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	PIIN/SIIN W56HZV-13-C-0056	MOD/AMD P00001

Name of Offeror or Contractor: LOC PERFORMANCE PRODUCTS, INC.

SECTION A - SUPPLEMENTAL INFORMATION

Buyer Name: RORY THELEN
 Buyer Office Symbol/Telephone Number: CCTA-ASG-B/(586)282-9753
 Type of Contract: Cost Plus Fixed Fee
 Kind of Contract: Research and Development Contracts
 Type of Business: Other Small Business Performing in U.S.
 Surveillance Criticality Designator: C
 Weapon System: No Identified Army Weapons Systems
 Contract Expiration Date: 2015JUL24

*** End of Narrative A0000 ***

Modification P00001

PREVIOUS NEGOTIATED AGREEMENT VALUE:	\$999,890.13
NEGOTIATED VALUE OF THIS ACTION:	-\$59.80
TOTAL NEGOTIATED AGREEMENT VALUE:	\$999,830.33
PREVIOUS OBLIGATED AMOUNT:	\$757,213.00
OBLIGATED AMOUNT THIS ACTION:	\$0.00
TOTAL OBLIGATED AGREEMENT AMOUNT:	\$757,213.00*

*The obligated funding for the first year of this phase II SBIR remains unchanged at \$757,213.00. The funding for year two shall be decreased by \$59.80 from \$242,677.13 to \$242,617.33 at the time of year two funding obligation.

1. This is a bilateral Modification. No further funds will be obligated as a result of this Modification P00001.
2. The purposes of this Modification P00001 are to:
 - i. Change all references to "G1 modified gear(s)" within the Statement of Work to "G1 and G2 gear set(s)."
 - ii. Update the language in section C.3.2.2.2 in the Statement of Work to discuss the new, fully rotational, unidirectional and bidirectional testing of gears.
 - iii. Update Est. Cost, Fixed Fee and Total Amount in CLIN 0001 to \$930,074.73, \$69,755.60, and \$999,830.33 respectively.
 - iv. Update the Est. Cost, Fixed Fee, and Total Amount in section B.1.1 to \$930,074.73, \$69,755.60, and \$999,830.33 respectively.
 - v. Update year two funding in section B.2.2, Funding Schedule, to \$242,617.33.
 - vi. Update the Total in section B.2.2, Funding Schedule, to \$999,830.33.
3. As a result of this Modification P00001, the following changes are hereby made to the contract:

SECTION DESCRIPTION

- B Decrease the Est. Cost in CLIN 0001 by \$55.62 from \$930,130.35 to \$930,074.73.
- B Decrease the Fixed Fee in CLIN 0001 by \$4.18 from \$69,759.78 to \$69,755.60.
- B Decrease the Total Amount in CLIN 0001 by \$59.80 from \$999,890.13 to \$999,830.33.
- B Update the Est. Cost, Fixed Fee, and Total Amount in section B.1.1 to \$930,074.73, \$69,755.60, and \$999,830.33 respectively.
- B Update year two funding in section B.2.2, Funding Schedule, to \$242,617.33.
- B Update the Total in section B.2.2, Funding Schedule, to \$930,830.33.
- C Change all references to "G1 modified gear(s)" within the Statement of Work to read "G1 and G2 gear set(s)."
- C Update the language in section C.3.2.2.2 in the Statement of Work to discuss the new fully rotational, unidirectional and bidirectional testing of gears.

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4. As a result of the Modification P00001, the total Est. Cost is decreased by \$55.62 from \$930,130.35 to \$930,074.73.
5. As a result of Modification P00001, the total fixed fee is decreased by \$4.18 from \$69,759.78 to \$69,755.60.
6. As a result of Modification P00001, the total negotiated value is decreased by \$59.80 from \$999,890.13 to \$999,830.33.
7. As a result of Modification P00001, the total obligated value for year one remains unchanged at \$757,213.00.
8. Except as specifically provided in this Modification P00001, all other terms and conditions remain unchanged.

*** END OF NARRATIVE A0001 ***

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ITEM NO	SUPPLIES/SERVICES	QUANTITY	UNIT	UNIT PRICE	AMOUNT									
0001	SECTION B - SUPPLIES OR SERVICES AND PRICES/COSTS 12.2 PHASE II SBIR The contractor shall furnish all the supplies and services to accomplish the tasks specified in Section C- Description/Specification/Work Statement Est. Cost: \$930,074.73 Fixed Fee: \$69,755.60 Total Amount: \$999,830.33 (End of narrative B001)													
0001AA	<u>SERVICES LINE ITEM:</u> GENERIC NAME DESCRIPTION: 12.2 PHASE II SBIR CLIN CONTRACT TYPE: Cost Plus Fixed Fee PRON: R322C225R3 PRON AMD: 01 ACRN: AA AMS CD: 665502M40 <u>Inspection and Acceptance</u> INSPECTION: Destination ACCEPTANCE: Destination <u>Deliveries or Performance</u> <table border="0" style="width: 100%;"> <tr> <td style="width: 30%;">DLVR SCH</td> <td style="width: 30%;"></td> <td style="width: 30%;">PERF COMPL</td> </tr> <tr> <td><u>REL CD</u></td> <td><u>QUANTITY</u></td> <td><u>DATE</u></td> </tr> <tr> <td>001</td> <td>1</td> <td>24-JUL-2014 (E)</td> </tr> </table> <p style="text-align: center;">\$ 757,213.00</p> (E) = Estimated	DLVR SCH		PERF COMPL	<u>REL CD</u>	<u>QUANTITY</u>	<u>DATE</u>	001	1	24-JUL-2014 (E)	1	LO		\$ 757,213.00
DLVR SCH		PERF COMPL												
<u>REL CD</u>	<u>QUANTITY</u>	<u>DATE</u>												
001	1	24-JUL-2014 (E)												
0002	<u>DATA ITEM</u>													
A001	<u>DATA ITEM: CDRL (DD FORM 1423) EXHIBIT A</u> GENERIC NAME DESCRIPTION: CDRL (DD FORM 1423) EXHIBIT A <u>Inspection and Acceptance</u> INSPECTION: Destination ACCEPTANCE: Destination	1	LO		\$ ** NSP **									

