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The FAA's Center of Excellence for UAS Research
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Alliance for System Safety of UAS through Research Excellence

Task A14: UAS Ground Collision Severity Evaluation 2017-2019

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LIST OF ACRONYMS

AIS^4 – Abbreviated Injury Scale (1=Minor, 2=Moderate, 3=Serious, 4=Severe, 5=Critical, 6=Maximal)

ARC – Advisory and Rulemaking Committee

ATD - Anthropomorphic Test Device

BrIC – Brain Injury Criteria

CG – Center of Gravity

CP – Combined Probability

FAA – Federal Aviation Administration

FE – Finite Element

FEA – Finite Element Analysis

FEM – Finite Element Model

FMVSS - Federal Motor Vehicle Safety Standard

HBM – Human Body Model

HIC – Head injury Criteria

IARV – Injury Assessment Reference Value

KE – Kinetic Energy (The impact KE forms the potential to cause injury due to the vehicle's mass and speed just prior to the collision while the material and structural response of the vehicle influence its ability to transfer KE to an impacted person and cause injury)

MRI – Magnetic Resonance Imaging

MSU – Mississippi State University

NCAP – New Car Assessment Program

NHTSA – National Highway Traffic and Safety Administration

NIAR - National Institute for Aviation Research

N_{ij} – Neck Injury Criteria

OSU – The Ohio State University

PMHS – Post Mortem Human Surrogate, commonly referred to as a cadaver

RSESC – Rotorcraft Systems Engineering and Simulation Center

SUAS – Small Unmanned Aircraft System

THUMS - Total Human Model for Safety

UAH – University of Alabama in Huntsville

UAS – Unmanned Aerial System

UN R94 – United Nations Regulation No. 94

WSU – Wichita State University

VT – Virginia Tech

EXECUTIVE SUMMARY

This 2017-2018 study, A14 Ground Collision Severity Evaluation, focused on increased testing to validate the hypothesis and findings of earlier ASSURE projects: A4 - Ground Collision Severity Evaluation and A11 – Part 107 Waiver Case Study. The testing results from the two previous projects indicate that the injury potential of a small unmanned aircraft system (SUAS) impacting a human is related to the vehicle's impact kinetic energy (KE) as well as the vehicle's construction and material properties that define the structural response during a collision with another body. The impact KE forms the potential to cause injury due to the vehicle's mass and speed just prior to the collision while the material and structural response of the vehicle influence its ability to transfer KE to an impacted person and cause injury. Our previous work developed an initial process for the testing and evaluation of SUAS models for human injury potential. The A4 project indicated that FAA's use of the long-standing Range Commanders Council (RCC) probability of fatality data was overly conservative and largely not applicable to elastic SUAS. However, the scope of the initial studies was limited to testing of a single vehicle, with a limited number of impact tests, and no correlation of the testing results to actual human injury using post mortem human surrogates (PMHS). The Task A14 team included The University of Alabama in Huntsville, The National Institute for Aviation Research at Wichita State University, the Ohio State University, and Mississippi State University. The goal for the Task A14 team was to assess injury potential of various SUAS of different material properties and construction. The team conducted fixed wing and multirotor SUAS failure flight testing and aerodynamic modeling, full anthropomorphic test device (ATD) impact testing, simplified head and neck only ATD impact testing, ATD and human-body model impact simulations, PMHS impact testing, and high-fidelity head and neck only impact simulations. During this project, researchers collected data on over 41 flight test points, 155 simplified impact tests, 133 ATD impact tests, 41 PMHS impact tests, over 100 full-ATD and human-body model impact simulations, and 15 high-fidelity head and neck simulations. Tests were conducted with 16 different multi-rotor and fixed-wing SUAS and objects (payloads, wood blocks and batteries) with weights ranging from 0.75 – 13.2 lbs. The ATD and PMHS testing provided insight into the applicability of automotive injury criteria in SUAS impact scenarios. In addition, experimental testing provided calibration data for ATD and human-body models, and correlation of ATD responses to PMHS injury data. The PMHS testing also enabled assessment of assumed injury thresholds from our previous studies. Only one out of 33 high-speed drone impacts during PMHS testing resulted in one observable skeletal injury. The PMHS testing and analysis of the injury data strongly support our previous study's assessment that the RCC probability of fatality data is overly conservative and largely not applicable to elastic SUAS. The preliminary injury thresholds for SUAS head impacts developed in our earlier work were also overly conservative. The study suggests that concussion may be a common injury outcome in higher energy drone collisions; however, concussion injury risk criteria have not been validated in SUAS impact scenarios and therefore should not be used in establishing regulatory guidelines. Additional PMHS testing is needed to develop more accurate probability-based injury risk curves, similar to those used by the automotive industry, but relevant to the impact characteristics of SUAS. Until they are, we recommend that the FAA use the automotive based injury criteria called out in this report as well as previously developed risk thresholds that have been further developed in this study to assess when additional operational risk mitigations are required to reduce the probability of serious injury.

1 Background

Earlier studies performed by ASSURE that have contributed to the formulation of the A14 Ground Collision Severity Evaluation include tasks A4 Ground Collision Severity and A11 Part 107 Waiver Case Study. [1,2] These tasks were comprised of ground collision studies and tests that were conducted in support of informing rulemaking waivers for SUAS flights operating over people. While the funding and scope of these studies was limited, the two studies provide a framework for quantifying the injury potential of small unmanned aircraft system (SUAS) platforms during collisions with the non-participating public and property on the ground. The Task A4 effort also identified 23 knowledge gaps that formed the basis of recommendations for future research. Following an FAA sponsored Peer Review of the research, specific research gaps were identified and formed the basis for the research questions requested by the FAA that are addressed by the research questions below:

1. As discussed during the FAA sponsored Peer Review, the concept of energy transferred is difficult to quantify. Instead, a comparison of calculated KE prior to impact will be correlated to human injuries using actual measured accelerations and durations. This injury potential of collision with a specific drone at a specific impact energy can be quantified using time histories of resultant acceleration to determine Head Injury Criteria (HIC), peak linear acceleration and rotational acceleration along with other similar metrics to determine concussion and neck injury potential. This research will address injury potential using these and similar metrics rather than KE transferred as stated in the FAA's original research question. Follow on research may be used to create models that correlate structure flexibility, and other structural attributes to human injury potential.
    a. What is a clear and easily repeatable test method to determine the injury potential from the amount of kinetic energy (KE) that is transferred to a person upon impact by a UAS under various conditions and scenarios?
    b. What are the research data (both rotorcraft and fixed wing UAS examples), detailed test methods, and other information that are necessary to develop and validate this type of test?
    c. Does the test method work when a parachute is engaged? How do the results differ?
2. What should an acceptable level of safety for the non-participating public be for such a test described above?
3. What is the energy transferred that would cause a concussion versus the skull fracture that was observed in the first year of research? (See Note above pertaining to energy transferred versus injury potential using other metrics)

2 Scope

The research was conducted over an 18-month period that included peer reviews at the beginning of the research task and after completion of the final reports occurring at the end of

[1] Arterburn, D., Ewing, M., Francis, D., Prabhu, R., Zhu, F., "Final Report for the FAA UAS Center of Excellence Task A4: UAS Ground Collision Severity Evaluation Revision 2", prepared for the FAA under Grant # 15-C-UAS-UAH-01, 03, 28 April 2017.
[2] Arterburn, D., Duling, C., Goli, N., "Final Report for the Task A11 - Part 107 Waiver Request Case Study Revision 1", prepared for the FAA under Grant # 15-C-UAS-UAH-02, 21st October 2016.

the program. The research was broken down into six fundamental tasks intended to answer the following research questions and any related questions that were formulated through the research process.

2.1 Task A: Simple and Repeatable Test Method Development [UAH, WSU]

a. What is a clear and easily repeatable test method to determine the injury potential to a person upon impact by a UAS under various conditions and scenarios?
b. What should an acceptable level of safety for the non-participating public be for such a test described above? This task will address the acceptable levels of safety for the non-participating public including neck injury, skull fracture and concussion.
c. Does the test method work when a parachute is engaged? How do the results differ?
d. What research data (both rotorcraft and fixed wing UAS examples), detailed test methods, and other information that are necessary to develop and validate this type of test?

Assumptions and Limitations. The research will assume the following operating limitations:

a. Development of the simplified test method will utilize test data from Hybrid III 50th percentile male ATD to quantify the initial test method and conduct an initial validation of results.
b. Data from Task B will be used to further validate the test method using a broader range of scenarios than could be accomplished via experimental testing.
c. Energy absorption will not be used as part of this test. The test approach will leverage injury potential as developed in Figure 21 and Figure 22 of the Task A4 Final Report, Revision 2.
d. At a minimum, simplified, ATD and flight-testing will include five aircraft; three multi-rotor and two fixed wing platforms. These vehicle types will be coordinated with the FAA prior to the initiation of testing. Additional platforms may have limited testing conducted to provide additional information as scope and time allows depending on availability of assets, schedule and cost.
e. ATD testing is limited by the number of available vehicles as well as overall cost. Exhaustive testing would require over 640 test points per vehicle, which is neither practical nor feasible within the scope of time and funding available. Testing will also be limited due to schedule and the availability of repair parts for vehicles. Limits of testing based upon the original proposal was 126 ATD impact test points.

2.2 Task B: Human Body Modeling [WSU, UAH]

a. What is a clear and easily repeatable test method to determine the injury potential from the amount of calculated KE that is transferred to a person upon impact by a SUAS under various conditions and scenarios?
b. Does the test method work when a parachute is engaged? How do the results differ?
c. What research data (both for rotorcraft and fixed wing UAS), detailed test methods, and other information that are necessary to develop and validate this type of test?
d. What should an acceptable level of safety for the non-participating public be for a repeatable test method?

Assumptions and Limitations. The research will assume the following operating limitations:

a. Task B will utilize results from the ATD testing done as part of Task A4 in addition to test results obtained during previous testing to calibrate the human body model.
b. Task B will be limited to three vehicles for the modeling effort, but will set the framework for testing a wider set of scenarios and test conditions beyond those available under specific test conditions. The numerical models help the team determine appropriate Post Mortem Human Surrogate (PMHS) test points when other forms of physical testing may be limited or unavailable.

2.3 Task C: High Biofidelity Human Head/Neck Modeling [MSU]

a. What is a clear and repeatable test method to evaluate the amount of KE transferred to the human head/neck model by the impact of a SUAS that would cause the onset of concussion and/or localized injuries such as skull fracture?
b. What is the energy transferred that would cause a concussion versus the skull fracture that was observed in the first year of research?

Assumptions and Limitations. The research will assume the following operating limitations:

a. The human head/neck finite element used is that of a 50^{th} percentile male.
b. Due to the high biofidelity of the human head/neck model (~1.12 Million elements), the computational cost is higher than that of the Total Human Model for Safety (THUMS) model, and it would best fit a study for high accuracy and investigation of localized injuries.

2.4 Task D: PMHS Testing [OSU]

a. What is the injury potential associated with SUAS impacts to human subjects?
b. What is the research data (both rotorcraft and fixed wing UAS examples), detailed test methods, and other information that are necessary to develop and perform this type of test?

Assumptions and Limitations. The research will assume the following operating limitations

a. PMHS testing will be limited to those tests required to validate the model developed in Tasks B and C and validate the injury metrics established by ATD tests and the simplified test developed in Task A (Table A-2).
b. Testing scope will be coordinated with the FAA prior to conducting the testing.
c. Testing will be conducted once Tasks A and B have developed sufficient testing and modeling to determine appropriate validation cases, but no less than six months after grant award.
d. Testing conducted in Tasks A, B, and C will also be utilized and compared with the results of the PMHS testing.
e. While PMHS testing will result in data from which concussion predicting injury criteria can be calculated, only gross injury (i.e. bone fractures) can be documented during autopsy following the impact.
f. Testing will include all limitations that are inherent to full body PMHS testing: lack of muscle activation, subject response variation, etc.

2.5 Task E: Injury Risk Analysis [VT]

a. What is a clear and easily repeatable test method to determine the injury potential to a person upon impact by a UAS under various conditions and scenarios?
b. What should an acceptable level of safety for the non-participating public be for such a test described above? This task will address the acceptable levels of safety for the non-participating public including neck injury, skull fracture and concussion.
c. Does the test method work when a parachute is engaged? How do the results differ?
d. What is the research data (both rotorcraft and fixed wing UAS examples), detailed test methods, and other information that are necessary to develop and validate this type of test?

Assumptions and Limitations. The research will assume the following operating limitations:

a. VT will coordinate test methods and instrumentation approaches for Hybrid III 50th percentile male ATD and PMHS tests to develop common test data for the sharing of test results (Table A-1).
b. VT will attend regular Technical Interchange Meetings (TIMs) with the team to discuss results and coordinate activities.
c. VT will coordinate with industry sponsors of their work to obtain permissions (as appropriate) to share the results with the team and the FAA. It is recognized that the team will comply with the provisions of the agreements with VT's industry partners.

2.6 Task F: Oversight of Research [UAH in conjunction with the PIs from WSU, MSU and OSU (as required)]

There are no research questions addressed by this administrative task.

3 Overview of Research

Research Tasks A-D are mutually supporting tasks to better understand the human injury potential of SUAS. The role that each test and simulation effort fulfills in defining human injury potential for the various SUAS platforms tested is depicted in Figure 1. The impact KE forms the potential to cause injury due to the vehicle's mass and speed just prior to the collision while the material and structural response of the vehicle influence its ability to transfer KE to an impacted person and cause injury. The effort leverages the research conducted as part of Task A4 and Task A11 including the evaluation of the linear relationship between maximum resultant acceleration as a function of impact KE and determining whether this relationship is consistent with human injury potential as defined by PMHS testing. The DJI Phantom 3 and Sensefly eBee+ were common to all testing and modeling efforts to provide continuity between datasets and representation of common multi-rotor and fixed wing configurations. When possible, common impact scenarios were developed to ensure overlap between the various testing methods. PrecisionHawk Lancaster platforms were originally planned to be included in testing and modeling efforts; however, the availability of consistent configurations of these platforms resulted in the decision to remove them from the test program even though these platforms were modeled as part of the effort. Additional flight testing and impact testing (using both the Simplified Testing and ATD testing) was used to broaden the understanding of injury potential of a wider range of vehicles.

The relationships between the various elements of the research shown in Figure 1 are briefly discussed here and have substantially more detail in the approved research plan[3]. Flight Testing was used to evaluate impact velocities, KE, angles and orientations that should be used for Simplified and ATD testing, as well as modeling efforts. The flight testing activity provided validation data for the Aircraft Failure Dynamics Modeling, which is depicted by the linkage between the Aircraft Failure Dynamics Flight Test and Aircraft Failure Dynamics Modeling. Simplified Testing developed lower velocity impact data points, determined the most probable worst case impact orientation of the vehicles, and estimated the impact KE versus Peak Acceleration to evaluate higher velocity impact test points. Task A ATD Testing developed higher velocity impact data points, provided calibration data for modeling efforts in Tasks B and C, and correlated data for Simplified Test and PMHS data. The National Institute for Aviation Research (NIAR) at Wichita State University (WSU) and Mississippi State University (MSU) executed impact simulations with the Human Body Model and Biofidelic Head/Neck, respectively. NIAR developed calibrated aircraft FE models (FEMs) for use in comprehensive simulation of impact testing of specific aircraft. The NIAR simulations were used in conjunction with UAH simplified tests to develop the worst-case impact test points for The Ohio State University (OSU) PMHS Testing. The ATD and Simplified Testing from Task A in conjunction with the modeling efforts in Tasks B and C established impact angles and impact KE parameters for the PMHS testing in Task D. PMHS test results from Task D helped to further refine the models in Task B and C and form the basis for determining the levels of safety required to be used for both the simplified and ATD test methods performed in Task A. While no one test or modeling effort was considered exhaustive or statistically significant for any one vehicle (with the potential exception of the Phantom 3), the research approach further refined three specific test methods; modeling, simplified tests, and ATD tests for evaluating SUAS platforms in terms of human injury potential. The tests are intended to increase the body of knowledge for the FAA in terms of rulemaking for flight over people operations by evaluating the various injury potential test methods and comparing them with actual PMHS injuries. The modeling efforts provide the FAA with refined tools that can be used for evaluating a broader number of SUAS impact scenarios.

[3]Arterburn, Bolte, J., Duma, S., D. Olivares, G., Prabhu, R., Research Plan for the FAA UAS Center of Excellence Task A14: UAS Ground Collision Severity Evaluation – Final, 6 Nov 2017.

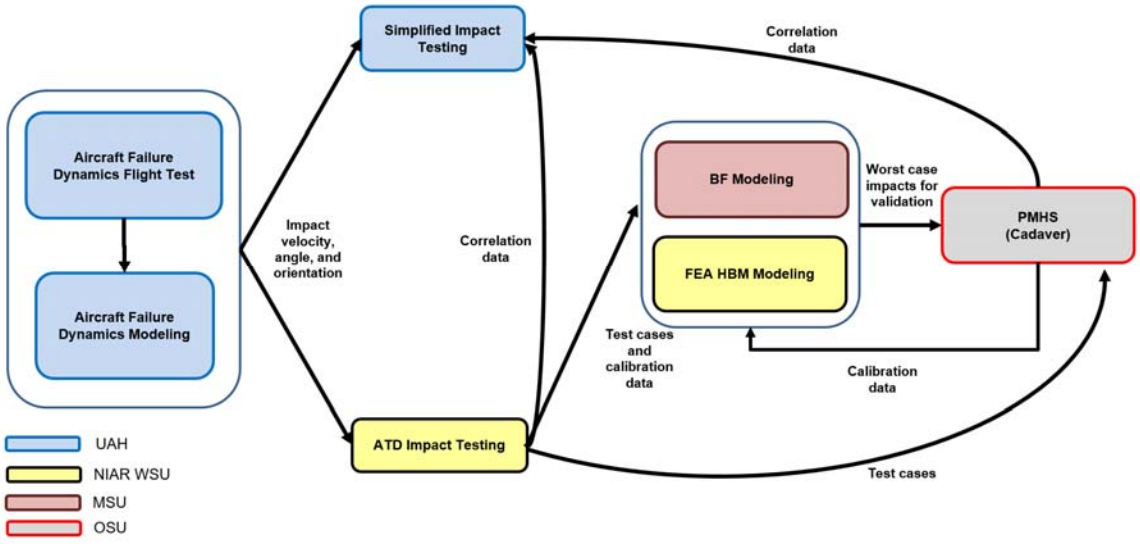

Figure 1 - Data Dependencies for Task A14

Table 1 provides a synopsis of the Task A14 testing and simulation efforts in terms of the vehicles tested during each task, number of tests conducted, and the key data outputs generated by each effort. The Flight Testing effort and Aircraft Failure Dynamic simulations provided aerodynamic information and dynamic response data for a group of eight of the eleven vehicles called out in the original research plan. The number of flight test vehicles was limited by the number of available flight worthy vehicles available and the total assets available to complete all of the overall tests. Flight testing was conducted under no or low wind conditions and test a range of propulsion and control surface failures designed to determine aircraft terminal velocity (multi-rotor vehicles), flat plate drag area estimates (multi-rotor vehicles), glide ratio and airspeed (fixed wing vehicles), and aircraft dynamics. The aircraft failure dynamics simulation provided larger datasets to encompass more combinations of failure types and environmental conditions, which provided insight into credible, worst case failure situations and impact parameters. The dynamic simulation outputs identified the terminal velocity of the respective vehicles based upon their actual configurations and not just ballistic flight performance. These terminal velocity estimates are critical to determining the level of injury that could occur throughout the vehicles operational profile due to an inflight failure from altitudes up to 400 ft above ground level. Simplified Testing produced low velocity impact human injury estimates for a set of seven multi-rotors, five fixed wing vehicles, a wooden block, two foam blocks of different foam thicknesses but common weights to the wood block, a Phantom 3 battery and an SLR camera payload under impact conditions specified during flight-testing and/or dynamic simulation. The ATD testing replicated credible high velocity impacts based on the outputs from flight-testing and dynamic simulation. Simplified Testing and ATD testing was used to support common impact conditions and in some cases support Simplified Testing parameters to help understand the correlation between the two methods. NIAR FEA Calibration impact tests replicated low velocity impact conditions to complete the NIAR dataset of calibrated FEMs that were initially developed with high velocity impacts conducted during the ASSURE Airborne Collision Study - Task A3. The OSU PMHS Impact tests focused on high velocity impacts at and above the limits of the ATD testing in order to provide correlation data for both

the Simplified and ATD impact testing, as well as correlation data for the NIAR and MSU FEA impact simulation efforts. NIAR and MSU impact simulations spanned the low and high velocity impacts with the MSU impact simulations being more narrowly focused on impact velocities and impact KE levels that correlate to head injury thresholds (skull fracture and concussion) and neck injury thresholds for each aircraft model.

