Appendix K – Phase 4, Phase 5 and Production ROM Estimated Cost and Schedule (EIR-3018318)

AREVA	AREVA Federal Services LLC
	Engineering Information Record

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Project No.:	00225.03.0050	**Project Name:**	DOE Atlas Railcar	
Title:	High Level Radioactive material (HLRM) Prototype Railcars Phase 4, Phase 5 and Production Estimates and Schedules			

This EIR provides Rough Order of Magnitude (ROM) cost and schedule estimates with related scope of work descriptions, assumptions and qualifications for the Phase 4 Single-Car Testing, Phase 5 Multi-Car Testing and HLRM Railcar Production phase of the Department of Energy's Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material project.

Contains Unverified Input / Assumptions: **Yes:** ☐ **No:** ☒

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DISCLAIMER

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Revision History

Rev.	Changes
000	Initial issue
001	Complete re-write and incorporation of DOE comments

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1.0 EXECUTIVE SUMMARY

This report provides Rough Order of Magnitude (ROM) cost and schedule estimates for prototype railcar testing and production for the Department of Energy's (DOE) contract DE-NE0008390, Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material (HLRM) project [1] to Association of American Railroads (AAR) standard S-2043, Performance Specification for Trains Used to Carry HLRM [2].

Phase 4 single-car testing has a ROM estimated range from $3,870,700 to $15,482,800 with a base sum (defined as the sum of the base cost estimate before Association for Advancement of Cost Engineering International (AACE) Class 5 ROM factors are applied [3]) of $7,741,400 during an estimated 13-month period after the receipt of prototype cask and buffer railcars, Instrumented Wheel Sets (IWS), test loads, test load cradles and end stops. An estimated 3-month approval period for the AAR Equipment Engineering Committee (EEC) occurs at the end of the Phase 4 single-car testing for a total estimated duration of 16 months.

Phase 5 multi-car testing has a ROM estimated range from $1,503,100 to $6,102,200 with a base sum of $3,006,100 during an estimated 11-month period after the receipt of single-car conditional railcar approval for the cask and buffer railcars. Again, an estimated 3-month AAR EEC approval period occurs for Phase 5 multi-car testing is included for a total estimated duration of 14-months. This provides a total HLRM testing ROM cost estimate of $5,373,800 to $21,495,000 with a base sum of $10,747,500 and estimated to be completed in 30 months after delivery of prototype railcars, test loads and IWS.

This report also provides detailed ROM cost and schedule estimates for the production phase of the project's cask and buffer railcars as conditionally approved for multi-car use by the AAR EEC. The total ROM estimated range for the fabrication and delivery of 120 cask railcars and 60 buffer railcars is from $101M to $407M with a base sum of $203M to be completed in 74 months after receipt of order.

The summary ROM estimated dollar range for testing and production is from $107M to $428M with a base sum of $214M. The summary ROM estimated schedule range is 104 months (8 years, 8 months).

Table 1-1: Railcar Testing and Production ROM Estimate Summary

(X $1000)

	Minimum	Maximum	Base Sum	Estimated Months
Phase 4 Single-Car Testing	$3,871	$15,483	$7,741	13
Phase 4 AAR EEC Approval Period				3
Phase 5 Multi-Car Testing	$1,503	$6,012	$3,006	11
Phase 5 AAR EEC Approval Period				3
Total Testing Estimate	$5,374	$21,495	$10,747	30
Railcar Production Phase	$101,693	$406,773	$203,387	74
Total	$107,067	$428,268	$214,134	104

Note: In 2016 dollars

Each phase – Phase 4 single-car testing, Phase 5 multi-car testing, and the production phase – are presented in the following report by providing a discussion of the following within each phase:

- Known and anticipated scope of work
- The phase's anticipated subcontractors completing the scope of work items
- Assumptions of that phase's scope of work, estimate, and schedule

- A detailed discussion of the ROM estimated cost and schedule
- Qualifications of the presented discussions and data for that phase

Appendix A provides a discussion of a conceptual design of the test loads, test load cradles, and its end stops. Appendix B provides a discussion of a conceptual design of a required ballast load for the Atlas railcar when in an empty condition.

2.0 PHASE 4 SINGLE-CAR TESTING

Phase 4 single-car testing has a ROM estimated range from $3,970,700 to $15,482,800 with a base sum of $7,741,400 during a 13-month period after the receipt of prototype cask and buffer railcars, IWS, test loads, test load cradles, and end stops. This estimate and schedule is further described in the following subsections detailing the assumed scope of work including its requirements for completion and deliverable(s), the scope of work's primary subcontractors, assumptions of the Phase 4 estimate, detail of the estimate and its schedule, and qualifications of the estimate.

2.1 Phase 4 Scope of Work and Suggested Contract Arrangements

A description of the Phase 4 single-car testing scope of work is described in the following subsections. The breakout by subsection also reflects each scope of work's anticipated subcontractor.

2.1.1 Instrumented Wheel Sets – TTCI

IWS are required for single-car testing. It is anticipated that the AAR EEC will require up to 8 IWS for single-car tests. Six IWS will be used for the Atlas railcar with all 6 IWS on a single end of the railcar, and 2 IWS will be used on the buffer railcar on a single end. These same wheel sets will need to be utilized for Phase 5 multi-car testing. It is suggested that a contract be placed with TTCI for eight IWS keeping in mind that IWS are long-lead items.

Deliverables of this scope of work are 8 purchased IWS. This contract to TTCI would be on a cost-plus basis.

2.1.2 Test Load – AFS

A test load to simulate cask/cradle payloads will be required for single-car and multi-car testing of the Atlas cask railcar. As a required contract deliverable, AFS will provide the DOE with design information necessary for fabrication of the test loads.

Currently, test load configurations are adopted to simulate bounding condition loads, including the HI-STAR 190 XL cask. Basic information concerning the selected test loads, test load configurations and conceptual designs of the test loads, cradles and end stops were developed by the AFS Federal Way, WA, office in order to provide an estimate for this report. A description is included as Appendix A.

As the interface entity with the EEC and the conceptual designer of the test loads, test load cradles and end stops, a contract for the test load equipment should be placed with AFS to ensure that AAR EEC test requirements are included in the test equipment design and fabrication thereby ensuring that test requirements are met.

A contract to purchase test load equipment can be placed with AFS (or other suitable designer/fabricators) on a cost-plus basis or as a firm-fixed price contract, depending on the negotiating parties' preferences. A contract can also be placed with AFS indirectly through TTCI. Deliverables of this scope of work would include:

- Fabrication designs for a minimum test load, a maximum test load, 2 test load cradles and a set of test load end stops with designs simulating the dynamics of required test payloads
- Fabrication of the minimum and maximum test loads

- Fabrication of 2 test load cradles utilizing the cask railcar's cradle-to-railcar attachment interface system
- Fabrication of 1 set of cradle end stops and attachment hardware
- Related desirable certificates of conformance, inspection requirements and reports

2.1.3 Single-Car Testing – TTCI

As the owner of the cask and buffer prototype railcars, it is suggested that DOE contract directly and submit the prototype railcars to TTCI, the ARR's testing entity, for single-car testing. This contract will be for TTCI – a small business – to furnish all management, supervision, personnel, materials, the use of necessary TTCI locomotives and instrument coach, and operating supplies necessary for accomplishment of the single-car testing.

The proposed contracted scope of work for single-car testing is to include testing requirements of AAR standard S-2043, Performance Specification for Trains Used to Carry HLRM, Section 5, Single-Car Tests [4], including the following specific testing activities to be performed by TTCI:

- Vehicle characterization tests
    - Component characterization (AAR S-2043 [4], Section 5.1.3)
    - Vertical suspension stiffness and damping (Section 5.1.4.3)
    - Lateral suspension stiffness and damping (Section 5.1.4.4)
    - Truck and span bolster rotation (Section 5.1.4.5)
    - Inter-axle longitudinal stiffness (Section 5.1.4.6)
    - Modal characterization (Section 5.1.4.7)
- Nonstructural static tests
    - Truck twist equalization (Section 5.2.1)
    - Car body twist equalization (Section 5.2.2)
    - Static curve stability (Section 5.2.3)
    - Horizontal curve negotiation (Section 5.2.4)
    - Static brake tests (Section 5.3)
- Structural tests
    - Squeeze (compressive end) load (Section 5.4.2)
    - Coupler vertical loads (Section 5.4.3)
    - Jacking (Section 5.4.4)
    - Twist (Section 5.4.5)
    - Impact (Section 5.4.6)
    - Note: Securement system test (Section 5.4.7) is not included as analysis will be used to verify the securement system during dynamic modeling. Physical testing of the cask cradles is not required by the AAR EEC and outside the scope of the Phase 4 single-car testing.
- Single-car dynamic tests
    - Hunting (Section 5.5.7)

- Twist and roll (Section 5.5.8)
- Yaw and sway (Section 5.5.9)
- Dynamic curving (Section 5.5.10)
- Pitch and bounce (Chapter XI) (Section 5.5.11)
- Pitch and bounce (Special) (Section 5.5.12)
- Single bump test (Section 5.5.13)
- Limiting spiral negotiation (Section 5.5.14.1)
- Spiral negotiation (Section 5.5.14.2)
- Curving with single rail perturbation (Section 5.5.15)
- Standard Chapter XI Constant Curving (Section 5.5.16)
- Special trackwork (Section 5.5.17)

In order for single-car testing to start, the DOE or its designated subcontractor(s) will provide the following:

- Eight IWS in functional condition
- The prototype cask railcar with the cradle attachment system in place and functional, and in the condition to be tested.
- One prototype buffer railcar in the condition to be tested.
- A suitable test load with cradle and end stops in the condition to be tested.

