MECHANICAL CHARACTERIZATION FACILITY

The Naval Research Laboratory (NRL), Washington, D.C. has a requirement for a mechanical characterization facility. This facility is expected to provide an integrated materials testing and characterization facility. This facility is comprised of three test systems: 1) a 3000 N linear motor electrodynamic-actuated test system for frequency and temperature dependent materials characterization 2) a 100 kN electromechanical test system for large-displacement, quasi-static materials characterization and 3) a 300 J low velocity impact test system (up to 5 m/s impact velocity) for impact damage characterization of materials. The first two systems must have computer automated data acquisition capabilities. The third system must have computer automated data acquisition capabilities at a minimum. The facility is expected to provide higher test loading frequency capability, larger load and displacement capabilities, and more immediate testing capability than NRL's current facilities. All of the equipment is expected to be all-electric. All offerors are expected to comply with installation, warranty, and documentation requirements as detailed in paragraph 10 below.

The test systems must meet or exceed the following minimum specifications:

1.0 Linear Motor Electrodynamic Materials Test System (CLIN 0001)

NRL has a requirement for a turnkey electrodynamic linear-motor actuated materials test system capable of high-frequency loading. This system will be used for dynamic mechanical analysis and cracking damage characterization of a wide variety of materials. The system must be suitable for research and development of new advanced material systems and must have wide-ranging capabilities for user control over the test conduct (e.g., selection and definition of test system's input control signal). The test system will be placed in a facility with multiple users and must provide ease of operation (suitable for use by multiple individuals with a range of experience in mechanical testing) and safety to those in the facility.

The system must be capable of automated high-frequency material testing (200 Hz or greater) under load, displacement, or strain control via computer software or "manual" input of an analog command signal. The system must be capable of computer automated measurement and recording of the test signals (load, displacement, strain, time, etc.) and "manual" measurement and recording via analog voltage signal outputs. The system must also include an electrical panel for manual control of the system during test-specimen set-up, etc. and basic mechanical grip fixtures for tension-tension loading of material samples over the range of system load, displacement, and frequency capabilities. To ensure operator safety, the test system must also include 1) power/emergency stop switch(s) visible to the operator located at the front of the machine; 2) motor overheat detection to automatically turn off the motor power supply and 3) capability for setting hardware or software limits on load, extension, strain, or any other data channel. The system must include, at a minimum, the following major components:

1) Electromagnetic linear-motor actuator-drive load-frame with load-cell(s) and displacement transducer(s).
2) Measurement and control capabilities, including a test system controller for interfacing to computer and manual control panel.
3) Electronics for both transducer conditioning and analog-to-digital signal conversion for load, position, and one or more additional transducer signals. This will also include data acquisition hardware.
4) Computer hardware and software for automated testing, control, and data acquisition.
5) Control panel for test setup, specimen installation/removal, and test start and stop.
6) Mechanical grips for tension-tension loading of material test specimens.

Each component must meet or exceed the following minimum specifications:

1.1 Load-Frame

The load-frame must be an electromagnetic linear-motor actuated machine with multiple columns for crosshead support. Hydraulic or pneumatic actuation is not acceptable. The load-frame can be a table-top or floor standing model; table-top configurations must provide a table which is capable of supporting the load frame while operating. The load frame must meet or exceed the following minimum specifications:

1.1.1 The minimum cyclic load capacity must be at least +-3000 N, and the minimum static load capacity must be at least +-2000 N.

1.1.2 The moving actuator must include low-friction lateral support (e.g., bearings or flexure) to guarantee precise guidance of the moving actuator under off-axis loads, bending moments, and wobble. Friction bushing designs are not acceptable.

1.1.3 The actuation stroke must be greater than or equal to 25 mm under static loading conditions.

1.1.4 The actuation speed must be electronically adjustable with a maximum frequency greater than or equal to 200 Hz (at small load/displacement values) and a minimum frequency less than or equal to 0.001 Hz at the maximum static load and displacement.

1.1.5 The distance between the actuator and load cell connection points ("testing space along the actuation axis") must be adjustable between 0 and 400 mm or greater.

1.1.6 The distance between columns must be greater than or equal to 450 mm.

1.1.7 The load-frame must include safety limits to protect the grips, fixtures, load cells from damage due to crosshead or actuator loading.

1.1.8 The load-frame must provide general attachment features (e.g., threaded bolt pattern, t-slots, etc.) for the mounting of test fixtures.

1.1.9 The load-frame must include an emergency shut-off switch located at the front of the machine which is easily visible to the operator.

