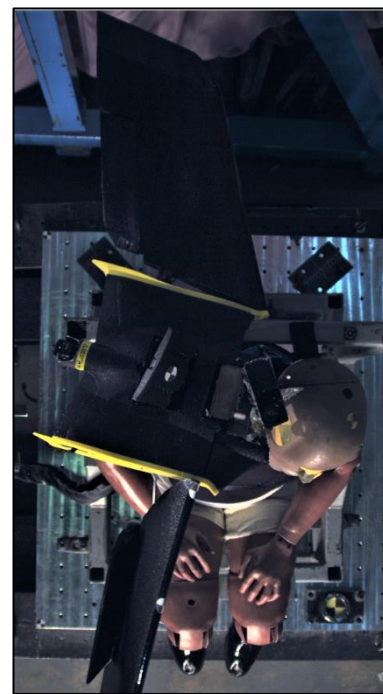
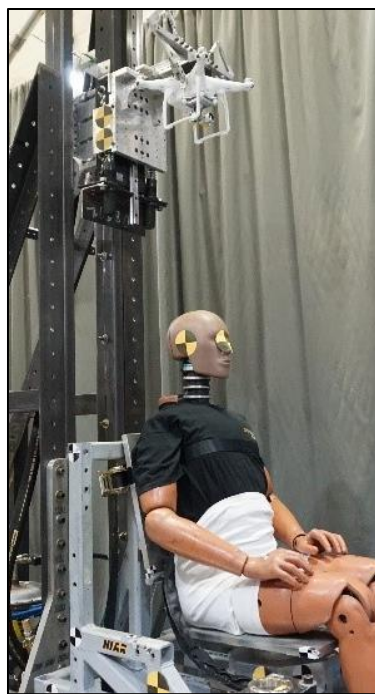
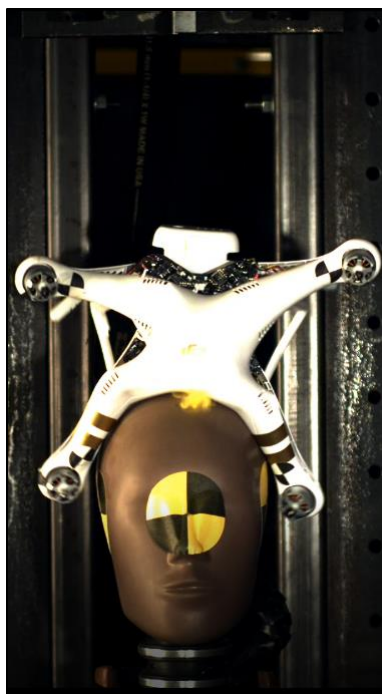