Deliverables of this scope of work are a cask railcar single-car test report and a buffer railcar single-car test report. The contract to TTCI would be on a cost-plus basis. A single contract to TTCI (a small business) could also be arranged to encompass the entire Phase 4 single-car testing scope of work including all supporting team members as subcontractors to TTCI.

2.1.4 Testing Support – Kasgro Rail

During single-car testing, technical and fabrication questions, railcar adjustments and modifications may be required. Kasgro Rail will also arrange for an independent third party review to be performed of the railcars' testing results. Kasgro will perform for the DOE, the submission of the single-car test reports to the AAR EEC for conditional approval of the cask and buffer railcars. Based on previous experience during single-car testing, it is recommended that a contract be placed directly with Kasgro Rail for these services.

The deliverable of this scope of work is Kasgro Rail project management and technical support. This contract would be placed on a cost-plus basis directly with the DOE or through TTCI.

2.1.5 Project Management and Integration Support - AFS

AFS will provide project management, project team integration and coordination, project reporting and project controls support during the Phase 4 single-car testing period. This contract should be placed through TTCI and on a cost-plus basis.

2.2 Phase 4 Testing Assumptions

Assumptions regarding the Phase 4 single-car testing are included to ensure test requirements are fully understood and to support the understanding of the scope of work descriptions.

Single-car testing assumptions are:

- Prior to starting single-car testing, authorization to perform single-car testing has been received from the AAR Chief – Technical Standards.
- Testing will be performed to AAR Standard S-2043, Performance Specification for Trains Used to Carry High Level Radioactive Material, Sections 5, Single-Car Tests [4].
- At a minimum, testing requirements will include testing of the cask railcar carrying a minimum payload, a payload comprised of the maximum weight, and a payload comprised of the highest combined center of gravity. These payloads will be determined during review of the design and dynamic modeling submission and received with a successful notification to proceed to test phase for the cask and buffer railcars.
- Additional specific testing requirements may be required or removed as determined by the AAR EEC during review of the design and dynamic modeling submission, or as initially advised and received with a notification to proceed to test phase for the cask and buffer railcars.
- AAR S-2043, Section 5.4.7, Securement System Test, is not included in this report, proposed scope of work, or ROM estimates. This test is to verify by analysis or test that the securement system – the cask cradle and its securement of the cask payload – meet the AAR Field Manual of AAR Interchange Rules, Rule 88 A.16.c(3) [5]. As the cask cradles have yet to be designed and fabricated, and their final design is not part of the Atlas Railcar Design Project, analysis and test cannot be performed. It is assumed that conditional approval of the cask and buffer railcars will be provided contingent on future performance of this verification by DOE and/or cask/cradle designers and fabricators. Finally, the Atlas railcar conceptual cradle designs and cradle attachment interface system will be verified by analysis during dynamic modeling.
- No specific risk evaluation has been performed as a part of this report. Instead, guidelines of AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System, [3] have been followed for providing ROM estimates.
- Estimated schedules are provided in months of duration.
- ROM estimates are provided in 2016 dollars.
- Specific assumptions of the Phase 4 ROM cost estimate are as follows:
    - TTCI estimates are based on a ROM proposal and include TTCI services and use of the TTC site and its equipment.
    - Kasgro Rail single-car testing support (see Section 2.3.3, Testing Support – Kasgro Rail) is based on a Kasgro Project Manager assigned on a 0.4 Full Time Equivalent (FTE) basis, and engineering support personnel assigned on a 0.15 FTE basis during the single-car testing period of performance. Related travel expenses are estimated to occur bimonthly as a 5-day trip by the Kasgro PM to the AAR's Transportation Technology Center (TTC) site utilizing government per diem rates.
    - The third-party independent review (see Section 2.3.3, Testing Support – Kasgro Rail) is to include an independent review by a third party subject matter expect of all reports as written by TTCI for AAR S-2043, Section 5.5, Single-Car Dynamic Test of the HLRM prototype cask and buffer railcars. The fee for this service is based on the 2016 AAR Office Manual [8].

- The AAR EEC application fees for single-car is included in ROM estimate (see Section 2.3.3, Testing Support – Kasgro Rail). The fee for this service is based on the 2016 AAR Office Manual [8].

- Provided ROM estimates are based on the current configuration of the cask and buffer railcars as of December 31, 2016 and do not reflect changes or modifications as a result of the completion of Phase 2, Preliminary Design, or Phase 3, Prototype Fabrication and Delivery.

2.3 Phase 4 Testing Estimate

This section provides ROM estimates for Phase 4 Single-Car Testing with detailed information provided by the major scope of work and supplier. ROM estimates are shown depicting the AACE Class 5 estimate range [3]. ROM estimates reflect the detailed scopes of work in Section 2.1, Phase 4 Scope of Work and Suggested Contract Arrangements, and assumptions detailed in Section 2.2, Phase 4 Testing Assumptions.

For Phase 4 single-car testing, the ROM estimated range is from $3,870,700 to $15,482,800 with a base sum of $7,741,400. Single-car testing ROM estimates are summarized in Table 2-1.

Table 2-1: Phase 4 Single-Car Testing ROM Estimate Summary

(X $1000)

	Minimum	Maximum	Base Sum
Single-Car Testing (TTCI)	$1,300	$5,200	$2,600
Instrumented Wheel Sets (TTCI)	$650	$2,600	$1,300
Testing Support (Kasgro Rail) Includes AAR EEC Third Party Independent Review and AAR EEC Application Fees	$181	$726	$363
Test Load Equipment Design and Fabrication (AFS)	$1,467	$5,866.0	$2,933.0
Project Management & Integration Support (AFS)	$273	$1,091.0	$545
Total	$3,871	$15,483	$7,741

Note: In 2016 dollars

These estimates are further described in the following subsections.

2.3.1 Instrumented Wheel Sets – TTCI

The purchase of eight IWS by TTCI is provided as a ROM estimated range of $650,000 to $2,600,000 with a base sum of $1,300,000 representing a 16 month lead time for an accelerated delivery of the IWS. This is supported by a ROM proposal from TTCI.

Due to the complexity of the IWS and specialized custom-fabricated hardware and assembly, it is advised that DOE start discussions regarding the purchase and delivery of the IWS as-soon-as-possible in order to properly ascertain IWS availability and cost, and to ensure that the start-up of single-car testing is not negatively impacted.

2.3.2 Test Load Equipment – AFS

The fabrication and supply of two test loads, test load cradles and one set of end stops by AFS is provided as a ROM estimated range of $1,237,700 to $5,866,000 with a base sum of $2,933,000 representing a 6 month lead time for delivery of the test load equipment. A breakout of test load designs and fabrication estimates in detailed in Table 2-2 below.

Table 2-2: Test Load ROM Estimate Detail

(X $1000)

	Minimum	Maximum	Base Sum
Test Load Designs	$60	$240	$120
Test Load Cradles and End Stop Designs	$169	$675	$338
Total Design Estimate	$229	$915	$458
Test Loads Fabrication	$886	$3,545	$1,772
Test Load Cradle & End Stops Fabrication	$352	$1,406	$703
Total Fabrication Estimate	$1,238	$4,951	$2,475
Total	$1,467	$5,866	$2,933

Note: In 2016 dollars

A detailed description of necessary test loads, test load cradles and end stops is included in Appendix A. This estimate is supported by a proposal from AFS and a fabrication subcontractor whose efforts also include non-recurring fabrication engineering, tool and gaging design and fabrication, generation of fabrication shop documentation, material procurement, and quality assurance oversight.

2.3.3 Single-Car Testing – TTCI

The ROM estimated range for the performance of single-car testing services by TTCI is from $1,300,000 to $5,200,000 with a base sum of $2,600,000. Single-car testing of the cask railcar ranges between $750,000 and $3,000,000 with a base sum of $1,500,000. Single-car testing of the buffer railcar ranges between $550,000 and $2,200,000 with a base sum of $1,100,000. The use of necessary locomotives and the TTCI instrument coach is included in these ROM estimates. These estimates are supported by a ROM proposal from TTCI.

2.3.4 Testing Support – Kasgro Rail

The ROM estimated range for Kasgro Rail to support TTCI in the performance of single-car testing services is from $181,450 to $725,800 with a base sum of $362,900. This includes support during both the cask and buffer railcar single-car testing duration and necessary travel at government per diem rates to the TTC site in Pueblo, CO bi-monthly for a one-week duration. This is supported by a ROM proposal from Kasgro Rail. Also included are the AAR EEC third party independent review fee and the single AAR EEC application fee which is a single fee for both single-car and multi-car testing.

