Dummy head motion tracking in crash tests with standard sensors

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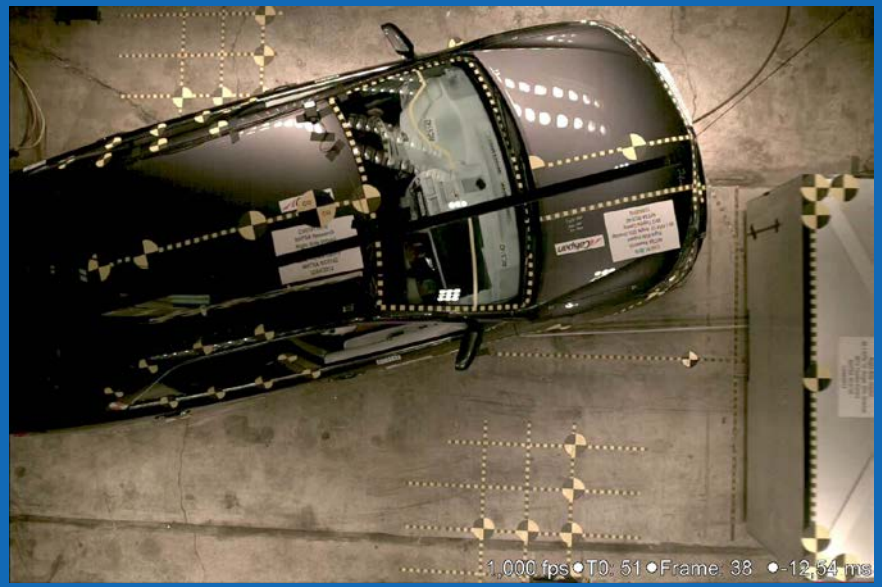
SAE Government Industry Meeting
January 24-26, 2018

