Attachment 0025

Performance Specification for the
Type II Heavy Crane Training Simulator

1.0 Description. The Crane Training Simulator (CTS) encompasses all of the hardware and software components and documentation required to operate, maintain and train on this equipment to the standards specified by this statement of work. This includes the computers (control and image generators), student station (cab assembly, interchangeable crane control sets, operator chair, displays, motion system, and intercom), instructor station (controls, monitor, and intercom), control and simulation software, scenario creation software, maintenance and diagnostic software, and all associated documentation.

The Crane Training Simulator (CTS) is intended to provide both basic and advanced set up and lifting operational training for the Type II Heavy Crane. Basic through advanced task instruction will be given to students using the CTS in order to develop both safety awareness and operating skills. Students will perform training tasks to become familiar with controls and operating characteristics of the Heavy Crane prior to use of actual cranes in the field.

The CTS will maximize an open architecture design and the use of common standards for ease of system upgrades, concurrency, technology insertions, software/configuration modifications, interoperability, and the ability to reprogram interfaces in order to support future changes.

1.1 Performance Data Collection. In addition to real-time, in-scenario monitoring from an instructor station, student performance data shall be automatically collected, recorded, and presented by the CTS for review and analysis by training staff to determine areas of weakness in crane operation for any given student or group of students. The following performance data is required:

1.1.1 Loads moved clamshell operations, loading ISO containers, pallets, barrels on truck using spreader/tandem lock/slings, loading round loads onto trailers with chocker slings, possible loading of equipment as well like dozers and trucks.

1.1.2 Cycle times will vary depending on operation being performed. (i.e. Different times, adjustments for each operation in both daylight/nighttime hours, weather conditions, operators' experience level).

1.1.3 Collisions (as defined by the contractor),
- Major
- Minor

1.1.4 Reaction times to faults
- Immediate response to hydraulic failure
- Immediate response to engine power loss
- Oil pressure display shows no pressure within 15 seconds, turn engine off
- Faults in LMI/SLI: (e.g. Boom isn't telescoping as designed to).

1.1.5 Reaction times to alarms
- Anti-two block (immediately)

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- Approaching overload (caution to be taking into affect or lower load to ground and readjust crane)
- Maximum capacity and overload reached (immediately)

1.1.6 Visual Model of load path performed by student

- Have arrows showing direction student has to manipulate a load through an obstacle (e.g.: cones on the ground 10 feet apart)

1.2 Design Priorities. The three priorities for the design and construction of the CTS are as follows:

1.2.1 Safety – The CTS shall have all comprehensive safety features ensuring safest operation and shutdown relative to personnel and equipment.

1.2.2 Training Effectiveness – CTS scenarios shall be realistic and accurately replicate the actual controls for the Design Basis Cranes. Students shall be able to perform basic through advanced equipment operations in realistic operating environments.

1.2.3 Durability – The CTS shall be fully functional following delivery and continue to work with minimal corrective maintenance for the life of the equipment. The CTS will be vigorously used in a military training environment by a high volume of junior students and shall be designed to withstand these conditions.

1.3 CTS Technical Specifications.

1.3.1 Electrical Requirements. The CTS shall use grounded, single phase, 120 VAC 30 amp or 220 VAC 60 amp power and shall include a signal conditioner and an Uninterruptable Power Supply (UPS) to prevent shutdown and/or damage to the CTS in the event of electrical current spikes and power outages.

1.3.2 Motion. The CTS shall include continuous, real-time physical motion such that the student can feel, first-hand, the stability of and structural strains on the Heavy Crane in various operating scenarios; for example, when lifting a load or being exposed to varying weather conditions. Motion shall be provided in pitch, roll and yaw axes.

Motion shall be directly related to the movement of the crane in the Virtual Training Environment (VTE). Presentation of the training scenario on displays described below shall enhance the sensation of motion by changing perspective as the student moves the crane through the VTE.

