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UNITED STATES DEPARTMENT OF TRANSPORTATION (U.S. DOT)

National Highway Traffic Safety Administration (NHTSA)

Cooperative Agreement for
Title: Discretionary Cooperative Agreement to Support Biomechanical Research

I. STATEMENT OF AUTHORITY

This Cooperative Agreement (also called "Agreement") between the National Highway Traffic Safety Administration (NHTSA), hereinafter referred to as "NHTSA", and the Rector and Visitors of the University of Virginia - Center for Applied Biomechanics (UVA), hereinafter referred to as "the Grantee," is hereby entered into under the authority of the Highway Safety Act of 1966, as amended (23 U.S.C. Chapter 4). This Cooperative Agreement provides for the limited exchange of personnel, equipment, facilities and funds to achieve the following purpose(s):

II. BACKGROUND, PURPOSE, and OBJECTIVE

A. BACKGROUND

Over the past twenty years under cooperative agreements with the NHTSA, UVA has conducted more than 1000 tests on component or intact human surrogates. UVA has clearly shown its ability to acquire human surrogates and have demonstrated an expertise in conducting biomechanical impact testing. The biomechanical testing has included full-scale sled tests for improving the understanding of frontal and lateral impacts and component studies that have provided a better understanding of injury mechanisms and tolerances for the ankle, leg, abdomen, thorax, and upper extremities as well as customized material characterization for tissues throughout the body including skin, aorta, brain, ligaments, liver, flesh, and bone.

In the most recent cooperative agreements, UVA has focused considerably on thoracic and lower extremity injury mechanisms. Their research results have gone far to expand the knowledge of thoracic and lower extremity injury mechanisms and have been crucial in the development of a more biofidelic advanced test device (THOR) with the associated THOR-LX lower extremities. The Grantee's work has also focused on pediatric biomechanics including sensitivity analysis of pediatric models and thorough literature review of hard and soft tissue properties for the pediatric population. Finally, UVA, in the most recent cooperative agreement, has begun the development of a test protocol to be used in the development of performance criteria for advanced frontal dummy thoracic response. The development of this test protocol and the research related to pediatrics and lower extremities represent a continuation of research efforts.

The proposed tasks in the statement of work will cover areas still considered to be critical to the understanding of injuries resulting from motor vehicle crashes (MVC). Areas of study will include the thorax and lower extremities. As a body region, thorax trauma is second only to head trauma in fatality from injuries sustained in MVC. Thoracic injuries are present in the vast majority of blunt trauma patients. NASS-CDS data shows 2 of the top 4 injuries in frontal crashes are thoracic injuries (rib fractures and pulmonary contusions). Chest injuries constitute

23% of all injuries in crashes. For 4- to 8-yr-olds, Abbreviated Injury Scale (AIS) 3+ injuries to the chest are second only to the head based on analysis of NASS-CDS data (Starnes and Eigen – NHTSA DOT HS 809 410). Regarding lower extremity injuries, Kuppa and Fessahaie (ESV 2003) showed that 36% of AIS 2+ injuries sustained by front seat occupants in frontal crashes were lower extremity injuries and that they represented 46% of life-years lost (LLI) to AIS 2+ injuries with 45% of the lower extremity LLI being attributed to below knee injuries.

There are an annual estimated 281,000 light vehicles that are towed from police-reported rollover crashes each year, in which 30,000 occupants are seriously and fatally injured. Of these, 16 percent (6,500) have at least one serious injury due to roof contact where some amount of roof intrusion is present. Over half (3,450) of these injured occupants were belted.

SAFETEA-LU mandated that NHTSA consider dynamic testing as part of the recent upgrade to FMVSS No. 216. While the agency encountered significant public and congressional interest in dynamic testing for rollover, there are significant challenges to the implementation of dynamic rollover testing within the SAFETEA-LU time constraints. The most significant limitations are the lack of a generally accepted test procedure, performance measure, and an anthropomorphic dummy to evaluate occupant injury potential.

