# Developing a Parametric Human Body Model for Pedestrian Safety Research

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UMTRI Summer 2026

MICHIGAN ENGINEERING SUMMER UNDERGRADUATE RESEARCH IN ENGINEERING UNIVERSITY OF MICHIGAN

## Introduction

- Pedestrian crashes can cause serious injuries, particularly to the head, pelvis, and lower limbs
- Computational human body models help predict pedestrian motion and injury during vehicle impacts
- HERMES is a **seated** parametric human body model that represents variations in age, sex, height, and body size and includes bones, internal organs, and soft tissues

## Objective

Develop a parametric standing version of HERMES with consistent mesh structure, enabling comparisons across seated and pedestrian simulations and across diverse body sizes and postures.

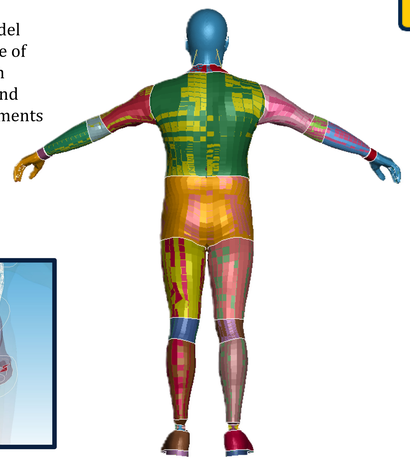


Fig. 3: Fitted Model with lower image of inner pelvis flesh (trans. purple) and poor-quality elements (red)

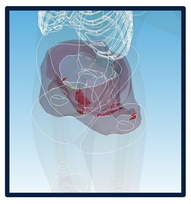
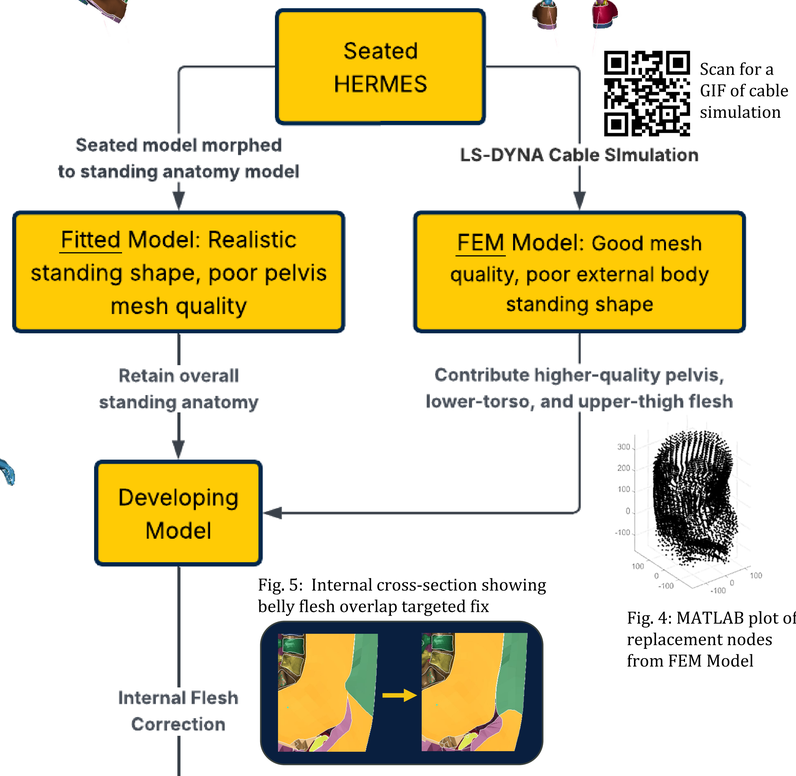


Fig. 1: Seated HERMES base model




Scan for a GIF of cable simulation



Fig. 4: MATLAB plot of replacement nodes from FEM Model

Fig. 5: Internal cross-section showing belly flesh overlap targeted fix



## Methods

- Generated an approximately standing human model via simulated cables pulling HERMES in LS-DYNA finite element modelling software, preserving mesh quality during deformation process -> "FEM Model" (Fig. 2)
- Compared FEM Model with a separate standing model derived by mesh morphing with correct external anatomy, but poor-quality mesh in pelvis region -> "Fitted Model" (Fig. 3)
- Replaced flesh nodes in the pelvis, belly, and upper thigh region of the Fitted Model with respective nodes from high-quality FEM Model (Fig. 4)
- Radial Basis Function (RBF) morphing and targeted repairs were used to ensure shape of transferred nodes matched Fitted Model and correct distorted or overlapping elements (Fig. 5)
  - RBF morphing traces a small sample of "landmark nodes" from source to target positions in different models and moves surrounding nodes via interpolation

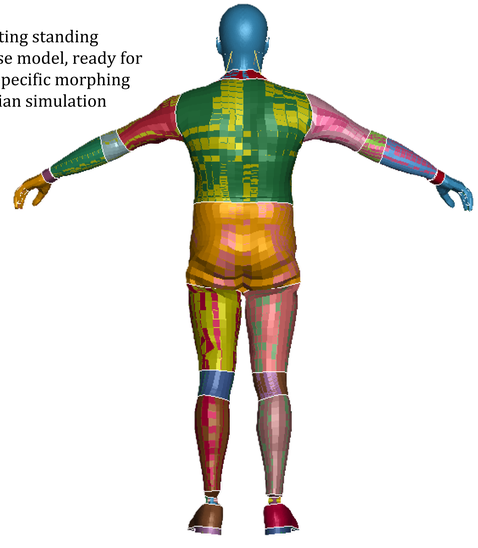


Fig. 6: Resulting standing HERMES base model, ready for parameter-specific morphing and pedestrian simulation

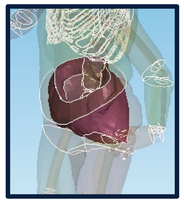
## Results

- Created standing HERMES base model with no inverted elements, realistic standing shape, and same mesh structure as seated model (Fig. 6)
- End model suitable for morphing into parameter-specific pedestrian models, which are then used in digital crash testing
- **Future work:** Specialized morphing for remaining crumpled pelvis flesh, verify bone geometry using existing parametric bone models

## Acknowledgements

Kyle Boyle for creating and providing the Fitted Model, Yang-Shen Lin for help with HyperMesh and LS-DYNA software, UMTRI and SURE for access to computing resources, research training, and funding.

Fig. 2: FEM Model with lower image of inner pelvis flesh (purple)



## Reference

Hu J, Dhawan M, Fan X, and Reed MP (2022) Toward Improved Safety Equity: An Efficient, Parametric, and Posable Finite Element Human Model Representing a Diverse Population, IRCOBI Europe Conference. http://www.ircobi.org/wordpress/downloads/irc22/pdf-files/2237.pdf