The motion platform shall provide realistic movement and feel of the equipment during motion and operation to train students to perform basic and advance tasks. The simulator motion-based platform shall provide the student with a realistic working environment that simulates motions associated with, swing, slewing, breaking, tipping, wind effects, as applicable, on various types of loads. The motion platform shall also provide a response to collisions. The motion platform shall respond to student inputs within 105 milliseconds. The displayed visual image of the operator compartment and motion platform movement shall be synchronized to produce a realistic simulation of the equipment in motion. Performance of the aural cues and visual display

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scenes shall be coordinated with movement of the motion platform. The motion simulation shall minimize the effect of the students to experience vertigo, motion sickness, or simulator sickness.

1.3.3 Processors. The CTS shall be capable of, under various operating conditions (such as inclement weather such as rain, sunlight, and wind conditions), providing high-quality, real-time (60 Hz minimum frame rate), realistic modeling and graphic simulation with no noticeable time delay between movement of the simulator controls and response of the visual display and motion systems. All computers shall be mounted into a standard 19" computer rack.

1.3.4 Displays and Monitors. The CTS shall provide real-time color computer generated, 3D visual images of sufficient detail to adequately train students. In addition, the visual simulation shall provide the essential cues and depth perception required by the student to assess simulated crane equipment position and velocity, characteristics of the terrain, and other information necessary to operate the simulated crane equipment in training scenarios. The CTS shall provide shading and lighting, model textures, and soft shadows to increase the realism and quality of the simulator. The simulator shall provide the correct field of view through the equipment student cab. The side mirrors, rear view mirror, and any cameras shall be simulated.
The visual system shall consist of the image generation system, display system, terrain database(s), static and dynamic models, and any associated hardware and software required to simulate the cranes visual sensor scene environment.

The CTS shall include high-resolution, realistic imagery of derived and perspective visual scenes. Visual field-of-view and field-of-regard shall replicate the characteristics of the operational equipment. Visibility range shall be to the degree of fidelity necessary to support realistic conditions and minimize the possibility of negative training or habit transfer.

The Computer-Generated Imagery (CGI) environment and entities shall be physics based and have the proper, accurate responses in the CTS scenarios. CGI shall not distract, detract from, or negatively disrupt student training by having visual anomalies such as smear, flicker, stepping, scintillation, stair-stepping of edges, break-up of long narrow surfaces, abrupt transition of scene elements, occulting errors, flashing, streaking, edge blending and abrupt changes in the displayed image due to interaction with visual scene elements.

The student station shall be four large format displays: (each with a 42" diagonal, high-definition, flat-panel) to provide a visual interface and simulate crane operations from the perspective of the crane operator. These displays shall provide the following perspectives:

- Forward
- Forward above
- Left
- Right

The visual display shall portray the simulated training environment utilizing the visual interface (e.g., windshield, windows, etc.) with applicable obscurations and restrictions of the specific equipment variant being simulated. This shall include the ability to display the operators cab in an armored and unarmored configuration.

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The requirement for the student field-of-view shall be 180° horizontal and 60° vertical. As described above, presentation of the training scenario shall enhance the sensation of motion by changing perspective as the student moves his crane through the virtual training environment.

The specifications for the of the monitors at the instructor station are: 21" diagonal, high-definition, flat-panel.

1.3.5 Sound System and Audio Cues. The CTS shall provide a sound system that reproduces equipment sounds and that correlates to the operating environment. The system shall include the sounds and communications from machine operations and, malfunctions. The aural cues shall include the following: engine power, engine startup, power shut down, horn, all warning buzzers and cab audio cues, engine idle, malfunctions, and operational differences between normal idle and under stress. Audio cues shall occur in real time and be directional, if appropriate to the circumstance, in order to provide a realistic training. The sound system for each simulator shall include a headset with microphone device so that it does not interfere with other students training in the same area. The sounds shall emanate from the headset.