The data to be generated and reported on in this cooperative agreement will improve the current knowledge of adult and pediatric thoracic response and adult lower extremity injury response to loading conditions that are prevalent in motor vehicle crashes. The development of new response requirements and injury criteria will potentially be used by the crashworthiness community (academia, automobile manufactures, ATD manufacturers, NHTSA) to improve current anthropometric test devices (ATDs). Additionally, the testing and modeling efforts herein will contribute to a better understanding of the effects of countermeasure design (airbags, seatbelts, etc.) on injury response. This improved understanding could aid the automobile and restraint system manufactures in designing restraint systems with improved capabilities to mitigate or prevent serious injuries. This improved understanding of injury response will also allow for improved prediction of chest and lower leg injury with the use of current ATDs. The research herein addresses areas covered by the current Federal Motor Vehicle Safety Standards (FMVSS) Nos. 208, 213, 214, and 216.

Rollover related research also makes up a significant portion of this effort. The rollover research will continue reviews of epidemiologic studies of rollover crashes and associated injuries that began under a previous Agreement. The efforts will lead to a test procedure and apparatus that can reproduce crash and vehicle parameters for prioritized rollover scenarios. A dynamic test protocol will be developed and evaluated for repeatability that can be used to assess vehicle crashworthiness and factors that influence occupant injuries in rollover events. The modeling efforts in this rollover research will make use of dummy models (Hybrid III and THOR) and parameter studies to assess sensitive variables that influence occupant outcome in rollover. Finally, the rollover studies will include an assessment of the biofidelity of current ATDs in comparison to post mortem human subjects (PMHS) under identical roll conditions.

B. PURPOSE

The agreement will focus on improving the understanding of the biomechanics of injury through frontal crash restraint and dummy evaluations, pediatric injury response research, lower limb injury, and rollover investigations through a combined experimental and computational research plan. The data generated in this study could be used by the crashworthiness community in the development of injury criteria and response requirements for future enhancements of pediatric and adult ATDs. The testing and modeling efforts herein will contribute to a better understanding of the effects of countermeasure design (airbags, seatbelts, etc.) on injury response that could be used by automobile manufacturers in efforts to improve vehicle safety and reduce serious injuries that result from motor vehicle crashes.

Finally, the Agreement will also improve the knowledge of test protocols related to rollover crashes. This will provide in turn a means to develop a dynamic test protocol for use in evaluating vehicle crashworthiness in field relevant rollover crash modes. Additionally, the research will provide an assessment of the biofidelity of current ATDs versus PMHS in identical rollover conditions. A dynamic test to evaluate vehicle performance in a rollover crash that integrates rollover protection initiatives such as roof strength, ejection mitigation and restraint performance is a long term goal of NHTSA.

III. <u>SCOPE OF WORK</u>

GENERAL REQUIRMENTS

For the period as hereinafter set forth in Section V, Performance Period, NHTSA and the Grantee shall furnish cooperatively the necessary personnel, equipment and facilities, and otherwise perform all things necessary for, or incident to, the performance of work (the accomplishment of tasks) as set forth below.

A. <u>Specifically NHTSA will:</u>

1) Provide a Contracting Officer's Technical Representative (COTR) to participate in the planning and management of this Cooperative Agreement and to coordinate activities between the grantee and NHTSA.
2) Provide information and technical assistance from government sources within available resources and as determined appropriate by the COTR.
3) Provide liaison with the Grantee and other government and private agencies as appropriate.
4) Stimulate the exchange of ideas and information among recipients of related projects through periodic meetings and
5) Maintain an on-going contact with the Grantee regarding conduct of this agreement.