Table 1 – Abbreviated Test Matrix Summary

Test/Simulation	Summary of Tests	sUAS/Articles Tested	Key Outputs
UAH Flight Test	80+ flight tests conducted 46 for record tests	**Multi-rotor:** DJI Inspire 2 (parachute), DJI Mavic Pro, DJI Phantom 3, DJI S800, Go Pro Karrma, Vendor 1 Quadrotor, Vendor 3 Quadrotor **Fixed Wing:** eBee+	**Multi-rotor:** V_{term} in vertical fall, vertical and horizontal flat plate drag area estimates, identification of post-failure vehicle dynamics **Fixed Wing:** Aircraft glide ratio, aircraft glide airspeed, stall dynamics, aircraft roll/spin dynamics and descent speeds
UAH Simplified Drop	200+ total tests conducted 153 for record tests conducted 27 test points deleted due to schedule and asset availability	**Multi-rotor:** DJI Inspire 2 (parachute), DJI Mavic Pro, DJI Phantom 3, DJI S800, Go Pro Karrma, Vendor 1 Quadrotor, Vendor 3 Quadrotor **Fixed Wing:** eBee Standard, eBee+, Nano Talon, Radian, Skyhunter **Payloads/Other:** Block, Foam (Steel Core), Block, Foam 2 (Aluminum Core), Block, Wood, DJI Phantom 3 Battery, SLR Camera	**sUAS data:** Impact speed, orientation, kinetic energy (KE) and vehicle configutation and weight **ATD data:** Rotational and linear acceleration **Other:** Assessment of injury metrics and video of test impacts
NIAR UAS Calibration Tests	1 DJI Drop and 24 A11 ATD Tests 10+ eBee Coupon Material and Flat Panel Tests 4 Precision Hawk Rev 3 Coupon Material and Flat Panel Tests	**Multi-rotor:** DJI Phantom 3 **Fixed Wing:** eBee+ and Precision Hawk Rev 3	**sUAS data:** Impact speed, Orientation, Kinetic Energy, and vehicle configuration and weight. **ATD data**: Linear acceleration, Rotational acceleration, neck forces and moments **Other:** Stress/Strain characteristics for coupon material testing, Load Transfer and frangibility of the sUAS for component level tests
NIAR ATD Tests	136 total tests conducted 112 for record tests 24 tests deleted from research plan due to schedule and asset availability or data not used	**Multi-rotor:** DJI Inspire 1, DJI Inspire 2 (parachute), DJI Mavic Pro, DJI Phantom 3, Go Pro Karrma, Vendor 1 Quadrotor, Vendor 3 Quadrotor, **Fixed Wing:** eBee+ **Payloads/Other:** Block, Foam (Steel Core), Block, Wood, DJI Phantom 3 Battery, SLR Camera,	**sUAS data:** Impact speed, orientation, kinetic energy (KE) and vehicle configuration and weight **ATD data:** Linear acceleration, Rotational acceleration, neck forces and moments **Other:** Assessment of injury metrics and video of test impacts
OSU PHMS	41 total tests conducted 3 tests conducted, but scored as a no test 20 tests deleted from research plan due to schedule and asset availability	**Multi-rotor:** DJI Inspire 2 (parachute), DJI Mavic Pro, DJI Phantom 3, Vendor 1 Quadrotor **Fixed Wing:** eBee+ **Payloads/Other:** Block, Foam (Steel Core), Block, Wood	**sUAS data:** Impact speed, orientation, kinetic energy (KE) and vehicle configuration and weight. Vicon data of vehicle motion. **Biomechanical data:** Kinematics of PMHS head and neck. PMHS skull strains; linear accelerations and angular velocities of the head and cervical spine. VICON data of PMHS movement. Vicon data of global PMHS displacement. **Other:** Assessment of injury metrics, autopsy results and video of test impacts. Pre and post test photos. Pre and post test CT scans. Pre and post test X-ray photos.

4 Organization of the Report

The report is organized into a cover report and individual university reports contained in Annexes to the cover report. The cover report summarizes the collective research results and the university reports address the detail of each universities unique research efforts.

4.1 Cover Report

The cover report summarizes the results of the individual universities research efforts and provides the most important conclusions and recommendations identified in the individual university reports and agreed to by all Task A14 universities. All tests and research were conducted as a Task A14 team in accordance with Figure 1 and the Task A14 Research Plan approved by the FAA[3]. Two internal peer reviews of the data were conducted with the principal researchers from each of the universities on 6-7 November and 11-12 December 2018. Select members of the FAA participated in these reviews prior to the FAA peer reviews to identify specific issues or concerns related to the development of test data and the assessment of conclusions and recommendations. The cover report also addresses common metrics and references used amongst the team to ensure consistency across the individual university reports as it relates to injury metrics/standards and nomenclature. The cover report utilizes appendices

to address nomenclature, injury metrics and the test matrix results for the entire Task A14 effort. These appendices serve as a roll-up of these areas and not the specific details of how injury metrics were applied by each of the respective universities nor the details of how each university conducted their test preparation and execution. The cover report is not intended to serve as a cross reference for all the available data within the report but to summarize the most important results and identify the reports that contain more detailed information by reference to the respective university annexes.

4.2 Individual University Reports

Individual university reports provide the specific detail of their respective research conducted as part of the overall task A14 effort shown in Figure 1. The university report content also provides specific test data and data analysis for their respective tests without a broad discussion of how their respective test results may compliment the details of another university's report. Individual university reports are arranged in Annexes to the cover report to allow each university to use their respective report formats and conduct their own internal peer reviews in accordance with their respective university policy.

5 Review of Common Injury Metrics

5.1 Overview

A critical objective of the Task A14 research is to assess human injury potential of SUAS. In order to achieve this objective, the Task A14 research team further evaluated the injury metrics applied as part of the Task A4 and A11 research efforts using peak acceleration and Federal Motor Vehicle Safety Standards (FMVSS) 208 head and neck injury metrics. Additionally, the team explored additional automotive and FAA injury metrics to determine how these metrics could be applied to the assessment of injury potential when compared with actual head and neck injuries resulting from the PMHS tests. A summary of the injury metrics used as part of this research is contained in Table 2.

As discussed in the Task A4 Final Report[1], there are no existing, recognized standards for SUAS-related injury severity classifications and or ways to align those injury classifications with the FAA safety definitions. However, severity classifications/definitions for injury to people (in this context, on the ground) have been found in the medical field and have been predominantly applied to automotive injury or to assess crash dynamics in aircraft accidents.[4,5,6] The Abbreviated Injury Scale (AIS) rates injuries on a 6-level ascending scale of: (1) minor, (2) moderate, (3) serious, (4) severe, (5) critical, and (6) maximal. The FAA System Safety Handbook[7] scale is a 5-level severity scale of: (1) no safety effect, (2) minor, (3) major, (4) hazardous and (5) catastrophic. There is no attempt in this report to correlate these two rating

[4] Association for the Advancement of Automotive Medicine Website, http://www.aaam.org/about-ais.html. Accessed 02/15/2016

[5] States, J., Fenner, H., Flamboe, E., Nelson, W. et al., "Field Application and Research Development of the Abbreviated Injury Scale," SAE Technical Paper 710873, 1971.

[6] Eppinger, R., Sun E., Kuppa, Shashi, Supplement Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, National Highway Transportation Safety Administration, March 2000

[7] https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/risk_management/ss_handbook/, Accessed 05/25/16

scales. To assess injury potential, only the AIS scale or metrics from automotive injury risk metrics are used in conjunction with ATD and actual human injury results from PMHS tests. The 30% probability of an AIS≥3 injury was chosen for evaluation since this limit was selected by the Micro-ARC as the appropriate injury risk for Category 3 operations. ATD tests and PMHS tests were used to evaluate the automotive injury limits and the 30% probability of an AIS≥3 injury limits from automotive injury risk curves to assess the applicability of these metrics to assess SUAS injury potential.

Table 2 – Common Injury Standards for Assessment of SUAS

Injury Criteria	Automotive Injury Limit	Automotive Injury Limit Source	Injury Risk Limit for 30% AIS 3	Injury Risk Source	Units
HIC	700	FMVSS 208	1170	NCAP	N/A
N_{ij}	1	FMVSS 208	1.21	NCAP	N/A
Fzc Compression	-1384.82 (-6160)	FMVSS 208	None Found	-	lbf , (N)
Fzc Tension	1530.05 (6806)	FMVSS 208	None Found	-	lbf , (N)
Myc Flexion	228.64 (310)	FMVSS 208	None Found	-	ft-lbf , (N*m)
Myc Extension	-99.57 (-135)	FMVSS 208	None Found	-	ft-lbf , (N*m)
Mod N_{ij}	1	Duma	None Found	-	N/A
Tension	937 (4170)	FMVSS 208	966 (4297)	NCAP	lbf , (N)
Compression	899 (4000)	FMVSS 208	966 (4297)	NCAP	lbf , (N)
Flexion	140 (190)	IARV	None Found	-	ft-lbf , (N*m)
Extension	42 (57)	UN R94	None Found	-	ft-lbf , (N*m)
Shear	696 (3100)	UN R94	None Found	-	lbf , (N)
*Mod Shear – Side Cond.	244 (1093)	NIAR	244 (1093)**	FAA/AR-09/41	lbf , (N)
Head 3ms	80	UN R94 / FAA ANM-03-115-31	None Found / WSTC	-	g
Peak Head Acceleration	200	FAA ANM-03-115-31	237***	Mertz (2016) Stapp	g
Peak Lateral Moment (M_x)	106 (144)	IARV (Lund)	None Found	-	ft-lbf , (N*m)
Peak Twisting Moment (M_z)	72 (97)	IARV (Lund)	None Found	-	ft-lbf , (N*m)
****BrIC	0.69	Takhounts	0.69	Takhounts (2013) Stapp	N/A
****VT CP	0.95	Duma	0.95*****	Duma	N/A

*Task A14 obtained by direct comparison and scaling of ES-2 shear value when using a FAA HIII ATD: 186 lbf for AIS 3 injury
** This represents 25% probability of an AIS 3 injury
*** This represents 30% probability of an AIS 2 injury
**** Not currently used as limits by any regulatory agency
*****This represents 95% probability of an AIS 1 concussion

It is important to recognize that the FMVSS 208 standards and other automotive standards such as the UN Regulation No. 94 (UN R94) Occupant Protection in Frontal Collisions[8] and the National Highway Transportation Safety Association (NHTSA) Injury Assessment Reference Values (IARV)[9] were developed to analyze impacts to ATDs for the range of vehicle crash tests (minor to severe). The ATD data collected during crash testing is correlated with injury data contained in the AIS database as reported by medical professionals who have experience with injury severity and, most importantly, the mortality resulting from such injuries. While automotive crashes are not the same as SUAS ground collisions, the impact forces and physics as it relates to the ATD are the same and, justifiably, can be analytically evaluated against similar injury metrics associated with automobile accidents until sufficient UAS data becomes available.

[8] 2.3.32.3.7 UN Regulation No. 94, Occupant Protection in Frontal Collisions Uniform Provisions Concerning the Approval of Vehicles with regard to the Protection of the Occupants in the Event of a Frontal Collision https://globalautoregs.com/rules/105-occupant-protection-in-frontal-collisions
[9] Injury Risk Curves and Protection Reference Values https://one.nhtsa.gov/cars/rules/rulings/80g/80gii.html

Many of the FMVSS 208 metrics have limits without reference to specific probability of AIS level injuries making them difficult to correlate with the Micro-UAS Advisory and Rulemaking Committee (ARC) injury standards developed in 2016. As such, the team developed Table 2 to evaluate and compare standards that could be used to better assess the injury potential against both the automotive injury standards and the 30% probability of an AIS≥3 injury established by the Micro-UAS ARC.

The A14 team also evaluated other academic and FAA standards for comparison with test results to expand metrics, where appropriate, to other injury mechanisms and standards.

5.2 New Car Assessment Program (NCAP)[10]

In July 2008, the NHTSA issued a notice proposing to improve not only the 2007 NCAP's front, side and rollover activities, but also approaches to improve its information with regards to rear impact, and certain crash avoidance (or active safety) technologies. As part of the notice, the NCAP established new testing methods and injury standards beyond those published as part of FMVSS 208. Some of the changes incorporated a new AIS+ injury criteria for head injuries that allows the Task A14 team to compare AIS≥3 injuries against the Micro-UAS ARC metric in addition to evaluating AIS≥2 level injuries using the injury risk curve currently outlined in FMVSS 208. Neck injury metrics are largely unchanged for the frontal impact portion of the NCAP and align with the FMVSS 208 injury risk curves.

5.3 Head Injury Metrics

5.3.1 A4 and A11 Peak Acceleration Injury Limit

The A4 and A11 Final Reports[1,2] outlined a skull fracture limit for evaluating injury potential of 198g for peak acceleration. This limit is evaluated extensively throughout the A4 and A11 reports and defined as the onset of skull fracture. Throughout the A14 research, an extensive review of the AIS injury definitions contained on the Association for the Advancement of Automotive Medicine Website[4] identified that skull fractures actually begin as AIS≥2 injury levels and not AIS≥3 injuries. As such, the 198g limit is analyzed extensively throughout the individual university reports. While no assessment is made as to suggesting a new limit value, the research suggests this value is very conservative when compared with other automotive injury risk curves and is also shown to be overly conservative relative to the results of the PMHS testing where actual injuries were evaluated. As a result of the analysis and research results, the team chose to review and analyze other head injury metrics for evaluation as part of this report.

5.3.2 Head Injury Values Using NCAP AIS≥3 Injury Risk Curve

To assess injury potential against the Micro-UAS ARC 30% probability of an AIS≥3 injury, the A14 team shifted various head injury values from their respective limits defined in the automotive standards to limits equivalent to the 30% probability of an AIS≥3 injury risk. The shifted injury risk values are shown in Table 2. When AIS≥3 injury risk curves were available for use as part of a specific metric such as NCAP, the limit value was determined by setting the AIS≥3 injury metric

[10] Consumer Information; New Car Assessment Program. Federal Register, Vol 73, No. 134. National Highway Traffic Safety Administration (Docket No. NHTSA-2006-26555), Department of Transportation, Final Decision Notice, July 2008

to 30%. Shifting of existing automotive values was not always possible for every injury metric as shown in the notes of Table 2.

5.3.3 Modified Skull Fracture Injury Risk Curve

In 2016, a modified injury risk curve for AIS≥2 skull fracture was published by Mertz[11]. The skull fracture AIS≥2 injury risk curve was used in conjunction with the 198g onset of skull fracture limit established in the A4 and A11 Final Report. The AIS≥2 injury risk curve for skull fracture also provided a means for shifting the Peak Acceleration value in comparison to a 30% probability of an AIS≥2 skull fracture as shown in Table 2. The 198g peak acceleration value from the A4 Final Report represents a 9% probability of an AIS≥2 skull fracture based upon this injury risk curve.

5.3.4 Alternative Head Acceleration Standards

The A14 team included the UN R94[8] in the analysis of human injury to address alternative methods of evaluating head acceleration other than the peak acceleration values and HIC_{15} values traditionally used as part of the FMVSS 208 and other injury standards. SUAS collisions tended to have very different acceleration curves depending on the collision type and vehicle construction. The evaluations of the peaks over different time metrics can have a substantial impact on the peak value and the nature of the assessment. See Table 2 for the application of specific metrics vs. their respective injury metric.

5.4 Neck Injury Metrics

5.4.1 Shifting of Neck Injury Standards from FMVSS 208

The A14 team shifted various neck injury values from their respective limits defined in the FMVSS 208 to assess injury potential against the Micro-UAS ARC 30% probability of an AIS≥3 injury. Many of the neck injury metrics, such as neck compression and tension, had no clear alignment with a specific probability of injury as it related to the AIS scale. As such, the team utilized NCAP injury risk curves to shift the FMVSS 208 values to the 30% probability of an AIS≥3 injury. The current FMVSS 208 injury limit of 1.0 represents a 22% probability of an AIS≥3 injury. Furthermore, Table 2 shows the shifted value for N_{ij} from FMVSS 208 to the 30% probability of an AIS≥3 injury. Shifting of existing limit values was not always possible for every neck injury metric as shown in the notes of Table 2.

5.4.2 Modified Shear for Evaluating Neck Injuries During Side Impact Conditions

The FAA Policy Statement PS-ANM-25-03-R1, Technical Criteria for Approving Side-Facing Seats[12] and Supplemental Injury Risk Considerations for Aircraft Side-Facing Seat Certification[13] were used to develop side impact standards that could be applied to ATD type side impact tests to reduce the cost and the time required to use two distinct ATDs during the A14 testing. NIAR worked with the FAA to establish the modified shear metrics as discussed in the NIAR Report contained in Annex B. Since the FAA Hybrid III ATD head and neck were not designed for

[11] Mertz, H., Irwin, A., Prasad, P., Biomechanical and Scaling Basis for Frontal and Side Impact Injury Assessment Reference Values, Stapp Car Crash Journal, Vol. 60 (November 2016), pp. 625-657.

[12] FAA Policy Statement PS-ANM-25-03-R1, Technical Criteria for Approving Side-Facing Seats – Final Report

[13] Moorcraft, D., Taylor, A., DeWeese, R., DOT/FAA/AM-17/2, Supplemental Injury Risk Considerations for Aircraft Side-Facing Seat Certification – Final Report, January 2017

evaluating loads in the lateral direction, a comparison study was conducted in an attempt to correlate lateral impacts on an 50th percentile ES-2re Side Impact ATD to the 50th Percentile FAA Hybrid III ATD. NIAR conducted an experimental comparison study to evaluate the ES-2re Upper Neck injury limits and kinematics compared to the FAA Hybrid III 50th percentile ATD. The results of the experimental study were approved by the FAA for use as part of this research prior to the start of testing. The metrics for the Modified Shear Side Condition is shown in Table 2.