1.3.6 Student Station Configuration. The student station shall be one integrated platform and be constructed to simulate the cab layout and controls of the Heavy Crane. The student station shall include the following basic components:

1.3.6.1 Operator seat that replicates the operators' seat in the heavy crane
1.3.6.2 Equipment instruments, gauges, indicators, switches, and displays
1.3.6.3 Provide a Common Access Card (CAC) reader for the purpose of logging student's information into the simulator for student data collection.
1.3.6.4 Operator controls
- The degree to which controls are manipulated will translate directly into speed and response of the virtual crane

1.3.6.5 Integrated displays as described above
1.3.6.6 Three (3) degree-of-freedom motion
- Pitch
- Roll
- Yaw

1.3.6.7 An intercom system permitting direct communications with the instructor station using the operators head set.
1.3.6.8 Emergency power off button: The intent of this feature is to immediately and safely shutdown the system without damage to personnel or equipment.
1.3.6.9 Capability to virtually simulate the crane operators cab in an armored and unarmored configuration.

1.3.7 Human Systems Integration. The design of the CTS shall be conducive to effective operation by all Students included in the target audience 5th percentile female to 95th percentile male Students. This requirement shall ensure the design accommodates target audience Students of varying sizes and body proportions (i.e., anthropometrics) with and without Personal Protective Equipment (PPE), i.e., combat helmets, body armor, and load bearing equipment. The Student Machine Interface (SMI) design of displays, controls, pedals, levers and labels shall

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enable Students with the minimum cognitive, educational, and experience factors to be able to operate the systems and provide the means for performing required tasks with 95% reliability and accuracy.

1.3.8 Hydraulic Heavy Crane Control and Indicator Specifications The CTS shall replicate the cab controls of the Heavy Crane with form, fit and function, to include joysticks, gauges, foot controls, switches, and controls necessary to properly replicate the proper operation of the heavy crane. To include:

1.3.8.1 Joystick controls
- Boom swing and hoist/lower
- Main winch hoist/lower

1.3.8.2 Foot controls
- Boom telescope
- Swing brake
- Engine throttle

1.3.8.3 Simulated instruments shall display real-time, in-scenario information from the lifting engine and hydraulic system. These instruments shall mimic those of the Heavy Crane in all respects to include relative size, layout, range, and units of measure.
- Hydraulic oil temperature
- Tachometer
- Voltmeter
- Water temperature
- Oil pressure
- Fuel

1.3.8.4 Simulated capacity limiter and Load Moment Indicator (LMI) which shall display real-time, in-scenario information.
- Boom length
- Boom angle
- Head height
- Load radius
- Allowed load
- Actual load
- % of allowed load
- Limit alarms

The CTS shall simulate the equipment dynamically to the level of detail required to support the training tasks. The CTS shall replicate the performance and handling of the actual equipment. The effects of the terrain, terrain obstacles, and loads shall be combined with the forces due to the mass, momentum, and position of the equipment to determine performance using multiple points. CTS shall include the following equipment components and their performance as observed from the super structure cab: engine noise, gauges, electrical system, hydraulic system, accelerator, field of view restrictions and mirrors, equipment attachments, and structure of the heavy crane chassis as observed from the superstructure operators cab.

The CTS shall have the ability to replicate the view of the superstructure cab in an armored and unarmored configuration.

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1.3.9 Instructor Operator Station (IOS) Configuration. The instructor station shall include the following physical components (simulation control requirements and functions are described under CTS Software below):

1.3.9.1 Instructor chair and table
1.3.9.2 Control station
- Display (specifications are described in the "Displays and Monitors" section above)
- Keyboard
- Mouse
- Printer
- Manipulator (e.g. joystick) for situational display and virtual pointer controls (described in the "Instructor Station Controls and Capabilities" section below)

1.3.9.3 Motion control toggle: This feature shall enable and disable motion of the student cab.
- When on, the student cab will be free to move as described above (see Motion).
- When off, motion of the student cab will be inhibited.
- In order to prevent possible damage to the student platform, the switch will only toggle motion on/off while the CTS is not in-scenario/moving

1.3.9.4 An intercom system to permit direct communications with the student through the use of the CTS headset.
1.3.9.5 Emergency power off button: This feature shall immediately and safely shutdown the system without damage to personnel or equipment.