B. <u>Specifically The Grantee shall:</u>

1) Perform the effort as discussed in Section C, Project Description of the scope of work.
2) Designate a Rector and Visitors of the UVA CAB Project Manager to serve as liaison and coordinator between NHTSA and the UVA CAB and to manage the tasks performed under this agreement.
3) Advise NHTSA's COTR of any problems in implementing or making progress on any tasks performed under this Cooperative Agreement, as well as strategy

recommendations or revisions to the Project description to permit successful performance. All significant decision points, written materials or other work products will be submitted to the NHTSA COTR for approval.

4) Not deviate from the procedures or objectives specified in this Cooperative Agreement unless presented in writing and written approval is received by the NHTSA Contracting Officer before such deviations are implemented.

C. <u>Specific Requirements / Project Description</u>:

TASKS 1 through 5 removed, not relevant to requestors interest in rollover research

Task 1: Characterize Response to Different Restraint Environment and Injury Criteria Development

Task 2. Development of Response Corridors of PMHS Lower Limb, Foot and Ankle FE Model and new Thor-LX tests

Task 3. Thoracic response data review and compilation, corridor development, and THOR upgrade assessments

Task 4. Experimental thorax characterization

Task 5. Further Validation and Updating of NHTSA Finite Element Model of the THOR-NT- Dummy

Task 6. Rollover – Epidemiology/Biomechanics Analysis

6.1: This task continues the initial research begun by the Grantee in the prior Agreement between NHTSA and the Grantee. This prior work is to include a report summarizing the existing rollover epidemiology research and NASS analyses. The purpose of the current task will be for the Grantee to perform additional analyses. The current analyses and the results of Task 6.2 will be used by the Grantee to support the identification of targeted rollover scenarios using Harm as a basis to quantify the combination of crash severity and frequency.

6.2: The purpose of this sub-task will be to require the Grantee to define the basic injury frequency information as well as stratified information involving crash, occupant and injury parameters. This will be defined using the epidemiologic information generated by the Grantee in the initial study and from Task 6.1. Given the inherent variability associated with certain crash and restraint conditions, the investigation will focus on pure roll events and belted occupants. If permitted by the quality and quantity of data, a more fundamental regression equation will be used by the Grantee to relate the various injury outcomes with vehicle, restraint, crash and occupant parameters and will later be used to develop the ranges of these parameters in subsequent modeling activities.

The results of this analysis will be coupled with subsequent analyses of the biomechanics and rollover literature to improve the Grantee's and the public's understanding of the mechanisms and sources of the most common and severe injuries. Injury mechanisms and crash scenarios will be cross-checked to identify the injuries, mechanisms and sources most relevant to the targeted rollover scenarios (Task 6.1). The injury biomechanics literature will be reviewed to develop a detailed understanding of the mechanisms for the identified injuries and to identify the most applicable injury criteria for the injuries. The results of this analysis will be summarized in a report that clearly identifies the weighted prioritization of injuries as defined based on crash scenario and occupant parameters, explains the sources and mechanisms for each injury with identification of the injury criteria, and explains the justification for the targeted rollover scenarios.

Task 7. Rollover Crash Modeling

The purpose of this task is to require the Grantee to develop rollover crash models that will assist in developing an understanding of crash, vehicle and occupant parameters that cause occupant injuries in rollovers. The task will also require the Grantee to develop models to support dynamic rollover test procedure development. The following subtasks describe the background study and modeling efforts that the Grantee will complete to meet the task's objectives.

7.1: The first step in the computational modeling effort will be to review computational modeling techniques used to simulate rollover simulations and test fixtures. The Grantee's review will focus on modeling real vehicle rollovers vs. test systems, model validation efforts, occupant kinematics and injury prediction modeling, and computational issues related to modeling rollover. The results of this literature review will be used by the Grantee to support all future modeling efforts so as to be sure to build upon previous work as opposed to repeating it.

