## EXECUTIVE SUMMARY:

The effect of an airborne collision between a UAS and a manned aircraft is a concern to the public and government officials at all levels. While the effects of bird impacts on airplanes are well documented, little is known about the effects of more rigid and higher mass UAS on aircraft structures and propulsion systems. This research proposes to evaluate the severity of small UAS (under 55 pounds) collisions on commercial and business jet airframes and propulsion systems. This research will utilize proven simulation techniques validated by test on aircraft hardware. Due to the high level of concern related to this topic, initial simulation analysis will be focused on providing a rough order of magnitude severity evaluation of a TBD UAS with a commercial jet airframe.

The tasks in this proposal will be completed cooperatively utilizing the resources at WSU-NIAR, Ohio State University, Montana State University, and Mississippi State University, and. Each university offers unique capability appropriate to the various tasks in this proposal.

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1. Introduction

Conventional 14 CFR system safety analyses include hazards to flight crew and occupants may not be applicable to unmanned aircraft. However, UAS operations may pose unique hazards to other aircraft and people on the ground. It is necessary to determine hazard severity thresholds for UAS using safety characteristic factors that affect the potential severity of UAS in collisions with other aircraft on the ground or in airborne encounters as well as collisions with people on the ground. Research is needed to establish airborne hazard severity thresholds for collisions between unmanned aircraft, ground aircraft, or collisions with people on the ground. This research will help determine airworthiness requirements for unmanned aircraft based on their potential hazard severity to other airspace users and third parties on the ground. The resulting severity thresholds will be based on UAS characteristics (kinetic energy, structure, shape, materials, etc.) under credible encounter scenarios and will provide for test criteria used to evaluate applicable operational and airworthiness standards. UAS that meet test criteria based on thresholds for these characteristics may be approved for operations over or near people on the ground and may be certified as airworthy under different criteria than other UAS [1].

The main research questions being answered through this research are [1]:

- What are the hazard severity criteria for a UAS collision (weight, kinetic energy, etc.)?
- How can UAS be designed as to minimize the potential damage done during a mid-air collision?
- What is the severity of a UAS collision with an aircraft in the air?
- Can a UAS impact be classified similar to a bird strike?
- Will a UAS impacting an engine be similar to a bird engine ingestion?
- What are the characteristics of a UAS where it will not be a risk to an aircraft collision in the air?
- Can the severity of a UAS mid-air collision with an aircraft be characterized into categories based on the UAS and what would those categories look like?
2. Project Scope

Using the approved hazard severity characteristics and approved method(s) develop comprehensive list of lethality characteristics thresholds using data and analysis from proposed methods and UAS system safety definitions provided by RTCA for airborne collision with other UAS and commercial aircraft. Scenarios should involve impacts with representative commercial aircraft structures, control surfaces, propellers and engines as well as representative small UAS. The scenarios should include analysis similar bird strike methods of impacts on windshields as well as an engine ingesting a small UAS. The analysis should include minimum characteristic thresholds for which there is no relevant risk of damage from a collision. In order to answer the aforementioned items NIAR proposes the following research approach:

- **Phase I - Projectile Definition:** Definition UAS Classes based on: GTOW, Speed, Altitude, Power-Plant, Material Construction, Geometry
- **Phase II - Target Definition:** General Aviation, Business Jet and Commercial Transport Jet
- **Phase III - UAS Projectile Model Development:** CAD, FEA, and Flight Model
- **Phase IV - Aircraft Target Development:** CAD, FEA, and Flight Model
- **Phase V - Safety Evaluation UAS to Aircraft**
- **Phase VI - Aircraft Susceptibility Evaluation:** Definition surrogate projectile and test condition
- **Phase VII - UAS Susceptibility Evaluation:** Definition UAS Crashworthiness Evaluation Method
3. Working Packages

The following section contains a summary of the proposed technical approach for each one of the R&D Phases defined for this project.