Advanced Virtual Engineering & Testing Laboratories

SMALL UNMANNED AIRCRAFT IMPACT TESTING

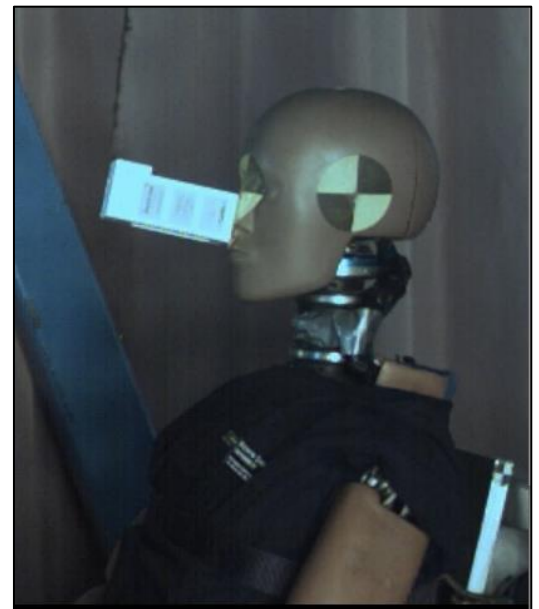
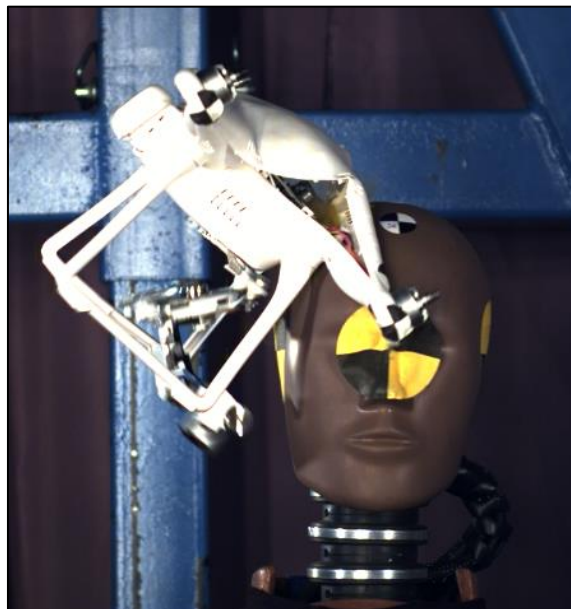
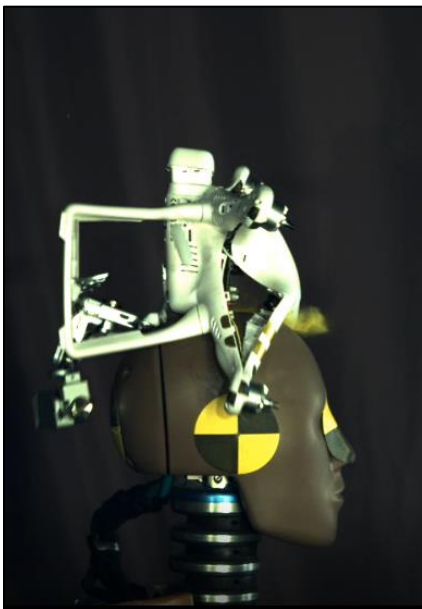


TESTING CAPABILITIES

AVET Lab Abilities

- Adhere to standard test method as outlined by F3389/F3389M
- Able to meet all impact orientations as outlined by F3389/F3389M – Method B, C, & D
- Able to accommodate most small unmanned aircrafts (sUA) Categories 1, 2, & 3
- Capable of achieving both critical speeds & operational speeds for most sUAs
- Adaptability of test apparatus allows for fixed-wing & rotor-wing sUAs, sUA parts, and rigid impactors
- Worst case testing for probable impact orientations
- Photographic & video documentation of testing procedures
- Data collection using data acquisition, instrumentation, and photometric analysis per SAE J211
- Generation of reports with data analysis & results