5.5 Concussion Injury Metrics

5.5.1 Brain Injury Criteria (BrIC) - Concussion

The brain injury criteria (BrIC) is used as a measure of evaluating both traumatic and minor brain injury, including concussion.[14] BrIC is defined using angular velocity kinematics only. BrIC has not been used as a regulatory standard for evaluating brain injury risk on a large scale because of the lack of human injury data needed to validate the specific injury limits.

5.5.2 VT Combined Probability Concussion Limits

The VT Combined Probability (CP)[15] of concussion limits were developed to assess the onset of concussion based upon data collected from head kinematics measured from football helmet instrumentation. The VT CP method includes both head rotational and linear acceleration kinematics in the assessment of concussion. The VT CP focuses on onset of concussion injury that is typically only scored as an AIS 1 level injury. Concussions are not typically a fatality risk and as such begin very low on the AIS scale. When football players die from head injuries, it is typically due to ruptured blood vessels in the brain that are AIS 4+ injuries. Therefore, the VT CP concussion curve is considered the onset of a minor brain injury (AIS 1). Other metrics include data for much more severe brain injury such as BrIC.

5.6 Micro-UAS ARC Injury Metrics and Safety Standards

The major distinction between unmanned aerial vehicle (UAV) safety and the safety of manned aircraft is that the failure of a UAV does not *inherently* put people at risk since no pilot or passengers are onboard. Instead, the greatest risk is experienced by those impacted by a UAV on the ground or possibly in another aircraft.

The Micro-UAS ARC, in their 1 April 2016[16] report to the FAA, recommended limits in terms of allowable impact energy density (KE per unit of contact area) on 4 categories of UAS flying in specified flight scenarios to avoid serious injury to persons on the ground due to blunt trauma. In particular, they suggested that allowable energy densities be determined by "industry consensus" standards to avoid an injury rating of AIS≥3 due to an impact with a person on the ground at a rate determined by the category. The allowable rate of serious or worse injury (AIS≥3) due to an impact was calculated at the levels shown in *Table 3*.

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[14] Takhounts EG, Craig MJ, Moorhouse K, McFadden J, Hasija V., Development of brain injury criteria (BrIC), Stapp Car Crash J. 2013 Nov;57:243-66.

[15] Rowson, Steven, Duma, Stefan M., Beckwith, Jonathan G., Chu, Jeffrey J., Greenwald, Richard M., Crisco, Joseph J., Brolinson, P. Gunnar, Duhaime, Ann-Christine, McAllister, Thomas W., Maerlender, Arthur C., "Rotational Head Kinematics in Football Impacts: An Injury Risk Function for Concussion," Annals of Biomedical Engineering, Vol. 40, pp. 1-13, 2012.

[16] http://www.faa.gov/uas/resources/public_records/media/micro-uas-arc-final-report.pdf

Table 3 – Micro-UAS ARC Recommended FAA Allowable Rates of Serious (or worse) Injury Due to an Impact with a Person on the Ground [16]

Category	Flight scenario in which an impact with a person the ground occurs	Acceptable rate of AIS≥3 Injury
2	No less than 20' above, 10' laterally from people	1%
3	In a specified region not over people except ground crew	30%
4	Over crowds, but with operational/other mitigation	30%

While permanent disability is not considered a metric in FAA safety definitions, permanent disability is used in Department of Defense and other injury metrics.[17] Laceration injuries with limited potential for fatality have already caused publicly documented permanent disability injuries. Therefore, permanent disability may define public acceptance of SUAS when operating near or over people.

6 Summary of Results

6.1 Overview

Table 4 shows the number of tests conducted by each university as part of the Task A14 study. The results show a range of data and provide a strong indication of the various constructions of vehicles and vehicle types and the potential for injury within the scope of the tests conducted. In many cases, the multirotor aircraft were tested at or near their terminal velocities and for larger vehicles were tested under the Vendor 2 parachute system to look at the injury potential of a potential parachute mitigation. While one type of parachute was evaluated here, both the platform and the parachute performance have a large impact on the effectiveness of the mitigation for a flight over people application. Results for each of the tasks are detailed in the individual university reports contained in Annex A-D. These reports contain the detailed data from the various Tasks A-F called out in the FAA Peer Reviewed and Approved Task A14 Research Plan[3].

[17] Military Standard, MIL-STD-882E, "Systems Safety", 11 May 2012.

Table 4 – Number of Tests and Vehicle Weights Evaluated in the Task A14 Study

Test Article	Deleted Tests (Note 1)	Total Number of Tests Conducted (Note 2)	Number of Tests				Vehicle Weights in lbf				
			UAH		NIAR	OSU	Nominal	UAH		NIAR	OSU
			Flight Test	Simplified	ATD	PMHS		Flight Test	Simplified	ATD	PMHS
Block, Foam (Steel Core)		43		25	15	3			2.7	2.75	2.75-2.78
Block, Foam 2 (Aluminum Core)		10		10					2.7		
Block, Wood	4	43		25	15	3			2.7	2.72-2.73	2.81
DJI Inspire 1	11	1	1					7.49			
DJI Inspire 2	6	8	4		3	1	8.82	9.82		9.11-9.15	9.59
DJI Mavic Pro	16	32	9	10	9	4	1.64	2.47	1.64	1.58	1.58-1.67
DJI Matrice 200	2	0					13.5		13.5		
DJI Phantom 3	5	66	11	7	27	21	2.67	3.13	2.67	2.45-2.59	2.44-2.67
DJI Phantom 3 battery		12		8	4		0.805		0.805		
DJI S800	4	16	12	4			13.2		13.2		
Go Pro Karma		36	17	12	7		4.07	4.83	4.07	4.14-4.17	
Nano Talon	4	6		6			1.5		1.5		
Radian	4	6		6			2.5		2.5		
Skyhunter	4	6		6			3		3		
SenseFly eBee		6		6			1.52		1.52		
SenseFly eBee+	8	26	5	6	10	5	2.4	2.87	2.58	2.51-2.55	2.43-2.48
SLR Camera	6	6		6			1.7		1.23		
Vendor 1 (with cage)(Quadcopter)	3	49	10	17	18	4	0.727	0.95	0.73	0.708-0.714	0.73-0.77
Vendor 1 (without cage)(Quadcopter)		9	9				0.6	0.84			
Vendor 3 (Quadcopter)(Note 3)		14	2	8	4		4.2	5.2	4.2		
Total	77	395	80	162	112	41					

Notes:
1. Deleted tests are from original test matrix. Deleted tests in many cases were due to availability of vehicles or by the number of PMHS assets.
2. Number of tests are the number of for record tests and do not include repeat tests for calibrating launchers or NIAR calibrarion tests for material evaluation.
3. Vendor 3 added after the initial test matrix was established.

6.2 PMHS, ATD and THUMS Model Comparisons

During the Task A14 severity evaluation, full body UAS impact tests were conducted on three different surrogate types: the THUMS FE model, the FAA Hybrid III ATD, and PMHS. To compare the response of the 3 surrogates, several common test scenarios were selected, each involving different impact directions, impact locations, and impact vehicles. For the purposes of this comparison, the response of the PMHS was considered the baseline response. Compared to the PMHS, both the THUMS and FAA Hybrid III obtained lower head kinematic values (Table 5). On average, FAA Hybrid III peak kinematics were 40%, 27% and 30% lower for head linear acceleration, angular velocity and angular acceleration, respectively. Whereas, THUMS peak kinematics were 44%, 24% and 21% lower for linear acceleration, angular velocity and angular acceleration, respectively.

There are several possible explanations for the decreased response of the FAA Hybrid III and THUMS in comparison to PMHS. First, previous studies have found increased neck stiffness in the THUMS and FAA Hybrid III when compared to PMHS and volunteers, which could lead to different head kinematics.[18,19] Additionally, the FAA Hybrid III head was only validated in drop testing forehead impacts on to a rigid plate.[20,21] This limited impact scenario may not capture the full frequency response of the human head, or the dampening effects of the FAA Hybrid III skin in other loading scenarios, such as UAS impact cases. Likewise, the THUMS has been validated in low-severity inertial load cases, or scenarios where the head was fixed in place.[22,23]

[18] Moorhouse, K., Donnelly, B., Kang, Y. S., Bolte IV, J. H., & Herriott, R. (2012). Evaluation of the internal and external biofidelity of current rear impact ATDs to response targets developed from moderate-speed rear impacts of PMHS (No. 2012-22-0005). SAE Technical Paper.
[19] Paas, R., Davidsson, J., & Brolin, K. (2015). Head kinematics and shoulder biomechanics in shoulder impacts similar to pedestrian crashes—a THUMS study. Traffic injury prevention, 16(5), 498-506.
[20] Hodgson, V. R., & Thomas, L. M. (1971). Comparison of head acceleration injury indices in cadaver skull fracture. *SAE Transactions*, 2894-2902.
[21] Mertz, H. J. (1985). *Biofidelity of the Hybrid III head* (No. 851245). SAE Technical Paper.
[22] Ewing, C. L., Thomas, D. J., Beeler, G. W., Patrick, L. M., & Gillis, D. B. (1968). *Dynamic Response of the Head and Neck of the Living Human to—G x Impact Acceleration* (No. 680792). SAE Technical Paper.
[23] Yoganandan, N., Pintar, F. A., Sances, A., Walsh, P.R., Ewing, C.L., Thomas, D.J., Snyder, R.,G. (1995). Biomechanics of skull fracture. *Journal of neurotrauma*, *12*(4), 659-668.

Thus, the model's validity in high-severity, direct impacts such as UAS scenarios should be investigated further. Furthermore, differences in instrumentation techniques may influence measured kinematics. PMHS head kinematics were recorded using a sensor array mounted on the periphery of the skull.[24,25] However, localized skull deformation in response to severe UAS impacts may affect measured kinematics when using these peripheral sensors; more detail is given in OSU Annex C and NIAR Annex B. Finally, differences in head kinematics could be due to one or many of other experimental testing variables, including: UAS impact location, subject head shape, UAS FE model calibration, subject boundary conditions, ATD biofidelity, FE model biofidelity, and PMHS anatomical variation. Further investigation is needed to determine which of these factors played a role in the differences observed during testing. Despite the variations in response of the three surrogates, the individual conclusions drawn from the current study remain valid, so long as the conclusions pertaining to a given surrogate are not extrapolated and applied to a different type of surrogate.

Table 5 -Percent Difference between PMHS, FAA HIII ATD & THUMS Model

	% Difference Linear Acceleration	% Difference Angular Velocity	% Difference Angular Acceleration
PMHS #1, Phantom 3, 0deg, right side, 61 fps			
FAA Hybrid III	-56	-4	13
THUMS	-28	-29	29
PMHS #2, Phantom 3, 90deg, top, 65 fps			
FAA Hybrid III	-39	-58	-30
THUMS	-57	-37	-31
PMHS #3, Phantom 3, 58deg, front, 71 fps			
FAA Hybrid III	-46	-44	-61
THUMS	-53	-12	-32
PMHS #4, eBee+, 0deg, right side, 64 fps			
FAA Hybrid III	-19	-3	-40
THUMS	-39	-16	-50

6.3 Assessment of Injury Metrics

The results shown in the individual university reports support the key conclusions and recommendations made below to define a range of ATD injury metrics. The metrics derived from the automotive injury risk metrics could be used to address SUAS tests to determine the injury potential of specific SUAS vehicles. Individual SUAS vehicles have unique impact characteristics based upon the construction and material composition in addition to their weight and impact KE should a collision occur with a person on the ground. For the PMHS testing conducted to date, multiple SUAS impacts exceeded the previously mentioned limits without injury. Moreover, no AIS≥3 level injuries were observed in PMHS testing, indicating that the proposed limits may be over-conservative. The 30% probability of an AIS≥3 injury was chosen for evaluation since this limit was selected by the Micro-ARC as the appropriate injury risk for

[24] Kang, Y. S., Moorhouse, K., & Bolte IV, J. H. (2015, June). Instrumentation technique for measuring six degrees of freedom head kinematics… In 24th International Technical Conference on the Enhanced Safety of Vehicles (ESV) (pp. 8-11).
[25] Yoganandan, N., Zhang, J., Pintar, F. A., & Liu, Y. K. (2006). Lightweight low-profile nine-accelerometer package to obtain head angular accelerations in short-duration impacts. Journal of biomechanics, 39(7), 1347-1354.

Category 3 operations. The 30% probability of AIS≥3 injury risk metrics applied to ATD impact tests could potentially be used as a baseline for the Category 2 operations requiring 1% probability of an AIS≥3 injury; additionally, these limits are corroborated by the fact that no AIS≥3 injuries occurred during the PMHS tests. Additional unique PMHS tests could be used to assess actual human injury for vehicles desiring full envelope evaluation without any conservatism. Additionally, PMHS tests could be conducted when the manufacturer cannot pass the ATD test thresholds and still desires a category 2 label.

Table 6 shows the standard automotive injury metric limits, the proposed threshold values for 30% chance of AIS≥3 injury, and the injury thresholds associated with the wood block impacts at 11 ft-lbf and 25 ft-lbf that are defined in the recently published Draft Notice of Proposed Rulemaking for Operations of Small Unmanned Aircraft Systems over People[26].

Table 6 – Potential Interim Category 2 ATD Metrics for Use in Establishing Category 2 and 3 Operations

Injury Criteria	Units	Automotive Standards Limit	Automotive Injury Risk Limit for 30% AIS ≥ 3	ATD Wood Block Testing Evaluation of 11 ft*lb Limits	ATD Wood Block Testing Evaluation of 25 ft*lb Limits
HIC15	N/A	700	1170	586.7	1333.4
N_{ij}	N/A	1	1.21	.76 (Note 3)	1.07 (Note 3)
Compression	lbf , (N)	899 (4000)	966 (4297)	1055 (4692) (Note 4)	1473 (6552) (Note 4)
Peak Resultant Head Acceleration	g	200	237(Note 1)	198 (Note 2)	384 (Note 2)

1. This represents 30% probability of an AIS 2 or greater skull fracture
2. Average values of linear, power fit and worse case impact oreitnation evaluation of a wood block.
3. Worst case Nij Power Fit of 58 deg Sideward Angled Impact with a Wood Block
4. Worst case Power Fit of compression data from ATD impact tests with a Wood Block

While the use of automotive injury metrics do not specifically capture the impact dynamics of SUAS, the results of the Task A14 testing and analysis provide a more realistic and scientifically developed framework for evaluating SUAS using these injury metrics. Furthermore, these metrics represent the worst case impact scenarios that are extremely difficult to achieve in even the most refined test conditions let alone in the public domain where vehicles and humans are not constrained to the boundary conditions found in typical ATD tests. All of the researchers in this study agree that the development of injury risk curves specific to SUAS collision dynamics should be developed and will require additional research. This research is considered essential

[26] Draft Notice of Proposed Rulemaking for Operations of Small Unmanned Aircraft Systems over People, DOT Docket Number RIN 2120-AK85

to refine the metrics outlined in this report and to achieve the full operational capability of SUAS operations over people in the National Airspace System.

The modeling efforts discussed in Annex A and Annex B include the use of aerodynamic modeling from flight test as well as human body modeling, respectively. Both modeling efforts effectively support injury assessments or address assessments of injury potential for a variety of operational and environmental impact scenarios. To continue to evolve the risk assessment of the operations of various vehicles, these modeling efforts should continue to support the development of Monte Carlo simulations of vehicle failure footprints and descent rates as well as the assessment of human injury for both new designs and scenario driven operational risk assessments based upon injury potential of the vehicles.

7 Key Conclusions and Recommendations

7.1 PMHS Human Injury Tests (OSU)

During the 33 UAS impacts carried out during this study, only one moderate skeletal injury was observed: a 5.1-inch AIS≥2 level skull fracture of the frontal bone. The injury occurred on a 71 ft/s, 58°, frontal impact with the DJI Phantom 3. The occurrence of this injury indicates that UAS impacts with the uninvolved public may pose a threat to public safety without appropriately established regulatory standards unique to SUAS collision dynamics.

Recommendation: More testing is needed to determine the specific prevalence and probability associated with skull fracture injuries in UAS impact scenarios.

7.2 Assessment of the 198g Peak Head Acceleration Metric (UAH, NIAR, OSU)

The proposed head acceleration limit of 198g is a conservative limit according to PMHS test data presented in this report. Of the 33 UAS tests conducted on 4 separate PMHS, 17 tests recorded linear accelerations above 198g. Of these 17 tests, only 1 skull fracture was observed. Based on a simple analysis of probability, 198g corresponds to about a 8% risk of sustaining an AIS≥2 or greater skull fracture due to SUAS impact.

7.3 Assessment of Skull Fracture Metrics (OSU)

Kinematics measured during PMHS tests indicate that automotive injury metrics may not be able to accurately predict skull fracture in the UAS scenario. To assess the risk of skull fracture, the Head Injury Criteria (HIC) and its associated risk curve were compared to PMHS head kinematics. Based on the HIC criteria, 5 UAS impacts had greater than an 85% probability of causing a skull fracture; yet only 1 skull fracture was observed.

Recommendation: Additional investigation is needed to determine appropriate criteria or limits to be used for predicting the severity of head injuries in UAS impact scenarios.

7.4 Assessment of Vehicle Variability on Injury Potential (UAH, NIAR, OSU)

The injury potential of a UAS impact depends on which vehicle model is being used as well as which injury mechanism is being investigated. Vehicles with less mass and lower stiffness characteristics, such as the eBee+ and Vendor 1 displayed a low risk of skull fracture, while heavier and stiffer vehicles such as the Phantom 3 and Mavic Pro incurred a higher risk of skull fracture. However, lightweight and flexible vehicles still display the potential to cause minor injuries such as concussion.

7.5 Assessment of Vehicle Impact Orientation and Location on Human Injury Potential (UAH, NIAR, OSU)

Small changes in SUAS impact orientation, Center of Gravity (CG) alignment of the skull and SUAS impact location, were found to cause large changes in impact energy transfer. For example, a 9° pitch downward and 2 inch offset during a 58° Phantom 3 test caused a 73% reduction in linear acceleration of the head. In ATD test replications of the worst case frontal angled impact from PMHS testing, an impact location offset of 0.5 inches on the surface of the ATD head form was shown to cause 30% difference in HIC and peak acceleration and 20% difference in neck compression loading.

Recommendation: While head injuries may occur as a result of UAS impacts, work is needed to define how likely these "worst case" impacts are to occur real life.

Recommendation: Due to the large scope of vehicles, test orientations and impact locations selected for this testing, few strong conclusions can be drawn concerning the risk of injury associated with UAS head impacts. It is recommended that future UAS impact studies focus on more clearly defining the injury thresholds and risks associated with UAS collisions. To accomplish this, probabilistic modelling can be employed to develop injury risk curves which define the likelihood of sustaining an injury based on parameters which are specific to UAS impacts. Development of such a curve would more accurately define what is safe and unsafe in terms of UAS operation.

