YEAR 3:

**Major activities**

Developments during year three focused on several aspects of this project including:

* Continued development of the general multiscale communication library, AMSI (Adaptive Multimodel Simulation Infrastructure), using the multiscale fibrous soft tissue model as a testbed.
* Completion of working (but unverified) version of two scale soft tissue model with fiber-only RVEs in which all parallelism is done by AMSI.
* Execution of above mentioned model on AMOS supercomputer (IBM Blue Gene/Q) utilizing up to 4000 processes.
* Development of migration and load balancing algorithms to improve scaling within both AMSI and the soft tissue model.

A general infrastructure for parallel communication of multimodel data has been developed and named AMSI (Adaptive Multimodel Simulation Infrastructure). This infrastructure has been integrated into the

multiscale soft tissue model which now completely relies on AMSI for multiscale data communication instead of ad-hoc methods typically present in multiscale simulations. The general nature of AMSI allows it to be utilized in any multimodel simulation, although so far, it has only been tested with the multiscale soft tissue model which is an RVE-based hierarchical two scale model. The development of additional features in AMSI has been influenced by the use of this model as well.

The above mentioned soft tissue model has been developed and is in a working state, but is still being verified. The current working version employs fiber-only RVEs at each integration point of the macroscale finite element analysis, constituting a two scale hierarchical model. The mechanical aspects of the current model are not novel but the computer science aspects, including AMSI and the potential scalability are. The current model also supports several features not included in previous models such as load balancing of RVEs and choice of RVE. The verified fiber-matrix RVE is currently being integrated into the simulation as an RVE choice. Software aspects have also been improved, including memory footprints and the generalization of the finite element analysis (now included as part of AMSI) for use in both the macroscale analysis as well as the fiber-matrix RVE.

The model has been run successfully on the AMOS supercomputer at CCI/RPI. Load balancing and migration of RVEs are being developed to improve scalability.

**Specific Objectives**

The specific objectives of this project are to:

* Define abstractions and methods that bridge physics and mathematics formalisms to the models and computational methods needed for component-based adaptive multimodel analysis. This infrastructure must maintain a clear understanding of all the relations and transformations executed and relate them to a multiscale design specification. Such capabilities are essential to tracking design sensitivities and uncertainties within a multiscale design process.
* Implement interoperable components that support the relations and transformations associated with the domain, model and field interactions of the abstracted simulation components.
* Define and implement a methodology to supports the full range of adaptive model, scale linking and discretization control techniques needed for multiscale simulations.
* Develop multilevel dynamic load balancing techniques to support the scalable execution of adaptive multiscale simulations on massively parallel computers.
* Develop multiscale simulation applications that demonstrate the effectiveness of the tools and technologies developed.

RESULTS and achievements

The partial results and achievements to date are indicated in the activities. As a project focused on the development of an overall software infrastructure, there is the need to address a large number of base technical issues and methods before useful results can be obtained.