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Motivation



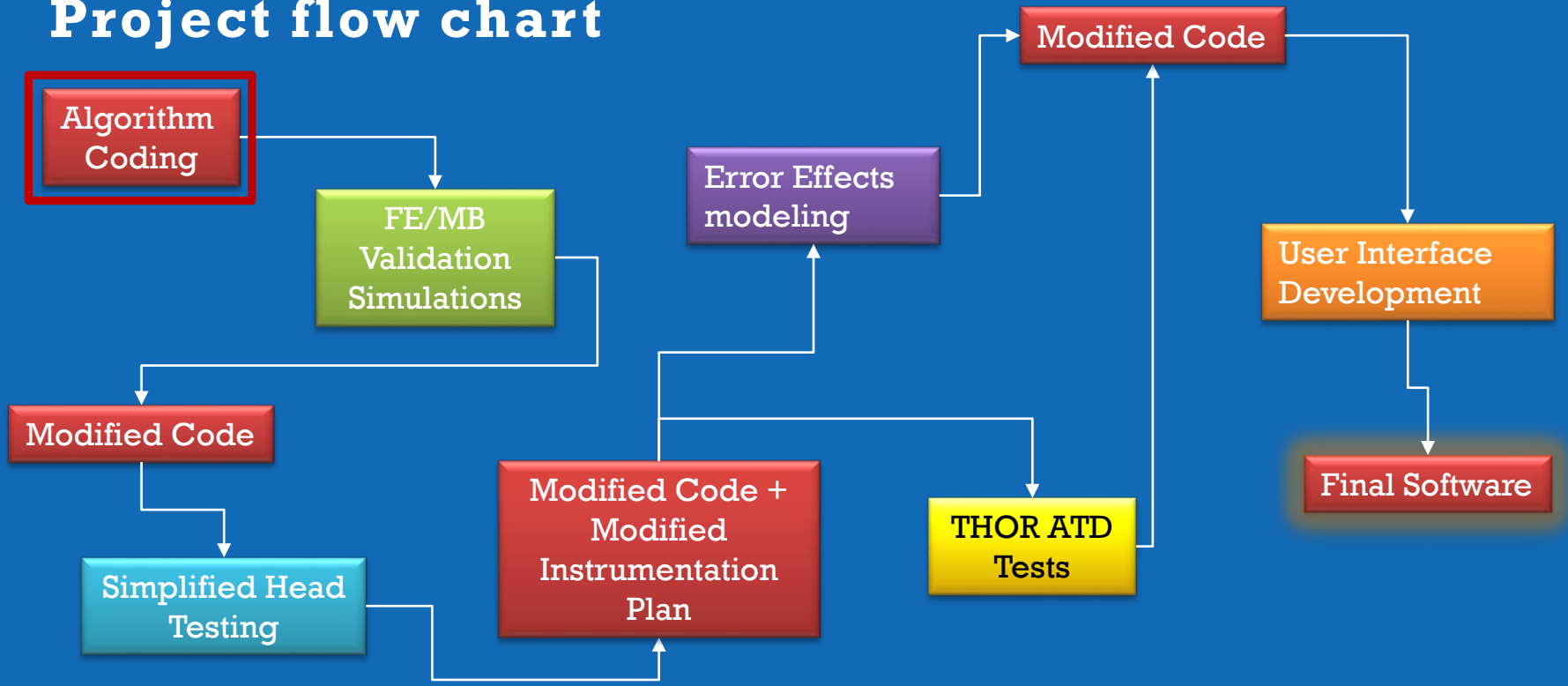
NHTSA's oblique crash test

On-board view

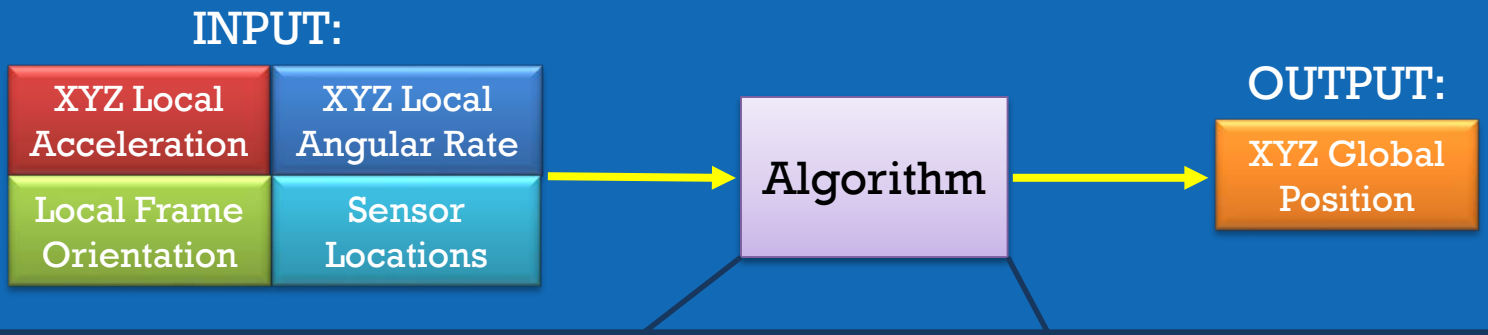
Overall Study Goals

- **Prepare a software package that calculates head trajectory in a global reference frame from onboard sensors**
- Application: THOR ATD in Oblique
  - Other applications: other tests, other body regions
- Additionally:
  - Evaluate potential and magnitude of error in calculated 3D trajectory from test procedure and sensor related errors