2.3.5 Project Management and Integration Support - AFS

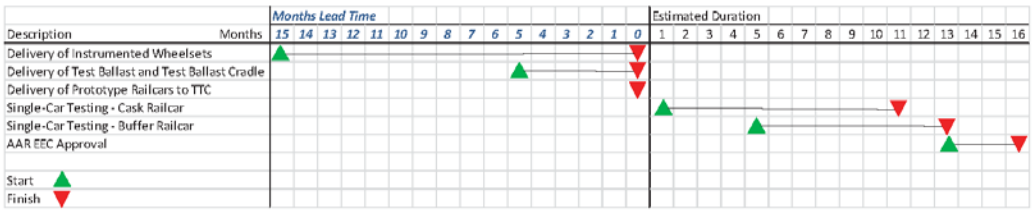
The ROM estimated range for AFS to support TTCI in the performance of single-car testing services is from $272,800 to $1,091,000 with a base sum of $545,500. This includes support during both the cask and buffer railcar single-car testing duration and necessary travel at government per diem rates to the TTC site in Pueblo, CO monthly for a one-week duration. This is supported by a ROM estimate from AFS.

2.4 Phase 4 Testing Schedule

Lead time for the 8 IWSs is estimated at 16 months for an accelerated delivery reduction from 20 months. It is suggested that the IWS be ordered immediately after receipt of the Phase 2 notice to proceed to test phase. This will ensure delivery of the needed IWS near the end of Phase 3 fabrication. Although not a crucial long lead purchase, the test load equipment should also be ordered during the Phase 3 fabrication of the prototype railcars to ensure its delivery in time to start testing.

Single-car testing is estimated to be completed in 16 months after delivery of the prototype railcars, test loads equipment, and IWS. The schedule of the single-car testing is broken into testing of the cask railcar over an estimated 11-month period and testing of the buffer railcar over an estimated 9-month period delayed 4 months after the start of the cask railcar testing. An additional estimated 3 months is needed for AAR EEC conditional approval notification. The Phase 4 single-car testing schedule is depicted in Figure 2-1.

Figure 2-1: Phase 4 Single-Car Testing Estimated Schedule



The above schedule estimates are supported by a proposal from TTCI. Also note qualifications as listed in Section 2.5, *Phase 4 Estimate Qualifications*.

2.5 Phase 4 Estimate Qualifications

The Phase 4 single-car testing ROM estimate and schedule are qualified based on the following statements:

- Funding for Phase 4 single-car testing is available from DOE for the entire test phase.
- All estimates provided in this report are Rough Order of Magnitude estimates and follow AFS procedure AFS-PC-PRC-005 which follows guidelines of AACE International Recommended Practice No. 18R-97, *Cost Estimate Classification System* [3]. ROM estimates provided in this report are within Class 5 estimate expected accuracy ranges.
- The cask and one buffer railcar will be available for testing in functional condition at the AAR TTC site, Pueblo, CO, when required for Phase 4 single-car testing.
- Necessary IWS will be available in functional condition for testing at the AAR TTC site, Pueblo, CO, when required for Phase 4 single-car testing.
- The test loads, test load cradles and end stops will be available in functional condition for testing at the AAR TTC site, Pueblo, CO, when required for Phase 4 single-car testing.
- Functional condition of IWS, cask railcar, buffer railcar, test loads or test load cradles will be at the discretion of TTCI.
- Provided ROM estimates or forecasted schedules do not include impact of downtime due to the lack of availability in functional condition due to component or railcar testing of IWS, cask railcar, buffer railcar, test loads or test load cradles necessary for single-car testing.

3.0 PHASE 5 MULTI-CAR TESTING

Phase 5 multi-car testing has a ROM estimated range from $1,503,100 to $6,012,200 with a base sum of $3,006,100 during an 11-month period after the receipt of conditional approval for single-car use for the cask and buffer railcars. This estimate and schedule are further described in the following subsections detailing the assumed scope of work including its requirements for completion and deliverables, the scope of work's primary subcontractors, assumptions of the Phase 5 estimate, detail of the estimate and its schedule, and qualifications of the estimate.

3.1 Phase 5 Scope of Work and Suggested Contract Arrangements

A description of the Phase 5 multi-car testing scope of work is described in the following subsections. The breakout by subsection also reflects each scope of work's anticipated subcontractor.

3.1.1 Multi-Car Testing – TTCI

Multiple railcar tests are designed to verify that the individual railcars do not adversely affect the performance of adjacent railcars of a mock HLRM train. During multi-car testing, the train consist is to include a single locomotive, cask railcar, two buffer railcars, and an escort railcar.

In order to maintain direct supervision and control of the multi-car testing, it is suggested that DOE contract directly with TTCI for multi-car testing. This contract will be to furnish all management, supervision, personnel, materials, single test locomotive for test performed at the TTC site, the use of TTCI locomotives and instrument coach while on the TTC site, and operating test supplies necessary for accomplishment of the multi-car testing. The proposed contracted scope of work for multi-car testing is to include testing requirements of AAR standard S-2043, Performance Specification for Trains Used to Carry High Level Radioactive Material, Section 6, Multiple-Car Tests [6], including the following specific testing activities to be performed by TTCI:

- Dynamic tests at the controlled test site
    - Braking tests (AAR S-2043 [4], Section 6.1.1)
    - Hand brake tests (Section 6.1.2)
    - Buff and draft curving (Section 6.1.3)
- System monitoring tests (Section 6.2)
- Revenue service tests
    - Turnouts, crossovers and tight curves (Section 6.3.1)
    - Poorly maintained track (Section 6.3.2)
    - Ride quality (Section 6.3.3)
    - Demonstration run (Section 6.3.4)

Requirements of this contract include that DOE will provide the following:

- Necessary IWS in functional condition
- The prototype cask railcar with the cradle-to-railcar attachment interface system in the condition to be tested, and conditionally approved by the AAR EEC for single-car test acceptance
- Two prototype buffer railcars in the condition to be tested, and conditionally approved by the AAR EEC for single-car test acceptance
- Minimum and maximum test loads with test cradles and end stops in the condition to be tested
- A suitable escort railcar for multi-car tests which is at a minimum, conditionally approved by the AAR EEC for single-car test acceptance

The deliverable of this contract is a multiple railcar test report. The contract to TTCI would be on a cost-plus basis. A single contract to TTCI (a small business) could also be arranged to encompass the entire Phase 5 multi-car testing scope of work including all supporting team members as subcontractors to TTCI.

3.1.2 Instrumented Wheel Sets – TTCI

These same 8 wheel sets used in single-car testing will be utilized for multi-car testing..

3.1.3 Test Load Equipment

The same minimum and maximum test loads, test load cradles and set of end stops supplied for single-car testing will be suitable for multi-car testing. Unless damaged beyond use during single-car testing (which is considered extremely unlikely), the same test load equipment should be utilized in multi-car testing.

3.1.4 Testing Support – Kasgro Rail

During multi-car testing, Kasgro Rail will arrange for an independent third party review to be performed of the railcars' testing results. Kasgro will also arrange for the revenue service test and demonstration run to be performed on commercial railroad tracks by a commercial rail service provider. Finally, Kasgro will submit the multi-car testing results to the AAR EEC for approval. A contract for these support services can be placed directly with Kasgro Rail or placed through TTCI.

The deliverable of this scope of work is Kasgro Rail technical support. This contract would be placed on a cost-plus basis.

3.1.5 Project Management and Integration Support - AFS

AFS will provide project management, project team integration and coordination, project reporting and project controls support during the Phase 5 multi-car testing period. This contract should be placed through TTCI on a cost-plus basis.

3.2 Phase 5 Testing Assumptions

Assumptions regarding the Phase 5 multi-car testing are included to ensure test requirements are fully understood and to support the understanding of the scope of work descriptions.

Multi-car testing assumptions are:

- Prior to starting multi-car testing, authorization to perform multi-car testing has been received from the AAR Chief – Technical Standards by means of conditional acceptance of the cask, buffer and escort railcars for single-car usage.
- Testing will be performed to AAR Standard S-2043, Performance Specification for Trains Used to Carry High Level Radioactive Material, Sections 6, and Multi-Car Tests [6].
- DOE will provide a suitable and functional escort railcar that is, at a minimum, conditionally approved for single-car use for multi-car testing.
- No specific risk evaluation has been performed as a part of this report. Instead, guidelines of AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System [3], have been followed for providing ROM estimates.
- Estimated schedules are provided in months of duration.
- ROM estimates are provided in 2016 dollars.