1.0 PHASE I-PROJECTILE (UAS CLASS) DEFINITION

**SCOPE:** Conduct a study to classify current and future UAS that can be operated within the National Airspace System (NAS).

**TASKS:** (performed by WSU-NIAR)

- Conduct a detailed study to classify the UAS types that could operate within the NAS.
- Literature Review FAA, and other worldwide agencies (Military and Commercial)
- Prepare a technical report that contains the following data:
  - UAS Type
  - Actual and Projected Number of Units
  - UAS Design Type Data:
    - Define Design Envelope, Dimensions
    - Layout Configuration
    - Material Types used for Construction
    - Propulsion System
    - Battery System
    - Fuel System
    - Payload Type
    - Empty Weight
    - Max GTOW
  - UAS Operations: Altitude, Speed

**DELIVERABLES:** (performed by WSU-NIAR)

- Technical Report UAS Classification
- Identify the configurations and scenarios with a higher probability of ground and midair collision
- Projectile Class (UAS) Definition for Impact Analysis
Figure 1. Example Classification Spectrum UAS [2]

Figure 2. Example Classification Maximum Altitude UAS [2]
2.0 PHASE II-TARGET (AIRCRAFT TYPE) DEFINITION:

**SCOPE:** Conduct a study to classify current aircraft and rotorcraft type that can be operated within the National Airspace System (NAS).

**TASKS:** (performed by WSU-NIAR)
- Conduct a detailed study to classify current aircraft and rotorcraft types that operate within the NAS.
- Literature Review FAA, and other worldwide agencies (Military and Commercial)
- Prepare a technical report that contains the following data:
  - Aircraft/Rotorcraft Type
  - Actual and Projected Number of Units
  - Aircraft/Rotorcraft Design Data:
    - Define Design Envelope, Dimensions
    - Layout Configuration
    - Estimate frontal, lateral and bottom surface areas
    - Material Types used for Construction
    - Propulsion System: Engine Configuration
    - Engine or Propeller Frontal Area Dimensions
    - Max GTOW
  - UAS Operations: Altitude, Speed Design Envelope
  - Conduct a Mid-Air Collision Risk Model to identify Critical Class Configuration [ see example Mid-Air Collision Risk Model reference 2]

**DELIVERABLES:** (performed by WSU-NIAR)
- Technical Report Aircraft/Rotorcraft Classification
- Identify the configurations and scenarios with a higher probability of midair collision
- Target Class (Aircraft Type) Definition for Impact Analysis

*Figure 3. Example Mid-Air Collision Model and Expected Level of Safety [2]*
3.0 PHASE III - UAS PROJECTILE MODEL DEVELOPMENT

**SCOPE:** Define and Validate detailed Finite Element Models and Flight Models of the critical UAS configurations identified in Phase I.

**TASKS:** (performed by WSU-NIAR)

- Generate Detailed 3D CAD Geometry. Two approaches depending on the funding:
  - **Option A:** Purchase and Reverse Engineer existing UAS that falls under the critical configuration categories defined in Phase I
  - **Option B:** Design a UAS that meets the specifications defined for the critical configuration categories defined in Phase I
- Develop detailed UAS FEA Model in Lsdyna to be used for analysis in phase V.
- Develop detailed UAS Flight Model in MIURA-NIAR Virtual Environment format for the flight impact scenarios simulations.
- Validate FEA and Flight Model with experimental data if funding is available for Option A [Following NIAR methodology for composite and metallic structures].

**DELIVERABLES:** (performed by WSU-NIAR)

- UAS CAD, FEA and Flight Model

**LAB Facilities:**

- NIAR-WSU Computational Mechanics Laboratory
- NIAR-WSU CAD Laboratory
- NIAR-WSU Reverse Engineering Laboratory
- NIAR-WSU Material Characterization Laboratory
- NIAR-WSU Virtual Flight Testing Laboratory
- NIAR-WSU Crashworthiness Laboratory

![Figure 4. Example NIAR CAD, FEA, Crashworthiness Testing UAS Capabilities](image-url)
4.0 Phase IV - Aircraft Target Development

**Scope:** Use NIARs Aircraft FEA and Virtual Flight Testing library to define a representative PART 25 Narrow Body Transport aircraft and a PART 23 Business Jet or General Aviation Aircraft, and representative turbine fans.