Project flow chart

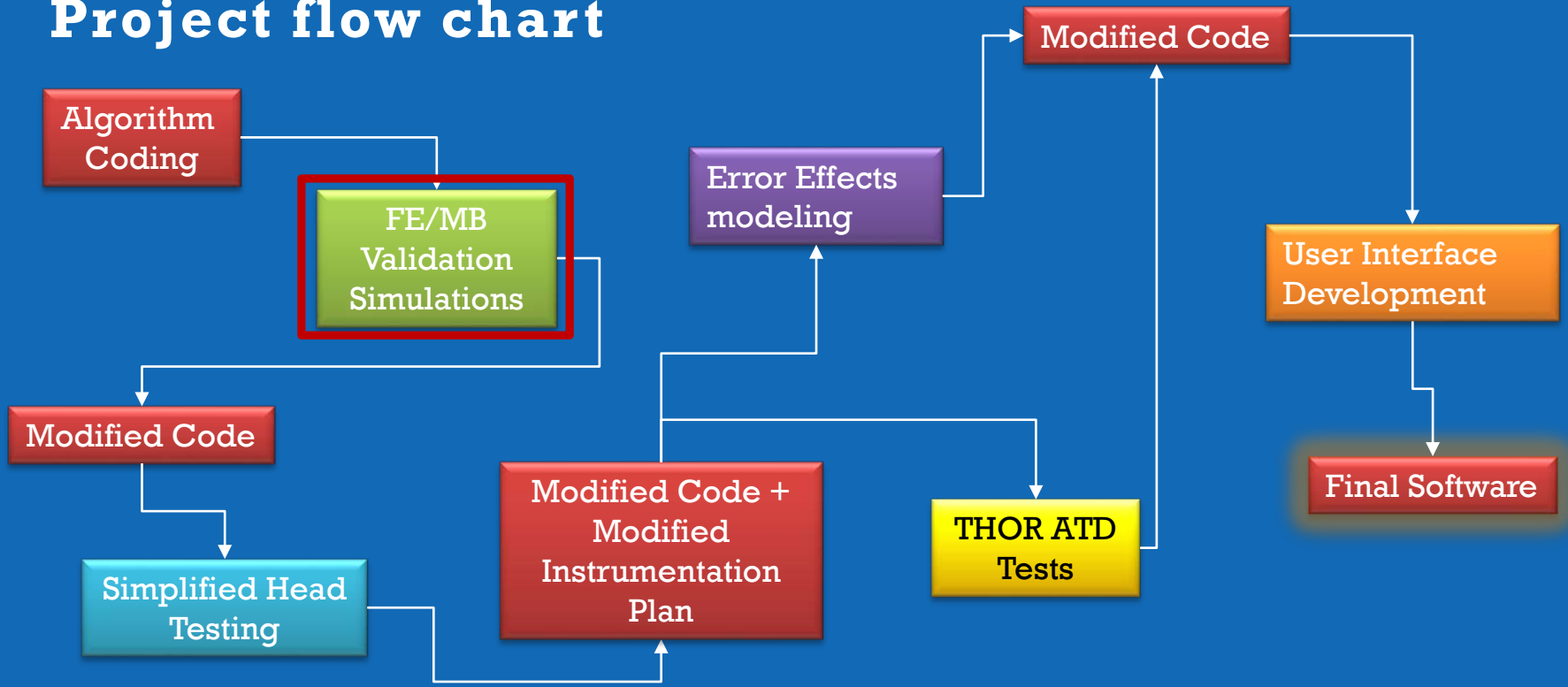


Algorithm coding (backend code)



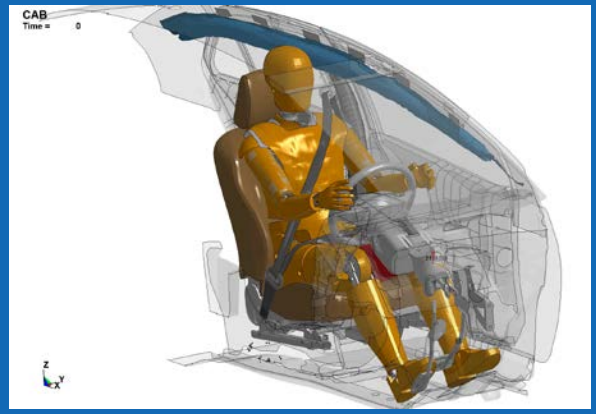
- Step 1: Translating acceleration from sensors to point of interest
- Step 2: Time History of Local/Global Transformation (7 methods identified)
- Step 3: Transformation of local acceleration to global frame and double integration

