Provide an abstract/succinct summary of the proposal (50 words or less):

There is a need to understand the material properties of air to air refueling hose so that new design may absorb energy of traveling wave at a receiver contact. The goal is to incorporate the hose structural properties into the aerial refueling hose drogue simulation program developed by the author.

Describe your proposed work (e.g., objectives or goals, activities, timeline, outcomes, products, or other relevant information), including the connection, if one exists, with any previous SFSA or FRACAA project:

Probe-drogue refueling (PDR) involves a tanker extending 70–80 feet of refueling hose with trailing end connect to a drogue which allows for a receiver plane to engage. If a receiver...
the drogue too fast, the hose reel on the tanker fails to keep the tension on the hose and a wave motion, or whipping motion, of the hose will develop. This wave motion often results in drogue rupture, probe breakage, damages on receiver radome, etc. It may also lead to catastrophic accidents if any wreckage may hit engine intake. For these reasons, there is a need to understand the material properties of the refueling hose so that the wave energy of the hose is somehow lessened with different types of hose material.

Over the past 5 years, the author has been working in the field of PDR research and published 4 articles on the most reputable international aerospace journals. In addition, a doctoral student was supervised and graduated in 2014 with a dissertation title, ‘Active Control of Aerial Refueling Drogue,’ which was also related to the SFSA projected award in 2010. One of the papers is on the modeling and simulation of hosedrogue dynamics, and the simulation computer code is currently registered as a WMU intellectual property for commercialization. There are some other methodologies for modeling the hose and drogue based on partial differential equations or finite element methods, and a few articles in public domain journals can be found. The author’s model took a different approach where the hose was treated as a link connected rigid-body, and the equations of motion were established in the multi-body dynamic analysis frame work. The benefits of such technique are faster execution time and expandability to other purposes such as control law design, autonomous refueling, etc. However, including the author’s model and simulation code, no attempts were made to investigate the material properties on the wave motion upon the receiver contact to this date.

The goal of this study is to:

- expand the existing link connected hose model to incorporate the structural properties (stiffness and damping)
- model the damping and stiffness properties of the refueling hose
- modify the exiting simulation code to incorporate the structural model
- understand the stiffness and the damping effect on the refueling hose before the receiver contact
- carry out, for the post contact, exhaustive executions with permutation of discretized range of allowed receiver closure rate from different range of stiffness
different range of damping
draw conclusion whether or not the hose structural property (stiffness & damping) could alleviate the whipping motion of the refueling hose

The work involved includes mathematical modeling of hose structural properties, modifying the simulation program, and model and code validation. However, much effort is need in exhaustive and extensive code execution which is very laborious and time consuming. Thus, once the code is validated a student will be
Describe how the proposed work will make (a) a significant and (b) original contribution to the discipline.:

The proposed work will make

a significant contribution because the result of this study may suggest a new design guideline for new refueling hose constructions if the structural properties are indeed those parameters that my alleviate the hose whipping

an original contribution to the probe-drogue refueling (PDR) research as this will be the first attempt in modeling and simulation study of hose material properties in the hose whipping motion after the contact

Describe the mechanism for dissemination.:

The outcome will include one conference paper/presentation at international aerospace conferences held by American Institute of Aeronautics and Astronautics (AIAA), 2018 Science and Technology Forum in January 2018, which will also be submitted to AIAA Journal of Guidance, Control and Dynamics in 11/2017.

Describe how the proposed work will enhance your reputation and that of WMU.:

The author and the Western Michigan University are already well-known in aerial refueling community for numerous publications and several video clips available online. In 2015, the following article, http://foxtrotalpha.jalopnik.com/the-future-of-aerial-refueling-includes-stabilized-drog-1673992575) was posted by a well-known military journalist on the internet. The model developed by the author is independently coded by a company funded by NAVY and now is used for autonomous refueling of unmanned aerial vehicles (confidential source).

Provide an itemized budget and budget justification. A proposed budget greater than the allowed maximum amount of $2,000 will disqualify the proposal. Such a proposal will not be reviewed. Fully justify why the budgeted expense is necessary for the project.:

The total requested budget is $2,000, which are itemized as follows:

Matlab/Simulink with necessary Toolbox license renewal: $1600
Travel Expenses to AIAA Conference: $400

The original simulation program was developed in MATLAB/SIMULINK, and the proposed model should be coded by modifying the original program developed earlier. The current version of the MATLAB/SIMULINK personally owned by this author is outdated (2014a), and several updates are made in the most recent version. Thus, renewing the license of MATLAB/SIMULINK software with necessary Toolboxes to the most up-to-date version is necessary for this project, which will cost approximately $1600. The college (CEAS) owns 20 licenses of MATLAB/SIMULINK, but the program of instruction license was purchased recently. The travel expenses of $400 is needed for the conference.
restricted for any type of research purpose. Further, the college does not own necessary Toolbox licenses for this study (especially, aerospace blockset and aerospace toolbox).

Travel funds can be awarded from Faculty Research Travel Fund, but the conference registration fee is around $1200 for a full member of AIAA. Thus, $400 is going to be used to cover additional travel cost (airline tickets and other expenses).