**Tasks:** (performed by WSU - NIAR, OSU, Montana as noted)
- Prepare baseline Metallic and Composite aircraft FEA, CFD and Flight Models from NIARS computational mechanics database to be used for analysis in phase V. (WSU-NIAR)
- Propulsion Bird Ingestion Experimental and Computational Models (OSU, Mont)

**Deliverables:** (performed by WSU - NIAR, OSU, Montana as noted)
- Narrow Body Transport and Business Jet Flight and FEA model to be used for analysis in Phase V. (WSU - NIAR)
- Turbine fan FEA model to be used in analysis in Phase V. (OSU, Montana)

**Lab Facilities:**
- NIAR-WSU Computational Mechanics Laboratory
- NIAR-WSU CAD Laboratory
- NIAR-WSU Material Characterization Laboratory
- NIAR-WSU Virtual Flight Testing Laboratory
- NIAR-WSU Crashworthiness Laboratory

*Figure 5. NIAR Part 25, Narrow Body Transport Aircraft CAD, FEA, and Flight Model*
5.0 **PHASE V - STRUCTURAL SAFETY EVALUATION MID-AIR COLLISION UAS TO AIRCRAFT – PART 23 & 25**

**SCOPE:** Based on the results of Phase I and II define impact scenarios that can be evaluated using the FEA, CFD and Flight Models developed in Phase III and IV to identify the airframe damage.

**TASKS:** (Performed by WSU-NIAR, OSU, Montana, Mississippi and UAH as noted)
- Conduct Crashworthiness Structural FEA Simulations and damage evaluation (WSU-NIAR)
- Conduct CFD analysis to study debris trajectories and identify post-secondary impact areas (WSU-NIAR)
- Modify flight model with structural damage and assess safety of flight post impact (WSU-NIAR)
- Document damage mechanics (WSU-NIAR)
- Experimental Component Level Validation Studies: Turbine (OSU, Montana) and Airframe Structure (WSU-NIAR, UAH)
- Post impact Damage Assessment (Mississippi)

**DELIVERABLES:** (Performed by WSU-NIAR, OSU, Montana, Mississippi and UAH)
- Airframe structural damage evaluation due to mid-air collision between a UAS and a Narrow Body and Business Jet Aircraft.

**LAB Facilities:**
- NIAR-WSU Computational Mechanics Laboratory
- NIAR-WSU Material Characterization Laboratory
- NIAR-WSU Virtual Flight Testing Laboratory
- NIAR-WSU Crashworthiness Laboratory
**Step 1.** Impact Simulation - Define Damage and Post Impact Debris Geometry

**Step 2.** Post Impact Debris Field CFD Analysis - Trajectory Secondary Impact

**Step 3.** Virtual Flight Evaluation Post Impact Safety of Flight

**Figure 7.** NIAR Proposed Structural Safety Evaluation Mid-Air Collision UAS to Aircraft
6.0 PHASE VI - AIRCRAFT SUSCEPTIBILITY AND CRASHWORTHINESS EVALUATION STANDARD

**SCOPE:** Define a test protocol to evaluate the Aircraft susceptibility and damage due to Mid-Air Collisions with UAS.

**TASKS:** (performed by WSU-NIAR)
- Review and summarize results from Phase I through Phase V
- Review the data generated by the OSU (UAS Ingestion) and other research partners
- Evaluate a UAS testing protocol based on 14 CFR 25.631, 25.775, 25.571 and 33.76
- Identify differences with Bird Strike impact testing requirements
- Provide an experimental and virtual UAS strike evaluation protocol