Project flow chart

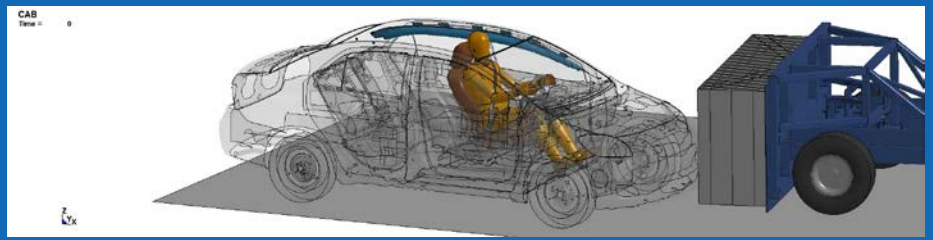


Validation Simulations

MB simulation

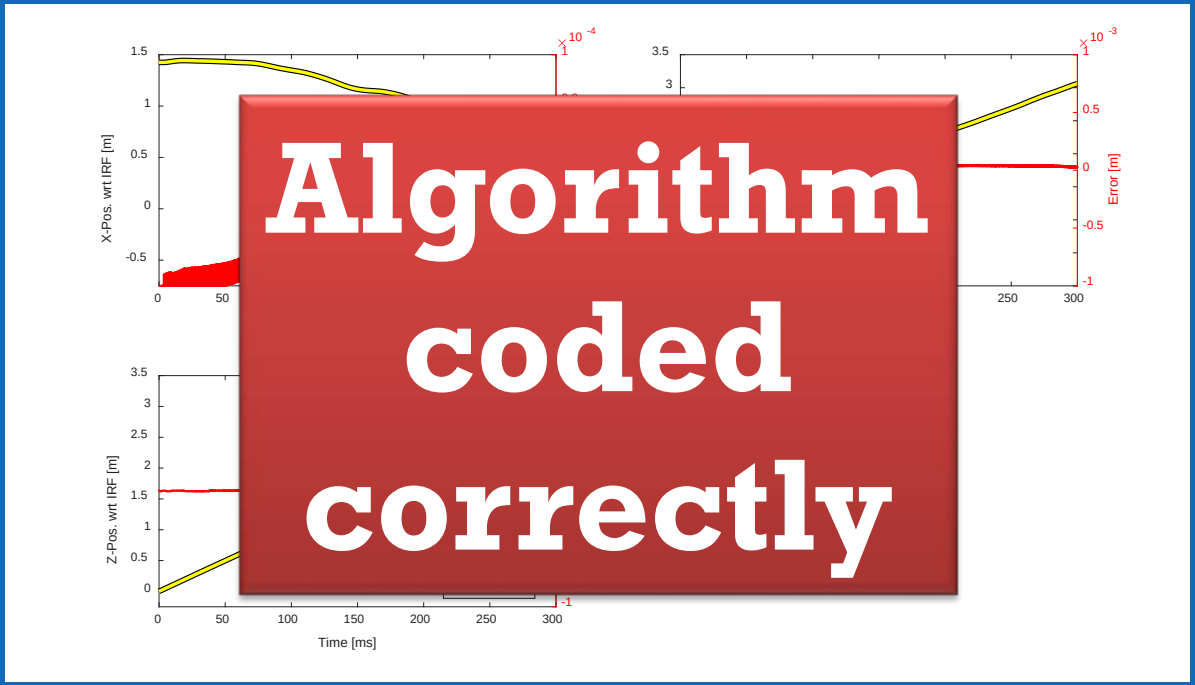


Sled test