1.3.10 CTS Software. Licensed copies of all software shall be installed upon delivery; updates shall be provided for the life of the contract at no cost to the Government. Additionally, software delivered with the CTS shall meet the following requirements:

1.3.10.1 All CTS stations shall have the ability to perform crane to crane interaction with multiple (2) simulators to execute collective training (i.e. dual crane lift).Licenses and users-guides for all copyrighted software shall be delivered with each training system.
1.3.10.2 CTS software shall be compatible with Microsoft Windows 7 (or newer version).
1.3.10.3 Real-time display. Display software and graphics hardware shall be capable of producing images at a continuous frame rate of at least 60 Hz to minimize stepping and artifacts during operation of the training system.
1.3.10.4 Dynamic crane model. The selected Heavy Crane model shall replicate the following
- The capacity of the Heavy Crane
- The correct boom
- Correct tip height
- Correct line (single and multipart), and hooks associated with the new crane.
- Correct slings and spreaders associated with the new heavy crane.

Incident occurrence information to include mishap or near mishap prevention data.
The CTS shall have a data analysis tool wherein student performance data is presented for review, analysis, and export by training staff in an easily understood and manipulable format. All data shall be exportable from the CTS in Microsoft Excel compatible files to determine areas

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of weakness in crane operation for any given student or group of trainees and to be able to compare performance between individuals and groups of students. Performance measures to be captured include: Initial leveling of crane on outriggers to 0 degrees, Check load chart against weight of load, Program LMI, Attach slings to hook block, Adjust slew regulator knob and disengage slew gear brake, Sound the horn three times, Slew right until boom is in line with load then telescope the boom until hook block and sling is centered over load, Engage the slew gear brake, Lower the sling and use assistant to attach to load, Raise the load approximately 6 to 12 inches off the ground, Disengage the slew gear brake and sound the horn three times, Swing to the right until boom is in line with first predetermined position, Extend the boom and lower the load at the first predetermined position, Raise the load approximately 6 to 12 inches off the ground, Sound the horn three times, Swing to the right until boom is in line with second predetermined position, Extend the boom and lower the load at the second predetermined position, Raise the load approximately 6 to 12 inches off the ground, Hold the load and fully retract the boom, Sound the horn three times, Swing to the left and return the load to its original start point, Lower the load and use assistant to disconnect from sling, Return the boom back to storage cradle and secure for travel, Engage the slew gear brake, Retract outriggers, Shut down engine in superstructure cab, Prepare crane for travel. Follow all hand and arm signals from a signal person. The scoring should be pass or fail for each event.

1.3.11 Instructor Station Controls and Capabilities

The instructor station shall control two student stations but shall have the ability to control up to 4 student stations. The instructor station shall be capable of defining user accounts, viewing student performance and printing class roster and student data. The instructor station shall monitor data on the students' performance and scoring, environmental conditions, scenario settings (stand-alone and collective training, database, etc.),

The instructor station shall edit, modify and save the training scenarios in real time to insert, remove, and reposition models and entities. The instructor station shall provide a stealth view capability of the scenario for the instructor to monitor student progress and performance. The instructor station shall have the ability to review training tasks completed After Action Review (AAR) without interfering with the instructor station functions or ongoing tasks performed. The AAR will have the ability to start, stop, rewind, fast forward, pause, zoom in, and zoom out the scenario it recorded. The AAR will have a slide bar to move to any time in the exercise. During a training scenario, the instructor's station shall be capable of bookmarking a time in the scenario execution that can be jumped to during AAR. During playback, a birds-eye view that is adjustable (pan and rotate in all directions and zoom in and out) from the instructor station shall be available. The AAR will recreate the visual, aural communications, and instrumentation cues of the exercise scenario.