- Specific assumptions of the Phase 5 ROM cost estimate are as follows:
    - TTCI estimates are based on a ROM proposal and include TTCI services and use of the TTC site and its equipment.
    - Kasgro Rail multi-car testing support (see Section 3.3.3, Testing Support – Kasgro Rail) is based on a Kasgro Project Manager assigned on a 0.4 FTE basis. Related travel expenses are estimated to occur bimonthly as a 5-day trip by the Kasgro PM to the AAR's TTC site utilizing government per diem rates.
    - The third-party independent review (see Section 3.3.3, Testing Support – Kasgro Rail) is to include an independent review by a third party subject matter expect of all reports as written by TTCI for AAR S-2043, Section 6.0, Multiple-Car Test of the HLRM prototype cask and buffer railcars. The fee for this service is based on the 2016 AAR Office Manual [8].
    - The revenue service test and demonstration run to be performed on commercial railroad tracks by a commercial rail service provider is supported by a ROM estimate as specific requirements will not be determined by the AAR EEC until the Phase 5 multi-car testing in initiated.
    - The AAR EEC application fee for multi-car testing is included in the ROM estimate (see Section 3.3.3, Testing Support – Kasgro Rail). The fee for this service is based on the 2016 AAR Office Manual [8].
- Provided ROM estimates are based on the current configuration of the cask and buffer railcars as of December 31, 2016 and do not reflect changes or modifications as a result of the completion of Phase 2, Preliminary Design, or Phase 3, Prototype Fabrication and Delivery, or Phase 4 single-car testing.

3.3 Phase 5 Testing Estimate

This section provides ROM estimates for Phase 5 multi-car testing with detailed information provided by the major scope of work task and supplier. ROM estimates are shown depicting the AACE Class 5 estimate range [3]. ROM estimates reflect the detailed scopes of work in Section 3.1, Phase 5 Scope of Work and Suggested Contract Arrangements, and assumptions detailed in Section 3.2, Phase 5 Testing Assumptions.

For Phase 5 multi-car testing, the ROM estimated range is from $1,503,100 to $6,012,200 with a base sum of $3,006,100. The multi-car testing ROM estimates are summarized in Table 3-1.

Table 3-1: Phase 5 Multi-Car Testing ROM Estimate Summary

(X $1000)

	Minimum	Maximum	Base Sum
Multi-Car Testing (TTCI)	$650	$2,600	$1,300
Instrumented Wheel Sets (TTCI)	$0	$0	$0
Testing Support (Kasgro Rail) Includes AAR EEC Third Party Independent Review and Revenue Service Test & Demonstration Run	$663	$2,652	$1,326
Test Load Equipment	$0	$0	$0
Project Management & Integration Support (AFS)	$190	$760	$380
Total	$1,503	$6,012	$3,006

Note: In 2016 dollars

These estimates are further described in the following subsections.

3.3.1 Multi-Car Testing – TTCI

The ROM estimated range for the performance of multi-car testing services by TTCI is from $650,000 to $2,600,000 with a base sum of $1,300,000. This includes testing services for a consist of a locomotive, 2 buffer railcars, a cask railcar, an escort railcar, and the TTCI instrument coach as required. This estimate is supported by a ROM proposal from TTCI.

3.3.2 Instrumented Wheel Sets – TTCI

It is assumed that the same 8 IWS utilized in Phase 4 single-car testing will be utilized in Phase 5 multi-car testing; therefore, no additional costs are included in this estimate.

3.3.3 Testing Support – Kasgro Rail

The ROM estimated range for Kasgro Rail to support TTCI in the performance of multi-car testing services is from $663,100 to $2,652,400 with a base sum of $1,326,200. This includes support during the multi-car consist testing duration and necessary travel at government per diem rates to the TTC site in Pueblo, CO bi-monthly for a one-week duration. This is supported by a ROM proposal from Kasgro Rail. Also included are the AAR EEC third party independent review fee and an estimate for the required revenue service test and demonstration run of the multi-car consist on commercial rail lines.

3.3.4 Test Load Equipment – AFS

It is assumed that the same test load equipment utilized in Phase 4 single-car testing will be utilized in Phase 5 multi-car testing; therefore, no additional costs are included in this estimate.

3.3.5 Project Management and Integration Support - AFS

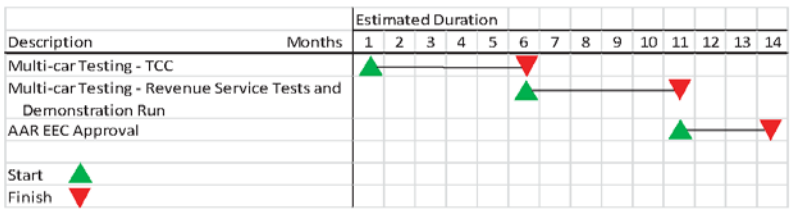
The ROM estimated range for AFS to support TTCI in the performance of Phase 5 multi-car testing services is from $190,000 to $760,000 with a base sum of $380,000. This includes support during the multi-car consist testing duration and necessary travel at government per diem rates to the TTC site in Pueblo, CO monthly for a one-week duration. This is supported by a ROM estimate from AFS.

3.4 Phase 5 Testing Schedule

It is suggested that the test load equipment and the IWS remain at the TTC site in functional condition immediately after Phase 4 testing in order to be available for Phase 5 multi-car testing.

Multi-car testing is estimated to be completed in 11 months with an additional estimated 3 months needed for AAR EEC conditional approval notification. Testing will start immediately after receipt of the single-car testing conditional approval for both the cask and buffer prototype railcars, and upon availability of a suitable escort railcar that is AAR EEC conditionally approved for single-car usage.

Figure 3-1: Phase 5 Multi-Car Testing Estimated Schedule



The above schedule estimates are supported by a proposal from TTCI. Also note qualifications as listed in Section 3.5, Phase 5 Estimate Qualifications.

3.5 Phase 5 Estimate Qualifications

The Phase 5 multi-car testing ROM estimate and schedule are qualified based on the statements below.

- Funding for Phase 5 Multi-Car testing is available from DOE for the entire test phase.
- All estimates provided in this report are Rough Order of Magnitude estimates and follow AFS procedure AFS-PC-PRC-005 which follows guidelines of AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System, [3]. ROM estimates provided in this report are within Class 5 estimate expected accuracy ranges.
- The cask and two buffer railcars will be available for testing in functional condition at the AAR TTC site, Pueblo, CO, when required for Phase 5 multi-car testing.
- Necessary IWS will be available in functional condition for testing at the AAR TTC site, Pueblo, CO, when required for Phase 5 multi-car testing.
- The minimum and maximum test load, test load cradles, and one set of end stops will be available in functional condition for testing at the AAR TTC site, Pueblo, CO, when required for Phase 5 multi-car testing.
- The escort railcar will be available in functional condition at the AAR TTC site, Pueblo, CO, when required for Phase 5 multi-car testing.
- Functional condition of IWS, cask railcar, buffer railcars, test load equipment, escort railcar or service locomotives will be at the discretion of TTCI.
- Provided ROM estimates or forecasted schedules do not include impact of downtime due to the lack of availability in functional condition of IWS, cask railcar, buffer railcars, test load equipment, escort railcar or service locomotives necessary for multi-car testing and/or revenue service tests and demonstration runs.

4.0 RAILCAR PRODUCTION

A summary of the production phase of the cask and buffer railcars reflects the following:

- The total ROM estimated range for the fabrication and delivery of 120 cask railcars and 60 buffer railcars is from $101,693,300 to $406,773,000 with a base sum of $203,386,500.
- The start of delivery begins at 15 Months After Receipt of Order (MARO) at a rate of two cask railcars and one buffer railcar per month and continues through 74 MARO.

This is detailed in the following subsections.

4.1 Production Scope of Work and Suggested Contract Arrangements

A description of the railcar production phase's scope of work is described in the following subsections. The scope of work also reflects the anticipated subcontractor.

4.1.1 Railcar Production – Kasgro Rail

The scope of work for the railcar fabricator during the production phase is:

- The purchase of all materials, assemblies, hardware, supplies
- Fabrication and inspection labor
- Certificates of conformance for each delivered railcar

The assumed quantities of railcars to be fabricated are 120 Atlas cask railcars and 60 buffer railcars.

These railcars are to match the as-built configuration of the prototype railcars delivered under Phase 3 and any subsequent changes/modifications necessary for receipt of the AAR EEC conditional approval for multi-car use as received at the completion of Phase 5 multi-car testing.

The production phase of the Atlas Railcar Design Project is currently planned by DOE for any qualified railcar fabricator meeting AAR M-1003 requirements eligible to bid the production of the HLRM railcars. However, currently only Kasgro Rail is qualified and knowledgeable of the HLRM railcar design, therefore they were the only railcar fabricator solicited and included in the generation of this report.

A resulting production contract to Kasgro Rail would be on a firm-fixed price basis. This estimate of production costs by Kasgro Rail is supported by a ROM proposal.

4.1.2 Production Management Support – AFS

AFS will support Kasgro Rail during the production phase by providing project management interface, project reporting, project controls and scheduling services to the railcar buyer. It is anticipated that AFS will be under contract to Kasgro Rail during the production phase under a firm-fixed price contract.

Currently, AFS would need to be a subcontractor to Kasgro Rail as AFS cannot accept the liabilities requirements of railcar production. This condition may change in the future and could be re-evaluated at the time that actual production quotes are solicited.

