TBDs, TBRs, and forward work items should be listed on the Change Request (CR) the next time the document is updated and submitted for formal review, and that will serve as the formal change record through the configuration management system.

### B1.0 TO BE DETERMINED

Table B1-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within carets. The TBD item is sequentially numbered as applicable (i.e., <TBD-001> is the first undetermined item assigned in the document). As each TBD is resolved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

**Table B1-1. To Be Determined Items**

TBD	Section	Description
TBD-001		

### B2.0 TO BE RESOLVED

Table B2-1 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within carets. The TBR issue is sequentially numbered as applicable (i.e., <TBR-001> is the first unresolved issue assigned in the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

**Table B2-1. To Be Resolved Issues**

TBR	Section	Description
TBR-001	2.0	Revision to PAD in work – Paragraph reference may change to 6.3

### B3.0 FORWARD WORK

Table B3-1 lists the specific forward work items identified during this document’s Change Request (CR) review and evaluation. Each item is given a sequential number using a similar format to that for the TBDs and TBRs. For each item, include the section number(s) of this document that the open work will impact, and in the Description include the specific number of the comment from the Change Evaluation (CE), i.e., CE-10, CE-27. Do not include a placeholder for forward work items in the body of the document; list them only in Table B3-1.

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*Note:* If there are no forward work items, do not include this subsection in your document.

**Table B3-1. Forward Work**

FWD	Section	Description
FWD-001		