1.3.12 Class Manager Software.

The software shall provide three types of users: student, instructor, and administrator and provide the following functionality to manage users: create new users, view user information, edit/modify user information, and delete a user. To efficiently manage student users, the class manager software shall allow the grouping of the student users into classes. The software shall allow the following functionality to manage classes: create a new class, view class information, edit/modify class information, and delete a class. The software shall allow one or more

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instructors to be grouped to a class. The class manager software shall be capable of receiving, saving, deleting, and printing student and class performance data. If the database approaches record limit, the class manager software shall display an archive prompt and provide the ability to archive the database to a Compact Disk.

The class manager software shall be capable of adding students to the class manager database by gathering data from the STS CAC readers or alternative input device. The class manager software shall mask all Personally Identifiable Information (PII). Access to PII shall be password or pin protected. The system shall also have a nine character alpha numeric field to manually input in the student unique identifier for students without a CAC. The IOS shall store all student data and allow for printing of student records/scores up to 3,000 students. The IOS shall provide a function that imports and exports student data, including student records/scores with a Compact Disc/Digital Versatile Disc (CD/DVD). The exported report shall be viewable using standard computer equipment (i.e., the report does not need the IOS database software to view the report).

The class manager software shall allow the instructor/administrator to select which scenarios from the Program of Instruction (POI) students or classes can have access to. The class manager software shall allow the instructor/administrator to edit POIs or delete POIs for students or classes. Once the scenarios have been selected for the students or classes, the POI will be self paced for each student.

The instructor station shall be able to select between a practice and examination mode for each scenario. The instructor station shall have the ability to toggle on or off the virtual demonstration and tutorial functionalities for each mode and scenario.

1.3.13.2 Instruction Station shall have the below controls:

- Run, stop, and pause trainer operation
- Independently have the ability to input student name and training information or identifier
- Modify environmental model variables before and during scenarios
- Initiate faults and malfunctions
- Modify load parameters
- Set and override the collision conditions
- Provide hand signals by an animated signalman

1.3.13.3 Real-time status display shall threshold requirement):

- Current trainer state (On/off, boom length and angle)
- Scenario description and summary
- Mission time, current time, and date
- Training-related statistical data and environmental conditions (trend analysis)
- Current load description
- Current state of motion system

1.3.13.4 Crane controls mimic display area. A graphic representation of student crane controls. The mimic control display shall move in correlation with the student controls enabling the instructor to observe control manipulation by the student.

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1.3.13.5 Situational display. This display shall provide an instructor-controlled "roving eye" for the instructor that will allow the instructor to view an area in the VTE from any camera position in order to monitor student performance in-scenario. The virtual camera shall be attached to either a fixed location or a moving object, as defined by the instructor.

1.3.13.6 Virtual pointer. While live or paused in-scenario, this function shall allow the instructor to insert a directional pointer into the VTE as a training aid. This directional pointer shall call specific items to the student's attention without the need for the instructor to physically point to items on the student's displays. Using the virtual pointer in conjunction with the intercom function shall allow the instructor to effectively interact with students in the CTS while in-scenario.

1.3.13 Scenario Generation and Simulation Modeling. Scenario Generation and Simulation Modeling software (the Software) shall be available at the instructor workstation and maximize control over creating, modifying and running scenarios. The Software shall have an intuitive Graphical User Interface. The CTS will have the capacity and capability to store training scenarios for later use. The following subparagraphs outline the Governments expectations for the Software and its capabilities.

1.3.13.1 Virtual Training Environment (VTE) shall include:

- Configurable urban and suburban setting (including a partially constructed building)
- Configurable industrial/tarmac setting
- Gravel, including gravel pit
- 300' ship port and loading dock
- Shallow water beach area
- Elevated highway to simulate bridge construction
- Paved and gravel roads across varying elevation terrain
- High voltage power lines
- Water tower
- Large radio and cell phone towers
- Vegetation including trees and shrubs
- Miscellaneous construction vehicles
- Pedestrians
- Flat bed trailers for loading and unloading