Test Summary																																							
GENERAL TEST INFORMATION																																							
Test Facility:	NIAR	Customer:	FAA																																				
Facility Test Number:	UA19A-109	Grant Number:	Task A14																																				
Test Date and Time:	11/27/2018 5:20:49 PM	Test Plan Number:	A14 Flight and Drop Test Matrix_Rev48																																				
UAV Model:	Phantom 3	Test Plan Date:	8/9/18																																				
UAV Serial Number:	Calibration Test	Test Plan Test Number:	133																																				
UAV Weight:	2.53 lbs.	Test Plan Test Description:	58 Degree - Front into front of head																																				
		Impact Angle:	58																																				
TEST CONDITIONS																																							
Impact Yaw and Direction:	0 deg Frontal	Laboratory Temperature:	72.3°F																																				
UAV Pitch:	58 deg	66°F to 78°F Maintained for previous 4 hours:	PASS																																				
UAV Roll:	0 deg	Laboratory Humidity:	39.6%																																				
		10% to 70% Maintained for previous 4 hours:	PASS																																				
TEST RESULTS AND INJURY CRITERIA																																							
	Desired	Achieved	ATD S/N: 290																																				
UAV Velocity:	71 ft/s	71.71 ft/s	ATD Weight: 170 lbs																																				
<table border="1"> <thead> <tr> <th>Maximum Peak Values</th> <th>Limit</th> <th>Result</th> <th>Pass/Fail</th> </tr> </thead> <tbody> <tr> <td>Head Acceleration (g)</td> <td>200</td> <td>311.27</td> <td>FAIL</td> </tr> <tr> <td>HIC15</td> <td>700</td> <td>830.20</td> <td>FAIL</td> </tr> <tr> <td>Upper Neck Tension (lbf)</td> <td>937</td> <td>60.26</td> <td>PASS</td> </tr> <tr> <td>Upper Neck Compression (lbf)</td> <td>899</td> <td>999.53</td> <td>FAIL</td> </tr> <tr> <td>Upper Neck Flexion (lbf-ft)</td> <td>140</td> <td>31.29</td> <td>PASS</td> </tr> <tr> <td>Upper Neck Extension (lbf-ft)</td> <td>42</td> <td>14.42</td> <td>PASS</td> </tr> <tr> <td>Upper Neck Shear (lbf)</td> <td>696</td> <td>312.42</td> <td>PASS</td> </tr> <tr> <td>Upper Neck Nij</td> <td>1.0</td> <td>0.76</td> <td>PASS</td> </tr> </tbody> </table>				Maximum Peak Values	Limit	Result	Pass/Fail	Head Acceleration (g)	200	311.27	FAIL	HIC15	700	830.20	FAIL	Upper Neck Tension (lbf)	937	60.26	PASS	Upper Neck Compression (lbf)	899	999.53	FAIL	Upper Neck Flexion (lbf-ft)	140	31.29	PASS	Upper Neck Extension (lbf-ft)	42	14.42	PASS	Upper Neck Shear (lbf)	696	312.42	PASS	Upper Neck Nij	1.0	0.76	PASS
Maximum Peak Values	Limit	Result	Pass/Fail																																				
Head Acceleration (g)	200	311.27	FAIL																																				
HIC15	700	830.20	FAIL																																				
Upper Neck Tension (lbf)	937	60.26	PASS																																				
Upper Neck Compression (lbf)	899	999.53	FAIL																																				
Upper Neck Flexion (lbf-ft)	140	31.29	PASS																																				
Upper Neck Extension (lbf-ft)	42	14.42	PASS																																				
Upper Neck Shear (lbf)	696	312.42	PASS																																				
Upper Neck Nij	1.0	0.76	PASS																																				
<table border="1"> <thead> <tr> <th>Injury Limit Source Legend</th> <th>Modified Nij</th> <th>NCE</th> <th>NCF</th> <th>NTE</th> <th>NTF</th> </tr> </thead> <tbody> <tr> <td>FAA ASNM-03-115.31 (Orange)</td> <td>mNCE 0.46</td> <td>0.44</td> <td>0.76</td> <td>0.17</td> <td>0.03</td> </tr> <tr> <td>FAA 7 mil A14 (Purple)</td> <td>mNCF 0.77</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PROCS-304 (Black)</td> <td>mNTE 0.17</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Limit (Pink)</td> <td>mNTF 0.03</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>DN 204 (Gray)</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>				Injury Limit Source Legend	Modified Nij	NCE	NCF	NTE	NTF	FAA ASNM-03-115.31 (Orange)	mNCE 0.46	0.44	0.76	0.17	0.03	FAA 7 mil A14 (Purple)	mNCF 0.77					PROCS-304 (Black)	mNTE 0.17					Limit (Pink)	mNTF 0.03					DN 204 (Gray)					
Injury Limit Source Legend	Modified Nij	NCE	NCF	NTE	NTF																																		
FAA ASNM-03-115.31 (Orange)	mNCE 0.46	0.44	0.76	0.17	0.03																																		
FAA 7 mil A14 (Purple)	mNCF 0.77																																						
PROCS-304 (Black)	mNTE 0.17																																						
Limit (Pink)	mNTF 0.03																																						
DN 204 (Gray)																																							