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Name of Offeror or Contractor: LOC PERFORMANCE PRODUCTS, INC.

ITEM NO	SUPPLIES/SERVICES	QUANTITY	UNIT	UNIT PRICE	AMOUNT
A002	<p><u>DATA ITEM: CONTRACTOR MANPOWER REPORTING</u></p> <p>GENERIC NAME DESCRIPTION: CONTRACTOR MANPOWER REPORTING</p> <p><u>Inspection and Acceptance</u> INSPECTION: Destination ACCEPTANCE: Destination</p>	1	LO		\$ _____ ** NSP **

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B.1 ESTIMATED COST & PAYMENT

B.1.1 The estimated cost for performance of the work required under this contract is stated in Section B under CLIN 0001, which shall constitute the estimated cost for the purpose of the Contract Clause entitled LIMITATION OF FUNDS, FAR 52.232-22.

Est. Cost: \$930,074.73*
 Fixed Fee: \$ 69,755.60*
 Total Amount: \$999,830.33*

B.1.2 The contractor will be paid for the fixed fee stated in Section B under CLIN 0001 for the performance of work under the contract and in accordance with the terms of the Contract Clause entitled FIXED FEE, FAR 52.216-8. The fixed fee together with the reimbursement of cost shall constitute full and complete consideration for the contractor's service in connection with the work required and performed under this contract.

B.1.3 Allowable cost shall be determined, and payment thereof shall be provided, in accordance with the Contract Clause entitled ALLOWABLE COST AND PAYMENT, FAR 52.216-7.

B.1.4 The contractor may submit public vouchers for payment under this contract in accordance with the Contract Clause hereof entitled ALLOWABLE COST AND PAYMENT, FAR 52.216-7.

B.1.5 The fee will be payable at the time of reimbursement of cost in the same proportion to such cost as the total fee of this contract bears to the total estimated cost thereof, subject to any withholding pursuant to provisions of this contract.

B.2 FUNDING

B.2.1. The Government will provide funds under this contract covering the estimated cost and fee on an incremental basis, as provided for in the funding schedule below and pursuant to the following Contract Clauses:

- LIMITATION OF FUNDS, FAR 52.232-22
- LIMITATION OF GOVERNMENT'S OBLIGATION, DFARS 252.232-7007

It is estimated that the incremental amounts are sufficient for the performance of work in each of the cited periods. The Government may, at its discretion, allot such funds on an incremental basis within each fiscal year. The contractor shall so plan and execute the work required by this contract as to expend and commit funds compatible with the schedule set forth below. Whenever the contractor has reason to believe that the funds allotted to this contract for any fiscal year are either insufficient or excessive for the performance of work required in that fiscal year, the Government shall be so notified.

B.2.2 Funding Schedule:

<u>Performance Period</u>	<u>Amount</u>
Date of contract award through twelve (12) months after date of contract award	\$757,213.00
Twelve (12) months and one (1) day after date of contract award through completion	<u>\$242,617.33*</u>
Total	\$999,830.33*

B.3 Funds Allotted: The amount of funds currently allotted to this contract is \$757,213.00.

* Changed with Modification P00001.

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SECTION C - DESCRIPTION/SPECIFICATIONS/WORK STATEMENT

Loc Performance Phase II Scope of Work
(Bradley Modernization Final Drive)

C.1 Scope

The contractor, acting as an independent contractor and not as an agent of the Government, shall develop a common Final Drive Solution that meets the long term needs for both the Bradley and Paladin platforms by enabling future platform weight and horsepower growth. This SBIR effort will allow the contractor to test and quantify new gear train technology that is not currently matured for combat tracked vehicle final drive units. The contractor shall mature its Quick Disconnect technology by testing its Phase I Quick Disconnect Design (QDD) to validate the extent of compatibility with the high power density final drive (HPDFD) for both Bradley A3 weighing 70,000 pounds and Bradley Modernization program (BMP) with loading conditions defined by the contractor in Phase I Option period for contract W56HZV-11-C-0313 In addition, the contractor shall evaluate new gear technologies for HPDFD which include: (i) new high strength gear material (Ferrium C61), and (ii) application processes to gears with either Superfinishing or Diamond-Like Coating (DLC) or both.