7.6 Assessment of Concussion Criteria for Use in Regulatory Standards (OSU)

Based on injury criteria developed to predict concussions in the football and automotive environments, most UAS impacts were likely to cause a concussion. However, current concussion diagnosis is based on verbal and motor skills tests, something not possible in PMHS testing. Thus, while UAS impacts caused concussion level kinematics, actual concussions could not be assessed in this scenario.

Recommendation: Due to inconsistency between concussion metrics measured during PMHS testing, as well as disagreement within the scientific community concerning which metric is more accurate, a concussion threshold for use in regulatory standards should be delayed until such a time when a more definitive and consensus-based criterion has been established.

7.7 Flight Testing of SUAS for Impact Studies (UAH)

Failure flight testing is essential for evaluating a vehicle's post-failure dynamic behavior to determine if the aircraft tumbles or stabilizes in a predictable orientation while falling.

Recommendation: Longer periods of data logging would further improve the fidelity of aerodynamic analysis and follow-on failure modeling and simulation. Flight testing must be conducted under as low of winds as possible in order to provide solid data for aerodynamic analysis. Winds and gusty conditions during flight test lead to inaccurate estimates of aircraft aerodynamic properties.

7.8 Assessment of Simplified Apparatus (UAH)

Impact testing using a full ATD Hybrid III or a simplified apparatus provides the capability of estimating injury potential/fatality risk based upon impact KE and resultant acceleration of the head for specific aircraft. Based on using a range of injury criterion, e.g. HIC_{15}, 3ms Minimum g-

loading, Virginia Tech Combined Probability of Concussion, Brain Injury Criteria, and Peak Resultant Acceleration, impact testing provides regulators with a range of options for setting injury thresholds that address multiple injury types and mechanisms.

7.9 Assessment of Energy Absorption Based Test Methods (UAH, NIAR, OSU)

Energy absorption-based testing methods cannot provide data that clearly translates to existing injury severity standards while addressing multiple injury types like skull fracture and concussion.

Recommendation: The FAA should support a comparison of energy based test methods and the data contained in this report to provide a clear understanding of how energy based test methods are capable of assessing injury potential for head and neck injuries typically associated with SUAS impacts following failures.

7.10 Assessment of ATD Impact Testing for SUAS (UAH, NIAR)

SUAS impact testing using Hybrid III ATDs can provide regulators a method for evaluating injury potential and risk based assessments using the modified injury metrics established in this report for multirotor and fixed-wing platforms up to 8-10 lbf and larger platforms up to 55 lbf at parachute impact speeds. The use of this data also supports a risk based approach to determine when and if additional operational mitigations are required for specific concept of operations.

7.11 Assessment of Puller Propeller Fixed Wing SUAS (UAH)

Fixed Wing aircraft impact test results show that puller prop aircraft have upwards of three times the injury potential to that of a pusher prop due to the pointed spinner and the concentrated mass of the prop, spinner, and motor located at the initial contact point. Without substantial mitigations to reduce the sharpness and impact severity during ground collision, puller prop platforms are not suitable for flight over people due to their increased injury potential and high increased impact velocities following failures.

7.12 Assessment of Externally Mounted Equipment and Batteries (UAH)

Externally mounted equipment and batteries that become dislodged can present a more substantial injury risk than that of the SUAS itself at equivalent impact KE. Components like batteries and cameras are typical denser and have less flat plate drag area than a multirotor aircraft, which makes them rigid and likely to impact at higher velocities than the aircraft themselves.

Recommendation: The FAA should develop performance-based standards for component mounting latches and other mechanisms for securing components to aircraft, e.g. minimum g-loading limits for latches to retain components if an operator is seeking approval for operations over people.

7.13 Examples of SUAS Platforms Appropriate for Flight Over People (UAH, NIAR, OSU)

The Vendor 1 Quadrotor and eBee+ fixed-wing aircraft testing showed that these aircraft have very low risk of causing skull fracture, head injuries, or neck injuries throughout their entire flight envelope and are good examples of platforms appropriate flight over people over approvals.

Appendix A: Test Matrix

Table A-1 - NIAR ATD Tests

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
1	UA19A-23	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Top Into Head
2	UA19A-25	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Side Into Head
3	UA19A-27	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Arm Into Head
4	UA19A-24	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Top Into Head
5	UA19A-26	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Side Into Head
6	UA19A-28	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Arm Into Head
7	UA19A-21	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Bottom Into Head
8	UA19A-22	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Bottom Into Head
9	UA19A-83	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	36	53.8	Sideward	Worst Case Orientation
10	UA19A-84	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	56	130.1	Sideward	Worst Case Orientation
11	UA19A-85	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	61	154.4	Sideward	Worst Case Orientation
12	UA19A-86	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	65	175.3	Sideward	Worst Case Orientation
13	UA19A-29	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	55	125.5	Top	Worst Case Orientation
14	UA19A-30	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	65	175.3	Top	Worst Case Orientation
15	UA19A-43	NIAR ATD Drop	DJI Phantom 3	Angled Impact	56	130.1	58 deg forward	Worst Case Orientation
16	UA19A-44	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg forward	Worst Case Orientation
17	UA19A-45	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg forward	Worst Case Orientation
18	UA19A-46	NIAR ATD Drop	DJI Phantom 3	Angled Impact	56	130.1	58 deg rearward	Worst Case Orientation
19	UA19A-47	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg rearward	Worst Case Orientation
20	UA19A-48	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg rearward	Worst Case Orientation
21	UA19A-39	NIAR ATD Drop	DJI Phantom 3	Angled Impact	36	53.8	58 deg - Sideward	Worst Case Orientation
22	UA19A-40	NIAR ATD Drop	DJI Phantom 3	Angled Impact	56	130.1	58 deg - Sideward	Worst Case Orientation
23	UA19A-41	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg - Sideward	Worst Case Orientation
23B	UA19A-41B	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg - Sideward	Worst Case Orientation
24	UA19A-42	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg - Sideward	Worst Case Orientation

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
23B	UA19A-41B	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg - Sideward	Worst Case Orientation
24	UA19A-42	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg - Sideward	Worst Case Orientation
25	UA19A-31	NIAR ATD Drop	eBee +	Vertical Impact	50	93.2	Top	Worst Case Orientation
26	UA19A-32	NIAR ATD Drop	eBee +	Vertical Impact	60	134.2	Top	Worst Case Orientation
27	UA19A-87	NIAR ATD Drop	eBee +	Horizontal Impact	25	23.3	Sideward	Worst Case Orientation
28	UA19A-88	NIAR ATD Drop	eBee +	Horizontal Impact	36	48.3	Sideward	Worst Case Orientation
29	UA19A-89	NIAR ATD Drop	eBee +	Horizontal Impact	59	129.7	Sideward	Worst Case Orientation
30	UA19A-90	NIAR ATD Drop	eBee +	Horizontal Impact	64	152.6	Sideward	Worst Case Orientation
31	UA19A-49	NIAR ATD Drop	eBee +	Angled Impact	25	23.3	58 deg - Sideward*	Worst Case Orientation
32	UA19A-50	NIAR ATD Drop	eBee +	Angled Impact	36	48.3	58 deg - Sideward*	Worst Case Orientation
33	UA19A-51	NIAR ATD Drop	eBee +	Angled Impact	59	129.7	58 deg - Sideward*	Worst Case Orientation
34	UA19A-52	NIAR ATD Drop	eBee +	Angled Impact	64	152.6	58 deg - Sideward*	Worst Case Orientation
35	UA19A-01	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Bottom Into Head
36	UA19A-03	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Top Into Head
37	UA19A-05	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Side Into Head
38	UA19A-02	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Bottom Into Head
39	UA19A-04	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Top Into Head
40	UA19A-06	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Side Into Head
41	UA19A-07	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Arm Into Head
42	UA19A-08	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Arm Into Head
43	UA19A-15	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Worst Case Orientation
44	UA19A-16	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Worst Case Orientation
45	UA19A-17	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Worst Case Orientation
46	UA19A-18	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Worst Case Orientation
47	UA19A-19	NIAR ATD Drop	Vendor 1	Vertical Impact	45	23.0	Top	Worst Case Orientation
48	UA19A-20	NIAR ATD Drop	Vendor 1	Vertical Impact	55	34.3	Top	Worst Case Orientation

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
49	UA19A-35	NIAR ATD Drop	Vendor 1	Angled Impact	45	23.0	80 deg forward	Worst Case Orientation
50	UA19A-36	NIAR ATD Drop	Vendor 1	Angled Impact	55	34.3	80 deg forward	Worst Case Orientation
51	UA19A-37	NIAR ATD Drop	Vendor 1	Angled Impact	45	23.0	80 deg - Sideward	Worst Case Orientation
52	UA19A-38	NIAR ATD Drop	Vendor 1	Angled Impact	55	34.3	80 deg - Sideward	Worst Case Orientation
53	UA19A-09	NIAR ATD Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface Forward
54	UA19A-10	NIAR ATD Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface Forward
55	UA19A-11	NIAR ATD Drop	Block, Wood	Vertical Impact	30	37.8	Top	Flat Surface Forward
56	UA19A-103	NIAR ATD Drop	Block, Wood	Horizontal Impact	20	16.8	Forward	Flat Surface Forward
57	UA19A-101	NIAR ATD Drop	Block, Wood	Horizontal Impact	30	37.8	Forward	Flat Surface Forward
58	UA19A-102	NIAR ATD Drop	Block, Wood	Horizontal Impact	40	67.1	Forward	Flat Surface Forward
59	UA19A-91	NIAR ATD Drop	Block, Wood	Horizontal Impact	20	16.8	Sideward	Flat Surface Forward
60	UA19A-92	NIAR ATD Drop	Block, Wood	Horizontal Impact	30	37.8	Sideward	Flat Surface Forward
61	UA19A-93	NIAR ATD Drop	Block, Wood	Horizontal Impact	40	67.1	Sideward	Flat Surface Forward
62	UA19A-62	NIAR ATD Drop	Block, Wood	Angled Impact	20	16.8	58 deg - Forward	Flat Surface Forward
63	UA19A-63	NIAR ATD Drop	Block, Wood	Angled Impact	30	37.8	58 deg - Forward	Flat Surface Forward
64	UA19A-64	NIAR ATD Drop	Block, Wood	Angled Impact	40	67.1	58 deg - Forward	Flat Surface Forward
65	UA19A-56	NIAR ATD Drop	Block, Wood	Angled Impact	20	16.8	58 deg - Sideward	Flat Surface Forward
66	UA19A-57	NIAR ATD Drop	Block, Wood	Angled Impact	30	37.8	58 deg - Sideward	Flat Surface Forward
67	UA19A-58	NIAR ATD Drop	Block, Wood	Angled Impact	40	67.1	58 deg - Sideward	Flat Surface Forward
68	UA19A-12	NIAR ATD Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface Forward
69	UA19A-13	NIAR ATD Drop	Block, Foam (Steel	Vertical Impact	20	16.8	Top	Flat Surface Forward
70	UA19A-14	NIAR ATD Drop	Block, Foam (Steel	Vertical Impact	30	37.8	Top	Flat Surface Forward
71	UA19A-97	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	20	16.8	Forward	Flat Surface Forward
72	UA19A-98	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	40	67.1	Forward	Flat Surface Forward
73	UA19A-99	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	60	151.1	Forward	Flat Surface Forward
74	UA19A-96	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	20	16.8	Sideward	Flat Surface Forward
75	UA19A-94	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	40	67.1	Sideward	Flat Surface Forward
76	UA19A-95	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	60	151.1	Sideward	Flat Surface Forward
77	UA19A-59	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	20	16.8	58 deg - Forward	Flat Surface Forward
78	UA19A-60	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	40	67.1	58 deg - Forward	Flat Surface Forward
79	UA19A-61	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	60	151.1	58 deg - Forward	Flat Surface Forward
80	UA19A-53	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	20	16.8	58 deg - Sideward	Flat Surface Forward
81	UA19A-54	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	40	67.1	58 deg - Sideward	Flat Surface Forward
82	UA19A-55	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	60	151.1	58 deg - Sideward	Flat Surface Forward
83	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Arm Into Head
84	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Arm Into Head
85	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Between Arms Forward
86	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Between Arms Forward
87	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Between Arms Side
88	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Between Arms Side
89	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Bottom Into Head
90	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Bottom Into Head
91	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Top Into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
92	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Top Into Head
93	UA19A-75	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	50	63.7	Top	Worst Case Orientation
94	UA19A-76	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	61	94.8	Top	Worst Case Orientation
95	UA19A-72	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	40	40.8	58 deg forward	Worst Case Orientation
96	UA19A-73	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	50	63.7	58 deg forward	Worst Case Orientation
97	UA19A-74	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	61	94.8	58 deg forward	Worst Case Orientation
98	UA19A-69	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	40	40.8	58 deg - Sideward	Worst Case Orientation
98B	UA19A-69B	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	40	40.8	58 deg - Sideward	Worst Case Orientation
99	UA19A-70	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	50	63.7	58 deg - Sideward	Worst Case Orientation
100	UA19A-71	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	61	94.8	58 deg - Sideward	Worst Case Orientation
101	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	8	7.5	Top	**Bottom Into Head**
102	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	16	29.8	Top	**Bottom Into Head**
103	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	8	7.5	Top	**Nose Into Head**
104	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	16	28.1	Top	**Nose Into Head**
105	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	30	104.8	Top	Worst Case Orientation
106	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	40	186.2	Top	Worst Case Orientation
107	Deleted	NIAR ATD Drop	DJI Inspire 1	Angled Impact	30	104.8	55 deg sideward	Worst Case Orientation
108	Deleted	NIAR ATD Drop	DJI Inspire 1	Angled Impact	40	186.2	55 deg sideward	Worst Case Orientation
109	UA19A-77	NIAR ATD Drop	Karma	Vertical Impact	40	101.2	Top	Worst Case Orientation
110	UA19A-78	NIAR ATD Drop	Karma	Vertical Impact	50	158.1	Top	Worst Case Orientation
111	UA19A-65	NIAR ATD Drop	Karma	Angled Impact	40	101.2	58 deg forward	Worst Case Orientation
112	UA19A-66	NIAR ATD Drop	Karma	Angled Impact	50	158.1	58 deg forward	Worst Case Orientation
112B	UA19A-66B	NIAR ATD Drop	Karma	Angled Impact	50	158.1	58 deg forward	Worst Case Orientation
113	UA19A-67	NIAR ATD Drop	Karma	Angled Impact	40	101.2	58 deg - Sideward	Worst Case Orientation
114	UA19A-68	NIAR ATD Drop	Karma	Angled Impact	50	158.1	58 deg - Sideward	Worst Case Orientation
115	UA19A-81	NIAR ATD Drop	Vendor 3	Vertical Impact	40	109.4	Top	Worse Case
116	UA19A-82	NIAR ATD Drop	Vendor 3	Vertical Impact	50	170.9	Top	Worse Case
117	UA19A-106	NIAR ATD Drop	Vendor 3	Angled Impact	40	109.4	58 deg - Angled	Worse Case
118	UA19A-107	NIAR ATD Drop	Vendor 3	Angled Impact	50	170.9	58 deg - Angled	Worse Case
119	UA19A-79	NIAR ATD Drop	DJI Phantom 3 battery	Vertical Impact	40	20.0	Top	Impact with smallest surface
120	UA19A-80	NIAR ATD Drop	DJI Phantom 3 battery	Vertical Impact	60	45.0	Top	Impact with smallest surface
121	UA19A-104	NIAR ATD Drop	DJI Phantom 3 battery	Horizontal Impact	40	20.0	Forward	Impact with smallest surface
122	UA19A-105	NIAR ATD Drop	DJI Phantom 3 battery	Horizontal Impact	60	45.0	Sideward	Impact with smallest surface
123	Deleted	NIAR ATD Drop	SLR Camera	Vertical Impact	25	16.5	Top	Worst Case Orientation
124	Deleted	NIAR ATD Drop	SLR Camera	Vertical Impact	36	34.2	Top	Worst Case Orientation
125	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	25	16.5	Forward	Worst Case Orientation
126	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	36	34.2	Forward	Worst Case Orientation
127	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	25	16.5	Sideward	Worst Case Orientation
128	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	36	34.2	Sideward	Worst Case Orientation
129	UA19A-33	NIAR ATD Drop	DJI Inspire 2	Vertical Impact	9	12.4	Vertical to Top of Head	Nose into top of head
130	UA19A-34	NIAR ATD Drop	DJI Inspire 2	Vertical Impact	15	34.3	Vertical to Top of Head	Nose into top of head
131	UA19A-100	NIAR ATD Drop	DJI Inspire 2	Angled Impact	30	137.3	20 deg to Right Side of Skull	Nose into top of head
132	UA19A-108	NIAR ATD Drop	DJI Phantom 3	Angled Impact	71	209.2	58 deg forward	Worst Case Orientation
133	UA19A-109	NIAR ATD Drop	DJI Phantom 3	Angled Impact	71	209.2	58 deg forward	Worst Case Orientation
NC1	Numerous	NIAR FEA Calibration	eBee +	Plate Impact				
NC2	Numerous	NIAR FEA Calibration	eBee +	Plate Impact				