4.2 Production Assumptions

Assumptions regarding the HLRM railcar production phase are included to ensure that production requirements are fully understood and to support the understanding of the scope of work descriptions.

The production phase assumptions are:

- The AAR EEC has conditionally approved the cask and buffer railcars for multi-car use.
- A production quantity of 120 cask railcars and 60 buffer railcars has been used as defined in DOE contract DE-NE 0008390, Part 1, Section C, Statement of Work, subsection 2.2, Phase 2: Preliminary Design [7].
- Production railcars will be built to AAR M-1003 quality assurance requirements.
- No specific risk evaluation has been performed as a part of this report. Instead, guidelines of AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System [3], have been followed for providing ROM estimates.
- The estimated production schedule is provided in MARO.
- ROM estimates are provided in 2016 dollars.
- Kasgro Rail estimates are based on a ROM proposal and include AFS as a project management subcontractor.
- Provided ROM estimates are based on the current configuration of the cask and buffer railcars as of December 31, 2016 and do not reflect changes or modifications as a result of the completion of Phase 2, Preliminary Design, or Phase 3, Prototype Fabrication and Delivery.
- The buffer railcar's truck configuration is based on current U.S. Navy Rail Escort Vehicle (REV) railcar truck design by Amsted Rail.
- AFS support includes:
    - A project manager at 0.5 FTE
    - A project control specialists at 0.25 FTE
    - Minor contractual support during startup
    - Associated travel to the Kasgro fabrication site on a monthly basis by the project manager for project status evaluation
    - Annual travel to the Kasgro site for production schedule baseline evaluation

4.3 Production Estimate

The total ROM estimated range for the fabrication and delivery of 120 cask railcars and 60 buffer railcars is from \$100,500,000 to \$402,000,000 with a base sum of \$201,000,000.

The ROM estimated unit price for the fabrication and delivery of Atlas cask railcars ranges from \$750,000 to \$3,000,000 with a base sum of \$1,500,000 per delivered cask railcar. This yields a total production ROM estimate range of from \$90,000,000 to \$360,000,000 with a base sum of \$180,000,000 for 120 delivered cask railcars.

The ROM estimated unit price for the fabrication and delivery of buffer railcars ranges from \$175,000 to \$700,000 with a base sum of \$350,000 per delivered buffer railcar. This yields a total production ROM estimate range of from \$10,500,000 to \$42,000,000 with a base sum of \$21,000,000 for 60 delivered buffer railcars.

The ROM estimate for AFS support during the production period ranges from \$1,193,300 to \$4,773,000 with a base sum of \$2,386,500.

Table 4-1 summarizes the estimated ROM production cost.

Table 4-1: Railcar Production Summary

	Minimum	Maximum	Base Sum
Single railcar unit pricing			
Cask railcar production	$750,000	$3,000,000	$1,500,000
Buffer railcar production	$175,000	$700,000	$350,000
Production railcar lot pricing (in $M)			
Cask railcar production; quantity = 120	$90	$360	$180
Buffer railcar production; quantity = 60	$11	$42	$21
Total Railcar Production ROM Estimate	$101	$402	$201
AFS Production Support	$1	$5	$2
Total	$102	$407	$203

Note: In 2016 dollars

4.4 Production Schedule

If a contract is awarded to Kasgro Rail for the production of 120 cask railcars and 60 buffer railcars, there would be a total of 74 MARO until production completion. The first 14 months will be used for material lead time, formalizing any potential engineering changes that occurred to components such as bearings, springs, air lines, connectors, brake pads, etc. as a result of single-car and /or multi-car testing, fabrication readiness, and the start of railcar fabrication. The delivery of production railcars will begin at 15 MARO and continue for 60 months at a rate of 2 cask railcars per month and 1 buffer railcar a month for a total project duration of 74 MARO.

4.5 Qualifications of Production Estimate and Schedule

The production phase ROM estimate and schedule are qualified based on the following statements:

- A production quantity of 120 cask railcar and 60 buffer railcars has been used as requested in DOE contract DE-NE 0008390, Part 1, Section C, Statement of Work, subsection 2.2, Phase 2: Preliminary Design [8]. Future pricing would change with changes in the production quantity.
- The buffer railcar truck estimated price included in the buffer railcar ROM estimate is based on the current U.S. Navy REV railcar truck price as designed and manufactured by Amsted Rail. If dynamic modeling results show a different truck type is required, the buffer railcar's truck and railcar unit ROM estimated price will be need to be revised accordingly.
- Funding is available for an entire single production run.
- All estimates provided in this report are Rough Order of Magnitude estimates and follow AFS procedure AFS-PC-PRC-005 which follows guidelines of AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System, [3]. ROM estimates provided in this report are within Class 5 estimate expected accuracy ranges.

5.0 BALLAST LOAD – AFS

During the development of the preliminary design of the Atlas railcar, it has been determined that a ballast load of approximately 200,000 pounds is required in order for the railcar to meet AAR S-2043 requirements when in an empty condition. An ROM estimate is included for the required ballast load. The ballast load is conceptual in design and consists of four modular weights of approximately 40,000 pounds each and two modular weights of approximately 20,000 pounds each; this is so the ballast weights can individually be transported to a location where needed. Based on the results of the dynamic modeling the ballast load may be used as a test load in the minimum condition 1 (see Appendix B, Table B-1).

A contract to purchase ballast loads can be placed with AFS (or other suitable designer/fabricators) on a cost-plus basis or as a firm-fixed price contract, depending on the negotiating parties' preferences. Deliverables of this scope of work include:

- Fabrication designs for the ballast load
- Fabrication of the ballast load(s)
- Related desirable certificates of conformance, inspection requirements and reports

The total ROM estimated range for the fabrication and delivery of a single ballast load ranges from $276,600 to $1,106,400 with a base sum of $553,200 per ballast load. The fabrication design and delivery of the first ballast load can occur in 6 MARO.

The utilization of ballast loads in future transportation operations is strictly at the option of future logistics/transportation service providers; therefore, its cost has not been included in the ROM cost and schedule estimates for the testing or production phases. Ballast loads are described in Appendix B.

6.0 ACCELERATION OF TEST AND PRODUCTION PHASES

This section provides possible approaches for acceleration of the Phase 3 prototype railcar fabrication, Phase 4 single-car testing, Phase 5 multi-car testing, and the production phase. Possible approaches are listed by project phase, include the performing subcontractor, and provide general information regarding the time-saving approach.

- Phase 3 fabrication approaches:
    - A second shift can be added to Kasgro Rail production staff to shorten duration of production and accelerate the delivery of prototype railcars. Kasgro Rail should be contacted for further information. AFS (as contract holder of Phase 3) should be contacted to coordinate additional information from Kasgro Rail.
    - Depending on the production start of Vigor Nuclear Products and their subsequent release of Amsted Rail for final design, preparation for production and fabrication the trucks for the REV railcar, the buffer railcar trucks may prevent acceleration of buffer railcar delivery. Premiums could be paid to accelerate Amsted's final design, production preparation and/or truck fabrication. AFS (as contract holder of Phase 3) should be contacted to coordinate additional information from Kasgro Rail and Amsted Rail.
- Phase 4 acceleration approaches:
    - Premiums to accelerate the fabrication and delivery of IWS are included in the provided ROM cost and schedule estimates reducing the lead time for 8 IWS from 22 to 16 MARO. Also, the contract for the IWS should be placed in the latter half of 2017. TTCI should be contacted for further information.
    - The generation of single-car test plans can be started during the Phase 3 prototype railcar fabrication before the prototype railcars and completed and delivered to the TTC site. TTCI should be contacted for further information.
    - Parallel testing of the cask and buffer railcars can occur by TTCI at the TTC site. This would require that both the cask and buffer railcars be delivered at the nearly the same time. Also,

additional test instrumentation and equipment would need to be secured by TTCI. This approach would require additional premiums to be paid. TTCI should be contacted for additional information.

 - Premiums could be paid to add additional testing shifts, weekend shifts and/or the doubling of support personnel during single-car testing by TTCI. TTCI should be contacted for additional information.
 - An incentive fee could be paid for resulting acceleration of testing duration. TTCI should be contacted for additional information.

- Phase 5 acceleration approaches:
  - The generation of multi-car test plans can be started during the Phase 4 single-car testing before an AAR EEC conditional approval for single-car use if received for the cask and buffer railcars. TTCI should be contacted for further information.
  - Premiums could be paid to add additional testing shifts, weekend shifts and/or the doubling of support personnel during multi-car testing by TTCI at the TCC site. TTCI should be contacted for additional information.
  - An incentive fee could be paid for resulting acceleration of testing duration. TTCI should be contacted for additional information.
- Production phase acceleration approaches:
  - Once the cask and/or buffer railcars are conditionally approved for single-car usage, Kasgro could be contracted for production materials shortening the start-up of railcar production. Kasgro Rail should be contacted for further information.
  - A second shift can be added to Kasgro Rail production staff to shorten duration of production and accelerate the delivery of railcars. Kasgro Rail should be contacted for further information.
  - For further information the DOE should contact each subcontractor directly and inquire regarding the specific acceleration approach detailed scope, possible time savings, required funding, and evaluation of potential risk of acceleration.