C.2 Background

The overall objective of this program is to develop and demonstrate a high power density common final drive solution that meets the needs for both the Bradley and Paladin platforms. The long-term modernization power needs of the U. S. military shall be addressed by the development of the high power density final drive to enable future platform and horsepower growth.

At the conclusion of this Phase II contract, the contractor shall provide the Army with a single vehicle set of Bradley Modernization Final Drives that are ready for extensive vehicle-level testing such as braking, maximum tractive effort, pivot steering, towing, acceleration, top speed, and rough terrain. The contractor shall mature the SBIR gear train technology sufficiently to enable insertion onto all ground vehicle platforms where custom geared applications warrant a higher power density final drive and the contractors unique Quick Disconnect Design. Some vehicle platform applications may not need both but only require an individual HPDFD or QDD approach.

C.3 Tasks

C.3.1 Utilization of Phase I Prototype

C.3.1.1 Testing requirement for QDD prototype developed in the predecessor Phase I SBIR contract:

The contractor shall perform physical (load) testing on the QDD components for a Bradley A3 weighing 70,000 pounds (sections C.3.1.3 through C.3.1.3.2) and then update the design of the QDD (section C.3.7.1) for Bradley Modernization Final Drive (BMFD) platforms weighing 90,000 pounds.

C.3.1.1.1 Engineering and component refinement of the Phase I QDD for Bradley A3:

The contractor shall refine the QDD, developed under the Phase I SBIR contract, to meet the following requirements of 5600 lb-ft for Bradley A3. Designs shall be modified using contractors software (Pro Engineering) to update the component and assembly level drawings.

C.3.1.2 Upgrade of QDD installed in Bradley A3 Final Drive for Load Testing:

C.3.1.2.1 The contractor shall disassemble and inspect the QDD to assess (i) whether current QDD components are properly sized; and (ii) whether current material properties, including processing characteristics, are adequate for passing torque load test of 5600 lb-ft for Bradley A3 platforms weighing 70,000 pounds. The contractor shall provide design changes, calculations, processing, schematics, and rationale for any changes in a report titled: QDD Design & Calculations, Test Results of Phase I SBIR Option, Report No.1 per (CDRL A003) of QDD components which may need to be replaced due to Bradley A3 vehicle weight class and torque loadings. Torque loading was defined during the option period of the predecessor Phase I SBIR contract. Report No. 1 shall include torque loading requirements and will be reviewed for approval by the COR. The contractor shall integrate one (1) up graded QDD prototype into the final drive for load testing. A second final drive is required in the test stand set-up and shall also be provided by the contractor. All work shall be performed at the contractors facility.

C.3.1.3 Perform load test on Upgraded QDD Designed for Bradley A3 Final Drive.

C.3.1.3.1 The contractor shall perform physical load testing using their calibrated dynamometer on the upgraded QDD. A draft test plan titled: QDD Test Plan for Load Test, Test Plan No.1 (IAW A002) shall be submitted no later than 30 calendar days before the test event by the contractor to the COR for review and approval prior to dynamometer tests. The COR shall review the test plan within 10 calendar days and return it to the contractor with comments or approval. The contractor shall then review and incorporate any COR comments and submit a final version of Test Plan No. 1 no later than 10 calendar days before the test event. The contractor shall also design and build fixtures to support the dynamometer test stand for mounting the QDD to a contractor-provided Bradley A3 final drive. The Bradley A3 final drive shall be oriented in such a way as to replicate its position on an actual vehicle. As part of Test Plan No. 1, the contractor shall develop different engineering methods, subject to COR review and approval, for inducing and controlling torque to the dynamometer test stand. In Test Plan No.1, the contractor shall also provide an analysis of the different methods used for inducing and

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controlling torque to the dynamometer. The contractor shall also develop a test cycle with variable torque and rotational speed levels in revolutions per minute (RPM). The torque and rotational speed levels shall be representative of a Bradley A3 weighing 70,000 pounds and shall be included in Test Plan No.1.

C.3.1.3.2 The contractor shall conduct a physical load test on the QDD which shall demonstrate the QDD being disengaged by applying variable input speeds and torque to the QDD in order to verify disengagement. This physical load test shall be completed at a minimum of six (6) times (3 times in engaged mode and 3 times in disengaged mode) to verify performance of the QDD in both disengaged and engaged modes. Following disengaged-mode QDD tests, the QDD shall then be re-engaged so that engaged-mode tests can be conducted. During engaged-mode tests, the same variable input speed and torque shall again be applied, as were used in disengaged-mode tests, to confirm that the QDD performs under load conditions as would be representative of an actual Bradley A3 platform under field conditions at a specified 70,000 pound vehicle weight. The total physical load test time of the QDD in both engaged and disengaged modes shall not exceed 40 hours for testing of both modes. The contractor shall conduct testing in equal time periods for each mode (20 hours engaged mode and 20 hours in disengaged mode) unless a design issue occurs in one specific mode. The contractor shall develop a corrective action, subject to COR review and approval, for any design issue identified during the tests and verify efficacy of the corrective action through re-testing.