Table A-2 - OSU PMHS Tests

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
1	DHIT01-Vendor1-0deg-right-70fps	OSU PHMS	Vendor 1	Horizontal Impact	70	57.0	Right Side of Head	Horizontal/Level with Ground
2	DHIT01-Phantom3-0deg-right-56fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	56	125.9	Right Side of Head	Forward - Impact Point between Arms
3	DHIT01-Phantom3-0deg-right-61fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	61	149.8	Right Side of Head	Forward - Impact Point between Arms
4	DHIT01-Phantom3-0deg-right-71fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	71	198.5	Right Side of Head	Forward - Impact Point between Arms
5	DHIT01-Vendor1-58deg-front-70fps	OSU PHMS	Vendor 1	Angled Impact	70	63.1	58 deg to Front Side of Skull	Inverted Horizontal/Level with the Ground
6	DHIT01-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	56	136.1	58 deg to Front Side of Skull	Forward - Impact Point between Arms
7	DHIT01-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	156.3	58 deg to Front Side of Skull	Forward - Impact Point between Arms
8	DHIT02-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	145.3	58 deg to Front Side of Skull	Forward - Impact Point between Arms
8a	DHIT02-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	147.9	58 deg to Front Side of Skull	Forward - Impact Point between Arms
9	DHIT02-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	71	204.8	58 deg to Front Side of Skull	Forward - Impact Point between Arms
10	DHIT02-Phantom3-58deg-right-61fps	OSU PHMS	DJI Phantom 3	Angled Impact	61	151.5	58 deg to Right Side of Skull	Forward - Impact Point between Arms
11	DHIT02-Phantom3-58deg-right-71fps	OSU PHMS	DJI Phantom 3	Angled Impact	71	208.5	58 deg to Right Side of Skull	Forward - Impact Point between Arms
11a	DHIT02-Phantom3-58deg-right-71fps-	OSU PHMS	DJI Phantom 3	Angled Impact	71	205.3	58 deg to Right Side of Skull	Forward - Impact Point between Arms
12	DHIT03-Vendor1-90deg-top-70fps	OSU PHMS	Vendor 1	Vertical Impact	70	56.8	Vertical to Top of Head	Inverted Horizontal/Level with the Ground
12a	DHIT03-Vendor1-90deg-top-70fps-02	OSU PHMS	Vendor 1	Vertical Impact	70	57.2	Vertical to Top of Head	Inverted Horizontal/Level with the Ground
13	DHIT02-Phantom3-90deg-top-55fps	OSU PHMS	DJI Phantom 3	Vertical Impact	55	117.5	Vertical to Top of Head	Forward - Impact Point between Arms
14	DHIT02-Phantom3-90deg-top-65fps	OSU PHMS	DJI Phantom 3	Vertical Impact	65	161.0	Vertical to Top of Head	Forward - Impact Point between Arms
15	DHIT02-Phantom3-90deg-top-71fps	OSU PHMS	DJI Phantom 3	Vertical Impact	71	195.6	Vertical to Top of Head	Forward - Impact Point between Arms
16	DHIT03-Phantom3-58deg-right-61fps	OSU PHMS	DJI Phantom 3	Angled Impact	61	143.0	58 deg to Right Side of Skull	Forward - Impact Point between Arms
16a	DHIT03-Phantom3-58deg-right-61fps-	OSU PHMS	DJI Phantom 3	Angled Impact	61	142.2	58 deg to Right Side of Skull	Forward - Impact Point between Arms
17	DHIT03-Phantom3-58deg-right-71fps	OSU PHMS	DJI Phantom 3	Angled Impact	71	209.1	58 deg to Right Side of Skull	Forward - Impact Point between Arms
18	DHIT03-Phantom3-58deg-front-61fps	OSU PHMS	DJI Phantom 3	Angled Impact	61	150.7	58 deg to Front Side of Skull	Forward - Impact Point between Arms
19	DHIT03-Phantom3-58deg-front-71fps	OSU PHMS	DJI Phantom 3	Angled Impact	71	197.6	58 deg to Front Side of Skull	Forward - Impact Point between Arms
20	DHIT03-MavicPro-58deg-front-61fps	OSU PHMS	DJI Mavic Pro	Angled Impact	61	88.5	58 deg to Front Side of Skull	Sideward - Impact between the Arms
21	DHIT03-MavicPro-58deg-front-71fps	OSU PHMS	DJI Mavic Pro	Angled Impact	71	121.8	58 deg to Front Side of Skull	Sideward - Impact between the Arms
22	DHIT03-Phantom3-90deg-top-65fps	OSU PHMS	DJI Phantom 3	Vertical Impact	65	167.8	Vertical to Top of Head	Forward - Impact Point between Arms
23	DHIT03-Phantom3-90deg-top-71fps	OSU PHMS	DJI Phantom 3	Vertical Impact	71	198.8	Vertical to Top of Head	Forward - Impact Point between Arms
24	DHIT04-Ebee-0deg-right-64fps	OSU PHMS	eBee +	Horizontal Impact	64	140.8	Right Side of Head	Nose into Head
25	DHIT04-Ebee-0deg-right-71fps	OSU PHMS	eBee +	Horizontal Impact	71	187.8	Right Side of Head	Nose into Head
26	DHIT04-Ebee-58deg-left-64fps	OSU PHMS	eBee +	Angled Impact	64	145.8	58 deg to Left Side of Skull	Nose into Head
27	DHIT04-Ebee-58deg-left-71fps	OSU PHMS	eBee +	Angled Impact	71	187.8	58 deg to Left Side of Skull	Nose into Head
27a	DHIT04-Ebee-58deg-left-71fps-02	OSU PHMS	eBee +	Angled Impact	71	185.9	58 deg to Left Side of Skull	Nose into Head
28	DHIT04-MavicPro-58deg-front-61fps	OSU PHMS	DJI Mavic Pro	Angled Impact	61	85.0	58 deg to Front Side of Skull	Sideward - Impact between the Arms
29	DHIT04-MavicPro-58deg-front-71fps	OSU PHMS	DJI Mavic Pro	Angled Impact	71	119.9	58 deg to Front Side of Skull	Sideward - Impact between the Arms
30	DHIT04-Inspire2-0deg-right-30fps	OSU PHMS	DJI Inspire 2	Horizontal Impact	30	146.9	Right Side of Head	Top of center body into the head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
1	DHIT01-Vendor1-0deg-right-70fps	OSU PHMS	Vendor 1	Horizontal Impact	70	57.0	Right Side of Head	Horizontal/Level with Ground
2	DHIT01-Phantom3-0deg-right-56fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	56	125.9	Right Side of Head	Forward - Impact Point between Arms
3	DHIT01-Phantom3-0deg-right-61fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	61	149.8	Right Side of Head	Forward - Impact Point between Arms
4	DHIT01-Phantom3-0deg-right-71fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	71	198.5	Right Side of Head	Forward - Impact Point between Arms
5	DHIT01-Vendor1-58deg-front-70fps	OSU PHMS	Vendor 1	Angled Impact	70	63.1	58 deg to Front Side of Skull	Inverted Horizontal/Level with the Ground
6	DHIT01-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	56	136.1	58 deg to Front Side of Skull	Forward - Impact Point between Arms
31	DHIT05-WBlockF-0deg-right-20fps	OSU PHMS	Block, Wood	Horizontal Impact	20	15.4	Right Side of Head	Flat Side to Head
32	DHIT05-WBlockF-0deg-right-30fps	OSU PHMS	Block, Wood	Horizontal Impact	30	39.8	Right Side of Head	Flat Side to Head
33	DHIT05-WBlockF-0deg-right-40fps	OSU PHMS	Block, Wood	Horizontal Impact	40	68.4	Right Side of Head	Flat Side to Head
34	DHIT05-FBlockF-0deg-right-20fps	OSU PHMS	Block, Foam (Steel	Horizontal Impact	20	18.1	Left Side of Head	Flat Side to Head
35	DHIT05-FBlockF-0deg-right-30fps	OSU PHMS	Block, Foam (Steel	Horizontal Impact	40	37.0	Left Side of Head	Flat Side to Head
36	DHIT05-FBlockF-0deg-right-40fps	OSU PHMS	Block, Foam (Steel	Horizontal Impact	60	71.7	Left Side of Head	Flat Side to Head
37	Deleted	OSU PHMS	Block, Wood	Horizontal Impact	20	16.7	Front Side of Head	Corner to the Head
38	Deleted	OSU PHMS	Block, Wood	Horizontal Impact	30	37.6	Front Side of Head	Corner to the Head
39	Deleted	OSU PHMS	Block, Wood	Horizontal Impact	40	66.8	Front Side of Head	Corner to the Head
40	Deleted	OSU PHMS	eBee +	Angled Impact	59	129.7	58 deg - Left Side	Nose into Head
41	Deleted	OSU PHMS	eBee +	Horizontal Impact	59	129.7	Left Side of Head	Nose into Head
42	Deleted	OSU PHMS	DJI Phantom 3	Angled Impact	70	203.2	58 deg to Front Side of Skull	Forward - Impact Point between Arms
43	Deleted	OSU PHMS	Vendor 1	Horizontal Impact	70	51.7	Left Side of Head	Horizontal/Level with Ground
44	Deleted	OSU PHMS	DJI Phantom 3	Horizontal Impact	56	130.0	Left Side of Head	Forward - Impact Point between Arms
45	Deleted	OSU PHMS	Vendor 1	Angled Impact	70	51.7	58 deg to Front Side of Skull	Inverted Horizontal/Level with the Ground
46	Deleted	OSU PHMS	DJI Phantom 3	Angled Impact	56	130.0	58 deg to Front Side of Skull	Forward - Impact Point between Arms
47	Deleted	OSU PHMS	DJI Phantom 3	Vertical Impact	55	125.4	Vertical to Top of Head	Forward - Impact Point between Arms
48	Deleted	OSU PHMS	Vendor 1	Vertical Impact	70	51.7	Vertical to Top of Head	Inverted Horizontal/Level with the Ground
49	Deleted	OSU PHMS	DJI Mavic Pro	Horizontal Impact	50	63.7	Right Side of the Head	Sideward - Impact between the Arms
50	Deleted	OSU PHMS	DJI Mavic Pro	Horizontal Impact	61	94.8	Right Side of the Head	Sideward - Impact between the Arms
51	Deleted	OSU PHMS	DJI Mavic Pro	Horizontal Impact	70	124.8	Right Side of the Head	Sideward - Impact between the Arms
52	Deleted	OSU PHMS	DJI Mavic Pro	Angled Impact	50	63.7	58 deg to Left Side of Head	Sideward - Impact between the Arms
53	Deleted	OSU PHMS	DJI Mavic Pro	Angled Impact	61	94.8	58 deg to Left Side of Head	Sideward - Impact between the Arms
54	Deleted	OSU PHMS	DJI Mavic Pro	Angled Impact	70	124.8	58 deg to Left Side of Head	Sideward - Impact between the Arms
55	Deleted	OSU PHMS	DJI Inspire 2	Vertical Impact	9	12.4	Vertical to Top of Head	Nose into top of head
56	Deleted	OSU PHMS	DJI Inspire 2	Vertical Impact	15	34.3	Vertical to Top of Head	Nose into top of head

Table A-3 - UAH Flight Tests

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
F1	2017-09-27 17-11-20	UAH Flight Test	DJI Phantom 3	1 motor fail, hover				
F2	2017-09-27 17-23-12	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, hover				
F3	2017-09-28 11-01-45	UAH Flight Test	DJI Phantom 3	2 motor fail on-axis, hover				
F4		UAH Flight Test	DJI Phantom 3	4 motor fail, hover				
F10	2017-09-14 10-19-29	UAH Flight Test	Vendor 1	2 motor fail on-axis, hover				
F11	2017-09-14 10-10-54	UAH Flight Test	Vendor 1	2 motor fail off-axis, hover				
F12	56 8-24-2017 9-48-00 AM	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12B	log_101_2017-8-29-17-18-16	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12C	2017-09-13 13-38-09	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12D	2017-09-14 08-06-12	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12E	2017-09-14 08-28-56	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12F	2017-09-14 08-09-47	UAH Flight Test	Vendor 1	4 motor fail, hover				
F13	2017-09-14 10-54-09	UAH Flight Test	Vendor 1	1 motor fail, max stab speed				
F14	2017-09-14 13-08-38	UAH Flight Test	Vendor 1	2 motor fail on-axis, max stab speed				
F14B	2017-11-16 11-53-42	UAH Flight Test	Vendor 1	2 motor fail on-axis, max stab speed				
F15	2017-09-14 13-30-54	UAH Flight Test	Vendor 1	2 motor fail off-axis, max stab speed				
F15B	2017-11-16 12-20-43	UAH Flight Test	Vendor 1	2 motor fail off-axis, max stab speed				
F16	2017-09-14 13-45-04	UAH Flight Test	Vendor 1	4 motor fail, max stab speed				
F16B	2017-09-19 10-18-47	UAH Flight Test	Vendor 1	4 motor fail, max stab speed				
F16C	2017-11-16 10-56-53	UAH Flight Test	Vendor 1	4 motor fail, max stab speed				
F20	2018-04-05 09-52-36	UAH Flight Test	DJI Inspire 1	4 motor fail, hover				
F21		UAH Flight Test	DJI Inspire 1	4 motor fail, hover				
F23		UAH Flight Test	DJI Inspire 1	4 motor fail, max stab speed				
F24		UAH Flight Test	DJI Inspire 1	4 motor fail, max stab speed				
F26	log_31_2018-3-27-14-48-40	UAH Flight Test	DJI S800	6 motor fail, hover				
F26B	log_33_2018-3-27-16-35-12	UAH Flight Test	DJI S800	6 motor fail, hover				
F26C	log_34_2018-3-27-16-54-14	UAH Flight Test	DJI S800	6 motor fail, hover				
F26D	log_37_2018-3-27-20-00-30	UAH Flight Test	DJI S800	6 motor fail, hover				
F26E	log_38_2018-3-27-20-17-38	UAH Flight Test	DJI S800	6 motor fail, hover				
F26F	log_40_2018-3-28-11-53-10	UAH Flight Test	DJI S800	6 motor fail, hover				
F27	log_36_2018-3-27-17-41-02	UAH Flight Test	DJI S800	6 motor fail, hover				
F27B	log_41_2018-3-28-12-21-38	UAH Flight Test	DJI S800	6 motor fail, hover				
F28	log_32_2018-3-27-15-49-02	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
F28B	log_35_2018-3-27-17-15-50	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
F28C	log_42_2018-3-28-12-44-42	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
F29	log_39_2018-3-28-11-25-10	UAH Flight Test	DJI S800	6 motor fail, max stab speed				

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
F31		UAH Flight Test	DJI Matrice 200	4 motor fail, hover				
F35		UAH Flight Test	DJI Matrice 200	4 motor fail, max stab speed				
F36	2018-01-30 11-28-49	UAH Flight Test	DJI Mavic Pro	1 motor fail, hover				
F37	2018-01-30 11-42-51	UAH Flight Test	DJI Mavic Pro	2 motor fail on-axis, hover				
F37B	2018-02-01 10-20-54	UAH Flight Test	DJI Mavic Pro	2 motor fail on-axis, hover				
F38	2018-01-30 11-35-36	UAH Flight Test	DJI Mavic Pro	2 motor fail off-axis, hover				
F39	2018-01-30 11-20-42	UAH Flight Test	DJI Mavic Pro	4 motor fail, hover				
F40	2018-01-30 12-00-59	UAH Flight Test	DJI Mavic Pro	1 motor fail, max stab speed				
F41	2018-02-01 10-10-14	UAH Flight Test	DJI Mavic Pro	2 motor fail on-axis, max stab speed				
F42	2018-02-01 09-57-49	UAH Flight Test	DJI Mavic Pro	2 motor fail off-axis, max stab speed				
F43	2018-01-30 11-50-25	UAH Flight Test	DJI Mavic Pro	4 motor fail, max stab speed				
F44	2018-04-30 10-00-28	UAH Flight Test	Karma	1 motor fail, hover				
F45	2018-04-24 10-59-35	UAH Flight Test	Karma	2 motor fail on-axis, hover				
F45B	2018-04-24 11-20-44	UAH Flight Test	Karma	2 motor fail on-axis, hover				
F46	2018-04-30 08-58-05	UAH Flight Test	Karma	2 motor fail off-axis, hover				
F47	2018-02-19 13-12-53	UAH Flight Test	Karma	4 motor fail, hover				
F47B	2018-03-13 11-40-51	UAH Flight Test	Karma	4 motor fail, hover				
F48	2018-04-30 10-32-27	UAH Flight Test	Karma	1 motor fail, max stab speed				
F48B	2018-05-02 09-12-57	UAH Flight Test	Karma	1 motor fail, max stab speed				
F48C	2018-05-03 08-32-03	UAH Flight Test	Karma	1 motor fail, max stab speed				
F49	2018-05-02 10-07-48	UAH Flight Test	Karma	2 motor fail on-axis, max stab speed				
F49B	2018-05-02 10-29-30	UAH Flight Test	Karma	2 motor fail on-axis, max stab speed				
F49C	2018-05-03 08-48-26	UAH Flight Test	Karma	2 motor fail on-axis, max stab speed				
F4B	2017-09-26 13-53-06	UAH Flight Test	DJI Phantom 3	4 motor fail, hover				
F50	2017-09-28 14-58-21	UAH Flight Test	DJI Phantom 3	1 motor fail, max stab speed				
F51	2018-04-30 10-43-06	UAH Flight Test	Karma	2 motor fail off-axis, max stab speed				
F51B	2018-05-02 09-41-42	UAH Flight Test	Karma	2 motor fail off-axis, max stab speed				
F51C	2018-05-02 09-41-42	UAH Flight Test	Karma	2 motor fail off-axis, max stab speed				
F52	2018-03-08 15-40-26	UAH Flight Test	Karma	4 motor fail, max stab speed				
F52B	2018-05-03 09-05-22	UAH Flight Test	Karma	4 motor fail, max stab speed				
F53	2017-10-30 13-20-42	UAH Flight Test	eBee +	Loss of motor, no lateral input				
F54	2017-10-24 12-23-22	UAH Flight Test	eBee +	Power On, Max Roll				
F55	2017-10-24 12-09-29	UAH Flight Test	eBee +	Max Pitch Up				
F56	2017-10-30 13-45-31	UAH Flight Test	eBee +	Max Pitch Down				
F57	2017-09-28 15-17-29	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, max stab speed				
F57B	2017-11-14 10-10-47	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, max stab speed				
F57C	2017-12-07 11-14-59	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, max stab speed				
F58	2017-11-14 09-55-47	UAH Flight Test	DJI Phantom 3	2 motor fail on-axis, max stab speed				
F58B	2017-12-07 11-36-04	UAH Flight Test	DJI Phantom 3	2 motor fail on-axis, max stab speed				
F59	2017-09-28 14-39-13	UAH Flight Test	DJI Phantom 3	4 motor fail, max stab speed				
F60	2017-09-14 08-37-13	UAH Flight Test	Vendor 1	1 motor fail, hover				
F61	2018-03-07 14-13-00	UAH Flight Test	DJI Inspire 2	4 motor fail, hover				
F61B	2018-03-28 16-14-54	UAH Flight Test	DJI Inspire 2	4 motor fail, hover				

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
F62	2018-03-28 16-14-54	UAH Flight Test	DJI Inspire 2	4 motor fail, max stab speed				
F62	2018-03-28 16-14-54	UAH Flight Test	DJI Inspire 2	1 motor fail, max stab speed				
F63	2018-05-23 10-47-35	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail on-axis, hover				
F64	2018-05-23 11-03-34	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail off-axis, hover				
F65	2018-05-17 14-25-56	UAH Flight Test	Vendor 1 (No Cage)	4 motor fail, hover				
F65B	2018-05-23 11-15-24	UAH Flight Test	Vendor 1 (No Cage)	4 motor fail, hover				
F66	2018-05-24 10-40-31	UAH Flight Test	Vendor 1 (No Cage)	1 motor fail, max stab speed				
F67	2018-05-24 10-53-15	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail on-axis, max stab speed				
F68	2018-05-24 11-34-28	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail off-axis, max stab speed				
F69	2018-05-21 07-45-46	UAH Flight Test	Vendor 1 (No Cage)	4 motor fail, max stab speed				
F70	2018-05-23 10-36-24	UAH Flight Test	Vendor 1 (No Cage)	1 motor fail, hover				
F71	2018-11-13 12-27-15	UAH Flight Test	eBee +	Pitch Sweep				
F72	2018-12-06 10-52-55	UAH Flight Test	eBee +	Pitch Sweep				
F73		UAH Flight Test	eBee +	Roll Sweep				