**DELIVERABLES:** (performed by WSU-NIAR)
- Test and simulation protocol to assess the airframe structural response to a UAS mid-air collision

**LAB Facilities:**
- NIAR-WSU Computational Mechanics Laboratory
- NIAR-WSU Virtual Flight Testing Laboratory
- NIAR-WSU Crashworthiness Laboratory
- NIAR-WSU Impact Dynamics and Bird Strike Laboratory

7.0 PHASE VII - UAS CRASHWORTHINESS EVALUATION STANDARD

**SCOPE:** Define a methodology to evaluate UAS Crashworthiness performance for mid-air, and ground [infrastructure & population] impact.

**TASKS:** (performed by WSU-NIAR)
- Review and summarize results from Phase I through Phase V
- Review the data generated by the OSU (UAS Ingestion) and other research partners
- Define a series of design recommendations that can be used by UAS manufacturers to design more crashworthy UAS in the future
- Provide an experimental and virtual UAS strike evaluation protocol

**DELIVERABLES:** (performed by WSU-NIAR)
- Test and simulation protocol to assess the crashworthiness response of UAS to mid-air and ground collisions

**LAB Facilities:**
- NIAR-WSU Computational Mechanics Laboratory
- NIAR-WSU Virtual Flight Testing Laboratory
- NIAR-WSU Impact Dynamics and Bird Strike Laboratory
4. References

1. FAA COE Task: A11LUAS.COE.7.2 UAS Airborne Collision Severity Evaluation
2. Weibel R., Hansman R., Safety Considerations for Operation of Different UAVs in the NAS, AIAA 2004
6. Key Personnel
Gerardo Olivares Ph.D. | Director Crash Dynamics and Computational Mechanics Laboratories NIAR

Professional Profile:

Dr. Gerardo Olivares joined the National Institute for Aviation Research (NIAR) as a Research Scientist in July 2005. Currently he is Director and Senior Research Scientist for the Computational Mechanics and Crash Dynamics laboratories. Dr. Olivares has developed a recognized world-class research program, personnel and laboratory facilities in the areas of computational\experimental crashworthiness, virtual product development, and certification by analysis methods. Since 2005 Dr. Olivares has been the principal investigator in over 110 research projects with funding in excess of $23.2M funded by various US Federal Agencies and private companies from 15 different countries. For the last fifteen years Dr. Olivares has been able to successfully negotiate and execute complex international engineering programs in the aerospace and automotive industry. Dr. Olivares has demonstrated a capacity to envision future industry needs and develop the tools and methods necessary to solve these issues. Since 2005 Dr. Olivares has sponsored in his labs 75 Graduate (MS and PhD), 18 Undergrad Students, and 19 Research Scholars from Universities and R&D Centers in Germany, Japan, Italy, France, and Spain.

Professional Experience:

- 6/2005-Present | **Director** | National Institute for Aviation Research | USA
- 6/2001-12/2004 | **Engineering Manager** | KSS Deutschland GmbH | Germany
- 1/1998-9/1998 | **Project Engineer** | TNO MADYMO North America | USA
- 5/1995-5/2001 | **Design Engineer** | McKechnie Aerospace | USA

Research Areas and Experience:

- **Fifteen years of international experience** directing and managing engineering organizations, complex engineering projects, and laboratory facilities for the aerospace and automotive industries.
- **Twenty years of experience** in structural crashworthiness and injury biomechanics:
  - Development and certification by analysis methods for aircraft interiors (FAA funded research programs and industry funded projects).
  - Development and certification by analysis methods to evaluate the crashworthiness performance of composite and metallic aerospace structures (FAA funded research programs and industry funded projects).
  - Crashworthy metallic and composite structural design: aerospace, automotive, buses and Light Rail Vehicles.
  - Safety systems design for aerospace, automotive, buses and Light Rail Vehicles occupants.
  - Airbag and advanced restraint systems design and development.
- **Twenty years of experience in virtual product and system development for the aerospace and automotive industries:**
  - Software development multidisciplinary\multiphysics analysis. Component to system level virtual development and testing methods. Real time flight and driving simulators.
- **Six years of experience** in electromechanical systems design for aerospace and military applications.