1.2 Measurement and Control Capabilities

1.2.1 Load Measurement and Control

A fatigue rated load cell with a minimum capacity of 3000 N tension and compression must be provided with the test system. All necessary hardware for connecting the load cell to the load frame, including all necessary electrical connection hardware/cabling for interfacing with the load cell signal conditioner and the data acquisition system must be included. The load cell must be capable of tolerating off-axis loading typically associated with test specimen failure. "S" type load cells are not acceptable. Load measurement and control accuracy with this load cell and system electronics (conditioner, A/D, controller, etc.) must be greater than or equal to +- 0.5% of the full scale load range. The load measurement system must meet or exceed ASTM E-4..

1.2.2 Actuator Position Measurement and Control

Actuator position measurement and control capability shall be provided and must meet the following specification:

1.2.2.1 Relative actuator position measurement accuracy must be better than or equal to 1 micrometer.

1.2.3 Strain Measurement and Control

The strain measurement and control system must have the capability to provide an adjustable excitation signal through software or hardware to interface to a variety of

transducers. The strain measurement system must be capable of conditioning and accepting inputs from DC devices (e.g., strain gage based), and digital devices (e.g., encoders). The strain measurement system must meet, or exceed ASTM E-83.

1.3 Electronics

1.3.1 Signal Conditioning

The test system must include conditioning electronics for the load, crosshead displacement, and one or more user-selected transducer (e.g., strain extensometers) signals. The signal conditioning electronics must provide input power for transducer operation (excitation) and amplification of the transducer output signal to achieve +-10 volts full-scale output for measurement by data acquisition or external equipment using the analog output ports.

1.3.2 Analog Outputs and Inputs

The test system must include analog output connections for external measurement of the conditioned test signals (load, position, and user-selected signal). The test system must also include an analog input for affecting test control through external signal generation. The analog output and input capabilities shall meet or exceed the following minimum specifications:

1.3.2.1 The test system must include a minimum of two analog outputs corresponding to any of the conditioned signals: load, displacement, or user-selected signal. Full-scale analog output must be +-10 volt.

1.3.2.2 The test system must include an analog input that can be used to arbitrarily control the load, displacement, or user-selected signal (e.g., strain) through external means. Full-scale analog input must be +-10 volt.

1.3.3 Data Acquisition Hardware

The test system must include hardware to acquire data from the load cell and actuator position transducer described in Subsections 1.2.1 and 1.2.2. In addition, at least one analog-to-digital (A/D) data acquisition channel with +-10 volt full-scale analog input range must be provided to acquire user-selected signal data (e.g., strain extensometer). The data acquisition hardware must meet or exceed the following minimum specifications:

1.3.3.1 A minimum of 16-bit digitization resolution over the full-scale analog input for all A/D channels (i.e., load, actuator displacement, and one or more user-selected signals).

1.3.3.2 Data capture rate greater than or equal to 5 kHz for synchronous (simultaneous in time) measurement of three or more test signals (load, actuator displacement, and one or more user-selected signals).

1.4 Computer Hardware and Software

1.4.1 Computer Hardware and Software for Test Control and Data Acquisition

The test system must include computer hardware and Windows XP compatible software for control of the test machine and concurrent data acquisition of three or more signals. All necessary electrical hardware/cabling between the load frame, controller, and computer must be provided. Additional requirements include:

1.4.1.1 The hardware must include a PC with Windows XP operating system with the following minimum configuration: 512 Mb RAM, 80 GB hard drive, CD/DVD RW drive, TCP/IP network card, and a 17” LCD monitor.

1.4.1.2 The software must provide system control, data acquisition and storage, calculations, etc. for standard test methods (e.g., tension, compression, shear, etc.).

1.4.1.3 The software must include the capability for user-defined custom testing methods using load, displacement, or user-selected-signal (e.g., strain) (or some function of these variables) as the test control signal.

1.4.1.4 The software must include the capability to customize the data acquisition and storage process for the load, displacement, and user-selected signal(s) (e.g., data acquisition rate, calculated values using A/D channel data, etc.).

1.4.1.5 The software must include the capability for test specimen break detection, limit detection on the load, displacement, and user-selected signal, and digital input detection.

1.4.1.6 The software must provide a means for real-time monitoring and testing through user-selectable digital display meters and auto-scaling graphics.

1.4.1.7 The software must provide the means for choosing the measurement units (e.g., SI, MKS, CGS, English, etc.).

1.5 Manual Controls for Test Set-up

The test system must include a control panel that can be placed within 0.5 m of the load train for manual control of the system (actuator position, crosshead position, test start, stop, limits, etc.) during test setup.