7.2: The research will build upon the work from the initial Grantee/NHTSA study and the results of the literature review to continue to explore the sensitivity of occupant dynamics to variations in vehicle characteristics, rollover boundary conditions and occupant parameters. In the initial study, a vehicle FE model validated for static roof crush testing will be developed and used to study the sensitivity of rollover input parameters (drop height, roll rate, vehicle pitch and lateral velocity, e.g.) without consideration for the boundary and initial conditions that were used to develop them. This reduction of the rollover event to a few basic crash and vehicle parameters will directly parallel the path envisioned for the design of and testing with the initial experimental rollover test system. With these input parameters defining the design space for the computational modeling, variations in occupant kinematics and injury values will be examined.

The current study will build upon this work to expand the design space to include occupant parameters including position, orientation and anthropometry as well as vehicle geometric and inertial characteristics. The goal of this work will be to improve knowledge of the parameters that are most sensitive to the characteristics that cause occupant injuries (occupant kinematics and kinetics) in rollovers through evaluation of relevant occupant, vehicle and crash parameters.

7.3: The computational sensitivity analysis will need to employ boundaries on the rollover crash parameters to ensure that the experimental scenarios ultimately tested are not only accurate simplifications, but provide for a reasonable representation of the possible rollover conditions. These boundaries will be determined through modeling of full vehicles in rollover crashes. Based on the Grantee's work in the epidemiology study, initially a single vehicle model will be developed to simulate the conditions that cause the rollover (e.g., friction trip, curb trip) and to simulate the resulting rollover crash. If appropriate data exists in the literature, the models' kinematic response to the rollover crash conditions will be compared to data from real vehicle tests. This first model, once validated, will be compared with simulations of the dynamic rollover test system or DROTS (Task 9) to ensure that the test system will be able to reproduce realistic rollover conditions.

7.4: After the first two years of the Agreement, and once the provisional test procedure has been identified and outlined (Task 11) by the Grantee, the computational effort in simulating real-world rollover crashes will be expanded to examine at least one more vehicle and additional conditions. It is anticipated that the review combined with the computational and experimental analyses performed in the first two years of the Agreement will significantly improve the understanding of the conditions originally chosen for the targeted scenario used in the dynamic test procedure. Thus, the objective of this next step will be to expand the modeling effort to include a broader range of conditions for use in refining the test procedure. Models of one or two more vehicles (a sedan and possibly a cross-over vehicle) will be developed and validated for real-world rollover crashes and additional analyses with all of the vehicles will be used to examine variations in initial and boundary conditions. Development and testing of these additional models will begin in year 2 and a final report describing this effort will be submitted at the end of year 3.

Task 8. Rollover Crashworthiness and Test Research Review

This purpose of this task will be to require the Grantee to build upon the rollover test system review completed under a prior effort of NHTSA and the Grantee. Since this initial review will be limited to examining previously used rollover test fixtures, the task in this current study will expand on this review. This task will improve the knowledge of rollover test methodology, factors that influence vehicle crashworthiness in rollover, and the current understanding and debates within the research community regarding injury mechanisms and sources. This effort will complement the other facets of this study including the initial Grantee/NHTSA project, Task 6 (6.1 and 6.4), and Task 7 to ensure that all of the understanding developed by previous researchers is applied to the tasks of the current study. For instance, while the analysis in Task 6.4 will examine the biomechanics literature to identify detailed injury mechanisms for the injuries identified in the epidemiological analyses, the current task will analyze and summarize previous research describing how such mechanisms, and their influencing factors, are applied to vehicle occupants. The results from this survey will be summarized in a report that highlights how this information will be utilized by the Grantee in other facets of this project.

Task 9. Design, Installation and Modeling of the Provisional Rollover Test System: DROTS - Decel

The purpose of this task will be to require the Grantee to design, develop and complete initial testing with the provisional rollover test fixture. In a prior effort, the Grantee was asked to provide proposed modifications to an existing DROTS to reduce the restrictions imposed by the fixture boundary conditions and to adapt its design for use on the Grantee's deceleration or decel sled system. In this task, the Grantee will finalize the detailed design of the fixture, develop a computational model of the design, simulate the experiments in order to verify operation before fabrication and compare the rollover fixture performance with real vehicle roll simulations, purchase and install the system, and finally test the DROTS-Decel system with both a real vehicle and the parametric buck (Task 10). This task will result in the development of a long term test protocol that can be used to improve the understanding of the factors that influence occupant injuries in rollovers.