Table A-4 - UAH Simplified Tests

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
1		UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
2	UAH-2-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
3	UAH-3-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
4	UAH-4-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
5	UAH-5-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
6	UAH-6-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
7	UAH-7-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
8	UAH-8-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
9	UAH-9-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
10	UAH-9-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
11	UAH-11-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
12	UAH-12-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
13	UAH-13-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
14	UAH-14-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
15	UAH-15-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
16	UAH-16-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
17	UAH-17-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
18	UAH-18-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
19	UAH-19-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
20	UAH-20-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
21	UAH-21-Foam 21-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
22	UAH-22-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
23	UAH-23-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
24	UAH-24-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
25	UAH-25-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
26	UAH-26-Foam 2-36	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
27	UAH-27-Foam 2-36	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
28	UAH-28-Foam 2-36	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
29	UAH-29-Foam 2-36	UAH Simplified Drop	Block, Foam 2	Vertical Impact	36	54.0	Top	Flat Surface into Head
30	UAH-30-Foam 2-36	UAH Simplified Drop	Block, Foam 2	Vertical Impact	36	54.0	Top	Flat Surface into Head
31	UAH-31-eBee+-25	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Nose into Head
32	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Bottom into Head
33	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Top Into Head
34	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Nose into Head
35	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Bottom into Head
36	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Top Into Head
37	UAH-37-eBee+-25	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Worst Case Orientation
38	UAH-38-eBee+-25	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Worst Case Orientation
39	UAH-39-eBee+-36	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Worst Case Orientation
40	UAH-40-eBee+-36	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Worst Case Orientation
41	UAH-41-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Bottom Into Head
42	UAH-42-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Top Into Head
43	UAH-43-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Side Into Head
44	UAH-44-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Arm Into Head
45	UAH-45-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Bottom Into Head
46	UAH-46-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Top Into Head
47	UAH-47-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Side Into Head
48	UAH-32-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Arm Into Head
49	No Test	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Worst Case Orientation
50	UAH-51c-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Worst Case Orientation
51	UAH-51c-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Worst Case Orientation
52	UAH-52-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Worst Case Orientation
53	UAH-53-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Small Side
54	UAH-54-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Small Side
55	UAH-55-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Long Side
56	UAH-56-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Long Side
57	UAH-32-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Worst Case Orientation
58	UAH-32-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Worst Case Orientation
59	UAH-32-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Worst Case Orientation
60	UAH-32-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Worst Case Orientation
61	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	12	20.0	Top	Bottom Into Head
62	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	12	20.0	Top	Nose Into Head
63	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	17	40.0	Top	Nose Into Head
64	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	17	40.0	Top	Bottom Into Head
65	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Top Into Head
66	UAH-66-DJI S+-10	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Between Arms
67	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Arm Into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
68	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Top Into Head
69	UAH-69-DJI S+-14	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Between Arms
70	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Arm Into Head
71	UAH-32-DJI S+-10	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Bottom Into Head
72	UAH-32-DJI S+-14	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Bottom Into Head
73	UAH-73-eBeestd-25	UAH Simplified Drop	eBee	Vertical Impact	25	15.2	Top	Worst Case Orientation from eBee+ Tests
74	UAH-74-eBeestd-25	UAH Simplified Drop	eBee	Vertical Impact	25	15.2	Top	Worst Case Orientation from eBee+ Tests
75	UAH-75-eBeestd-25	UAH Simplified Drop	eBee	Vertical Impact	25	15.2	Top	Worst Case Orientation from eBee+ Tests
76	UAH-76-eBeestd-36	UAH Simplified Drop	eBee	Vertical Impact	36	30.4	Top	Worst Case Orientation from eBee+ Tests
77	UAH-77-eBeestd-36	UAH Simplified Drop	eBee	Vertical Impact	36	30.4	Top	Worst Case Orientation from eBee+ Tests
78	UAH-78-eBeestd-36	UAH Simplified Drop	eBee	Vertical Impact	36	30.4	Top	Worst Case Orientation from eBee+ Tests
79	UAH-79-SLR-25	UAH Simplified Drop	SLR Camera	Vertical Impact	25	16.5	Top	Flat Surface Forward
80	UAH-80-SLR-25	UAH Simplified Drop	SLR Camera	Vertical Impact	25	16.5	Top	Flat Surface Forward
81	Deleted - Camera damaged	UAH Simplified Drop	SLR Camera	Vertical Impact	25	16.5	Top	Flat Surface Forward
82	UAH-82-SLR-36	UAH Simplified Drop	SLR Camera	Vertical Impact	36	34.2	Top	Flat Surface Forward
83	UAH-83-SLR-36	UAH Simplified Drop	SLR Camera	Vertical Impact	36	34.2	Top	Flat Surface Forward
84	Deleted - Camera damaged	UAH Simplified Drop	SLR Camera	Vertical Impact	36	34.2	Top	Flat Surface Forward
85	UAH-85-Rad-25	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Nose into Head
86	UAH-86-Rad-25	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Nose into Head
87	UAH-87-Rad-25	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Nose into Head
88	UAH-88-Rad-36	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Nose into Head
89	UAH-89-Rad-36	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Nose into Head
90	UAH-90-Rad-36	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Nose into Head
91	Deleted	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Worst Case Orientation
92	Deleted	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Worst Case Orientation
93	Deleted	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Worst Case Orientation
94	Deleted	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Worst Case Orientation
95	UAH-95-Sky-20ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Nose into Head
96	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Bottom into Head
97	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Top Into Head
98	UAH-98-Sky-40ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Nose into Head
99	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Bottom into Head
100	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Top Into Head
101	UAH-101-Sky-20ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Worst Case Orientation
102	UAH-102-Sky-20ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Worst Case Orientation
103	UAH-103-Sky-40ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Worst Case Orientation
104	UAH-104-Sky-40ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Worst Case Orientation
105	UAH-105-Nano-25	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Nose into Head
106	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Bottom into Head
107	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Top Into Head
108	UAH-108-Nano-36	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.2	Top	Nose into Head
109	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.0	Top	Bottom into Head
110	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.0	Top	Top Into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
111	UAH-111-Nano-25	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Worst Case Orientation
112	UAH-112-Nano-25	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Worst Case Orientation
113	UAH-113b-Nano-36	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.2	Top	Worst Case Orientation
114	UAH-114-Nano-36	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.2	Top	Worst Case Orientation
115	UAH-115-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Arm Into Head
116	UAH-116-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Arm Into Head
117	UAH-117-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Between Arms Forward
118	UAH-118-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Between Arms Forward
119	UAH-119-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Between Arms Side
120	UAH-120-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Between Arms Side
121	UAH-121-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Bottom Into Head
122	UAH-122-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Bottom Into Head
123	UAH-123-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Top Into Head
124	UAH-124-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Top Into Head
125	UAH-125-Green-20ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	17	19.7	Top	Between Arms Forward
126	UAH-126-Green-40ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Between Arms Forward
127	UAH-127-Green-20ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	17	19.7	Top	Bottom Into Head
128	UAH-128-Green-40ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Bottom Into Head
129	UAH-129-Green-20ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Top Into Head
130	UAH-130-Green-40ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Top Into Head
131	UAH-131-Green-36	UAH Simplified Drop	Vendor 3	Vertical Impact	36	88.5	Top	Between Arms Forward
132	UAH-132-Green-36	UAH Simplified Drop	Vendor 3	Vertical Impact	36	88.5	Top	Between Arms Forward
133	UAH-133-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Top into Head
134	UAH-177d-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Between Arms Forward
135	UAH-178b-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Between Arms Forward
136	UAH-179-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Top into Head
137	UAH-180b-PH3-36	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	36	54.3	Top	Top into Head
138	UAH-182-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Bottom into Head
139	UAH-183-PH3-36	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	36	54.3	Top	Bottom into Head
140	UAH-150-Wood-10	UAH Simplified Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface into Head
141	UAH-151-Wood-10	UAH Simplified Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface into Head
142	UAH-152-Wood-10	UAH Simplified Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface into Head
143	UAH-153-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface into Head
144	UAH-154-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface into Head
145	UAH-154b-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface into Head
146	UAH-155-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	25	26.2	Top	Flat Surface into Head
147	UAH-141b-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	26.2	Top	Flat Surface into Head
148	UAH-142-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	26.2	Top	Flat Surface into Head
149	UAH-143-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	30	37.7	Top	Flat Surface into Head
150	UAH-172-Wood-30	UAH Simplified Drop	Block, Wood	Vertical Impact	30	37.7	Top	Flat Surface into Head
151	UAH-174-Wood-30	UAH Simplified Drop	Block, Wood	Vertical Impact	30	37.7	Top	Flat Surface into Head
152	UAH-175Wood-30	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head
153	UAH-144-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
154	UAH-145-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head
155	UAH-144b-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head
156	UAH-270-Steel-10	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	10	4.2	Top	Flat Surface into Head
157	UAH-271-Steel-10	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	10	4.2	Top	Flat Surface into Head
158	UAH-272-Steel-10	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	10	4.2	Top	Flat Surface into Head
159	UAH-273-Steel-20	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	20	16.8	Top	Flat Surface into Head
160	UAH-274-Steel-20	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	20	16.8	Top	Flat Surface into Head
161	UAH-275-Steel-20	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	20	16.8	Top	Flat Surface into Head
162	UAH-276-Steel-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	26.2	Top	Flat Surface into Head
163	UAH-277-Steel-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	26.2	Top	Flat Surface into Head
164	UAH-278-Steel-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	26.2	Top	Flat Surface into Head
165	UAH-184b-Steel-30	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	30	37.7	Top	Flat Surface into Head
166	UAH-279-Steel-30	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	30	37.7	Top	Flat Surface into Head
167	UAH-280-Steel-30	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	30	37.7	Top	Flat Surface into Head
168	UAH-281-Steel-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.3	Top	Flat Surface into Head
169	UAH-282-Steel-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.3	Top	Flat Surface into Head
170	UAH-283-Steel-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.3	Top	Flat Surface into Head
171	UAH-260-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
172	UAH-261-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Bottom into Head
173	UAH-262-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Arm Into Head
174	UAH-263-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Between Arms Forward
175	UAH-264-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
176	UAH-265-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	36	4.9	Top	Bottom into Head
177	UAH-266-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	36	4.9	Top	Arm Into Head
178	UAH-267-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	36	4.9	Top	Between Arms Forward
179	UAH-268-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
180	UAH-269-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head

Table A-5 - Tests by Model

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
68	UA19A-12	NIAR ATD Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface Forward
69	UA19A-13	NIAR ATD Drop	Block, Foam (Steel	Vertical Impact	20	16.8	Top	Flat Surface Forward
70	UA19A-14	NIAR ATD Drop	Block, Foam (Steel	Vertical Impact	30	37.8	Top	Flat Surface Forward
71	UA19A-97	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	20	16.8	Forward	Flat Surface Forward
72	UA19A-98	NIAR ATD Drop	Block, Foam (Steel Core)	Horizontal Impact	40	67.1	Forward	Flat Surface Forward
73	UA19A-99	NIAR ATD Drop	Block, Foam (Steel Core)	Horizontal Impact	60	151.1	Forward	Flat Surface Forward
74	UA19A-96	NIAR ATD Drop	Block, Foam (Steel Core)	Horizontal Impact	20	16.8	Sideward	Flat Surface Forward
75	UA19A-94	NIAR ATD Drop	Block, Foam (Steel Core)	Horizontal Impact	40	67.1	Sideward	Flat Surface Forward
76	UA19A-95	NIAR ATD Drop	Block, Foam (Steel	Horizontal Impact	60	151.1	Sideward	Flat Surface Forward
77	UA19A-59	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	20	16.8	58 deg - Forward	Flat Surface Forward
78	UA19A-60	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	40	67.1	58 deg - Forward	Flat Surface Forward
79	UA19A-61	NIAR ATD Drop	Block, Foam (Steel Core)	Angled Impact	60	151.1	58 deg - Forward	Flat Surface Forward
80	UA19A-53	NIAR ATD Drop	Block, Foam (Steel Core)	Angled Impact	20	16.8	58 deg - Sideward	Flat Surface Forward
81	UA19A-54	NIAR ATD Drop	Block, Foam (Steel	Angled Impact	40	67.1	58 deg - Sideward	Flat Surface Forward
82	UA19A-55	NIAR ATD Drop	Block, Foam (Steel Core)	Angled Impact	60	151.1	58 deg - Sideward	Flat Surface Forward
34	DHIT05-FBlockF-0deg-right-20fps	OSU PHMS	Block, Foam (Steel	Horizontal Impact	20	18.1	Left Side of Head	Flat Side to Head
35	DHIT05-FBlockF-0deg-right-30fps	OSU PHMS	Block, Foam (Steel	Horizontal Impact	40	37.0	Left Side of Head	Flat Side to Head
36	DHIT05-FBlockF-0deg-right-40fps	OSU PHMS	Block, Foam (Steel Core)	Horizontal Impact	60	71.7	Left Side of Head	Flat Side to Head
11	UAH-11-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
12	UAH-12-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
13	UAH-13-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
14	UAH-14-Foam1-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
15	UAH-15-Foam1-25	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	25	27.0	Top	Flat Surface into Head
16	UAH-16-Foam1-36	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	36	54.0	Top	Flat Surface into Head
17	UAH-17-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
18	UAH-18-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
19	UAH-19-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
20	UAH-20-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
156	UAH-270-Steel-10	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface into Head
157	UAH-271-Steel-10	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface into Head
158	UAH-272-Steel-10	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface into Head
159	UAH-273-Steel-20	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	20	16.8	Top	Flat Surface into Head
160	UAH-274-Steel-20	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	20	16.8	Top	Flat Surface into Head
161	UAH-275-Steel-20	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	20	16.8	Top	Flat Surface into Head
162	UAH-276-Steel-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	26.2	Top	Flat Surface into Head
163	UAH-277-Steel-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	26.2	Top	Flat Surface into Head
164	UAH-278-Steel-25	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	25	26.2	Top	Flat Surface into Head
165	UAH-184b-Steel-30	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	30	37.7	Top	Flat Surface into Head
166	UAH-279-Steel-30	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	30	37.7	Top	Flat Surface into Head
167	UAH-280-Steel-30	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	30	37.7	Top	Flat Surface into Head
168	UAH-281-Steel-36	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	36	54.3	Top	Flat Surface into Head
169	UAH-282-Steel-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.3	Top	Flat Surface into Head
170	UAH-283-Steel-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.3	Top	Flat Surface into Head
21	UAH-21-Foam 21-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
22	UAH-22-Foam 2-25	UAH Simplified Drop	Block, Foam 2	Vertical Impact	25	27.0	Top	Flat Surface into Head
23	UAH-23-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
24	UAH-24-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
25	UAH-25-Foam 2-25	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	25	27.0	Top	Flat Surface into Head
26	UAH-26-Foam 2-36	UAH Simplified Drop	Block, Foam 2 (Aluminum Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
27	UAH-27-Foam 2-36	UAH Simplified Drop	Block, Foam 2	Vertical Impact	36	54.0	Top	Flat Surface into Head
28	UAH-28-Foam 2-36	UAH Simplified Drop	Block, Foam 2	Vertical Impact	36	54.0	Top	Flat Surface into Head
29	UAH-29-Foam 2-36	UAH Simplified Drop	Block, Foam 2	Vertical Impact	36	54.0	Top	Flat Surface into Head
30	UAH-30-Foam 2-36	UAH Simplified Drop	Block, Foam 2	Vertical Impact	36	54.0	Top	Flat Surface into Head
53	UA19A-09	NIAR ATD Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface Forward
54	UA19A-10	NIAR ATD Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface Forward
55	UA19A-11	NIAR ATD Drop	Block, Wood	Vertical Impact	30	37.8	Top	Flat Surface Forward