1.6 Tension Grips

A set of tension grips with a minimum of 3 kN of load capacity (fatigue-rated) and a preloading mechanism that ensures pure side loading on the test specimens (i.e., no axial loading during tightening) must be provided with the system. All necessary hardware for attachment to the test system must be provided. Appropriate jaw faces must be provided to accommodate flat specimen geometries with widths from 0 to 25 mm or greater and thicknesses from 0 to 6.5 mm or greater.

2.0 Acceptance Criteria

The contractor shall demonstrate the machine's capability and functions at time of installation. The contractor shall demonstrate use of the materials test system for static and cyclic characterization of NRL-DC supplied test coupons including: polymer; carbon-epoxy, steel, aluminum, and an elastomer.

3.0 Installation and Training

The contractor shall deliver and install the materials test system at the Naval Research Laboratory, Washington DC 20375, at the location specified by the authorized government representative. The contractor shall calibrate the test system (all loads cells and crosshead position) to meet the customary industrial standards (e.g., ASTM E4). The contractor shall provide calibration records for the load cells and crosshead position transducer. The contractor shall provide a minimum of 2 days of training for up to six people at NRL-DC. The training shall be conducted immediately following contractor installation and calibration of the system. The topics to be covered in the training session shall include: test system functionality, operation, procedures, maintenance, and software. An option for additional training is included in Section 4.8.

4.0 OPTION ITEMS FOR CLIN 0001

4.1 Environmental Chamber (CLIN 0002)

The contractor shall provide an environmental chamber for conducting tests over a temperature range from -70 (or lower) to 350 (or higher) deg C. The chamber shall have PID auto-tuning control and a programmable control capability (e.g., temperature ramping). The chamber shall also provide an instrumentation port. All mounting hardware and load cell/actuator extensions must be provided.

4.2 Environmental Chamber Control (CLIN 0003)

The contractor shall provide for temperature control of a test specimen within CLIN 0002 by using an attachable temperature probe.

4.3 Automated Environmental Chamber Control (CLIN 0004)

The contractor shall provide computer automated temperature measurement and control for CLIN 0002.

4.4 Fatigue-Rated Wedge Grips (CLIN 0005)

The contractor shall provide fatigue-rated wedge grips with a +-3 kN capacity over a temperature range from -70 (or lower) to 350 (or higher) deg C (over the temperature range achievable by CLIN 0002) with various grip faces for testing flat specimens. All attachment hardware must be included.

4.5 Fatigue-Rated Pneumatic Wedge Grips (CLIN 0006)

The contractor shall provide fatigue-rated pneumatic grips with a +-3 kN capacity with various grip faces for testing flat specimens. All attachment hardware and all control hardware must be included.

4.6 Fatigue Rated Extensometer (CLIN 0007)

The contractor shall provide an axial extensometer with a variety of knife-edge contacts (e.g., flat, round, soft, hard). All necessary electrical connection hardware/cabling for interfacing with the test system signal conditioner and data acquisition system must be included. The extensometer must be capable of outputting an analog voltage signal with +- 10 volts corresponding to full-scale and shall meet or exceed the following minimum specifications:

4.6.1 Gage length of 25mm.
4.6.2 Maximum strain greater than or equal to 25% to -10%.

4.7 Advanced Software (CLIN 0008)

The contractor shall provide advanced software for system control and data acquisition during dynamic mechanical analysis testing (i.e., complex modulus, stress relaxation, creep, etc.) at various temperatures. Additional features may include typical elastomer characterization test control and the monitoring and control of temperature of an attached environmental chamber (CLIN 0002).

4.8 Advanced Training (CLIN 0009)

The contractor shall provide up to three days of training for two NRL personnel at a location selected by the contractor (e.g., NRL-DC or offsite). The topics to be covered shall include advanced testing operations, procedures, and software.

5.0 Quasi-Static Materials Test System (CLIN 0010)

The Naval Research Laboratory (NRL), Washington, D.C. has a requirement for a turnkey electro-mechanical materials test system. This system will be used for quasi-static characterization of the mechanical properties of a wide variety of materials. The system must be suitable for the purposes of research and development of new advanced material systems and must have wide-ranging capabilities for user control over the test conduct (e.g., selection and definition of test system's input control signal). The system must be capable of automated quasi-static material testing under load, displacement, or strain rate control via computer software, or "manual" testing via input of an analog voltage command signal. The system must be capable of computer automated measurement and recording of the test signals (load, displacement, strain, time, etc.) and "manual" measurement and recording via analog voltage signal outputs. The system must also include an electrical panel for manual control of the system during test-specimen set-up, etc. and a basic mechanical wedge grip fixture for tension-tension loading of material samples over the range of system load/displacement capabilities. To ensure operator safety, the test system must also include: 1) power/emergency stop switch(s) visible to the operator located at the front of the machine; 2) adjustable mechanical limits to stop the crosshead at predetermined points; 3) a motor overheat detector to automatically turn off the motor power supply and 4) the ability to set software limits for load, extension, strain, or any other data channel.