C.3.2 Testing of Ferrium C61 components to compare to results against those obtained in the predecessor Phase I SBIR contract.

C.3.2.1 The contractor shall perform physical (bending fatigue) testing on gears made of Ferrium C61 and compare the results of these tests against tests of standard production final drive gears made of baseline material that is used on Bradley Final Drives. Evaluation of Ferrium C61 in the Phase I SBIR effort utilized ISO 6336 standards and material properties of Ferrium C61 (no physical testing was conducted) to predict Ferrium C61's lifetime performance improvement over the baseline Bradley Final Drive gear material. Analysis predictions during the Phase I SBIR effort indicated that Ferrium C61 would last 2 to 3 times longer than current Bradley baseline gear material. Performance of physical bending fatigue testing shall confirm or disconfirm those predictions.

C.3.2.2 Bending Fatigue Test Plan for Ferrium C61 Gear and comparison tests with Bradley Baseline Gear Material:

C.3.2.2.1 The contractor shall develop draft and final test plans titled: Ferrium C61Bradley Baseline Gears Bending Fatigue Test Plan, Test Plan No.2 (CDRL A002) for performing physical (bending fatigue) laboratory tests on: (i) Ferrium C61, and (ii) Bradley baseline gear material to determine if analysis predictions for torque capacity and reliability from the Phase I SBIR contract are accurate. The draft of Test Plan No. 2 shall be submitted to the COR no later than 30 days before the test event. The COR will then review the test plan and return it to the contractor no later than 10 calendar days after receipt with comments or concurrence. The contractor shall review and incorporate the CORs comments and submit a final Test Plan No. 2 no later than 10 calendar days before the test event.

(a) The test plan shall include (i) G1 and G2 baseline gear sets (One G1 and one G2 gear per set); and (ii) Ferrium C61 G1 and G2 gear sets (one Ferrium C61 G1 gear and one Ferrium C61 G2 gear per set).

(b) Eight (8) Ferrium C61 Gland G2 gear sets and eight (8) Bradley baseline material G1 and G2 gear sets shall be of identical geometry so that the only differences between the test groups are: (i) the material properties and, (ii) the resultant unique processing methods required for each gear type.

(c) The contractor shall (i) control the surface finish properties so that the test samples are consistent in surface quality; and (ii) ensure that performance differences are due to the material property differences and not other factors.

C.3.2.2.2 Per Ferrium C61Bradley Baseline Gears Bending Fatigue Test Plan No. 2, found in section C.3.2.2.1, the contractor shall perform low cycle fatigue testing of (i) Bradley baseline material input gear sets and (ii) Ferrium C61 input gear sets. A low cycle fatigue test for the Bradley Final Drive is based on a final drive service life of an average of 10,000 cycles. The contractor shall utilize a test stand whereby the input gears are mounted to a hydraulically actuated loading device. A load shall be cyclically applied to the input gears to induce unidirectional or bidirectional loading at a selected frequency. The two input gear sets (baseline material set and Ferrium C61 set) shall be cyclically loaded under a fixed frequency and load profile until bending failure occurs on the gear teeth or until the test run reaches 10,000 cycles, whichever comes first. The contractor shall conduct a minimum 48 tests of both the baseline input gear sets (24 tests) and the Ferrium input gear sets (24 tests) under four (4) different loading points to be determined by contractor and specified in Test Plan No. 2. For each control group (Bradley baseline material input gear sets and Ferrium C61 material input gear sets), the contractor shall perform a minimum 24 tests in low cycle fatigue range and will induce gear set failures to occur in approximately 6 hours. Test Plan No. 2 shall specify the minimum number of Bradley baseline material input gears and Ferrium C61 input gears to be tested.

C.3.2.3 Perform Bending Fatigue Testing on baseline and C61 components:

C.3.2.3.1 The contractor shall perform the bending cycle fatigue testing in-house for each of the Bradley baseline gears and Ferrium C61 gears under cycle and load conditions described in paragraph C.3.2.2.1, Test Plan No.2. Test data shall be collected and test results shall be presented in a report titled: Ferrium Gears versus Baseline Gears, Stress versus Cycle Failure, Test Results: Report No. 2 (CDRL A003). The test results shall allow the contractor to obtain a statistical understanding and perform a statistical analysis of each material to be used in constructing a bending stress versus life plot (S-N curves of the baseline material and the Ferrium C61 material used).

Name of Offeror or Contractor: LOC PERFORMANCE PRODUCTS, INC.**C.3.2.4 Quantify Improvements Over Baseline Material:**

C.3.2.4.1 The contractor shall quantify any improvements of Ferrium C61 gears over baseline material gears. These findings shall be reported in Report No.2 specified in paragraph C.3.2.4.1 above.

C.3.3 Comparison of Baseline and C61 gears with Superfinishing.

C.3.3.1 The contractor shall submit a draft test plan, titled: Superfinish Performance Test Plan on Baseline and Ferrium C61 Gears: Test Plan No. 3 to the COR no later than 30 calendar days prior to the test event. The COR shall review the test plan and provide feedback no later than 10 calendar days after receipt of draft test plan. The contractor shall review and incorporate the CORs comments and submit a final test plan no later than 10 calendar days before the test event.