9.1: The Grantee will continue the work to refine and add details to the proposed design of this new DROTS system and create detailed designs for the components required to implement the system at the Grantee's facility. After successive collaborations with NHTSA and implementation of necessary capabilities defined in the literature review processes (Tasks 6, 7 and 8), the Grantee will finalize the design of the system by the end of the first year.

9.2: A FE model of the Grantee's proposed dynamic rollover test system will be developed to assist in finalizing the design of the DROTS-Decel, and to assist in validating the system's performance relative to real vehicle rollovers for the test procedure specification.

The model will assist in 1) examining the effects of changes to the proposed test system prior to finalizing the DROTS-Decel design, 2) verifying the design of the provisional dynamic test procedure (Task 11) simulates the targeted crash scenario in a controlled and repeatable way; and 3) examining occupant/restraint/vehicle interactions in simulations with a FE model of the THOR dummy.

The first priority of the modeling effort will be to adjust the test system to examine structural loads applied to the system to verify that supporting hardware are adequate and to elucidate any potential roadblocks to the experimental tests. To make these evaluations, initial simulations using either a real vehicle (Task 7.3) or the simplified vehicle (Task 7.2) will be used to ensure appropriate geometric and inertial characteristics.

Next, the model will be used to assist in the Grantee's design of a provisional test procedure (Task 11). By comparing the dynamic response of the real vehicle model in DROTS-Decel simulations to its response in the whole vehicle real-world rollover simulations (Task 7.3), the five variables that can be adjusted in the DROTS-Decel will be adjusted until the dynamics of the vehicle in both systems achieve the best match. These finalized parameters will form the basis for application of the provisional test procedure with the provisional test system. The input and output parameters will be evaluated experimentally (see 9.4) through the initial testing to validate the model's responses. This work will be completed in the second year of the Agreement and summarized in a report to be submitted at the end of year 2 of this Agreement.

Finally, in the third year of the Agreement, the test system will be used by the Grantee to test both a real vehicle model and the parametric buck model (Task 10.1). This testing will serve to improve understanding of the interactions between the occupant, the restraint system and the vehicle. Using the FE model of the THOR dummy, the results of the modeling sensitivity analysis (Task 7.2) will be used by the Grantee to determine which of the sensitive parameters can be evaluated with the provisional test system and to define the limitations of the provisional test system. This information, with experimental test results and other modeling results, will be used to assist the Grantee in specifying the conditions for the revised test system (Task 13).

9.3: Once the detailed DROTS-Decel design is finalized, the system will be purchased from the manufacturers and materials used to build custom components will be ordered. Prior to any purchasing of the system, the Grantee and the NHTSA will hold a design review meeting to finalize the design of the DROTS-Decel. As components are received by the Grantee, installation and construction of the system and its adaptation to the Grantee's decel sled system will begin at the beginning of Year 2.

9.4: Completion of system installation will occur by the end of 2010, and starting in January of 2011, initial tests with the system will be performed using both the parametric buck (Task 10) and a real vehicle. These initial tests will provide the Grantee with the following information:

1. Repeatability of the system when testing a real vehicle
2. Repeatability of the system when testing the parametric buck
3. Differences in vehicle dynamics between the real vehicle and the parametric buck

Task 10. Rollover – Parametric Buck Design and Development

The purpose of this task will be to require the Grantee to create a parametric test buck to be used for testing on both the provisional and revised rollover test systems to minimize both the cost of repeated tests and the time between tests and to maximize both the potential to achieve repeatable testing and the potential to vary individual vehicle parameters. This parametric buck will allow the Grantee to study the effects of different vehicle and occupant parameters on occupant injury outcome. The parametric buck will be created to allow for variation in the mass, moment of inertia, center of gravity, interior and exterior geometry, and roof/A-pillar stiffness.