The test system will be placed in a facility with multiple users and must provide ease of operation (suitable for use by multiple individuals with a range of experience in mechanical testing) and safety to those in the facility. The materials test system must include, at a minimum, the following major components:

1) Electro-mechanical screw-driven load-frame with load-cell(s) and crosshead displacement transducer(s).
2) Measurement and control capabilities, including a test system controller for interfacing to computer and manual control panel.
3) Electronics for both transducer conditioning and analog-to-digital signal conversion for load, position, and two additional arbitrary transducer signals. This will include data acquisition hardware
4) Computer hardware and software for automated testing, control, and data acquisition.
5) Control panel for test setup, specimen installation/removal, and test start and stop.
6) Mechanical wedge grips for tension loading of material test specimens.

The major components must meet or exceed the following minimum specifications:

5.1 Load-Frame

The load-frame must be an electro-mechanical screw-drive machine with dual-columns and a minimum 100 kN load capacity. The load-frame must be capable of operation when mounted on the laboratory floor or mounted on a base that can be placed on the

laboratory floor (i.e., a floor standing model). The load frame must meet or exceed the following minimum specifications:

5.1.1 The load-frame must include preloaded anti-backlash ball-screws for crosshead position accuracy and zero backlash in tension-to-compression load transitions.

5.1.2 The load-frame must include lateral bearings to guarantee precise guidance of the moving crosshead under off-axis loads, bending moments, and wobble. Friction bushing designs are not acceptable.

5.1.3 The load-frame must include safety limits to protect the grips, fixtures, load cells from damage due to the crosshead running them together.

5.1.4 The load-frame must include bellows to protect the ball-screws and the cross-head guidance system from dust and dirt. The crosshead speed shall be electronically adjustable between a minimum of 0.01 mm/min and a maximum of 500 mm/min at all rated loads. Crosshead speed accuracy shall be greater than or equal to 0.1% at all rated speeds. Mechanical clutches, gear or belt-pulley changes in the drive system to achieve the required speed range capability are not acceptable. The total crosshead travel shall be greater than or equal to 1200 mm. The distance between columns shall be greater than or equal to 575 mm.

5.2 Measurement and Control Capability

5.2.1 Load Measurement and Control

The contractor shall provide a primary load cell with a capacity of 100 kN tension and compression (or equal to the capacity of the load-frame if the load frame is larger than 100 kN) with the test system. All necessary hardware for connecting the load cell to the load frame must be included. All necessary electrical connection hardware/cabling for interfacing with the test system signal conditioner and data acquisition system must be included. The load cell must be capable of tolerating off-axis loading typically associated with test specimen failure; “S” type load cells are not acceptable. Load measurement and control accuracy with this load cell and system electronics (conditioner, A/D, controller, etc.) shall be better than or equal to +- 0.5% of the reading down to 0.5 kN load. The load cell must include self-identification capabilities following the IEEE 1451.4 standard, and the load measurement system must conform to, meet, or exceed ASTM E-4.

5.2.2 Crosshead Position Measurement and Control

The contractor shall provide relative crosshead position measurement and control capability with crosshead position measurement accuracy greater than or equal to +- 0.020 millimeters over the full range of crosshead displacement.

5.2.3 Strain Measurement and Control

The contractor shall provide a strain measurement system with the capability of providing an adjustable excitation signal through software or hardware for maximum

ability to interface to a variety of transducers. The strain measurement system must be capable of conditioning and accepting inputs from DC devices (e.g., strain gage based), and digital devices (e.g., encoders). The strain measurement system must meet, or exceed ASTM E-83.

5.3 Electronics

5.3.1 Signal Conditioning

The test system must include conditioning electronics for the load, crosshead displacement, and two user-selected transducer (e.g., strain extensometers) signals. The signal conditioning electronics must provide (input) power for transducer operation and amplification of the transducer output signal to achieve +-10 volts full-scale output for measurement by the data acquisition system or via external equipment using the analog output ports.