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
19	UAH-19-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
20	UAH-20-Foam1-36	UAH Simplified Drop	Block, Foam (Steel Core)	Vertical Impact	36	54.0	Top	Flat Surface into Head
156	UAH-270-Steel-10	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface into Head
157	UAH-271-Steel-10	UAH Simplified Drop	Block, Foam (Steel	Vertical Impact	10	4.2	Top	Flat Surface into Head
56	UA19A-103	NIAR ATD Drop	Block, Wood	Horizontal Impact	20	16.8	Forward	Flat Surface Forward
57	UA19A-101	NIAR ATD Drop	Block, Wood	Horizontal Impact	30	37.8	Forward	Flat Surface Forward
58	UA19A-102	NIAR ATD Drop	Block, Wood	Horizontal Impact	40	67.1	Forward	Flat Surface Forward
59	UA19A-91	NIAR ATD Drop	Block, Wood	Horizontal Impact	20	16.8	Sideward	Flat Surface Forward
60	UA19A-92	NIAR ATD Drop	Block, Wood	Horizontal Impact	30	37.8	Sideward	Flat Surface Forward
61	UA19A-93	NIAR ATD Drop	Block, Wood	Horizontal Impact	40	67.1	Sideward	Flat Surface Forward
62	UA19A-62	NIAR ATD Drop	Block, Wood	Angled Impact	20	16.8	58 deg - Forward	Flat Surface Forward
63	UA19A-63	NIAR ATD Drop	Block, Wood	Angled Impact	30	37.8	58 deg - Forward	Flat Surface Forward
64	UA19A-64	NIAR ATD Drop	Block, Wood	Angled Impact	40	67.1	58 deg - Forward	Flat Surface Forward
65	UA19A-56	NIAR ATD Drop	Block, Wood	Angled Impact	20	16.8	58 deg - Sideward	Flat Surface Forward
66	UA19A-57	NIAR ATD Drop	Block, Wood	Angled Impact	30	37.8	58 deg - Sideward	Flat Surface Forward
67	UA19A-58	NIAR ATD Drop	Block, Wood	Angled Impact	40	67.1	58 deg - Sideward	Flat Surface Forward
31	DHIT05-WBlockF-0deg-right-20fps	OSU PHMS	Block, Wood	Horizontal Impact	20	15.4	Right Side of Head	Flat Side to Head
32	DHIT05-WBlockF-0deg-right-30fps	OSU PHMS	Block, Wood	Horizontal Impact	30	39.8	Right Side of Head	Flat Side to Head
33	DHIT05-WBlockF-0deg-right-40fps	OSU PHMS	Block, Wood	Horizontal Impact	40	68.4	Right Side of Head	Flat Side to Head
37	Deleted	OSU PHMS	Block, Wood	Horizontal Impact	20	16.7	Front Side of Head	Corner to the Head
38	Deleted	OSU PHMS	Block, Wood	Horizontal Impact	30	37.6	Front Side of Head	Corner to the Head
39	Deleted	OSU PHMS	Block, Wood	Horizontal Impact	40	66.8	Front Side of Head	Corner to the Head
1		UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
2	UAH-2-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
3	UAH-3-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
4	UAH-4-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
5	UAH-5-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
6	UAH-6-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	25	27.0	Top	Flat Surface into Head
7	UAH-7-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
8	UAH-8-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
9	UAH-9-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
10	UAH-9-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.0	Top	Flat Surface into Head
140	UAH-150-Wood-10	UAH Simplified Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface into Head
141	UAH-151-Wood-10	UAH Simplified Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface into Head
142	UAH-152-Wood-10	UAH Simplified Drop	Block, Wood	Vertical Impact	10	4.2	Top	Flat Surface into Head
143	UAH-153-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface into Head
144	UAH-154-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface into Head
145	UAH-154b-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	20	16.8	Top	Flat Surface into Head
146	UAH-155-Wood-20	UAH Simplified Drop	Block, Wood	Vertical Impact	25	26.2	Top	Flat Surface into Head
147	UAH-141b-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	26.2	Top	Flat Surface into Head
148	UAH-142-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	25	26.2	Top	Flat Surface into Head
149	UAH-143-Wood-25	UAH Simplified Drop	Block, Wood	Vertical Impact	30	37.7	Top	Flat Surface into Head
150	UAH-172-Wood-30	UAH Simplified Drop	Block, Wood	Vertical Impact	30	37.7	Top	Flat Surface into Head
151	UAH-174-Wood-30	UAH Simplified Drop	Block, Wood	Vertical Impact	30	37.7	Top	Flat Surface into Head
152	UAH-175Wood-30	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head
153	UAH-144-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head
154	UAH-145-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head
155	UAH-144b-Wood-36	UAH Simplified Drop	Block, Wood	Vertical Impact	36	54.3	Top	Flat Surface into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
101	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	8	7.5	Top	**Bottom Into Head**
102	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	16	29.8	Top	**Bottom Into Head**
103	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	8	7.5	Top	**Nose Into Head**
104	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	16	28.1	Top	**Nose Into Head**
105	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	30	104.8	Top	Worst Case Orientation
106	Deleted	NIAR ATD Drop	DJI Inspire 1	Vertical Impact	40	186.2	Top	Worst Case Orientation
107	Deleted	NIAR ATD Drop	DJI Inspire 1	Angled Impact	30	104.8	55 deg sideward	Worst Case Orientation
108	Deleted	NIAR ATD Drop	DJI Inspire 1	Angled Impact	40	186.2	55 deg sideward	Worst Case Orientation
F20	2018-04-05 09-52-36	UAH Flight Test	DJI Inspire 1	4 motor fail, hover				
F21		UAH Flight Test	DJI Inspire 1	4 motor fail, hover				
F23		UAH Flight Test	DJI Inspire 1	4 motor fail, max stab speed				
F24		UAH Flight Test	DJI Inspire 1	4 motor fail, max stab speed				
129	UA19A-33	NIAR ATD Drop	DJI Inspire 2	Vertical Impact	9	12.4	Vertical to Top of Head	Nose into top of head
130	UA19A-34	NIAR ATD Drop	DJI Inspire 2	Vertical Impact	15	34.3	Vertical to Top of Head	Nose into top of head
131	UA19A-100	NIAR ATD Drop	DJI Inspire 2	Angled Impact	30	137.3	20 deg to Right Side of Skull	Nose into top of head
30	DHIT04-Inspire2-0deg-right-30fps	OSU PHMS	DJI Inspire 2	Horizontal Impact	30	146.9	Right Side of Head	Top of center body into the head
55	Deleted	OSU PHMS	DJI Inspire 2	Vertical Impact	9	12.4	Vertical to Top of Head	Nose into top of head
56	Deleted	OSU PHMS	DJI Inspire 2	Vertical Impact	15	34.3	Vertical to Top of Head	Nose into top of head
F61	2018-03-07 14-13-00	UAH Flight Test	DJI Inspire 2	4 motor fail, hover				
F61B	2018-03-28 16-14-54	UAH Flight Test	DJI Inspire 2	4 motor fail, hover				
F62	2018-03-28 16-14-54	UAH Flight Test	DJI Inspire 2	4 motor fail, max stab speed				
F62	2018-03-28 16-14-54	UAH Flight Test	DJI Inspire 2	1 motor fail, max stab speed				
61	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	12	20.0	Top	Bottom Into Head
62	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	12	20.0	Top	Nose Into Head
63	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	17	40.0	Top	Nose Into Head
64	Deleted	UAH Simplified Drop	DJI Inspire 2	Vertical Impact	17	40.0	Top	Bottom Into Head
F31		UAH Flight Test	DJI Matrice 200	4 motor fail, hover				
F35		UAH Flight Test	DJI Matrice 200	4 motor fail, max stab speed				
83	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Arm Into Head
84	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Arm Into Head
85	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Between Arms Forward
86	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Between Arms Forward
87	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Between Arms Side
88	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Between Arms Side
89	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Bottom Into Head
90	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Bottom Into Head
91	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	25	16.4	Top	Top Into Head
92	Deleted	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	36	32.8	Top	Top Into Head
93	UA19A-75	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	50	63.7	Top	Worst Case Orientation
94	UA19A-76	NIAR ATD Drop	DJI Mavic Pro	Vertical Impact	61	94.8	Top	Worst Case Orientation
95	UA19A-72	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	40	40.8	58 deg forward	Worst Case Orientation
96	UA19A-73	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	50	63.7	58 deg forward	Worst Case Orientation
97	UA19A-74	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	61	94.8	58 deg forward	Worst Case Orientation
98	UA19A-69	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	40	40.8	58 deg - Sideward	Worst Case Orientation
98B	UA19A-69B	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	40	40.8	58 deg - Sideward	Worst Case Orientation
99	UA19A-70	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	50	63.7	58 deg - Sideward	Worst Case Orientation
100	UA19A-71	NIAR ATD Drop	DJI Mavic Pro	Angled Impact	61	94.8	58 deg - Sideward	Worst Case Orientation

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
20	DHIT03-MavicPro-58deg-front-61fps	OSU PHMS	DJI Mavic Pro	Angled Impact	61	88.5	58 deg to Front Side of Skull	Sideward - Impact between the Arms
21	DHIT03-MavicPro-58deg-front-71fps	OSU PHMS	DJI Mavic Pro	Angled Impact	71	121.8	58 deg to Front Side of Skull	Sideward - Impact between the Arms
28	DHIT04-MavicPro-58deg-front-61fps	OSU PHMS	DJI Mavic Pro	Angled Impact	61	85.0	58 deg to Front Side of Skull	Sideward - Impact between the Arms
29	DHIT04-MavicPro-58deg-front-71fps	OSU PHMS	DJI Mavic Pro	Angled Impact	71	119.9	58 deg to Front Side of Skull	Sideward - Impact between the Arms
49	Deleted	OSU PHMS	DJI Mavic Pro	Horizontal Impact	50	63.7	Right Side of the Head	Sideward - Impact between the Arms
50	Deleted	OSU PHMS	DJI Mavic Pro	Horizontal Impact	61	94.8	Right Side of the Head	Sideward - Impact between the Arms
51	Deleted	OSU PHMS	DJI Mavic Pro	Horizontal Impact	70	124.8	Right Side of the Head	Sideward - Impact between the Arms
52	Deleted	OSU PHMS	DJI Mavic Pro	Angled Impact	50	63.7	58 deg to Left Side of Head	Sideward - Impact between the Arms
53	Deleted	OSU PHMS	DJI Mavic Pro	Angled Impact	61	94.8	58 deg to Left Side of Head	Sideward - Impact between the Arms
54	Deleted	OSU PHMS	DJI Mavic Pro	Angled Impact	70	124.8	58 deg to Left Side of Head	Sideward - Impact between the Arms
F36	2018-01-30 11-28-49	UAH Flight Test	DJI Mavic Pro	1 motor fail, hover				
F37	2018-01-30 11-42-51	UAH Flight Test	DJI Mavic Pro	2 motor fail on-axis, hover				
F37B	2018-02-01 10-20-54	UAH Flight Test	DJI Mavic Pro	2 motor fail on-axis, hover				
F38	2018-01-30 11-35-36	UAH Flight Test	DJI Mavic Pro	2 motor fail off-axis, hover				
F39	2018-01-30 11-20-42	UAH Flight Test	DJI Mavic Pro	4 motor fail, hover				
F40	2018-01-30 12-00-59	UAH Flight Test	DJI Mavic Pro	1 motor fail, max stab speed				
F41	2018-02-01 10-10-14	UAH Flight Test	DJI Mavic Pro	2 motor fail on-axis, max stab speed				
F42	2018-02-01 09-57-49	UAH Flight Test	DJI Mavic Pro	2 motor fail off-axis, max stab speed				
F43	2018-01-30 11-50-25	UAH Flight Test	DJI Mavic Pro	4 motor fail, max stab speed				
115	UAH-115-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Arm Into Head
116	UAH-116-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Arm Into Head
117	UAH-117-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Between Arms Forward
118	UAH-118-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Between Arms Forward
119	UAH-119-Mavic-25	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Between Arms Side
120	UAH-120-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Between Arms Side
121	UAH-121-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Bottom Into Head
122	UAH-122-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Bottom Into Head
123	UAH-123-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	25	16.2	Top	Top Into Head
124	UAH-124-Mavic-36	UAH Simplified Drop	DJI Mavic Pro	Vertical Impact	36	32.4	Top	Top Into Head
1	UA19A-23	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Top Into Head
2	UA19A-25	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Side Into Head
3	UA19A-27	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Arm Into Head
4	UA19A-24	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Top Into Head
5	UA19A-26	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Side Into Head
6	UA19A-28	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Arm Into Head
7	UA19A-21	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	25	26.7	Top	Bottom Into Head
8	UA19A-22	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	36	53.4	Top	Bottom Into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
9	UA19A-83	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	36	53.8	Sideward	Worst Case Orientation
10	UA19A-84	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	56	130.1	Sideward	Worst Case Orientation
11	UA19A-85	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	61	154.4	Sideward	Worst Case Orientation
12	UA19A-86	NIAR ATD Drop	DJI Phantom 3	Horizontal Impact	65	175.3	Sideward	Worst Case Orientation
13	UA19A-29	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	55	125.5	Top	Worst Case Orientation
14	UA19A-30	NIAR ATD Drop	DJI Phantom 3	Vertical Impact	65	175.3	Top	Worst Case Orientation
15	UA19A-43	NIAR ATD Drop	DJI Phantom 3	Angled Impact	56	130.1	58 deg forward	Worst Case Orientation
16	UA19A-44	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg forward	Worst Case Orientation
17	UA19A-45	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg forward	Worst Case Orientation
18	UA19A-46	NIAR ATD Drop	DJI Phantom 3	Angled Impact	56	130.1	58 deg rearward	Worst Case Orientation
19	UA19A-47	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg rearward	Worst Case Orientation
20	UA19A-48	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg rearward	Worst Case Orientation
21	UA19A-39	NIAR ATD Drop	DJI Phantom 3	Angled Impact	36	53.8	58 deg - Sideward	Worst Case Orientation
22	UA19A-40	NIAR ATD Drop	DJI Phantom 3	Angled Impact	56	130.1	58 deg - Sideward	Worst Case Orientation
23	UA19A-41	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg - Sideward	Worst Case Orientation
23B	UA19A-41B	NIAR ATD Drop	DJI Phantom 3	Angled Impact	61	154.4	58 deg - Sideward	Worst Case Orientation
24	UA19A-42	NIAR ATD Drop	DJI Phantom 3	Angled Impact	65	175.3	58 deg - Sideward	Worst Case Orientation
132	UA19A-108	NIAR ATD Drop	DJI Phantom 3	Angled Impact	71	209.2	58 deg forward	Worst Case Orientation
133	UA19A-109	NIAR ATD Drop	DJI Phantom 3	Angled Impact	71	209.2	58 deg forward	Worst Case Orientation
2	DHIT01-Phantom3-0deg-right-56fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	56	125.9	Right Side of Head	Forward - Impact Point between Arms
3	DHIT01-Phantom3-0deg-right-61fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	61	149.8	Right Side of Head	Forward - Impact Point between Arms
4	DHIT01-Phantom3-0deg-right-71fps	OSU PHMS	DJI Phantom 3	Horizontal Impact	71	198.5	Right Side of Head	Forward - Impact Point between Arms
6	DHIT01-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	56	136.1	58 deg to Front Side of Skull	Forward - Impact Point between Arms
7	DHIT01-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	156.3	58 deg to Front Side of Skull	Forward - Impact Point between Arms
8	DHIT02-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	145.3	58 deg to Front Side of Skull	Forward - Impact Point between Arms
8a	DHIT02-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	147.9	58 deg to Front Side of Skull	Forward - Impact Point between Arms
9	DHIT02-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	71	204.8	58 deg to Front Side of Skull	Forward - Impact Point between Arms
10	DHIT02-Phantom3-58deg-right-61fps	OSU PHMS	DJI Phantom 3	Angled Impact	61	151.5	58 deg to Right Side of Skull	Forward - Impact Point between Arms
11	DHIT02-Phantom3-58deg-right-71fps	OSU PHMS	DJI Phantom 3	Angled Impact	71	208.5	58 deg to Right Side of Skull	Forward - Impact Point between Arms
11a	DHIT02-Phantom3-58deg-right-71fps	OSU PHMS	DJI Phantom 3	Angled Impact	71	205.3	58 deg to Right Side of Skull	Forward - Impact Point between Arms
13	DHIT02-Phantom3-90deg-top-55fps	OSU PHMS	DJI Phantom 3	Vertical Impact	55	117.5	Vertical to Top of Head	Forward - Impact Point between Arms
14	DHIT02-Phantom3-90deg-top-65fps	OSU PHMS	DJI Phantom 3	Vertical Impact	65	161.0	Vertical to Top of Head	Forward - Impact Point between Arms
15	DHIT02-Phantom3-90deg-top-71fps	OSU PHMS	DJI Phantom 3	Vertical Impact	71	195.6	Vertical to Top of Head	Forward - Impact Point between Arms
16	DHIT03-Phantom3-58deg-right-61fps	OSU PHMS	DJI Phantom 3	Angled Impact	61	143.0	58 deg to Right Side of Skull	Forward - Impact Point between Arms
16a	DHIT03-Phantom3-58deg-right-61fps	OSU PHMS	DJI Phantom 3	Angled Impact	61	142.2	58 deg to Right Side of Skull	Forward - Impact Point between Arms
17	DHIT03-Phantom3-58deg-right-71fps	OSU PHMS	DJI Phantom 3	Angled Impact	71	209.1	58 deg to Right Side of Skull	Forward - Impact Point between Arms
18	DHIT03-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	61	150.7	58 deg to Front Side of Skull	Forward - Impact Point between Arms
19	DHIT03-Phantom3-58deg-front-	OSU PHMS	DJI Phantom 3	Angled Impact	71	197.6	58 deg to Front Side of Skull	Forward - Impact Point between Arms
22	DHIT03-Phantom3-90deg-top-65fps	OSU PHMS	DJI Phantom 3	Vertical Impact	65	167.8	Vertical to Top of Head	Forward - Impact Point between Arms
23	DHIT03-Phantom3-90deg-top-71fps	OSU PHMS	DJI Phantom 3	Vertical Impact	71	198.8	Vertical to Top of Head	Forward - Impact Point between Arms
42	Deleted	OSU PHMS	DJI Phantom 3	Angled Impact	70	203.2	58 deg to Front Side of Skull	Forward - Impact Point between Arms
44	Deleted	OSU PHMS	DJI Phantom 3	Horizontal Impact	56	130.0	Left Side of Head	Forward - Impact Point between Arms
46	Deleted	OSU PHMS	DJI Phantom 3	Angled Impact	56	130.0	58 deg to Front Side of Skull	Forward - Impact Point between Arms
47	Deleted	OSU PHMS	DJI Phantom 3	Vertical Impact	55	125.4	Vertical to Top of Head	Forward - Impact Point between Arms