(a) Test Plan No. 3 shall detail, (i) bending fatigue testing on G1 and G2 gear sets (as performed in C.3.2.4.1 on Ferrium C61 gear material and Bradley baseline material in matched G1 and G2 gear sets) and (ii) surface contact fatigue and efficiency testing on a four square dynamometer with G1, G2, G3 and G4 matched gear sets utilizing baseline material and Superfinishing added to the gear teeth.

(b) For surface contact fatigue and efficiency tests, the contractor shall detail specific test methods and procedures to be run on assembled Bradley final drive units.

(c) The laboratory tests on Superfinished gears shall help to assess the gears performance improvements for torque capacity and reliability over baseline material gears.

(d) Test Plan No. 3 shall include tests on baseline gear sets along with Superfinished gear sets.

C.3.3.2 Manufacture gear prototypes and apply Superfinishing:

C.3.3.2.1 The contractor shall manufacture the following gear prototypes and apply Superfinishing in preparation for bending fatigue testing.

C.3.3.2.1.1 Eight (8) baseline G1 gears and four (4) baseline G2 gears.

C.3.3.2.1.1.1 Eight (8) Ferrium C61 G1 gears and four (4) Ferrium C61 G2 gears.

C.3.3.2.2 The contractor shall build or supply four (4) Bradley final drive assemblies. The final drive units consist of G1, G2, G3 and G4 gears which are included in the final drive assembly. Four (4) baseline material G1 gears, four (4) baseline material G2 gears, four (4) baseline material G3 gears and four (4) baseline material G4 gears with Superfinishing applied shall be used for comparison against standard baseline material gears without Superfinishing which are normally installed in Bradley final drive assemblies. The other four (4) baseline material G1 gears, four (4) baseline material G2 gears, four (4) baseline material G3 gears and four (4) baseline material G4 gears shall be used in later contact fatigue testing and efficiency testing with DLC applied on top of the Superfinishing.

C.3.3.3 Perform Bending Fatigue Tests on components with Superfinishing:

C.3.3.3.1 The contractor shall perform bending fatigue tests on Superfinished gear sets made of baseline gear material and gear sets made of Ferrium C61 material as described in Test Plan No. 3 per paragraph C.3.3.1. A minimum of 24 bending fatigue test runs shall be conducted for each of the two gear sets. Gear set number one shall contain one (1) baseline material G1 gear and one baseline G2 gear, and gear set number two shall contain one (1) Ferrium C61 G1 gear and one Ferrium C61 G2 gear. The low cycle bending fatigue testing shall be similar to the low cycle bending fatigue testing conducted in paragraph C.3.2.2.1.

C.3.3.4 Perform Surface Contact Fatigue and Efficiency Testing on Final Drives:

C.3.3.4.1 The contractor shall perform a total of four (4) test runs on two final drive assemblies (set 1 and set 2) as described in paragraph C.3.3.2.2. (Note: for preparation of surface contact fatigue testing and efficiency testing there is no gear modification required as there was for bending fatigue testing.) The surface contact fatigue testing and efficiency testing shall be performed with two (2) fully assembled final drive units (a left and right final drive makes one final drive assembly). Initial testing shall contain baseline material gears that shall be run under two high loading condition test points (specified in Test Plan No. 3) to establish an approximate life span of baseline material gears. After the tests with the baseline material gears, the contractor shall tear down the drives and rebuild them with a fresh set of Superfinished baseline material G1, G2, G3, and G4 gears. The contractor shall then conduct four (4) test runs consisting of two (2) test runs with baseline gears in final drive units and the other two (2) test runs shall be conducted with a final drive built up with baseline Superfinished gear sets. Performance testing on baseline material Superfinished gear sets shall be run at the same loading conditions as baseline gears in order to assess any improved performance for surface contact fatigue. The contractor shall record efficiency performance by recording actual torque values and calculating the power losses with the four (4) square power loop. All data, which includes the torque levels, torque losses, speed, temperatures and vibration levels, shall be collected and used to perform statistical analysis described in section C.3.3.5 below. At completion of testing, the contractor shall refurbish the final drive assemblies. The contractor shall also develop a method in accordance with AGMA 912 to determine the onset of

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surface fatigue failure in each test run.

C.3.3.5 Quantify Improvements of Superfinished gears:

C.3.3.5.1 With the bending fatigue test data from C.3.3.3.1 and contact fatigue data from C.3.3.4.1, the contractor shall compile test results in a report titled: Superfinished Gear Improvements, a Statistical Analysis of Test Results: Report No. 3 (CDRL A003). The statistical analysis data shall be used to construct bending stress versus life plots (S-N curves) of Superfinished gears made from both baseline material and Ferrium C61. The contractor shall also plot improvements in surface contact fatigue life and efficiency improvements afforded by Superfinishing. These curves shall be used to reassess predicted performance from the predecessor Phase I SBIR contract, which included no physical tests, of the Superfinishing process.

C.3.4 Utilization of Diamond-Like Coating (DLC) Technology:

C.3.4.1 The contractor shall apply, and physically test the performance of, DLC to gears that have already been treated with the Superfinishing described in paragraph C.3.3.2.2 which lists the number of gear prototypes with Superfinishing applied. Four (4) each of G1, G2, G3 and G4 shall be used to apply the DLC over the Superfinishing.

