DEVELOPMENT OF A HIGH FIDELITY DYNAMIC MODULE OF THE ADVANCED RESISTIVE EXERCISE DEVICE (ARED) USING ADAMS®


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NASA’s Digital Astronaut Project (DAP) implements well-vetted computational models to predict and assess spaceflight health and performance risks, and enhance countermeasure development. DAP provides expertise and computation tools to its research customers for model development, integration, or analysis.

DAP is currently supporting the NASA Exercise Physiology and Countermeasures (ExPC) project by integrating their biomechanical models of specific exercise movements with dynamic models of the devices on which the exercises were performed. This presentation focuses on the development of a high fidelity dynamic module of the Advanced Resistive Exercise Device (ARED) on board the ISS. The ARED module, illustrated in the figure below, was developed using the Adams (MSC Santa Ana, California) simulation package.

The Adams package provides the capabilities to perform multi rigid body, flexible body, and mixed dynamic analyses of complex mechanisms. These capabilities were applied to accurately simulate:

- Inertial and mass properties of the device such as the vibration isolation system (VIS) effects and other ARED components
- Non-linear joint friction effects
- The gas law dynamics of the vacuum cylinders and VIS components using custom written differential state equations
- The ARED flywheel dynamics, including torque limiting clutch

Design data from the JSC ARED Engineering team was utilized in developing the model. This included solid modeling geometry files, component/system specifications, engineering reports and available data sets.

The Adams ARED module is importable into LifeMOD (Life Modeler, Inc., San Clemente, CA) for biomechanical analyses of different resistive exercises such as squat and dead-lift. Using motion capture data from ground test subjects, the ExPC developed biomechanical exercise models in LifeMOD. The Adams ARED device module was then integrated with the exercise subject model into one integrated dynamic model.

This presentation will describe the development of the Adams ARED module including its capabilities, limitations, and assumptions. Preliminary results, validation activities, and a practical application of the module to inform the relative effect of the flywheels on exercise will be discussed.
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REFERENCES