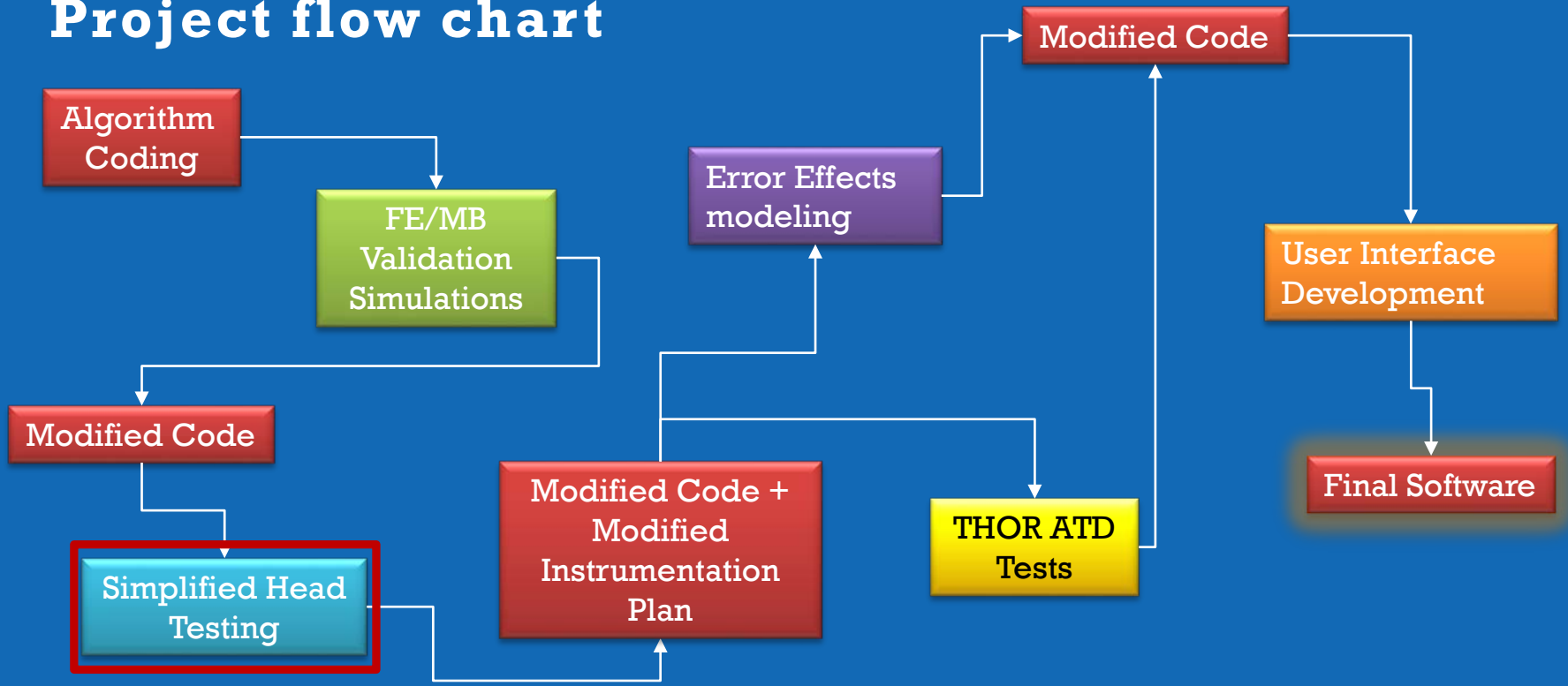


OMDB-to-vehicle

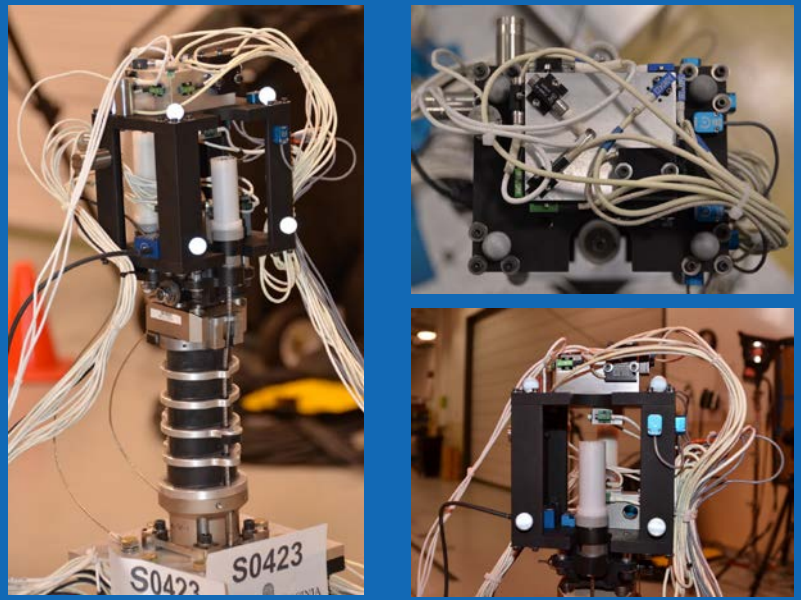
Validation Simulations



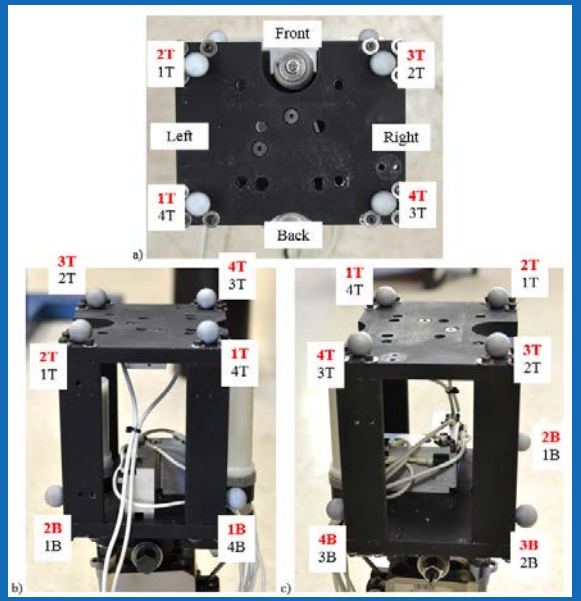