10.1: As a first step, a computational FE model of the parametric buck will be constructed by the Grantee. Rollover simulations using the DROTS-Decel model and parametric buck model (using a baseline structural design that incorporates features that permit easy adjustment of the geometric, inertial and stiffness properties of the buck) will be performed in order for the Grantee to understand the limits of the variation in geometric and inertial properties that are capable with the initial design. The parametric buck design will be adjusted by the Grantee until the buck model is able to be adjusted to match ranges for the geometric and inertial properties of targeted vehicle fleet.

10.2: After these initial simulations, a detailed design and drawings of the parametric buck will be developed by the Grantee.

Task 11. Development and Testing of Provisional Dynamic Rollover Test Procedure

The purpose of this task will be to require the Grantee to document a provisional dynamic rollover test procedure. In the first two years of the Agreement, the Grantee will focus on developing a provisional dynamic test system and procedure that generates realistic and repeatable vehicle responses for a prescribed set of vehicles and crash conditions. If after these initial tests, adjustments to the test system, procedure or buck are necessary to align the tests with the targeted crash scenario or for other yet to be known reasons, subsequent tests aimed at refining the test procedure will be performed by the Grantee with the DROTS-Decel and parametric buck at the outset of year 3.

Task 12. Rollover – Dummy Biofidelity Evaluations

The goal of this task is to improve the understanding of the biofidelity and injury prediction capabilities of existing crash dummies and injury criteria in experimental analyses. This will be achieved through multiple series of tests using both the Hybrid III and THOR dummies and PMHS. All of the tests will be performed with the parametric buck (Task 10) and on the DROTS-Decel test system. The Grantee will be required to develop and submit a test plan to NHTSA for review and approval before conducting any tests. The injury predictive capabilities of the dummies will be examined relative to the PMHS using existing Injury criteria and dummy injury assessment reference values. The Grantee will complete a report summarizing the results for each series of tests (five series are listed in the milestones and deliverables table in Section IV).

Task 13. Design, Installation and Testing of Revised Rollover Test System: DROTS-RA

The purpose of this task is to require the Grantee to develop a revised dynamic rollover test system with expanded capabilities that will be implemented on a new sled system that is being funded in part through this Agreement. It is anticipated that the experimental and computational work the Grantee will complete on the test fixture over the first two and a half years of the Agreement will provide knowledge on the benefits of implementing an improved test fixture capable of demonstrating rollover procedures for a broader range of vehicle and occupant parameters. A more generalized system that permits alterations of the parameter specification ranges as well as system degrees of freedom will be able to simulate more realistic rollover conditions.

13.1: All of the review, computational and experimental work will provide the Grantee with the knowledge to formulate a baseline design of a revised system with expanded capabilities. The expanded capabilities of the system will be determined using the results of the first year's analyses and could include some or all of the characteristics mentioned above as well as additional characteristics. The system design will begin with the development of a detailed computational model of the system permitting the simulation of rollover tests and easy adjustment of parameters and hardware capabilities of the system. The system (referred to as DROTS-RA) will be designed to run on a new reverse acceleration (RA) sled system at the Grantee's facility that will be funded in part by this Agreement and will also be used in the completion of work in Tasks 1 and 4. This new sled will overcome space and mass limitations that will exist with the DROTS implemented on the Grantee's deceleration sled and will allow for testing of larger vehicles of up to 240 inches in length. The DROTS on the decel sled will be limited to vehicle to lengths of 192 inches.