5.3.2 Analog Outputs and Inputs

The test system must include analog output connections for external measurement of the conditioned test signals (load, crosshead position, and the two user-selected signals). The test system must also include an analog input for affecting test control through external signal generation. The analog output and input capabilities must meet or exceed the following minimum specifications:

5.3.2.1 The test system must include at least two analog outputs that can be selected to correspond to any two of the four test system conditioned signals: load, displacement, or the two user-selected signals. Full-scale analog output shall be +-10 volts

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5.3.2.2 The test system must include an analog input capability that can be used to arbitrarily command and control the load, displacement, or user-selected signal (e.g., strain) through external means. Full-scale analog input shall be +-10 volts.

5.3.2.3 The test system must include one or more digital input channels that can be used to input an external user-selected signal (e.g., strain).

5.3.3 Data Acquisition Hardware

The test system must include appropriate hardware for acquiring data from the load cell and crosshead position transducer described in Subsections 5.2.1 and 5.2.2. In addition, a minimum of two analog-to-digital (A/D) data acquisition channels with +-10 volt full-scale analog input range shall be provided for acquiring user-selected signal

data (e.g., two strain extensometers). The data acquisition hardware must meet or exceed the following minimum specifications:

5.3.3.1 19-bit or higher digitization resolution over the full-scale analog input for all A/D channels (i.e., load, crosshead position, and the two or more arbitrary channels).

5.3.3.2 Data capture rate greater than or equal to 500 Hz for synchronous (simultaneous in time) measurement of four or more test signals (load, crosshead displacement, and two or more user-selected signals).

5.4 Computer Hardware and Software

5.4.1 Computer Hardware and Software for Test Control and Data Acquisition

The test system must include appropriate computer hardware and Windows XP compatible software for control of the test machine (i.e., load, displacement, or strain as a function of time) and concurrent data acquisition on four or more independent channels. All necessary electrical hardware/cabling between the load frame, controller, and computer shall be provided. Additional requirements include:

5.4.1.1 The hardware must include a PC with Windows XP operating system and the following minimum configuration: 512 Mb RAM, 80 GB hard drive, CD/DVD RW drive, TCP/IP network card, and a 17” LCD monitor.

5.4.1.2 The software must provide a suite of standard test methods (system control, data acquisition and storage, calculations, etc.): tension, compression, shear, etc.

5.4.1.3 The software must include the capability for user-defined custom testing methods using load, crosshead displacement, user-selected signal (e.g., strain), or some function of those signals as the test control signal.

5.4.1.4 The software must include the capability for customizing data acquisition and storage of the load, crosshead displacement, and the two or more user-selected signals generated during testing (e.g., data acquisition rate, calculated values using A/D channel data, etc.).

5.4.1.5 The software must include the capability for collecting data based on: constant rate, level crossing, or peak and valley. It must also allow customization of the buffer size and the actions taken when the buffer is full.

5.4.1.6 The software must include the capability for break detection, limit detection and digital input detection.

5.4.1.7 The software must provide a means of real-time monitoring of the system and test through user-selectable digital display meters and auto-scaling graphics.

5.4.1.8 The software must provide full network functionality for data and test method storage, file-sharing, and back-up. The software must provide security features that allow for the assignment of user-privileges and protection of the programs, test methods, and data depending on user-privilege level. The software must provide the means for choosing the measurement units (e.g., SI, MKS, CGS, English, etc.).

5.4.1.9 The software must provide a means of real-time control and monitoring of external devices (e.g., environmental chamber, pneumatic-grips, video strain extensometers, etc.).

5.5 Manual Controls for Test Set-up

The test system must include a control panel that can be placed within 0.5 m of the load train for manually controlling the system (crosshead position, start, stop, limits, etc.) during test setup

5.6 Test Specimen Gripping Fixture

A set of mechanical wedge grips with 100 kN load capacity and a specimen grip-preloading mechanism that ensures pure side loading on the test specimens (i.e., no axial loading during tightening) must be provided with the test system. All necessary hardware for attachment to the test system must be provided. Appropriate jaw faces must be provided to handle flat test specimens with widths ranging from 0 to 50 mm and thicknesses ranging from 0 to 12.5 mm or greater.

6.0 Acceptance Criteria

The contractor shall demonstrate the machine's capability and functions at time of installation. The contractor shall demonstrate use of the materials test system for tensile characterization of NRL-DC supplied test coupons including: polymer; carbon-epoxy, steel, aluminum, and an elastomer.

7.0 Installation and Training

The contractor shall deliver and install the materials test system at the Naval Research Laboratory, Washington DC 20375, at the location specified by the authorized government representative. The contractor shall calibrate the test system (all loads cells and crosshead position) to meet customary industrial standards (e.g., ASTM E4). Calibration records for the load cells and crosshead position transducer (see Section 4.0 below) shall be provided. The contractor shall provide a minimum of 2 days of training for up to six people at NRL-DC. The training shall be conducted immediately following contractor installation and calibration of the system. The topics to be covered in the training session shall include: test system functionality, operation, procedures, maintenance, and software. An option for additional training is included in Section 8.5.