Project flow chart



Simplified Head Testing



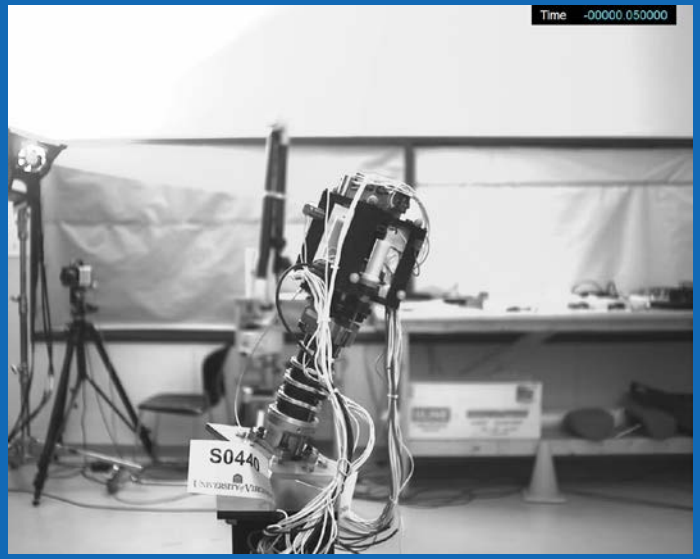
Multiple sensors including ARS & linear and angular ACC