1.3.13.2 Load models shall include:

- Large diameter concrete pipe
- Concrete bucket
- Steel rebar bundle
- Steel pipe bundle
- Wood bundle
- Wooden crane
- I beam
- Quadcon container
- Tricon container
- Half-height container
- Empty wooden pallet (40" x 48")
- Wooden pallet with barrels
- 20' ISO container

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- 40’ ISO container

1.3.13.3 Behavioral characteristics of objects in the VTE (examples are: cranes, traffic, loads, etc.) shall have the ability to be manipulated from the instructor console while developing a scenario and while the scenario is running. Manipulable behavioral characteristics include:

a. Initial configuration
b. Orientation
c. Speed
d. Direction
e. Path
f. Transit and wait time
g. Color
h. Weight and balance

1.3.13.3 Collision modeling. Collisions between cranes and crane components with situational obstacles are a real and ever-present danger when operating cranes in the field; therefore, virtual collisions shall be modeled to accurately represent real life situations in order to enhance the quality of training. Simulations shall provide realistic visual, audio, and motion feedback. Collisions shall be possible between the student controlled crane and the following virtual obstacles:

i. Crane components
j. Vehicles and pedestrians
k. Other cranes in the scenario
l. All containers, trailers, and loads in the scenario
m. Other structures and elements in the VTE

1.3.13.4 Fault and Malfunction model. A fault and malfunction model shall simulate instructor induced faults and malfunctions. The following malfunctions, shall be included:

a. Mechanical failure
b. Structural failure
c. Loss of stability
d. Broken Sling
e. Personnel injury or acutely unsafe working environment

1.3.13.4 Interactive Environmental modeling. Environmental features shall be available in all scenarios and shall influence the operation of the virtual crane and the operator’s ability to employ the virtual crane as they would in reality.

f. Visibility (for example: fog, rain, snow and haze)
g. Wind (for example: speed, direction, and gusting)
h. Time-of-day
i. Shadows
j. Terrain

1.3.14 Safety. The motion platforms are prone to sudden movement during scenarios; safety is a prime consideration, and therefore, a safety mechanism shall be in place. A visual warning device should activate when the motion platform is in use and should not interfere with training or the fidelity of the simulation. If the motion platform encounters an error while in motion, the

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motion platform shall settle to a park position. No battery shall be required for the motion platform to settle when there is a loss in power or the emergency stop button has been engaged. The motion platform shall settle to the parked position when the student unbuckles the safety restraint.

CTS sounds must be limited to safe levels. CTS shall comply with applicable safety design requirements and not present any uncontrollable health-safety hazards to personnel throughout the life cycle of the system. The CTS shall provide a safe training environment by implementing all Occupational Safety and Health Administration (OSHA) safety requirements. The CTS shall comply with the MIL-STD-882D, MIL-STD-1472D, and MIL-STD-1472F.

1.3.14.1 Emergency Equipment Power Disconnects.

The trainer power distribution system shall include the power disconnects required by OSHA 1910.302 - 308. Additional disconnects shall be provided at the instructor station(s) and student station(s). Each of the disconnecting points shall be legibly and permanently marked to indicate its purpose and operating instructions.

1.3.14.2 Temperature Sensing Alarms.

All heat producing equipment cabinets shall be equipped with temperature sensing devices, which shall be integrated into an over-temperature alarm system.

1.3.14.3 Equipment Energized from Multiple Power Sources. A warning label in accordance with Figure shall be securely affixed to electrical and electronic units which have more than one source of electrical power. The warning label shall be located in such a manner as to allow operation and maintenance personnel to identify all of the circuits providing electrical power, and the location and designation of the de-energizing switches.

Figure 1. Multiple Power Source Label

1.3.14.4 Security and Privacy. All equipment storage cabinet doors shall be equipped with key operated locks. All cabinet locks shall be keyed alike.

1.3.15 Information Assurance. CTS and Instructor Operator Stations shall be in compliance with the Department of Defense Information Assurance Certification and Accreditation Process (DIACAP) per DoDI 8510.01 and with Army Regulation 25-2, Information Assurance, dated 23 Mar 2009.

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