8.0 Option Item for CLIN 0010

8.1 Secondary Load Cell (CLIN 0011)

A secondary load cell with a capacity of 10 kN tension and compression must be provided with the test system. All necessary hardware for connecting the load cell to the load frame or to the primary 100 kN load cell must be included. All necessary electrical connection hardware/cabling for interfacing with the test system signal conditioner and data acquisition system must be included. The load cell must be capable of tolerating off-axis loading typically associated with test specimen failure; “S” type load cells are not acceptable. Load measurement and control accuracy with this load cell and system electronics (conditioner, A/D, controller, etc.) must be at least +- 0.5% of the reading down to 50 N load. The load cell must include self-identification capabilities following the IEEE 1451.4 standard, and the load measurement system shall meet, or exceed ASTM E-4.

8.2 Axial Extensometer (CLIN 0012)

The contractor shall supply an axial extensometer with a variety of knife-edge contacts (e.g., flat, round, soft, hard). All necessary electrical connection hardware/cabling for interfacing with the test system signal conditioner and data acquisition system must be included. The extensometer must be capable of outputting an analog voltage signal with +-10 volts corresponding to full-scale. Strain measurement and control with this extensometer shall meet or exceed the following minimum specifications:

8.2.1 Gage length of 50mm.
8.2.2 Maximum strain greater than or equal to 50% to -10%.
8.2.3 Maximum travel greater than or equal to 25 to -5 mm.
8.2.4 Strain calibration to ASTM E-83.

8.3 Large Displacement Axial Extensometer (CLIN 0013)

The contractor shall supply a large-displacement (high strain) axial extensometer with digital encoder measurement and a variety of knife-edge contacts (e.g., flat, round, soft, hard). All necessary hardware for interfacing the extensometer with test system must be included. All necessary electrical connection hardware/cabling for interfacing with the test system signal conditioner and data acquisition system must be included. The extensometer must be capable of outputting an analog voltage signal with +-10 volts corresponding to full-scale extension. Strain measurement with this extensometer must meet or exceed the following minimum specifications:

8.3.1 Range of travel: at least 250 mm.
8.3.2 Adjustable gage length capability.
8.3.3 Displacement resolution: 0.1 mm or less.

8.4 Video or Laser Extensometer (CLIN 0014)

The contractor shall provide a non-contacting video or laser extensometer. All necessary hardware for interfacing the extensometer with test system must be included.

All necessary electrical connection hardware/cabling for interfacing with the test system signal conditioner and data acquisition system must be included. All necessary software for interfacing the extensometer with test system must be included. The extensometer must be capable of outputting a digital signal and a +-10 volt analog signal corresponding to full-scale extension. Strain measurement with this extensometer must meet or exceed the following minimum specifications:

8.4.1 Adjustable gage length capability.
8.4.2 Displacement measurement range: at least 100 mm
8.4.3 Displacement resolution: 0.005 mm or less.

8.5 Advanced Training (CLIN 0015)

The contractor shall provide up to three days of training for two NRL personnel at a location selected by the contractor (e.g., NRL-DC or offsite). The topics to be covered shall include advanced testing operations, procedures, and software.

8.6 Mechanical Wedge Grips (CLIN 0016)

The contractor shall provide a set of mechanical wedge grips with 10 kN load capacity and a specimen grip-preloading mechanism that ensures pure side loading on the test specimens (i.e., no axial loading during tightening). All necessary hardware for attachment to the test system must be provided. Various grip faces must be provided to handle flat test specimens.

9.0 Low-Velocity Impact Materials Test System (CLIN 0017)

The Naval Research Laboratory (NRL), Washington, D.C. has a requirement for a turnkey low-velocity impact materials test system. This system will be used for impact and damage characterization of a wide variety of materials. The system must be suitable for the purposes of research and development of new advanced material systems and must have wide-ranging capabilities for user control over the test conduct (e.g., impact energy and velocity, impact profile, etc.). The system must be capable of low-velocity impact testing with user selectable impact energies, velocities, or heights to cover a wide range of materials testing requirements. The system must be capable of imparting impact energies up to 300 J or greater and impact velocities up to 5.0 m/s or greater. Electronic instrumentation must be provided for measuring and recording impact loads and velocities (impact and rebound). A basic set of fixtures (e.g., tups, and material fixtures) must be provided for testing polymer-fiber composite laminate samples over the range of system energy and velocity capabilities. The system must have clear protective safety doors/panels on all sides for full viewing of test.