7.0 REFERENCES

1. U.S. Department of Energy, Contract DE-NE0008390, *Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material*, Contract Modification #0005, December 20, 2016.
2. Association of American Railroads Manual of Standard and Recommended Practices, Car Construction Fundamental and Details, *Performance Specification for Trains Used to Carry High Level Radioactive Material*, Standard S-2043, 2003.
3. AACE (formerly the Association for the Advancement of Cost Engineering) International Recommended Practice No. 18R-97, *Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for the Process Industries*, TCM Framework 7.3 – Cost Estimating and Budgeting, Rev November 29, 2011. Note that per Practice No. 18R-97, a Class 5 ROM estimate is defined as -50% to +100% of the base sum.
4. Association of American Railroads Manual of Standard and Recommended Practices, Car Construction Fundamental and Details, *Performance Specification for Trains Used to Carry High Level Radioactive Material, Standard S-2043*, Section 5, *Single-Car Tests*, 2003

5. Association of American Railroads, Safety and Operations, "2015 Field Manual of the AAR Interchange Rules" AAR Rule 88 for New Cars, Section A Equipment Requirements for Transporting HLRM, 2015.
6. Association of American Railroads Manual of Standard and Recommended Practices, Car Construction Fundamental and Details, *Performance Specification for Trains Used to Carry High Level Radioactive Material, Standard S-2043*, Section 6, *Multiple-Car Tests*, 2003
7. U.S. Department of Energy, Contract DE-NE0008390, *Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material*, Contract Modification #0005, December 20, 2016, Part 1, Section C, *Statement of Work*, subsection 2.2, *Phase 2: Preliminary Design.*
8. Association of American Railroads, *2016 Office Manual*, Appendix E, *Service Fees*, 2016

APPENDIX A: ATLAS RAILCAR PROJECT TEST LOAD AND TEST LOAD CRADLE CONCEPT

This appendix describes the railcar test loads needed for use during the Atlas Phase 4 Single Railcar Testing and Phase 5 Multi-Railcar Testing. The test load is defined as the weight of the dummy cask payload and its required cradle. The ballast load is defined as the physical ballast payload necessary on the Atlas railcar so it meets S-2043 requirements when in an empty condition.

A.1 Test Load Conditions

Based on previous experience with the M-290 railcar, it is assumed that three test load configurations will be required. These conditions are adopted to simulate the two minimum load conditions, the maximum load condition and the highest cg condition. By coincidence, the maximum load and highest cg condition represent the same load case, which is the loaded HI-STAR 190 XL cask. The final required test loads and conditions will not be fully defined until the conclusion of the Atlas railcar S-2043 dynamic modeling. The test load conditions are shown in Table A-1 below.

Table A-1: Test Load Conditions

Minimum Condition 1	Minimum Condition 2(1)	Maximum Condition(2)
Atlas Railcar + Ballast Load (Estimated weight – to be confirmed by final dynamic modeling) **Test Load = 200,000 lb.**	Atlas Railcar + Lightest Cask Weight / Conceptual Cradle (Empty MP197 cask and conceptual cradle) **Test Load = 202,710 lb.** (176,710 + 26,000) Taken from Table 4-3 and Table 4-4 of [1]	Atlas Railcar + Maximum Cask Weight / Conceptual Cradle (Also Maximum cg case) (Loaded HI-STAR 190 XL Cask and conceptual cradle) **Test Load = 474,405 lb.** (420,769 + 53,636) Taken from Table 4-3 and Table 4-4 of [1]

Notes:

1) Based on the results of the dynamic modeling, a second minimum load case may be required.
2) The dynamic modeling plan requires a maximum weight condition and a maximum cg condition. For this project the HI-STAR 190 XL cask and conceptual cradle is both the maximum weight and maximum height cg case.

A.2 Test Load Description

Minimum Condition 1

The minimum test load condition is the "empty condition" defined here as the Atlas railcar loaded with the ballast load. The ballast load design is described in Appendix B: *Atlas Railcar Project ROM Estimate for Minimum Condition Test Load.*

Minimum Condition 2

Based on the results of the dynamic modeling, a second minimum test load condition may be required. The lightest cask and conceptual cradle load may need to be tested separately from the "empty condition". The empty

MP197 cask and conceptual cradle is the lightest combined load and was used as a basis for the minimum condition 2 test load. The MP197 conceptual cradle is constructed from two main I-beams, which sandwich saddle cross members and a central shear key. There are four pin locations in the main I-beams for attachment of the cradle to the railcar. The conceptual cradle is 178 inches long and 116 inches wide. The minimum condition 2 test load is fabricated out of 4-inch-thick circular plates welded together circumferentially using skip welds. The test load is 208 inches long and has a maximum diameter of 91.5 inches. See Figure A-1 and Figure A-2 below for more dimensions. The test load and cradle are constructed from carbon steel. The critical characteristics of the minimum condition 2 test cradle and load are shown in Table A-2. The minimum condition 2 test load was designed to match weight, mass moments of inertia and cg with the empty MP197 cask and conceptual cradle.

Table A-2: Characteristics of Minimum Condition 2 Test Load

Test Load	Required Weight, lb.	Conceptual Test Load Design Weight, lb.
Conceptual Cradle	26,000	26,000
Minimum Condition 2	176,710	186,000
Total	202,710	212,000

A sketch of the minimum condition 2 conceptual cradle is shown in Figure A-1 and the test load is shown in Figure A-2. The test load is restrained to the railcar with the shear key in the longitudinal direction and with the saddle assembly and tie-down restrain band in the lateral and vertical directions. The minimum condition 2 test load is shown on the railcar in Figure A-3.

