TARDEC Occupant Protection Seat

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Technology Transition – Supporting DoD Readiness, Sustainability, and the Warfighter
# TARDEC Occupant Protection Seat

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Presentation Overview

- Objective
- Program Overview
- Seat Design Overview
- Subscale Energy Attenuation (EA) Testing
- Phase II Design Updates
- Seat Fabrication Progress
- Remaining Work
Objective

- To develop an innovative, robust blast mitigating seat design that maximizes occupant safety during blast, slamdown and crash events.
  - The NDCEE blast mitigation seat design utilizes a robust wire bender Energy Attenuation (EA) system with a reset mechanism that protects the occupant during both the upward blast acceleration and slam down deceleration events.
Program Overview

• Phase 1 (November 2010 - December 2011)
  – Develop requirements
  – Develop EA system design / finite element analysis (FEA)
  – Design / build / test a subscale EA test fixture to verify EA performance and correlate with FEA models
  – Complete seat design to CDR level (CDR held 22 Dec 2011)

• Phase 2 (November 2011 - Present)
  – Update seat design to optimize performance based on test results
  – Fabricate four (4) prototype seats for testing
  – Perform drop tower testing to evaluate seat performance
  – Perform blast testing to evaluate seat performance
Design Overview

Stroking Seat Bucket

Fixed Seat Structure

Nominal position

Stroked 8 inches
Design Overview – EA System

- Breakout spring clip
- Return spring
- Ratchet mechanism (attached to fixed seat structure)
- EA wire
- EA roller (attached to stroking bucket)
Design Overview – EA System

Nominal position

Initial blast (stroked 8 inches)

Rebound

Slamdown

Wire bent around roller

Ratchet moves up

Additional wire pulled around roller
EA System FEA

ABAQUS Explicit Analysis
Design Overview – Cushions / Harness

- Removable center cushion
- Hydration pack pocket
- 5-point harness
- Single action harness release
- Shoulder harness retractor
- Lap belt retractors
Design Overview – Floor Deformation

Seat is designed to function nominally with up to ±10° rotation of one mounting foot relative to the other in any direction.

Flexible links to mitigate floor deformations.
Subscale EA Test Fixture

Purpose: To test all critical energy attenuation components on the TARDEC drop tower without incurring the cost of building a complete seat.

Design

- Spring clip
- Return spring
- EA wire
- Variable mass (add / remove plates)

Analyze

Test
Subscale EA Test Fixture Results

7 mass plates (represents 276 lb occupant),
182.3g input pulse
49.6g max on mass plates

7 mass plates (represents 276 lb occupant),
299.5g input pulse
63.6g max on mass plates
Test Results vs FEM Predictions

7 mass plates (represents 276 lb occupant), 182.3g input pulse

7 mass plates (represents 276 lb occupant), 299.5g input pulse

GOOD CORRELATION!
Subscale Test Summary Achievements
Phase I Wrap Up

- The EA wire bender design worked exactly as intended. No issues were observed with the roller or EA wire.
- The ability for this design to provide protection for two equivalent impact events was clearly demonstrated at both the 200g and 325g impact levels. (Seat was dropped twice in a row without modifying or replacing EA wire).
- The spring return and ratchet mechanism worked very well throughout the testing.
- Typically the seat was reset and ready for a second hit approximately 0.2 sec after the initial impact.
- The breakout spring clip functioned as intended. It was shown that the spring clip could be re-engaged after the first hit, thus providing identical performance for the second hit.
Subscale Test Summary Achievements
Phase I Wrap Up

• The seat design was able to provide shock mitigation when the drop table was rotated 15º forward and aft to simulate offset loading.
• The dynamic frictional properties of various coatings were evaluated, providing excellent data for future design activities.
• The test fixture survived 30 drop tests with minimal damage. This clearly demonstrates the robust nature of the design approach.
• FEA model predictions were validated, providing a correlated analysis tool for future design studies.
Phase II design updates

- Updated design to improve seat performance for full occupant range from 5th% female (108 lb) through 95th% male + 100 lb gear (323 lb).
  - Updated EA system to utilize a total of four (4) bend wires
  - Each EA wire engages at a different point during the stroke
  - Performed over 50 analysis iterations to optimize design
- Optimization of flexible link design
- Finalized restraint system / interface
- Numerous manufacturability improvements
Phase II – EA System

- Breakout spring clip
- Return spring
- Ratchet mechanisms
- 4 EA wires
- Variable engagement
- 4 EA rollers (attached to stroking bucket)
Other Completed Phase II tasks

- Performed preliminary Design Failure Modes and Effects Analysis (DFMEA)
- Performed FEA of crash loads per FMVSS standards
- Documented all structural analysis and DFMEA in the “Design Analysis Report” deliverable document
- Generated drop tower test plan, provided in the “Demonstration Plan for Occupant Seat” deliverable document
- Updated drawing package to reflect latest design
Seat Fabrication – Currently Ongoing
Remaining Work

- Complete fabrication of four (4) seats
  - Estimated completion date: 15 August 2012

- Perform drop tower testing using TARDEC drop tower located at Selfridge Air National Guard Base
  - Late August / Early September 2012

- Perform vehicle or “generic hull” blast testing with seats
  - Blast testing is a complex event that requires input and hardware from many different organizations outside the control of CTC. It is possible that this testing will be scheduled outside this contract’s performance deadline.

- Evaluate test results and generate final report
  - Will be complete by November 2012
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