Education:

- **Doctor of Philosophy** in Mechanical Engineering – 2001 - Wichita State University, Wichita, KS, USA
- **Master of Science** in Aerospace Engineering – 1997 - Wichita State University, Wichita, KS, USA
- **Bachelor of Science** in Aerospace Engineering – 1995 - Wichita State University, Wichita, KS, USA
**Tom Aldag | Director Research and Development NIAR**

**Professional Profile:**

As director of research and development for the National Institute for Aviation Research at Wichita State University, Tom Aldag oversees R&D programs, identifies opportunities for new programs and develops growth strategies. He has been instrumental in NIAR’s expansion into the wind and UAS industries and the founding and operation of the Center of Innovation for Biomaterials in Orthopaedic Research.

Tom has 25 years of airframe structural design experience including 13 years focused on composite designs.

Before joining NIAR in 2007, he worked for Cessna Aircraft Company for 16 years, where he was involved with the FAA certification of three new aircraft models and worked on numerous other models with Cessna’s advanced design team. He began at Cessna in 1991 as a senior structures engineer for fuselage and composite control surface certification. He later headed an advanced design team investigating composite and metallic manufacturing methods for next generation propeller products. In 2003, he became director of single engine and propeller products engineering. In this capacity, he managed four engineering departments covering eight production aircraft models, McCauley propellers, and legacy aircraft. He provided input on products under development and interfaced with internal and external customers to define needs and set priorities.

Tom also spent eight years at Beech Aircraft in the project and structures areas working extensively on design, structural certification, and manufacturing issues related to composite structures.

Tom graduated from Wichita State University in 1983 with a Bachelor’s degree in aeronautical engineering and later received a mini-MBA from WSU. He is a Six Sigma Greenbelt, and a 2500 hour pilot and flight instructor.
Suresh Keshavanarayana Ph.D. | Associate Professor in the Department of Aerospace Engineering, WSU

Professional Profile:

Dr. Suresh Keshavanarayana (K.S. Raju) is an Associate Professor in the Department of Aerospace Engineering, Wichita State University. Prior to this appointment, he was a Research Scientist at the National Institute for Aviation Research. He specializes in the area of solid mechanics with emphasis on experimental work. His research interests include fatigue behavior of fastener joints, damage resistance and tolerance of laminated and sandwich construction, indentation behavior, crashworthiness, failure mechanisms in heterogeneous media, high strain rate characterization of composite materials, cure characterization and modeling of composites. Some of the ongoing work includes evaluation of embedding tubular sensors in laminated composites, development of tension test apparatus for dynamic testing using servo-hydraulic testing machines, evolution of surface roughness and friction coefficients in fatigue loaded aluminum fastener joints.

Relevant Publications/Presentations:

- K.S. Raju and J.F. Acosta, Crashworthiness of composite fuselage structures: material dynamic properties phase I, DOT/FAA/AR-09/8
Juan Acosta Ph.D. | Research Scientist Computational Mechanics Laboratory NIAR

Professional Profile:

Dr. Acosta joined NIAR in October 2009 as a Research Engineer. Since then his primary research focuses on developing analysis methods to evaluate the crashworthiness performance of composite and metallic structures during crashes. He is currently a Research Scientist for the Computational Mechanics Lab. He is also the Co-PI for the FAA sponsored research project Certification by Analysis – Structural Crashworthiness. Before returning to NIAR, he served the aerospace industry as a consultant in the fabrication of composite components and the research world as an instructor of experimental methods. He has developed high speed experimental methods to generate dynamic material properties used in the simulation of impact events. He first joined NIAR in 2000 as a research assistant and worked for several years for the Composites Lab and the Structures Lab conducting research on damage tolerance of composite sandwich structures.