Figure A-1: Minimum Condition 2 Test Load Cradle

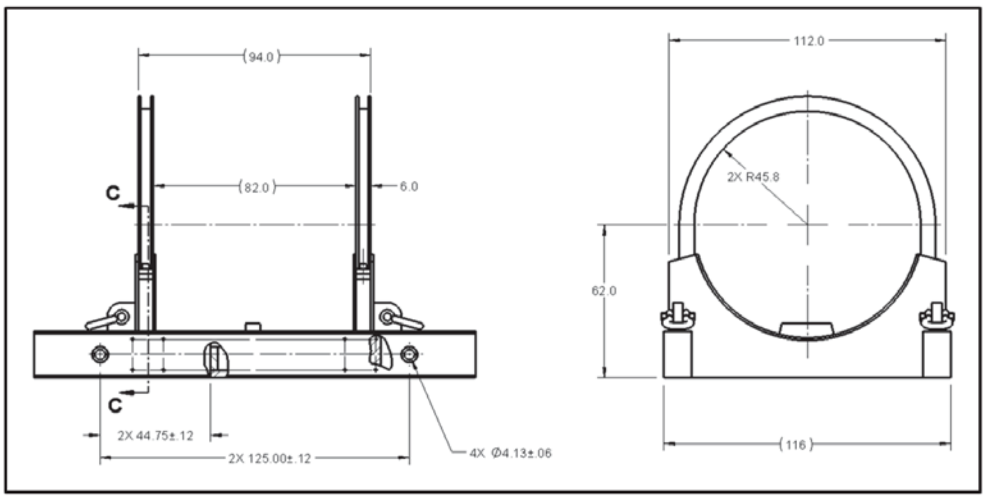


Figure A-2: Minimum Condition 2 Test Load

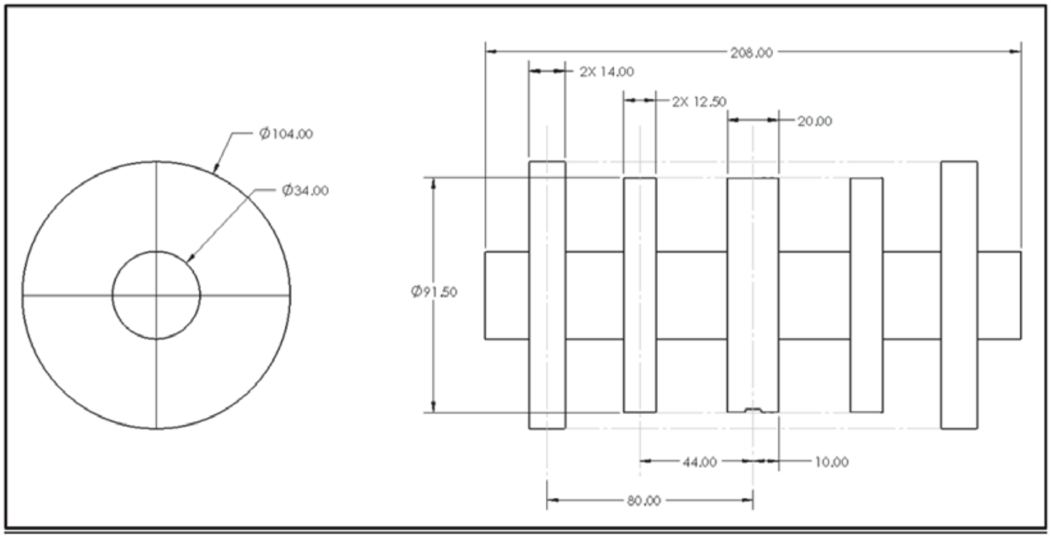
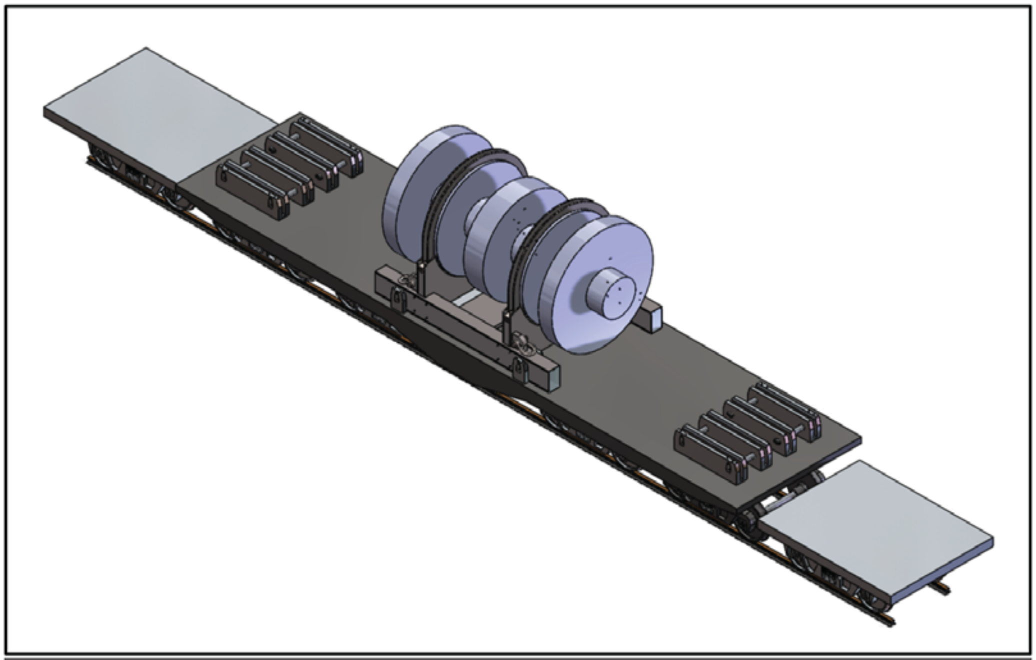


Figure A-3: Minimum Condition 2 Test Load on Atlas Railcar



Maximum Condition

The maximum test condition is simulated by the Atlas railcar loaded with the maximum condition test load. The loaded HI-STAR 190 XL cask and conceptual cradle and end stop design was used as a basis for the maximum condition test load. The HI-STAR 190 XL conceptual cradle is constructed from two main I-beams, which sandwich saddle cross members. There are four pin locations in the main I-beams for attachment of the cradle to the railcar. The maximum condition test load is fabricated out of 4-inch-thick circular plates welded together circumferentially using skip welds. The test load is 237 inches long with a maximum outer diameter of 106.5 inches. The center beam is 74 inches in diameter and there is a center circular disk 98 inches thick. See Figure A-4 and Figure A-5 below for more dimensions. The test load and test load cradle are constructed from carbon steel. The critical characteristics of the maximum condition test load are shown in the Table A-3. The maximum condition test load was designed to match weight, mass moments of inertia and cg with the loaded HI-STAR 190 XL cask and conceptual cradle.

Table A-3: Characteristics of Maximum Condition Test Load

Test Load	Required Weight, lb.	Conceptual Test Load Design Weight, lb.
Conceptual Cradle	53,636	53,636
Maximum Condition	420,769	420,865
Total	474,405	474,501

A sketch of the maximum condition test load is shown in Figure A-4 and Figure A-5. The test load is restrained to the railcar with the saddle assembly and tie-down band in the lateral and vertical directions. Shoring is used between the test load and the cradle end stop to secure the load in the longitudinal direction. The maximum condition test load is shown on the railcar in Figure A-3.

Figure A-4: Maximum Condition Test Load Cradle

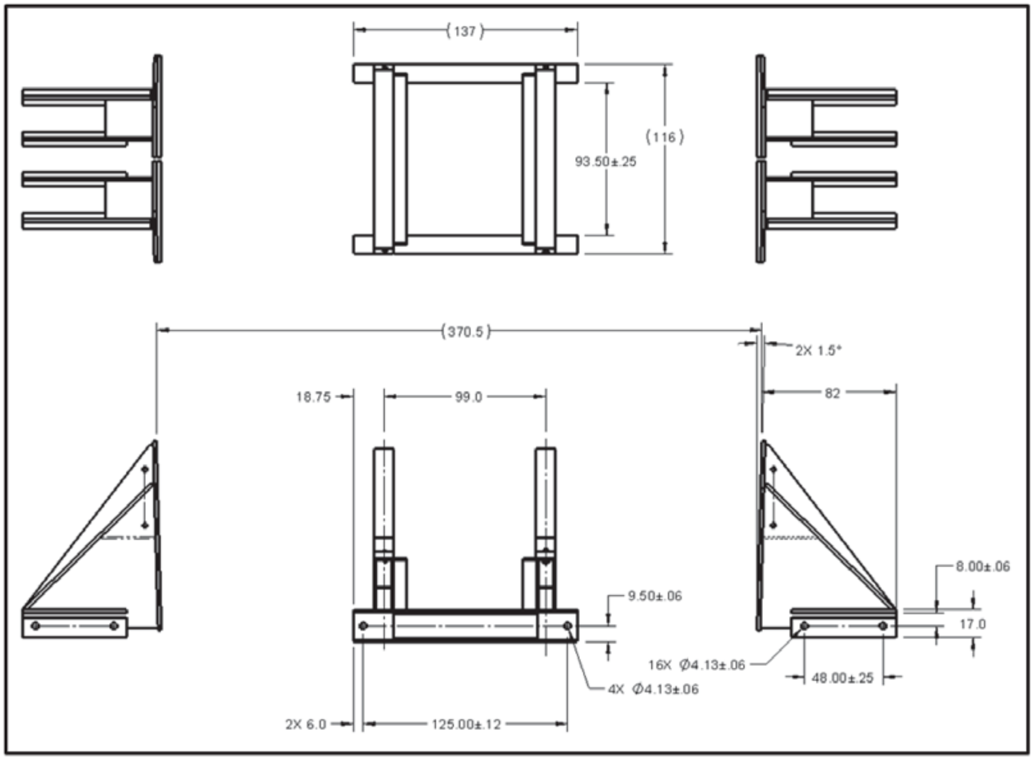


Figure A-5: Maximum Condition Test Load

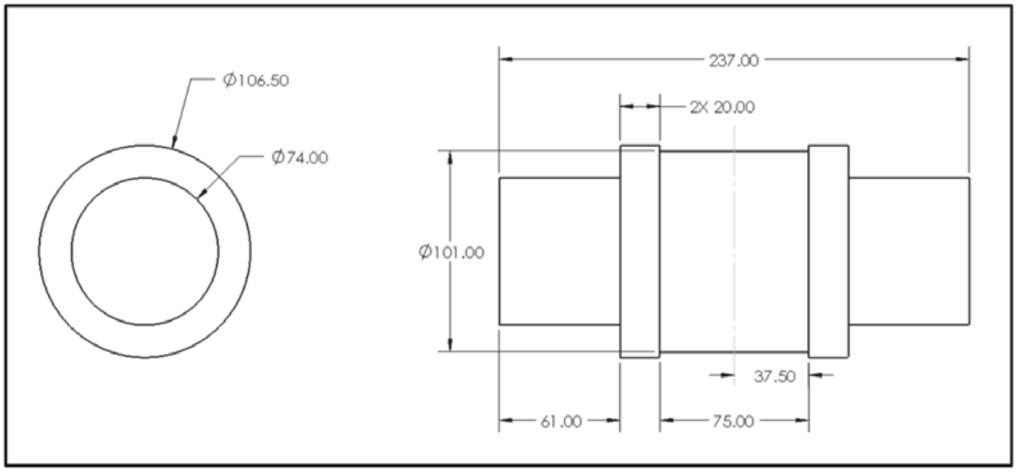
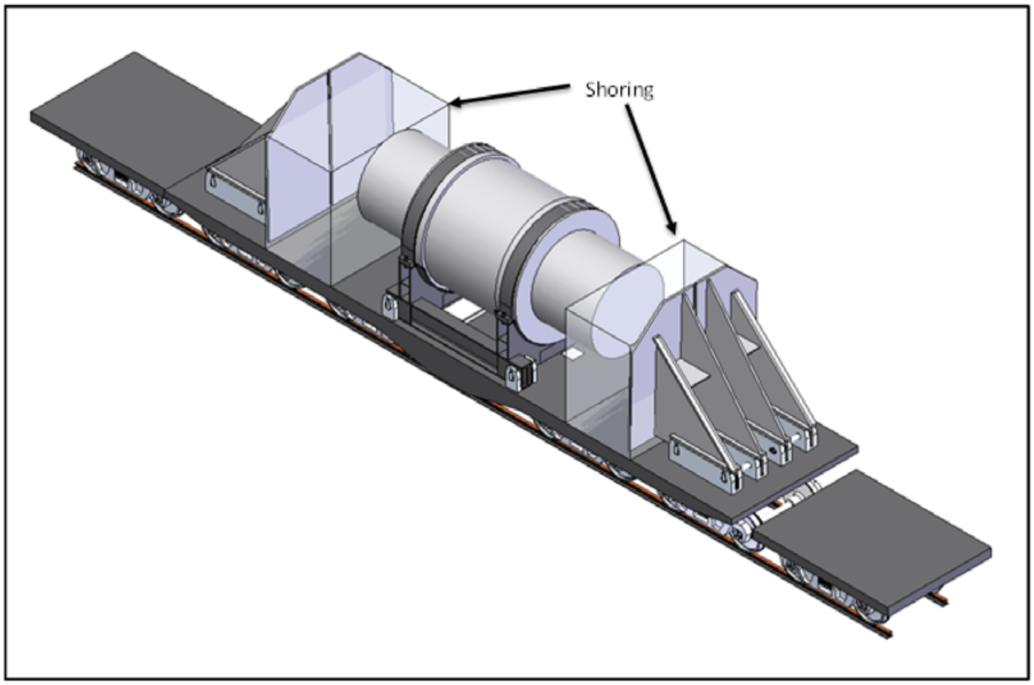