sUA IMPACT LAUNCHER

sUA Impact Launcher with Rigid Seat

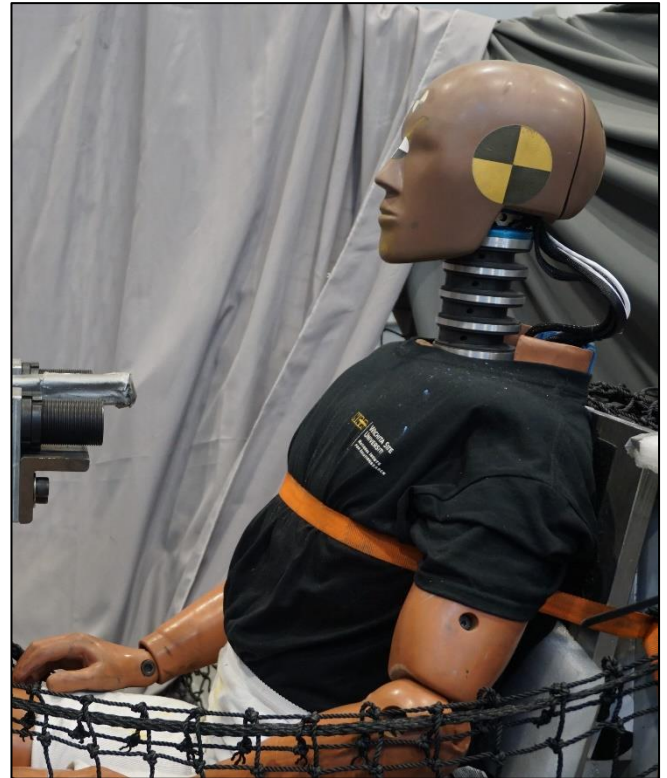
- Adjustability to allow for vertical drops, horizontal impacts, and angled impacts
- Ability to adjust launch speeds to meet various velocity requirements
- Attachable sled permits a variety of fixtures to be mounted to accommodate the variation in sUA orientations
- Lift table with fixed mounting plate provides adjustability and stability
- Rigid Seat offers ability to restrain ATD to increase stability and repeatability of impacts



ATD & DATA ACQUISITION

FAA 50TH Percentile Male Hybrid III

- Instrumented with three head accelerometers
- Three head angular rate sensors
- Six-axis upper neck load cell
- ATD & instrumentation meets standards outlined in SAE J211
- All instrumentation calibrations documented and traceable to national standard
- Targets located at head CGs for photometric tracking
- Colored chalk available to apply on sUA and/or ATD for easy identification of impact areas



Data Acquisition System

- System is used to acquire data during sled tests & component tests and is typically ran at 20,000 samples/second.
- Shock hardened, mega-sample modular data acquisition system
- 96 channels; sampling rate up to 500K samples/sec/channel; programmable analog filtering; full- and half-bridge sensors; accuracy within 0.2%
- Compliant with SAE J211, ISO 6487, and FAA/NHTSA requirements
- NIST traceable calibration performed by Diversified Technical Services
- Uses DTS SLICEWare Data Collection Control and Processing Software



PHOTOMETRIC INSTRUMENTATION

PHOTRON FASTCAM SA-Z Digital High Speed Cameras

- Two (2) Digital High-Speed, High Resolution, Color Imagers (Off-board)
- Two (2) Digital High-Speed, High Resolution, Monochrome Imagers (Off-board)
- 1024x1024 pixilation (at or below 20,000 frames/second)
- Up to 480,000 frames/second (at lower resolution)
- Various lens options



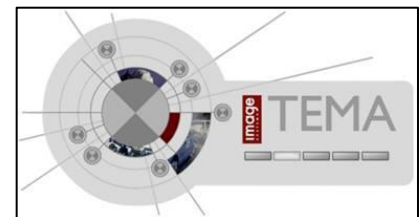
AOS S-VIT Digital High Speed Cameras

- Six (6) Digital High-Speed, High Resolution, Color Imagers (Onboard/Off-board capable)
- 1000 frames/second at 800x600 pixilation
- Onboard junction box and battery
- Color correction
- Improved light sensitivity
- Onscreen display of test number, camera location, time, and frame number
- Various lens options



TEMA Automotive Motion Analysis Photometric Software

- 2D and 3D trajectory plots from both left and right sides of sled
- Simplified lens correction
- Built-in perspective and parallax compensation
- Polynomial spline and other filtration
- 3D tracking with relative camera orientation
- Automatic target tracking
- Virtual point tracking



GOM/Trilion Digital Image Correlation (DIC) Software

- Full-field and point based measurements
- 3D acceleration, velocity, and displacement plots
- Simple system calibration procedure
- Automatic target tracking
- Compatible with industry used CAD and FE software packages