System safety features must include: 1) protection from possible flying debris while providing open visual access to the test area, 2) safety interlocks to prevent access during testing, and 3) an emergency stop button.

The test system will be placed in a facility with multiple users and must provide ease of operation (suitable for use by multiple individuals with a range of experience in mechanical testing) and safety to those in the facility. The system must include, at a minimum, the following major components:

1) Load frame with electric screw drive for raising the drop-weight crosshead.
2) Measurement and control capabilities, including modular drop-weight change and universal impact-tup fixturing capabilities.
3) Conditioning electronics for the impact load and striker-tup velocity signals. This will include a control panel for test setup, specimen installation/removal, and test start and stop.
4) Data acquisition and analysis hardware/software.
5)Testing fixtures

The major components must meet or exceed the following minimum specifications:

9.1 Load-Frame

The load-frame must be capable of operation when mounted on the laboratory floor or mounted on a base that can be placed on the laboratory floor (i.e., a floor standing model). The load frame must meet or exceed the following minimum specifications:

9.1.1 Drop-weight crosshead positioning must be via motor-driven pre-loaded ball screws for accurate and repeatable positioning.

9.1.2 The drop-weight positioning mechanism must be capable of applying a force of 7500 N or greater for withdrawal of the striker-tup from the test specimen.

9.1.3 Enough space shall be provided to allow for test fixturing of dimension 800 mm x 600 mm x 500 mm or greater in size (WxDxH). General attachment features (e.g., threaded bolt pattern, t-slots, etc.) must also be provided to mount a variety of test fixtures.

9.1.4 Protection from flying debris during test shall be provided via transparent\safety shields and doors with safety interlocks. An emergency stop switch must be provided in a convenient location (e.g., front of the load frame) for quick system shut-down.

9.1.5 Maximum height of the load frame must not exceed 3000 mm (~10 ft).

9.2 Measurement and Control Capabilities

9.2.1 Drop-Weight Mass Measurement and Control

Drop-weight mass must be adjustable via automated or manual addition or subtraction of weights. Changes in drop-weight mass must be able to be accomplished by one person within 10 minutes. The mass of the drop-weight shall be measurable using manual or automated methods.

9.2.2 Drop-Weight Height Measurement and Control

The height of the drop-weight striker-tup above the test specimen surface shall be controllable via test panel or software settings. The drop-weight height must also be meet or exceed the following minimum specifications:

9.2.2.1 A capability for measuring and recording the drop-weight height must be provided.

9.2.2.2 The user shall be able to position the drop-weight height to within 0.25 mm or less of a chosen point.

9.2.2.3 Accuracy of the drop-weight height measurement must be better than or equal to +-0.020 mm or +-0.05% of the displayed reading over the full range of height settings.

9.2.2.4 Repeatability of positioning the drop-weight height must be better than or equal to +-0.015 mm over the full range of height settings.

9.2.3 Drop-Weight Velocity Measurement and Control

The velocity of the drop-weight at the moment of impact must be controllable via test panel or software settings. The drop-weight velocity must meet or exceed the following minimum specifications:

9.2.3.1 A capability for measuring and recording the impact velocity and cross-head rebound velocity must be provided.

9.2.3.2 Measurement accuracy of the impact velocity must be better than or equal to +-0.01%.

9.2.3.3 The difference between impact velocity and the user-set value of impact velocity must be less than or equal to +-2% of the setting.

9.2.3.4 The position of the drop-weight velocity transducer along the drop path must be user-adjustable.

9.3 Electronics

9.3.1 Impact Load and Velocity Signal Conditioning

The test system must include appropriate conditioning electronics for all transducer signals relevant to the measurement of impact load, and drop-weight acceleration and velocity. The signal conditioning electronics must provide (input) power for transducer operation and amplification of the transducer output signals to achieve +10 volts full-scale analog outputs for measurement by a data acquisition system or other measurement equipment. Appropriate signal shielding and isolation must be provided to avoid high-voltage surges, common-mode voltages, ground-loops, etc. The load measurement system must meet or exceed ASTM E-4.

9.3.2 Test System Control

All test system functions must be controllable through an electronic control panel and/or software controller or some combination of these. Basic test system functions (e.g., test start and stop, drop-weight height adjustment, etc.) must be controllable via an electronic control panel that can be placed within 0.5 m of the load train.

9.4 Computer Hardware and Software

9.4.1 Hardware for Data Acquisition and Analysis

The test system must include a computer and appropriate hardware for acquiring data from the impact load and velocity conditioners and analyzing the data. The hardware must meet or exceed the following minimum requirements:

9.4.1.1 The computer must be a PC with Windows XP and the following minimum configuration: 512 MB RAM, 80 GB hard drive, CD/DVD RW drive, TCP/IP network card, and 17” LCD monitor.