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
F1	2017-09-27 17-11-20	UAH Flight Test	DJI Phantom 3	1 motor fail, hover				
F2	2017-09-27 17-23-12	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, hover				
F3	2017-09-28 11-01-45	UAH Flight Test	DJI Phantom 3	2 motor fail on-axis, hover				
F4		UAH Flight Test	DJI Phantom 3	4 motor fail, hover				
F4B	2017-09-26 13-53-06	UAH Flight Test	DJI Phantom 3	4 motor fail, hover				
F50	2017-09-28 14-58-21	UAH Flight Test	DJI Phantom 3	1 motor fail, max stab speed				
F57	2017-09-28 15-17-29	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, max stab speed				
F57B	2017-11-14 10-10-47	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, max stab speed				
F57C	2017-12-07 11-14-59	UAH Flight Test	DJI Phantom 3	2 motor fail off-axis, max stab speed				
F58	2017-11-14 09-55-47	UAH Flight Test	DJI Phantom 3	2 motor fail on-axis, max stab speed				
F58B	2017-12-07 11-36-04	UAH Flight Test	DJI Phantom 3	2 motor fail on-axis, max stab speed				
F59	2017-09-28 14-39-13	UAH Flight Test	DJI Phantom 3	4 motor fail, max stab speed				
133	UAH-133-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Top into Head
134	UAH-177d-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Between Arms Forward
135	UAH-178b-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Between Arms Forward
136	UAH-179-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Top into Head
137	UAH-180b-PH3-36	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	36	54.3	Top	Top into Head
138	UAH-182-PH3-25	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	25	26.2	Top	Bottom into Head
139	UAH-183-PH3-36	UAH Simplified Drop	DJI Phantom 3	Vertical Impact	36	54.3	Top	Bottom into Head
119	UA19A-79	NIAR ATD Drop	DJI Phantom 3 battery	Vertical Impact	40	20.0	Top	Impact with smallest surface
120	UA19A-80	NIAR ATD Drop	DJI Phantom 3 battery	Vertical Impact	60	45.0	Top	Impact with smallest surface
121	UA19A-104	NIAR ATD Drop	DJI Phantom 3 battery	Horizontal Impact	40	20.0	Forward	Impact with smallest surface
122	UA19A-105	NIAR ATD Drop	DJI Phantom 3 battery	Horizontal Impact	60	45.0	Sideward	Impact with smallest surface
53	UAH-53-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Small Side
54	UAH-54-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Small Side
55	UAH-55-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Long Side
56	UAH-56-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Long Side
57	UAH-32-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Worst Case Orientation
58	UAH-32-DJI Phantom 3 battery+-25	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	25	8.1	Top	Worst Case Orientation
59	UAH-32-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Worst Case Orientation
60	UAH-32-DJI Phantom 3 battery+-36	UAH Simplified Drop	DJI Phantom 3 battery	Vertical Impact	36	16.1	Top	Worst Case Orientation
F26	log_31_2018-3-27-14-48-40	UAH Flight Test	DJI S800	6 motor fail, hover				
F26B	log_33_2018-3-27-16-35-12	UAH Flight Test	DJI S800	6 motor fail, hover				
F26C	log_34_2018-3-27-16-54-14	UAH Flight Test	DJI S800	6 motor fail, hover				
F26D	log_37_2018-3-27-20-00-30	UAH Flight Test	DJI S800	6 motor fail, hover				
F26E	log_38_2018-3-27-20-17-38	UAH Flight Test	DJI S800	6 motor fail, hover				
F26F	log_40_2018-3-28-11-53-10	UAH Flight Test	DJI S800	6 motor fail, hover				
F27	log_36_2018-3-27-17-41-02	UAH Flight Test	DJI S800	6 motor fail, hover				
F27B	log_41_2018-3-28-12-21-38	UAH Flight Test	DJI S800	6 motor fail, hover				
F28	log_32_2018-3-27-15-49-02	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
F28B	log_35_2018-3-27-17-15-50	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
F28C	log_42_2018-3-28-12-44-42	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
F29	log_39_2018-3-28-11-25-10	UAH Flight Test	DJI S800	6 motor fail, max stab speed				
65	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Top Into Head
66	UAH-66-DJI S+-10	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Between Arms
67	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Arm Into Head
68	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Top Into Head
69	UAH-69-DJI S+-14	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Between Arms
70	Deleted	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Arm Into Head
71	UAH-32-DJI S+-10	UAH Simplified Drop	DJI S800	Vertical Impact	10	20.0	Top	Bottom Into Head
72	UAH-32-DJI S+-14	UAH Simplified Drop	DJI S800	Vertical Impact	14	40.0	Top	Bottom Into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
73	UAH-73-eBeestd-25	UAH Simplified Drop	eBee	Vertical Impact	25	15.2	Top	Worst Case Orientation from eBee+ Tests
74	UAH-74-eBeestd-25	UAH Simplified Drop	eBee	Vertical Impact	25	15.2	Top	Worst Case Orientation from eBee+ Tests
75	UAH-75-eBeestd-25	UAH Simplified Drop	eBee	Vertical Impact	25	15.2	Top	Worst Case Orientation from eBee+ Tests
76	UAH-76-eBeestd-36	UAH Simplified Drop	eBee	Vertical Impact	36	30.4	Top	Worst Case Orientation from eBee+ Tests
77	UAH-77-eBeestd-36	UAH Simplified Drop	eBee	Vertical Impact	36	30.4	Top	Worst Case Orientation from eBee+ Tests
78	UAH-78-eBeestd-36	UAH Simplified Drop	eBee	Vertical Impact	36	30.4	Top	Worst Case Orientation from eBee+ Tests
25	UA19A-31	NIAR ATD Drop	eBee +	Vertical Impact	50	93.2	Top	Worst Case Orientation
26	UA19A-32	NIAR ATD Drop	eBee +	Vertical Impact	60	134.2	Top	Worst Case Orientation
27	UA19A-87	NIAR ATD Drop	eBee +	Horizontal Impact	25	23.3	Sideward	Worst Case Orientation
28	UA19A-88	NIAR ATD Drop	eBee +	Horizontal Impact	36	48.3	Sideward	Worst Case Orientation
29	UA19A-89	NIAR ATD Drop	eBee +	Horizontal Impact	59	129.7	Sideward	Worst Case Orientation
30	UA19A-90	NIAR ATD Drop	eBee +	Horizontal Impact	64	152.6	Sideward	Worst Case Orientation
31	UA19A-49	NIAR ATD Drop	eBee +	Angled Impact	25	23.3	58 deg - Sideward*	Worst Case Orientation
32	UA19A-50	NIAR ATD Drop	eBee +	Angled Impact	36	48.3	58 deg - Sideward*	Worst Case Orientation
33	UA19A-51	NIAR ATD Drop	eBee +	Angled Impact	59	129.7	58 deg - Sideward*	Worst Case Orientation
34	UA19A-52	NIAR ATD Drop	eBee +	Angled Impact	64	152.6	58 deg - Sideward*	Worst Case Orientation
NC1	Numerous	NIAR FEA Calibration	eBee +	Plate Impact				
NC2	Numerous	NIAR FEA Calibration	eBee +	Plate Impact				
24	DHIT04-Ebee-0deg-right-64fps	OSU PHMS	eBee +	Horizontal Impact	64	140.8	Right Side of Head	Nose into Head
25	DHIT04-Ebee-0deg-right-71fps	OSU PHMS	eBee +	Horizontal Impact	71	187.8	Right Side of Head	Nose into Head
26	DHIT04-Ebee-58deg-left-64fps	OSU PHMS	eBee +	Angled Impact	64	145.8	58 deg to Left Side of Skull	Nose into Head
27	DHIT04-Ebee-58deg-left-71fps	OSU PHMS	eBee +	Angled Impact	71	187.8	58 deg to Left Side of Skull	Nose into Head
27a	DHIT04-Ebee-58deg-left-71fps-02	OSU PHMS	eBee +	Angled Impact	71	185.9	58 deg to Left Side of Skull	Nose into Head
40	Deleted	OSU PHMS	eBee +	Angled Impact	59	129.7	58 deg - Left Side	Nose into Head
41	Deleted	OSU PHMS	eBee +	Horizontal Impact	59	129.7	Left Side of Head	Nose into Head
F53	2017-10-30 13-20-42	UAH Flight Test	eBee +	Loss of motor, no lateral input				
F54	2017-10-24 12-23-22	UAH Flight Test	eBee +	Power On, Max Roll				
F55	2017-10-24 12-09-29	UAH Flight Test	eBee +	Max Pitch Up				
F56	2017-10-30 13-45-31	UAH Flight Test	eBee +	Max Pitch Down				
F71	2018-11-13 12-27-15	UAH Flight Test	eBee +	Pitch Sweep				
F72	2018-12-06 10-52-55	UAH Flight Test	eBee +	Pitch Sweep				
F73		UAH Flight Test	eBee +	Roll Sweep				
31	UAH-31-eBee+-25	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Nose into Head
32	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Bottom into Head
33	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Top Into Head
34	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Nose into Head
35	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Bottom into Head
36	Deleted	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Top Into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
37	UAH-37-eBee+-25	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Worst Case Orientation
38	UAH-38-eBee+-25	UAH Simplified Drop	eBee +	Vertical Impact	25	24.0	Top	Worst Case Orientation
39	UAH-39-eBee+-36	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Worst Case Orientation
40	UAH-40-eBee+-36	UAH Simplified Drop	eBee +	Vertical Impact	36	48.0	Top	Worst Case Orientation
109	UA19A-77	NIAR ATD Drop	Karma	Vertical Impact	40	101.2	Top	Worst Case Orientation
110	UA19A-78	NIAR ATD Drop	Karma	Vertical Impact	50	158.1	Top	Worst Case Orientation
111	UA19A-65	NIAR ATD Drop	Karma	Angled Impact	40	101.2	58 deg forward	Worst Case Orientation
112	UA19A-66	NIAR ATD Drop	Karma	Angled Impact	50	158.1	58 deg forward	Worst Case Orientation
112B	UA19A-66B	NIAR ATD Drop	Karma	Angled Impact	50	158.1	58 deg forward	Worst Case Orientation
113	UA19A-67	NIAR ATD Drop	Karma	Angled Impact	40	101.2	58 deg - Sideward	Worst Case Orientation
114	UA19A-68	NIAR ATD Drop	Karma	Angled Impact	50	158.1	58 deg - Sideward	Worst Case Orientation
F44	2018-04-30 10-00-28	UAH Flight Test	Karma	1 motor fail, hover				
F45	2018-04-24 10-59-35	UAH Flight Test	Karma	2 motor fail on-axis, hover				
F45B	2018-04-24 11-20-44	UAH Flight Test	Karma	2 motor fail on-axis, hover				
F46	2018-04-30 08-58-05	UAH Flight Test	Karma	2 motor fail off-axis, hover				
F47	2018-02-19 13-12-53	UAH Flight Test	Karma	4 motor fail, hover				
F47B	2018-03-13 11-40-51	UAH Flight Test	Karma	4 motor fail, hover				
F48	2018-04-30 10-32-27	UAH Flight Test	Karma	1 motor fail, max stab speed				
F48B	2018-05-02 09-12-57	UAH Flight Test	Karma	1 motor fail, max stab speed				
F48C	2018-05-03 08-32-03	UAH Flight Test	Karma	1 motor fail, max stab speed				
F49	2018-05-02 10-07-48	UAH Flight Test	Karma	2 motor fail on-axis, max stab speed				
F49B	2018-05-02 10-29-30	UAH Flight Test	Karma	2 motor fail on-axis, max stab speed				
F49C	2018-05-03 08-48-26	UAH Flight Test	Karma	2 motor fail on-axis, max stab speed				
F51	2018-04-30 10-43-06	UAH Flight Test	Karma	2 motor fail off-axis, max stab speed				
F51B	2018-05-02 09-41-42	UAH Flight Test	Karma	2 motor fail off-axis, max stab speed				
F51C	2018-05-02 09-41-42	UAH Flight Test	Karma	2 motor fail off-axis, max stab speed				
F52	2018-03-08 15-40-26	UAH Flight Test	Karma	4 motor fail, max stab speed				
F52B	2018-05-03 09-05-22	UAH Flight Test	Karma	4 motor fail, max stab speed				
41	UAH-41-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Bottom Into Head
42	UAH-42-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Top Into Head
43	UAH-43-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Side Into Head
44	UAH-44-Karma+-18	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Arm Into Head
45	UAH-45-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Bottom Into Head
46	UAH-46-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Top Into Head
47	UAH-47-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Side Into Head
48	UAH-32-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Arm Into Head
49	No Test	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Worst Case Orientation
50	UAH-51c-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	18	20.0	Top	Worst Case Orientation
51	UAH-51c-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Worst Case Orientation
52	UAH-52-Karma+-25	UAH Simplified Drop	Karma	Vertical Impact	25	40.0	Top	Worst Case Orientation

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
105	UAH-105-Nano-25	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Nose into Head
106	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Bottom into Head
107	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Top Into Head
108	UAH-108-Nano-36	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.2	Top	Nose into Head
109	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.0	Top	Bottom into Head
110	Deleted	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.0	Top	Top Into Head
111	UAH-111-Nano-25	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Worst Case Orientation
112	UAH-112-Nano-25	UAH Simplified Drop	Nano Talon	Vertical Impact	25	15.0	Top	Worst Case Orientation
113	UAH-113b-Nano-36	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.2	Top	Worst Case Orientation
114	UAH-114-Nano-36	UAH Simplified Drop	Nano Talon	Vertical Impact	36	30.2	Top	Worst Case Orientation
85	UAH-85-Rad-25	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Nose into Head
86	UAH-86-Rad-25	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Nose into Head
87	UAH-87-Rad-25	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Nose into Head
88	UAH-88-Rad-36	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Nose into Head
89	UAH-89-Rad-36	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Nose into Head
90	UAH-90-Rad-36	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Nose into Head
91	Deleted	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Worst Case Orientation
92	Deleted	UAH Simplified Drop	Radian	Vertical Impact	25	25.0	Top	Worst Case Orientation
93	Deleted	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Worst Case Orientation
94	Deleted	UAH Simplified Drop	Radian	Vertical Impact	36	50.4	Top	Worst Case Orientation
95	UAH-95-Sky-20ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Nose into Head
96	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Bottom into Head
97	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Top Into Head
98	UAH-98-Sky-40ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Nose into Head
99	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Bottom into Head
100	Deleted	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Top Into Head
101	UAH-101-Sky-20ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Worst Case Orientation
102	UAH-102-Sky-20ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	25	29.1	Top	Worst Case Orientation
103	UAH-103-Sky-40ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Worst Case Orientation
104	UAH-104-Sky-40ftlb	UAH Simplified Drop	Skyhunter	Vertical Impact	36	60.4	Top	Worst Case Orientation
123	Deleted	NIAR ATD Drop	SLR Camera	Vertical Impact	25	16.5	Top	Worst Case Orientation
124	Deleted	NIAR ATD Drop	SLR Camera	Vertical Impact	36	34.2	Top	Worst Case Orientation
125	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	25	16.5	Forward	Worst Case Orientation
126	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	36	34.2	Forward	Worst Case Orientation
127	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	25	16.5	Sideward	Worst Case Orientation
128	Deleted	NIAR ATD Drop	SLR Camera	Horizontal Impact	36	34.2	Sideward	Worst Case Orientation
79	UAH-79-SLR-25	UAH Simplified Drop	SLR Camera	Vertical Impact	25	16.5	Top	Flat Surface Forward
80	UAH-80-SLR-25	UAH Simplified Drop	SLR Camera	Vertical Impact	25	16.5	Top	Flat Surface Forward
81	Deleted - Camera damaged	UAH Simplified Drop	SLR Camera	Vertical Impact	25	16.5	Top	Flat Surface Forward
82	UAH-82-SLR-36	UAH Simplified Drop	SLR Camera	Vertical Impact	36	34.2	Top	Flat Surface Forward
83	UAH-83-SLR-36	UAH Simplified Drop	SLR Camera	Vertical Impact	36	34.2	Top	Flat Surface Forward
84	Deleted - Camera damaged	UAH Simplified Drop	SLR Camera	Vertical Impact	36	34.2	Top	Flat Surface Forward

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
35	UA19A-01	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Bottom Into Head
36	UA19A-03	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Top Into Head
37	UA19A-05	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Side Into Head
38	UA19A-02	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Bottom Into Head
39	UA19A-04	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Top Into Head
40	UA19A-06	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Side Into Head
41	UA19A-07	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Arm Into Head
42	UA19A-08	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Arm Into Head
43	UA19A-15	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Worst Case Orientation
44	UA19A-16	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Worst Case Orientation
45	UA19A-17	NIAR ATD Drop	Vendor 1	Vertical Impact	25	7.3	Top	Worst Case Orientation
46	UA19A-18	NIAR ATD Drop	Vendor 1	Vertical Impact	36	14.6	Top	Worst Case Orientation
47	UA19A-19	NIAR ATD Drop	Vendor 1	Vertical Impact	45	23.0	Top	Worst Case Orientation
48	UA19A-20	NIAR ATD Drop	Vendor 1	Vertical Impact	55	34.3	Top	Worst Case Orientation
49	UA19A-35	NIAR ATD Drop	Vendor 1	Angled Impact	45	23.0	80 deg forward	Worst Case Orientation
50	UA19A-36	NIAR ATD Drop	Vendor 1	Angled Impact	55	34.3	80 deg forward	Worst Case Orientation
51	UA19A-37	NIAR ATD Drop	Vendor 1	Angled Impact	45	23.0	80 deg - Sideward	Worst Case Orientation
52	UA19A-38	NIAR ATD Drop	Vendor 1	Angled Impact	55	34.3	80 deg - Sideward	Worst Case Orientation
1	DHIT01-Vendor1-0deg-right-70fps	OSU PHMS	Vendor 1	Horizontal Impact	70	57.0	Right Side of Head	Horizontal/Level with Ground
5	DHIT01-Vendor1-58deg-front-70fps	OSU PHMS	Vendor 1	Angled Impact	70	63.1	58 deg to Front Side of Skull	Inverted Horizontal/Level with the Ground
12	DHIT03-Vendor1-90deg-top-70fps	OSU PHMS	Vendor 1	Vertical Impact	70	56.8	Vertical to Top of Head	Inverted Horizontal/Level with the Ground
12a	DHIT03-Vendor1-90deg-top-70fps-02	OSU PHMS	Vendor 1	Vertical Impact	70	57.2	Vertical to Top of Head	Inverted Horizontal/Level with the Ground
43	Deleted	OSU PHMS	Vendor 1	Horizontal Impact	70	51.7	Left Side of Head	Horizontal/Level with Ground
45	Deleted	OSU PHMS	Vendor 1	Angled Impact	70	51.7	58 deg to Front Side of Skull	Inverted Horizontal/Level with the Ground
48	Deleted	OSU PHMS	Vendor 1	Vertical Impact	70	51.7	Vertical to Top of Head	Inverted Horizontal/Level with the Ground
F10	2017-09-14 10-19-29	UAH Flight Test	Vendor 1	2 motor fail on-axis, hover				
F11	2017-09-14 10-10-54	UAH Flight Test	Vendor 1	2 motor fail off-axis, hover				
F12	56 8-24-2017 9-48-00 AM	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12B	log_101_2017-8-29-17-18-16	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12C	2017-09-13 13-38-09	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12D	2017-09-14 08-06-12	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12E	2017-09-14 08-28-56	UAH Flight Test	Vendor 1	4 motor fail, hover				
F12F	2017-09-14 08-09-47	UAH Flight Test	Vendor 1	4 motor fail, hover				
F13	2017-09-14 10-54-09	UAH Flight Test	Vendor 1	1 motor fail, max stab speed				
F14	2017-09-14 13-08-38	UAH Flight Test	Vendor 1	2 motor fail on-axis, max stab speed				
F14B	2017-11-16 11-53-42	UAH Flight Test	Vendor 1	2 motor fail on-axis, max stab speed				
F15	2017-09-14 13-30-54	UAH Flight Test	Vendor 1	2 motor fail off-axis, max stab speed				
F15B	2017-11-16 12-20-43	UAH Flight Test	Vendor 1	2 motor fail off-axis, max stab speed				
F16	2017-09-14 13-45-04	UAH Flight Test	Vendor 1	4 motor fail, max stab speed				
F16B	2017-09-19 10-18-47	UAH Flight Test	Vendor 1	4 motor fail, max stab speed				
F16C	2017-11-16 10-56-53	UAH Flight Test	Vendor 1	4 motor fail, max stab speed				
F60	2017-09-14 08-37-13	UAH Flight Test	Vendor 1	1 motor fail, hover				
171	UAH-260-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
172	UAH-261-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Bottom into Head
173	UAH-262-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Arm Into Head
174	UAH-263-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Between Arms Forward
175	UAH-264-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
176	UAH-265-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	36	4.9	Top	Bottom into Head

UAH Test #	Other ID Number	Organization, Test Type	Model	Impact Trajectory Relative to Head	Impact Speed (fps)	Impact KE (ft-lbs)	Head Impact Location	Vehicle Orientation wrt Head
177	UAH-266-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	36	4.9	Top	Arm Into Head
178	UAH-267-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	36	4.9	Top	Between Arms Forward
179	UAH-268-V1-25	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
180	UAH-269-V1-36	UAH Simplified Drop	Vendor 1	Vertical Impact	25	2.4	Top	Top Into Head
F63	2018-05-23 10-47-35	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail on-axis, hover				
F64	2018-05-23 11-03-34	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail off-axis, hover				
F65	2018-05-17 14-25-56	UAH Flight Test	Vendor 1 (No Cage)	4 motor fail, hover				
F65B	2018-05-23 11-15-24	UAH Flight Test	Vendor 1 (No Cage)	4 motor fail, hover				
F66	2018-05-24 10-40-31	UAH Flight Test	Vendor 1 (No Cage)	1 motor fail, max stab speed				
F67	2018-05-24 10-53-15	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail on-axis, max stab speed				
F68	2018-05-24 11-34-28	UAH Flight Test	Vendor 1 (No Cage)	2 motor fail off-axis, max stab speed				
F69	2018-05-21 07-45-46	UAH Flight Test	Vendor 1 (No Cage)	4 motor fail, max stab speed				
F70	2018-05-23 10-36-24	UAH Flight Test	Vendor 1 (No Cage)	1 motor fail, hover				
115	UA19A-81	NIAR ATD Drop	Vendor 3	Vertical Impact	40	109.4	Top	Worse Case
116	UA19A-82	NIAR ATD Drop	Vendor 3	Vertical Impact	50	170.9	Top	Worse Case
117	UA19A-106	NIAR ATD Drop	Vendor 3	Angled Impact	40	109.4	58 deg - Angled	Worse Case
118	UA19A-107	NIAR ATD Drop	Vendor 3	Angled Impact	50	170.9	58 deg - Angled	Worse Case
125	UAH-125-Green-20ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	17	19.7	Top	Between Arms Forward
126	UAH-126-Green-40ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Between Arms Forward
127	UAH-127-Green-20ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	17	19.7	Top	Bottom Into Head
128	UAH-128-Green-40ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Bottom Into Head
129	UAH-129-Green-20ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Top Into Head
130	UAH-130-Green-40ftlb	UAH Simplified Drop	Vendor 3	Vertical Impact	24	39.4	Top	Top Into Head
131	UAH-131-Green-36	UAH Simplified Drop	Vendor 3	Vertical Impact	36	88.5	Top	Between Arms Forward
132	UAH-132-Green-36	UAH Simplified Drop	Vendor 3	Vertical Impact	36	88.5	Top	Between Arms Forward