13.2: Similar to the use of computational modeling to assist in the development of the initial test system (Task 9), a detailed computational model of the DROTS-RA will be used by the Grantee in a similar three tiered approach to improve knowledge in these three areas:

1. Effects of changes to the test system prior to finalizing the design
2. Assist in the design of the final dynamic test procedure (Task 15) by verifying that the proposed system simulates the targeted crash scenario in a controlled and repeatable way
3. Occupant/restraint/vehicle interactions in simulations with a FE model of the THOR dummy

13.3: Once the detailed DROTS-RA design is finalized (at the end of year 3), the system will be purchased from the manufacturers and materials used to build custom components will be ordered.

13.4: Completion of system installation will occur by the end of 2012 (middle of year 4), and starting in January of 2013, initial tests with the system will be performed using both the parametric buck (Task 10) and a real vehicle. The knowledge to be gained in these initial tests is as follows:

1. Repeatability of the system when testing a real vehicle
2. Repeatability of the system when testing the parametric buck
3. Differences in vehicle dynamics between the real vehicle and the parametric buck

13.5: A series of parametric buck tests that incorporate dummy occupants will be performed by the Grantee to provide an initial experimental investigation into the sensitivity of the interaction of the vehicle, restraint and occupant systems using the parametric buck. This effort will improve understanding of the sensitivity of the interaction between vehicle, restraint and occupant based systems on dummy response during dynamic rollover events.

Task 14. Rollover – Vehicle Crashworthiness Analysis

One of the main objectives of this study is to improve understanding of the benefits of a dynamic, over a static, test procedure for evaluating vehicle crashworthiness. At this point in the research the dynamic test procedure will have been developed and tested by the Grantee using the parametric buck, and only full vehicle tests aimed at validating the performance of the parametric buck will have been performed.

The purpose of this task will be to require the Grantee to apply the proposed dynamic test procedure using the revised test system (DROTS-RA) on real vehicles in an effort to collect information in addition to what was learned from computational simulations using full vehicles and experimental work with the parametric buck. These tests will compare the performance of real vehicles in the dynamic test procedure as evaluated using both dummy-based injury risk estimates as well as structural deformation with the crashworthiness predictions derived from static crush testing. Furthermore, these tests will be used by the Grantee to complete further assessments of their proposed test procedure using the DROTS-RA.

14.1: The first whole vehicle tested with the DROTS-RA system will include dummy occupants and serve to support the vehicle crashworthiness analysis. Applicable injury metrics defined through the epidemiology analyses (Task 6) and the dummy biofidelity analyses (Task 12) will be used by the Grantee to evaluate vehicle crashworthiness. Repeatability of the test system will be verified through repetition of the tests. This task will improve the understanding of the structural crashworthiness of the vehicles as predicted in an FMVSS 216 static crush test versus that predicted from the dynamic tests.

14.2: In the final year of the Agreement, additional whole vehicle tests will be performed by the Grantee using the DROTS-RA system to evaluate the crashworthiness of the vehicles based on dummy response. This testing will provide the Grantee with the ability to assess structural deformations and the applicable injury metrics defined through the epidemiology (Task 6) and the dummy biofidelity (Task 12) efforts. The testing will also help document the repeatability of the test procedure.

Task 15. Finalized Dynamic Rollover Test Procedure

One of the main objectives of this overall rollover research effort is to assist the Grantee in developing a repeatable dynamic test fixture and associated test procedure capable of simulating the dynamic rollover loading environment in a repeatable and realistic manner. The individual rollover related research tasks the Grantee will complete over the five year Agreement are all in support of the development of this dynamic rollover test procedure. The Grantee's final objective in this research effort is to make any final adjustments to the proposed test procedure based on the experimental and computational rollover simulations with the DROTS-RA test system. The Grantee will generate a document that provides a detailed explanation of the finalized test procedure and system with appendices documenting pertinent test results, justification for the characteristics of the test procedure, and explanation of the benefits of this procedure over the initial procedure developed on the decel sled.

Remaining sections removed, not relevant to requestors interest in rollover research

IV. REPORTING REQUIREMENTS
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