Professional Experience:

- 10/2009 - Present | Research Scientist | Computational Mechanics Lab | NIAR | USA
- 1/2007 - 9/2009 | Research Assistant | Solid Mechanics Lab | Wichita State University | USA
- 9/2002 - 1/2007 | Research Technician | Structures Lab | NIAR | USA
- 2/2000 - 7/2002 | Research Assistant | Composites Lab | NIAR | USA
- 1/1997 - 12/1998 | Mechanical Engineer | Carboquimica S.A. | COL

Research Areas and Experience:

- **Fifteen years of experience** in composite materials
  - Manufacturing, testing, qualification, certification, design, and analysis
  - Material qualification and equivalency to control composites material properties and processes
  - Development test methods for fiber reinforced composites: ASTM D 790
  - Development process, fabrication, and assembly plans for composite components: propellers, pressure vessels, etc.
  - Failure analysis on composite and metallic structures
  - Full field measuring equipment, e.g., photogrammetry
  - Fatigue and damage tolerance capabilities of composites used for GA aircraft
- **Nine years of experience** in structural crashworthiness and numerical methods
  - Development of high speed testing procedures on metallic and composite materials
  - High speed testing instrumentation
  - Development of material models for simulation of dynamic events
  - Design of crashworthy metallic and composite aerospace and automotive structures
  - Development and certification by analysis methods to evaluate the crashworthiness performance of composite and metallic aerospace structures
  - Development of test protocols for seat cushions and restraint systems to generate material properties suitable for simulation of dynamic events

Education:

- **Doctor of Philosophy** in Aerospace Engineering – 2012 – Wichita State University, Wichita, KS, USA
- **Master of Science** in Aerospace Engineering – 2002 – Wichita State University, Wichita, KS, USA
- **Bachelor of Science** in Mechanical Engineering – 1998 – University of the Andes, Bogota, COL
Nilesh Dhole | Research Engineer Computational Mechanics Laboratory NIAR

Professional Profile:

Nilesh Dhole joined the National Institute for Aviation Research (NIAR) in August 2007 as a Graduate Research Assistant while doing his Master’s degree in Mechanical Engineering. During this time he developed his knowledge and skills in experimental and computational work, in the area of crashworthiness. In 2010, after finishing Master’s degree he joined the Computational Mechanics laboratory as a Research Engineer. As a Research Engineer, Nilesh is working on various research projects for both aerospace and automotive industries.

Professional Experience:

- 5/2010 - Present  | Research Engineer  | National Institute for Aviation Research  | USA
- 8/2007 - 5/2010  | Graduate Research Assistant  | National Institute for Aviation Research  | USA

Research Areas and Experience:

- Six years of experience in Finite Element Modeling using LS-DYNA for High Speed Impact events:
  - Research on the development of Gelatin Substitute for the real chickens used in bird strike tests. Conducted various bird strike tests on metallic and composite structures to develop the gelatin bird substitute. Developed and validated the FE model of gelatin bird substitute.
  - Research on FE model development of real 4lb chicken used on bird strike test. Conducted CT scan of 2lb, 4lb and 8lb chicken to obtain geometric shape and density information of different organs/bones. Developed FE/SPH models out of this CT scan data and validated against the tests conducted on metallic and composite parts.
  - Conducted a bird strike test of radome enclosing a antenna used to provide internet service on airplanes. Developed FE model of antenna and radome and validated the FE model against the test data. This validated FE model of radome and antenna was then used to certify the bird strike event on four different airplanes.
  - Supported bird strike certification by simulation for various aircraft structures like canopy, belly fairing, windshield and radomes.
  - Research on front, side and rear crash simulation of public transit bus with and without occupants. Research was funded by Federal Transit Administration.
  - Completed various projects for Certification by Analysis of aircraft seats as per AC20-146 for various aircraft and Seat Manufacturing companies.
  - Experience in development and validation of FE models for economy class seats, business class seats and side facing divans.
  - Conducted fuselage drop simulations for a Part23 type aircraft to support the crashworthiness certification.
  - Finite element model (LS-DYNA) development and validation of HII 50th % ATD.
  - Research on FE model development of 737-800 equivalent aircraft. Conducted crash simulation for accident recreation with 75 FE ATD models.