C.3.5 Diamond-Like Coating Performance Test Plan.

C.3.5.1 The contractor shall create a draft test plan titled: Diamond-Like Coating Performance Test Plan: Test Plan No.4 (IAW A002). The contractor shall submit the draft Test Plan No. 4 to the COR no later than 30 calendar days before the test event. The COR will review the draft and return it with any comments no later than 10 days after receipt of the draft test plan. The contractor shall review and incorporate any COR comments, and deliver a final Test Plan No. 4 no later than 10 calendar days before the test event. Test Plan No. 4 shall detail the test methods and procedures for performing laboratory tests on DLC gears to assess any performance improvements with regard to torque capacity and reliability over the contractors current baseline material gears and Superfinished gears. The contractor shall use a four-square dynamometer which is designed to test Bradley left and right final drives together for performing the surface contact fatigue tests as well as efficiency testing. The lab tests shall be performed with two (2) fully assembled final drive units, 4 final drives assemblies total (a left and right final drive make one (1) final drive assembly). Each final drive assembly (left and right) shall contain gear sets which include Baseline gears, Superfinished gears, and DLC gears. The two (2) final drive units used in C.3.3.4 which were used to test Superfinished gears shall be torn down and re-furbished with new and unused gears made of baseline material which have Superfinishing and DLC applied.

C.3.5.1.2 Utilize gear prototypes (four (4) each of baseline material G1, G2, G3 and G4 gears with Superfinishing and DLC) manufactured in C.3.3.2.2.

(Note: These 4 G1, G2, G3, and G4 gears as well as the 4 G1, G2, G3 and G4 gears manufactured in C.3.3.2.2 with Superfinishing for surface contact fatigue and efficiency and efficiency testing on the final drive (C.3.3.4.1) equal the 8 prototypes G1, G2 G3 and G4 Baseline gears which were Superfinished in paragraph C.3.3.2.2).

C.3.5.1.3 Perform Surface Contact fatigue and Efficiency Testing on the DLC gears:

The contractor shall perform a total of two (2) test runs on two (2) final drive assemblies. Test methods and procedures shall conform to the same speed and torque levels as previously run for Superfinished gears evaluated in C.3.2.2.1. All data, which includes the torque levels, torque losses, speed, temperatures, and vibration levels, shall be collected and used to perform statistical analysis described in section C 3.5.2.1 below. The contractor shall also develop a method in accordance with AGMA 912 to determine the onset of surface contact fatigue failure in each test run.

C.3.5.2 Quality Improvements of DLC gears and other items evaluated:

C.3.5.2.1 With the surface contact fatigue data and efficiency data, the contractor shall compile test results in a report titled: Diamond-Like Coating (DLC) Gear Improvement, a Statistical Analysis of Test Results: Report No. 4 (CDRL A003). This report shall also plot any improvements in surface contact fatigue life and efficiency improvements afforded by DLC and shall also be used to reassess predicted performance of the DLC process from the predecessor Phase I SBIR contract, which included no physical tests. This report shall be submitted no later than 30 days after test completion for review and approval by the COR.

C.3.6 Design Bradley Modernization Final Drive (BMFD):

C.3.6.1 Using all test results gathered from lab test results of Ferrium C61 gear material, Superfinished gears, gears with DLC, and QDD, together with the material and process characterization, the contractor shall formulate and characterize the Best Technical Approach (BTA) through a report titled: Analysis of Test Findings of Material and Processes and Combinations Including QDD Test Results: Report No.5 (CDRL A003) for the final-drive gear design. Report No. 5 shall encompass cost and performance trade-offs for an overall comparative ranking based on parameter weightings of up to the best three gear designs which include baseline gear material, Ferrium C61 gear material, Ferrium C61 or baseline material gears with Superfinishing, DLC, or both. For each gear design combination being ranked, the one (1) gear design selected as best must provide a balance between reliability, efficiency and product life cycle costs. The contractor shall determine balance in a manner similar to that which the contractor used in the Phase I SBIR effort to arrive at its

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recommendation to pursue the 24,000 mile life solution which provided the best reliability at a comparable life cycle cost to the competing alternatives. The COR will review and approve the BTA ranking process and the overall gear design combination processes selected, including selection of QDD, within two weeks of receipt.

C.3.7 Update Design of the QDD for BMFD:

C.3.7.1 The contractor shall prepare the QDD for insertion of QDD into the BMFD based on findings from C.3.1 through C.3.1.3 which designed and load tested the QDD mechanism for insertion into the baseline Bradley A3 final drive configuration. Lessons learned from testing in C.3.1.3.1 shall be applied in this task to detail engineer the QDD. The detail engineering of the QDD for BMFD shall include: (i) functional details of QDD description and operation, and (ii) physical teardown and logistic demonstration of QDD with invitation extended to the COR and PM-ABCTPM Engineering (POC Steve Weisenhaus) support team to witness this event at the contractors facility.