VICON data used as Reference

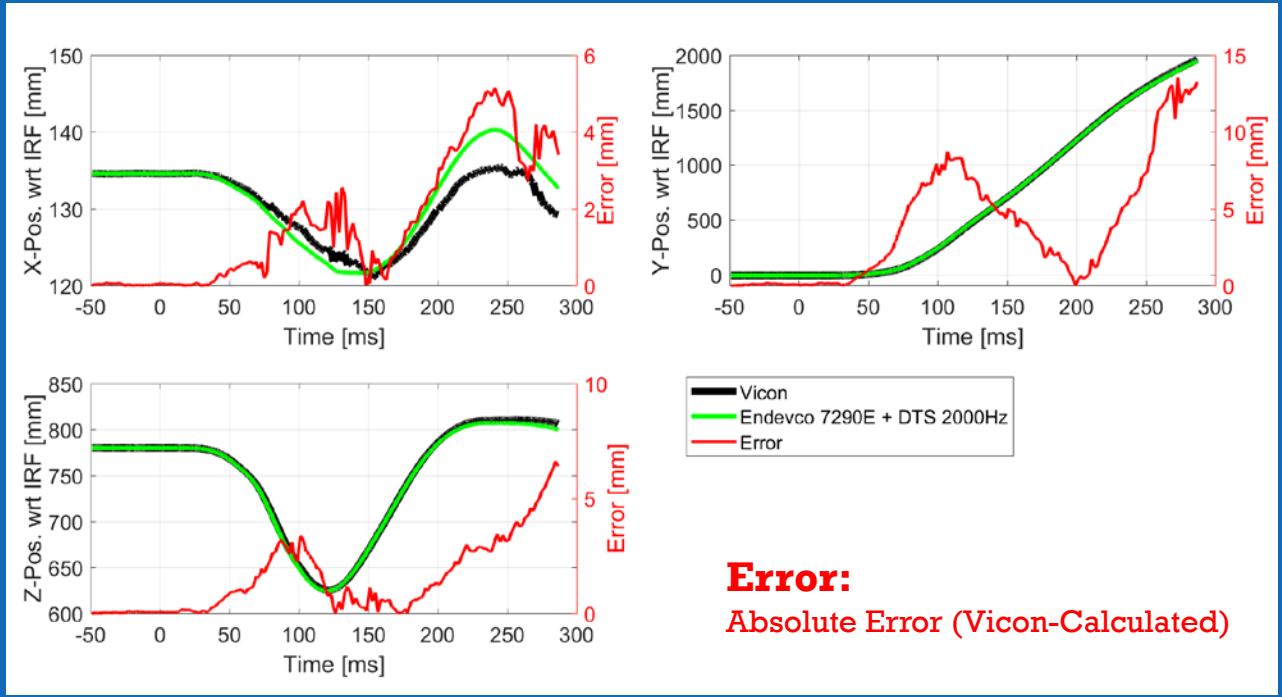
Simplified Head Testing

Flat, 0 deg



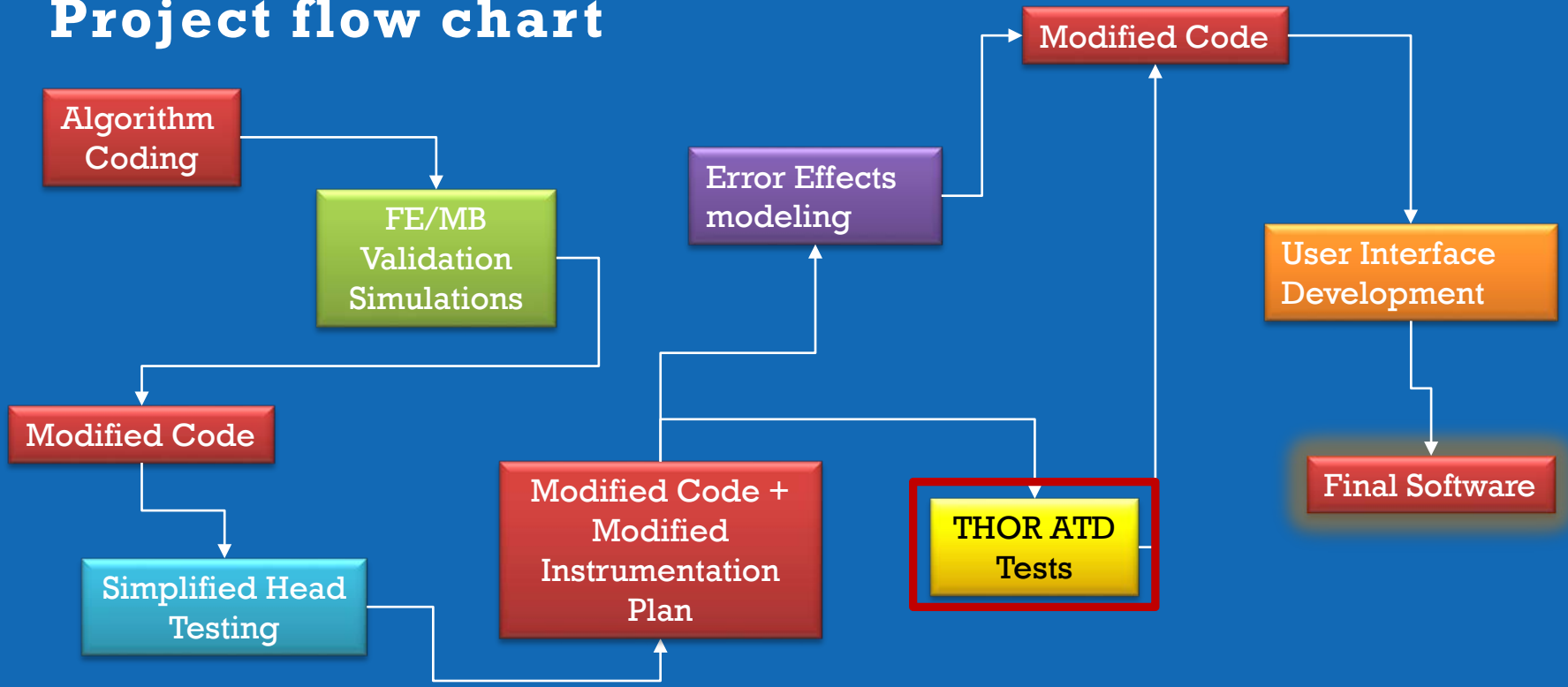
Wedge, at 45 deg

Simplified Head Testing



Error:
Absolute Error (Vicon-Calculated)