9.4.1.2 Two or more analog-to-digital (A/D) converters with 12-bit or higher signal digitization must be provided.

9.4.1.3 The data capture rate for the A/D converters must be adjustable.

9.4.1.4 The maximum synchronous (simultaneous in time) data capture rate for the two channels must be greater than or equal to 500 kS/s.

9.4.1.5 Data buffering must be provided to allow for the capture of a minimum of 10,000 data points corresponding to 10 milliseconds of data from two channels at a 500 kS/s capture rate (simultaneous) and longer times at lower capture rates.

9.4.1.6 Hardware for triggering the A/D process prior to impact must be provided.

9.4.1.7 All necessary electrical hardware/cabling between the load frame, conditioners, data acquisition converters, and computer must be provided.

9.4.2 Software for Data Acquisition and Analysis

9.4.2.1 Computer software must be provided to control the data acquisition process and storage of the data onto the computer.

9.4.2.1 Impact analysis software must be provided to determine: total impact energy, energy at maximum load and at the yield load, load at failure, time to yield, and user-defined functions using the impact load/velocity/time data.

9.5 Testing Fixtures

The contractor shall provide fixtures/equipment for measuring the damage resistance of fiber-reinforced polymer matrix composite materials following ASTM D 7136. Such equipment must include an impact support fixture with a 75 mm by 125 mm cut-out, test specimen clamps, a rigid base, and a 16 mm diameter hemispherical striker with load measurement instrumentation. All necessary hardware for attachment to the test system must be provided.

9.6 Acceptance Criteria

The contractor shall demonstrate the machine's capability and functions at time of installation. The contractor shall demonstrate use of the materials test system for low-velocity impact characterization of the following NRL-DC supplied composite plate test coupons: glass-epoxy, carbon-epoxy, and glass-pps.

9.7 Installation and Training

The contractor shall install the test system at NRL-DC. The contractor shall calibrate the test system (all transducers) to meet any customary industrial standards. Calibration records for all pertinent test transducers shall be provided. The contractor shall provide a minimum of one day of training for up to six people at NRL-DC. The training shall be conducted immediately following contractor installation and calibration of the system. The topics to be covered in the training session shall include: test system functionality, operation, procedures, maintenance, and software.

9.8 Option Items

9.8.1 Testing Fixtures/Equipment (CLIN 0018)

The contractor shall provide fixtures/equipment for measuring the puncture properties of polymer materials following ASTM D 3763 and covering the capacity range of the system (energy, load, and velocity). Such equipment must include a pneumatic clamping fixture for the test samples and instrumented strikers. All necessary hardware for attachment to the test system must be provided.

9.8.2 Computer Test Control (CLIN 0019)

The contractor shall supply the necessary software and hardware to enable automation and control of the impact testing process (e.g., drop height, velocity or energy)

10.0 General Requirements

The following information/requirements apply to all instruments which make up the mechanical characterization facility:

10.1 Used Equipment

Offers of used equipment will not be accepted.

10.2 Installation Site.

The contractor shall deliver and install the materials test system to the Naval Research Laboratory, Washington DC 20375, at the location specified by the authorized government representative. NRL will be responsible for providing the necessary facilities and utility hook-ups at that location for proper installation and operation of the materials test system. The contractor shall provide a pre-installation guide with its proposal submitted in response to the solicitation. The pre-installation guide shall indicate, in detail, all of the site requirements including, but not limited to: utility hook-ups (e.g. electrical, air, water, vacuum, etc.); required space (e.g., doorway passage, floor, operating, maintenance access, etc.); environment (e.g. temperature, vibration, air flow, etc.); procedures for receiving the equipment and placing it in its laboratory location; and communication hook-ups (e.g. Ethernet). The materials test system shall be ready for immediate use following installation/set-up by the contractor.

10.3 Warranty

The contractor shall offer the Government at least the same warranty terms, including offers of extended warranties, offered to the general public in customary commercial practice. These warranty terms must be included in the system price. The period of the warranty shall begin upon contractor installation and calibration of the test system.

10.4 Documentation

Written documentation customarily provided to the public with a commercial item shall be provided. This shall include user manual(s) or equivalent as well as copies of any software, and any manuals for the software included with the system, if customarily provided. This documentation must be received at NRL with the system hardware, unless other arrangements are agreed to by the authorized Government representative. This documentation shall also include all documentation, drawings and schematics for full site preparation, operation, troubleshooting, servicing and repair of the system and its components.