Education:

- Master of Science in Mechanical Engineering – 2010 – Wichita State University, Wichita, KS, USA
- Bachelor of Engineering in Mechanical Engineering – 2006 – University of Pune, India
Luis Gomez | Lab Manager Computational Mechanics Laboratory NIAR

Professional Profile:

Luis Gomez joined the National Institute for Aviation Research (NIAR) as a Research Engineer in September 2008. Currently he is the Research Lab Manager for the Computational Mechanics laboratory. Over a seven years period Luis Gomez has developed and improved his knowledge and skills in experimental and computational work, in particular in the area of crashworthiness. Since 2008 Luis Gomez has participated in over 30 research projects funded by various US Federal Agencies and private companies for both aerospace and automotive industry. For the last seven years, Luis Gomez has been able to coordinate and manage an interdisciplinary team of full time and students employees that assures that all the clients’ requests are successfully accomplished in time and manner.

Professional Experience:

- 6/2015-Present  | Computational Mechanics Lab Manager | NIAR | USA
- 5/2014-5/2015 | Res. Engineer/Project Manager | National Institute for Aviation Research | USA
- 9/2008-4/2014 | Research Engineer | National Institute for Aviation Research | USA

Research Areas and Experience:

- Eight years of experience in structural crashworthiness and numerical methods:
  - Development of analysis methods to evaluate the crashworthiness performance of composite and metallic aerospace structures
  - Development of test protocols for metals and seat cushions to generate material properties suitable for numerical methods
  - Crashworthiness research using numerical methods for forward, aft, and side-facing aircraft seats for different FAA and industry projects
  - Design and development, using numerical methods, of a new pilot seat capable of withstand up to 32 g’s of deceleration in order to meet Part23 FAA lumbar load criterion.
  - Evaluation of different energy absorbing systems using numerical methods for a helicopter seat under MIL-STD-58095A dynamic conditions.
  - Certification through numerical methods (finite element and multi-body) of a Head-Up Display system following FAA Advisory Circular AC 20.146.
  - Evaluation of 2pt belt airbag restraint systems for aerospace commercial seats using numerical methods, including validation through dynamic testing.
  - Experience conducting dynamic testing according to different standards, including but not only: FAA 14 CFR Part 23, 25, 27, and 29, FMVSS 208, ECE R16...
  - Federal Transit Administration founded project for analysis of current level of safety in Light Rail Vehicles. Forward, Aft, and Side-facing seats were evaluated.
  - Federal Transit Administration founded project to design and develop a lap-belt airbag system for a bus driver by dynamic testing and computational analysis.
  - Dynamic testing and numerical analysis of different automotive crash scenarios for an analytical tool benchmark program following ECE R16 protocol.

Education:

- Master of Business Administration – Ongoing – Wichita State University, Wichita, KS, USA
- Master of Science in Mechanical Engineering – 2011 – Wichita State University, Wichita, KS, USA
- Bachelor of Science in Mechanical Engineering – 2009 – Polytechnic University of Madrid, Spain
7. Points of Contact

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James Gregory
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Mississippi State University
Ratan Jha
Tom Lacy
J. Mark Janus
J.C. Newman Jr

University of Alabama in Huntsville
David Arterburn
Steve Messervy
8. NIAR Facilities Overview