Figure A-6: Maximum Condition Test Load on Atlas Railcar



A.3 References

1. AREVA Federal Services, Calculation CALC-3015276, *Atlas Railcar Cradle Attachment and Combined Center of Gravity Calculation*. Latest revision.

2. Department of Energy Contract DE-NE0008390, latest revision, Part I, Section C, Statement of Work, Attachment A, Transport Cask Characteristics.

APPENDIX B: ATLAS RAILCAR PROJECT ROM ESTIMATE FOR MINIMUM CONDITION TEST LOAD

It has been determined that the Atlas railcar will require additional mass to be able to be transported in the "empty condition" under AAR S-2043. The required additional mass, called ballast load, is estimated to be 200,000 pounds. The ballast load may have to be transported separately from the consist and is conceptually designed to be transported by truck. The maximum load to be transported by truck is assumed to be 40,000 pounds; therefore, the ballast load will need to be modular. To keep operational options open, it is assumed that the Atlas railcar may transport an empty cradle at the same time and therefore the ballast load is designed to connect to the railcar's outer pin blocks. Based on the results of the dynamic modeling the ballast load may be used as a test load in the minimum condition 1.

This document describes the minimum condition 1 railcar test load needed for use during the Atlas Phase 4 Single Railcar Testing and Phase 5 Multi-Railcar Testing. The required test load conditions are presented in Appendix A and are repeated in Table B-1 below for clarity.

B.1 Test Load Conditions

The test load conditions are shown in Table B-1 below.

Table B-1: Test Load Conditions

Minimum Condition 1	Minimum Condition 2(1)	Maximum Condition(2)
Atlas Railcar + Ballast Load (Estimated weight – to be confirmed by final dynamic modeling) **Test Load = 200,000 lb.**	Atlas Railcar + Lightest Cask Weight / Conceptual Cradle (Empty MP197 cask and conceptual cradle) **Test Load = 202,710 lb.** (176,710 + 26,000) Taken from Table 4-3 and Table 4-4 of [1]	Atlas Railcar + Maximum Cask Weight / Conceptual Cradle (Also Maximum cg case) (Loaded HI-STAR 190 XL Cask and conceptual cradle) **Test Load = 474,405 lb.** (420,769 + 53,636) Taken from Table 4-3 and Table 4-4 of [1]

Notes:

1) Based on the results of the dynamic modeling, a second minimum load case may be required.
2) The dynamic modeling plan requires a maximum weight condition and a maximum cg condition. For this project the HI-STAR 190 XL cask and conceptual cradle is both the maximum weight and maximum height cg case.

B.2 Test Load Description

Minimum Condition 1

The minimum condition 1 test load is the "empty condition" defined here as the Atlas railcar loaded with the ballast load. The ballast load conceptual design has two different ballast assembly designs: 1) four main assemblies weighing 40,000 pounds each, and; 2) two top assemblies weighting 20,000 pounds each. This allows the entire ballast load to be transported by truck in five loads. The four main assemblies are constructed from thick plates 48 inches by 106 inches welded together circumferentially and two bottom rails that are 2.5 inches thick for attachment to the Atlas railcar's outer pin blocks. The two top assemblies are constructed from thick plates 48 inches by 106 inches also welded at the edges. The top assembly is mechanically attached to the main assemblies. The main and top assemblies are to be carbon steel coated for corrosion protection. The critical characteristics of the ballast load are shown in Table B-2. The minimum condition 1 test load was designed to match weight, mass moments of inertia and cg with the conceptual test load design.

Table B-2: Characteristics of Minimum Condition 1 Test Load

Test Load	Required Weight, lb.	Conceptual Test Load Design Weight, lb.
Ballast Load	200,000	200,000

A sketch of the minimum condition 1 test load is shown in Figure B-1 and Figure B-2. The test load is restrained to the railcar at the outer attachment blocks using inserted pin. The minimum condition 1 test load is shown on the railcar in Figure B-3.

Figure B-1: Minimum Condition 1 Ballast Load

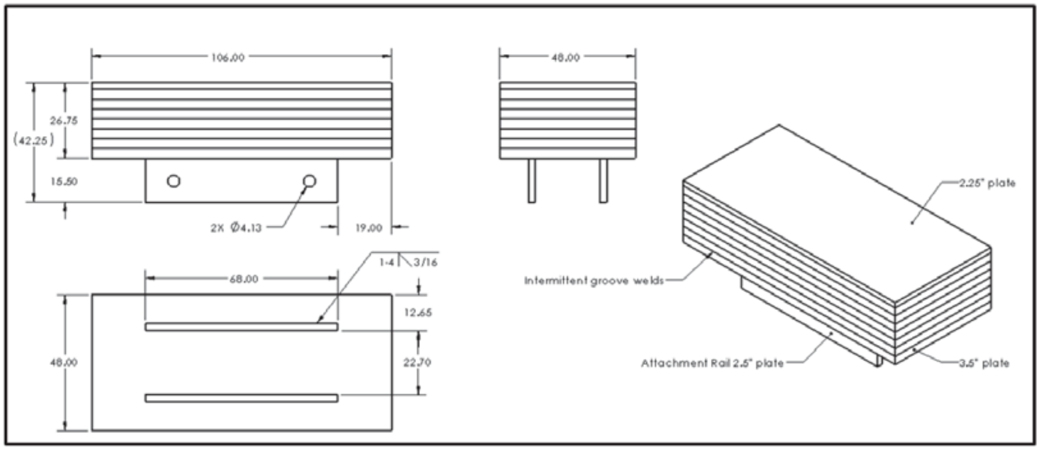


Figure B-2: Minimum Condition 1 Ballast Load Top

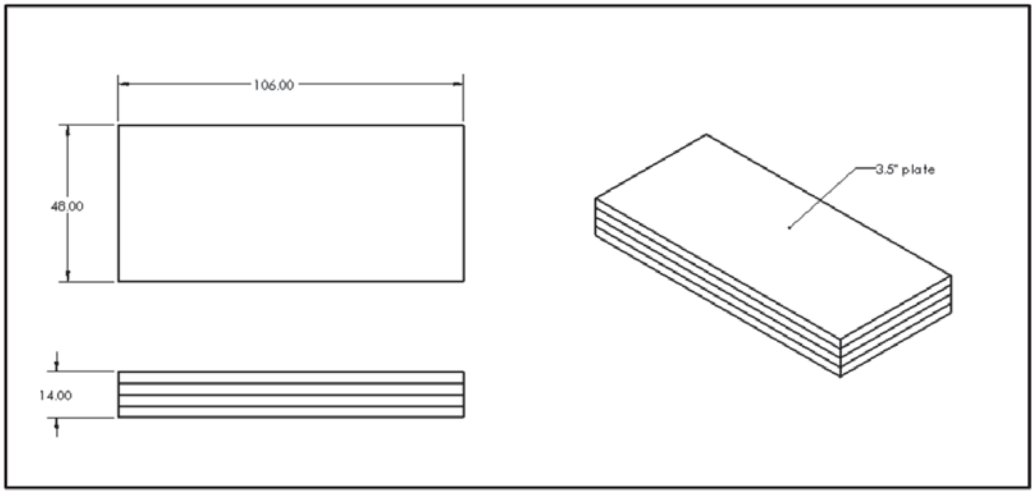


Figure B-3: Minimum Condition 1 Ballast Load on Railcar