C.3.8 Manufacturer and Acceptance Test of BMFD:

C.3.8.1 The contractor shall manufacture two (2) final drive assemblies. Each final drive consists of: two (2) baseline material PIM G1 gears with Superfinishing and DLC, two (2) baseline material PIM G2 gears with Superfinishing and DLC, two (2) Ferrium C61 G3 gears with Superfinishing and DLC, and two (2) baseline material PIM G4 gears with Superfinishing and DLC. These gears, two sets of G1, G2, G3 and G4 gears shall be based on the optimal gear train based on BTA established in C.3.6.1 These items shall be installed into BMFD if substantiated by lab test results and approved by the COR. It is also assumed that QDD will be selected as a BTA item in C.3.6.1 and the detail engineering of QDD design for BMFD established in C.3.7.1. The contractor shall provide two PIM final drives which shall be torn down and re-assembled with components established in C.3.6.1 based on BTA findings and the QDD established in C.3.6.2. This shall produce the two (2) manufactured BMFD final drive assemblies for acceptance testing.

C.3.8.2 Develop Test Plan and Perform Acceptance Testing of the Bradley Modernization Final Drive (BMFD):

C.3.8.2.1 The contractor shall develop an acceptance test plan Titled: Bradley Final Drive Acceptance Test Plan: Test Plan No. 5 (CDRL A002) which shall be based on a previously developed acceptance test plan for the M1 Abrams final drive. The contractor shall provide the speeds and load conditions. The contractor shall submit the draft Test Plan No. 5 no later than 30 days before the test event. The COR will review and return the draft test plan with comments or concurrence no later than 10 calendar days after receiving the draft Test Plan No. 5. The contractor shall then review and incorporate any COR comments, and submit a final Test Plan No. 5 to the COR no later than 10 calendar days before the test event.

C.3.8.2.1.1 The proposed acceptance testing in Test Plan No. 5 shall include the following tests:

- (i) free spin performance test,
- (ii) dynamometer testing on the contractors four (4) square test stand,
- (iii) cold testing, and
- (iv) water submergence testing.

The contractor shall detail all operating conditions, measurements points, time periods and other conditions within Test Plan No. 5 for the four above-mentioned tests. In addition, the free spin performance test shall require that the drives be spun through their full range of operating speeds while monitoring free spin torque. The dynamometer test shall be limited to 50 hours to ensure that maximum service life remains for future BMFD demonstrations and testing. Cold soaking of each drive to -60 degrees Fahrenheit shall be performed and input connection shall be turned a minimum of one revolution in both directions (forward and reverse) before returning to room temperature prior to performance testing and inspecting for fluid leaks. During the submergence testing, the final drive shall be supported so that all parts are under water and air pressure of 5 psig (pounds per square inch gauge) is applied to verify that no air leaks come through the seals and gaskets of the final drive.

C.3.9 Draft and Final Technical Report

C.3.9.1 The contractor shall submit a draft Technical Report to the COR no later than 30 days before the end date of the contract (IAW A004). The Technical Report shall explain the contractors findings regarding how well the predecessor Phase I SBIR effort predicted the performance of Ferrium C61 gear material, Superfinishing, and the QDD when compared to the physical lab tests conducted in this Phase II SBIR effort. The COR shall review and approve or identify required changes within 10 calendar days of receiving the draft Technical Report.

C.3.9.2 The contractor shall submit a final Technical Report (IAW A005) to the COR no later than 15 calendar days after receipt of the CORs approval or corrections on the draft Technical Report.

C.4 Reporting**C.4.1 Project Planning:**

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C.4.1.1 The project planning for this effort is based on the contractors Phase II proposal submitted 23 July 2012 which is, in turn, based on test results obtained from the predecessor Phase I effort to include the Phase I Option effort.

C.4.1.2 Laboratory Test Plan:

C.4.1.2.1 The contractor shall develop a draft laboratory test plan titled: Laboratory Test Plan No. 1 per CDRL A002 for performing the proposed laboratory tests and subsequent analyses of Phase II technologies. The draft shall be submitted to the COR 30 calendar days prior to the commencement of laboratory tests. The COR will return the test plan back to the contractor within 10 days of receipt with any comments or corrections. The contractor shall review and incorporate any COR comments, and then submit a Laboratory Test Plan No. 1 no later than 10 calendar days prior to the first laboratory test event. Laboratory Test Plan No. 1 shall be developed by the contractor and approved by the COR to accurately quantify the performance characteristics of Ferrium C61 material, gears with Superfinishing and DLC for improving load carrying capability and improving efficiency of tracked vehicle geared systems. The test plan shall incorporate considerations for statistical confidence of the data produced and resultant usefulness for predicting gear life based on follow-on gear product design efforts utilizing the SBIR technology. Other considerations that shall be accounted for are available funding for performing the test, design of experiments, test repeatability, test inputs and test control methods.

C.4.1.3 Program Management Report.

C.4.1.3.1 The contractor shall include a detailed Program Management Report (IAW A008) for planning and risk management so that the contractor can ensure successful management of the Phase II cost and schedule performance. At the conclusion of this task, the contractor shall have a detailed schedule in Microsoft Project and an associated spending profile plan by month for the entire Phase II project. The contractor shall report against this cost and schedule plan on a monthly basis throughout Phase II execution.