The National Institute for Aviation Research (NIAR) at Wichita State University was established in 1985 in order to strengthen research and services support to the aviation industry. Today NIAR provides research, design, testing, and certification services to industry, government agencies and educational entities. With more than 120,000 square feet of laboratory space, NIAR is home to several major laboratories including: Computational Mechanics, Crash Dynamics, ATD Calibration, Advanced Joining, Aging Aircraft, CAD/CAM, Composites & Advanced Materials, Fatigue & Fracture, Full-Scale Structural Testing, Human Factors, and Structures. The Institute employs approximately 60 professionals with Ph.D.s, 30 with master's degrees and 90 with bachelor's degrees. With a full-time staff of more than 200 and nearly 100 student and graduate research assistants, NIAR is well-equipped to meet the changing needs of aviation and non-aviation organizations. NIAR is also proud to hold three FAA Centers of Excellence designations. Together, they promote the safety, research, manufacturing and design elements of today's aviation industry. These include the FAA Center of Excellence for General Aviation Research (CGAR), the Airworthiness Assurance Center of Excellence (AACE) and most recently a Center of Excellence in Composites and Advanced Materials (CECAM). In 2001, NIAR was awarded the prestigious FAA Excellence in Aviation Institutional Award for our ability to partner with industry, academia and government to advance aviation research.
Aerospace Crashworthiness CBA: World Class Research Program

- Worldwide Leading Research Group in Certification by Analysis Methods for Aircraft Interiors and Metallic /Composite Aircraft Structures
- First Certification by Analysis Program for a HUD Pilot Installation - 2011
- Over 70 Aerospace Crashworthiness Related R&D Projects with clients in 15 countries since 2005:
  - Ten years of FAA, Industry and Internally Funded R&D Programs on Certification by Analysis Methods for Aerospace Seats and Metallic/Composite Structures
  - Multiple Seat Development and Certification Programs [ Gulfstream, HBC, JMU, JEC...]
  - Composite and Metallic Airframe Crashworthiness Development and Certification Program [Lear 85]
  - HUD Installation Certification by Analysis Programs [First CBA Program approved by the FAA]
  - ADI Numerical Model Development [Humanetics HIL and internal HIL \ FAA HIL]
  - Development of Advanced Seat Modeling Methods
  - Seat Design Applications (Design to Proof of Concept)
  - Advanced Restraint Systems Development
  - Implementation of ISOFIX and LATCH equipped CRS in aircraft seats
  - Evaluation and development of Human Body Models for Aerospace Crashworthiness Applications
- Development of future industry standard(s): coupon to full scale testing methodologies
- Build State of the Art Modeling and Testing Facilities from Coupon to Full Scale Level
- First R&D group to model successfully detailed aircraft FE models with complete interiors and occupants (10 + million elements)
- Organized and hosted multiple meetings, workshops on the topic of Aerospace Crashworthiness. Host and organizer of the upcoming Inaugural Aerospace Structural Impact Dynamics International Conference and Workshops on November 2012
- Computational Mechanics Group growth from 1 researcher in 2005 to 40 in 2015
- Since the R&D Program inception in 2005, 75 GRA, 18 Undergrad and 19 Research Scholars
Crashworthiness Research Facilities

- Crashworthiness Main Laboratory Facilities:
  - Experimental:
    - NIAR Crash Dynamics Laboratory
    - NIAR ATD Calibration Laboratory
  - Computational:
    - NIAR Computational Mechanics Laboratory
    - NIAR Virtual Reality Laboratory
  - 30 R&D Engineers:
    - 10 FTE and 20 Research Assistants
- Crashworthiness Support Laboratory Facilities:
  - NIAR Structures Laboratory
  - NIAR Composites Laboratory
  - NIAR Research Machine Shop
  - NIAR CAD/CAM and Reverse Engineering Laboratories

NIAR Virtual Flight Environment Collaboration Lab
Ballistic and Impact Dynamics Lab

- Ballistic Rounds from Small arms to high caliber including 50 cal. Tumbling
- High speed video and data acquisition
- Close cooperation with NIAR’s Computational Lab
- 30 ft Drop Test Capable
- High-energy containment structure

Bird-strike Capability

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