C.4.1.4. Monthly Reports.

C.4.1.4.1. The contractor shall submit monthly Progress Reports to the COR (IAW A001). Any draft or final test plans or any of the five, above-mentioned reports may be delivered with the monthly Progress Reports if the schedule allows it.

C.4.5.4 Research and Development (R&D) Project Summary.

C.4.1.5.1 The contractor shall submit a draft and final publicly releasable SBIR Phase II R&D Project Summary (IAW A007). The summary is an unclassified, non-sensitive, and non-proprietary summation of results that is intended for public viewing on the Army SBIR/STTR Small Business Portal. It should address the Data Item requirements on a summary basis and must not exceed 700 words. The draft shall be submitted at least 30 days prior to the contract completion date; the COR shall have ten days after receipt to provide comments or concurrence. The contractor shall incorporate any COR comments and submit the final SBIR Phase II R&D Project Summary not later than the contract completion date.

C.5 Deliverables:

C.5.1 QDD Design & Calculations, Report No. 1 per C.3.1.2.1 (CDRL A003).

C.5.2 QDD Test Plan for Load Test, Test Plan No.1 per C.3.1.3.1 (CDRL A002).

C.5.3 Ferrium C61 Bradley Baseline Gears Bending Fatigue Test Plan, Test Plan No. 2, per C.3.2.2.1 (CDRL A002).

C.5.4 Superfinish Performance Test Plan on Baseline and Ferrium C61 Gears, Test Plan No. 3, per C.3.3.1 (CDRL A002).

C.5.5 Superfinished Gear Improvements, a Statistical Analysis of Test Results, Report No. 3, per C.3.3.5.1 (CDRL A003).

C.5.6 Diamond-Like Coating Performance Test Plan, Test Plan No. 4, per C.3.5.1 (CDRL A002).

C.5.7 Diamond-Like Coating (DLC) Gear Improvement, a Statistical Analysis of Test Results, Report No. 4, per C.3.5.2.1 (CDRL A003).

C.5.8 Draft Technical Report, per C.3.6.1 (CDRL A004).

C.5.9 Final Technical Report, per C.3.6.2 (CDRL A005).

C.5.10 Engineering details and drawings for insertion of QDD per C.3.7.1 (CDRL A009).

C.5.11 Analysis of Test Findings of Material and Processes and Combinations Including QDD Test Results, Report No. 5 per C.3.8.1 (CDRL A003).

C.5.12 Bradley Final Drive Acceptance Test Plan, Test Plan No. 5, per C.3.8.2.1 (CDRL A002).

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C.5.13 Laboratory Test Plan No. 1 per C.4.1.2.1 (CDRL A002).

C.5.14 Program Management Plan per C.4.1.3.1 (CDRL A008).

C.5.15 Monthly Progress Status and Management Reports to the COR per C.4.1.4.1 (CDRL A001).

C.5.16 Draft and Final R&D SBIR Phase II Project Summary per C.4.1.5.1 (CDRL A007).

C.5.17 Final Prototype Assemblies. The contractor shall deliver two (2) final drive assemblies for Bradley Modernization Final Drive (BMFD) Program application. The components and processes for BMFD shall be based on best technical approach (BTA) determination made in C.3.7.1. This determination will decide whether Ferrium C61 gear material, Superfinished gears, gears with DLC, or a combination of the items plus whether the QDD is incorporated into the BMFD design before final prototype assembly. The contractor shall ship the two Phase II BMFD final drive prototypes to the Army upon request (location to be specified by the COR).

C.6 Meetings

C.6.1 Kickoff Meeting: The contractor shall plan a kick-off meeting to last no longer than one day either at TACOM, the contractor's site, or via teleconference no later than 30 days after contract award. The contractor shall coordinate the date, time, and location of this meeting with the COR. At the meeting, the contractor shall explain its intended approach for accomplishing the contract's Statement-of-Work. The contractor shall submit meeting minutes IAW A006.

C.6.2 In Process Reviews: The contractor shall plan and conduct in process reviews at six (6), twelve (12) and eighteen (18) months after contract award. These meetings are not anticipated to exceed one day each in duration unless the parties agree otherwise. The dates, location, personnel in attendance, mode of meeting (via teleconference or on-site), and start times shall be coordinated between the contractor and the COR.

C.7 Government Furnished Equipment/Materials/Property

None

C.8 Contractor Manpower Reporting

C.8.1 The contractor shall report ALL contractor labor hours (including subcontract labor hours) required for performance of services provided under this contract for the Bradley Modernization Final Drive via a secure data collection site. The contractor is required to completely fill in all required data fields using the following web address: <http://www.ecmra.mil/>, and then click on Department of the Army CMRA or the icon of the DoD organization that is receiving or benefitting from the contracted services.

C.8.2 Reporting inputs will be for the labor executed during the period of performance during each Government fiscal year (FY), which runs October 1 through September 30. While inputs may be reported any time during the FY, all data shall be reported no later than October 31 of each calendar year, beginning with 2013. Contractors may direct questions to the help desk by clicking on Send an email which is located under the Help Resources ribbon on the right side of the login page of the applicable Service/Components CMR website.

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