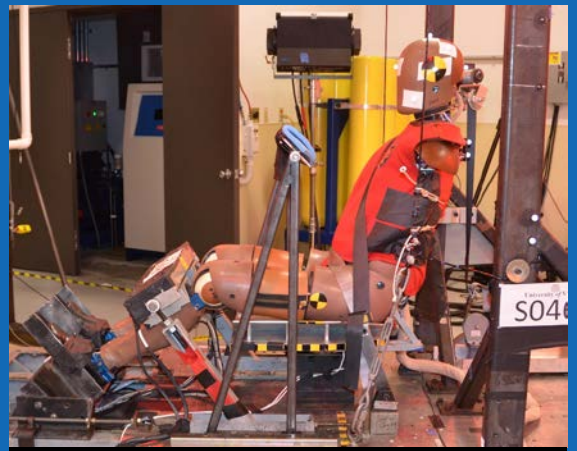
Project flow chart



THOR ATD tests

Simplified Head; 2kN FL

Regular Head; 4kN FL



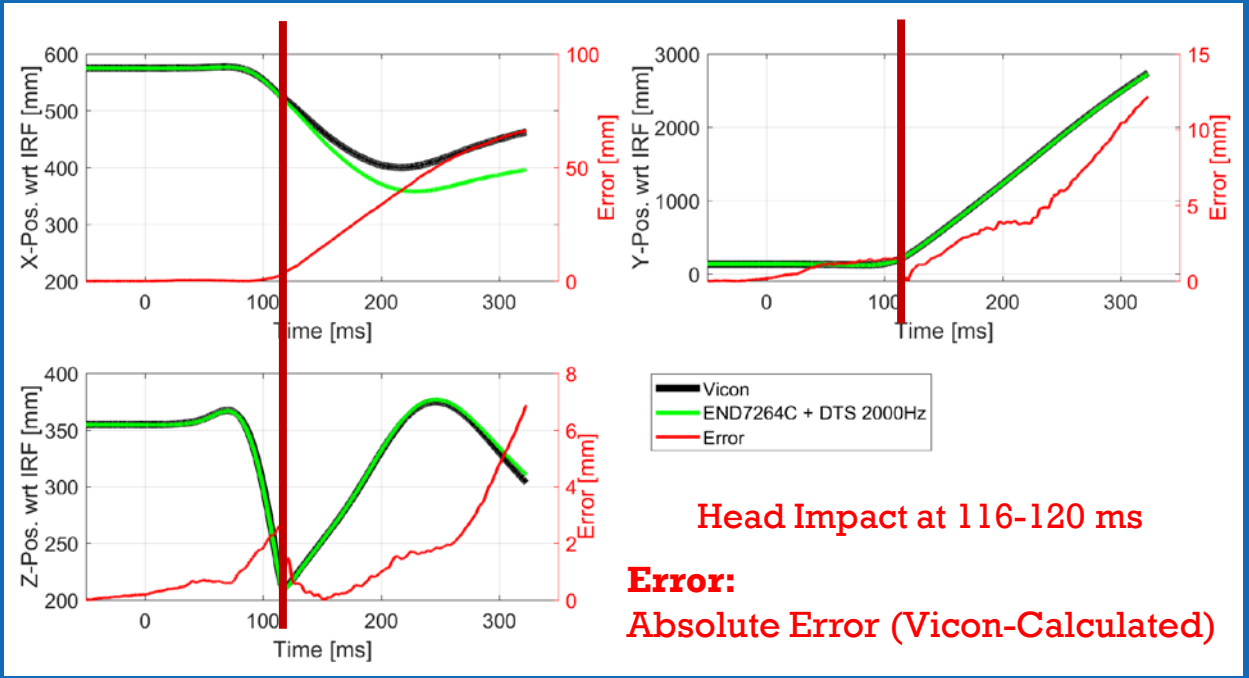
Regular Head; 4kN FL; impact

8 tests in total

THOR ATD tests

8 tests in total

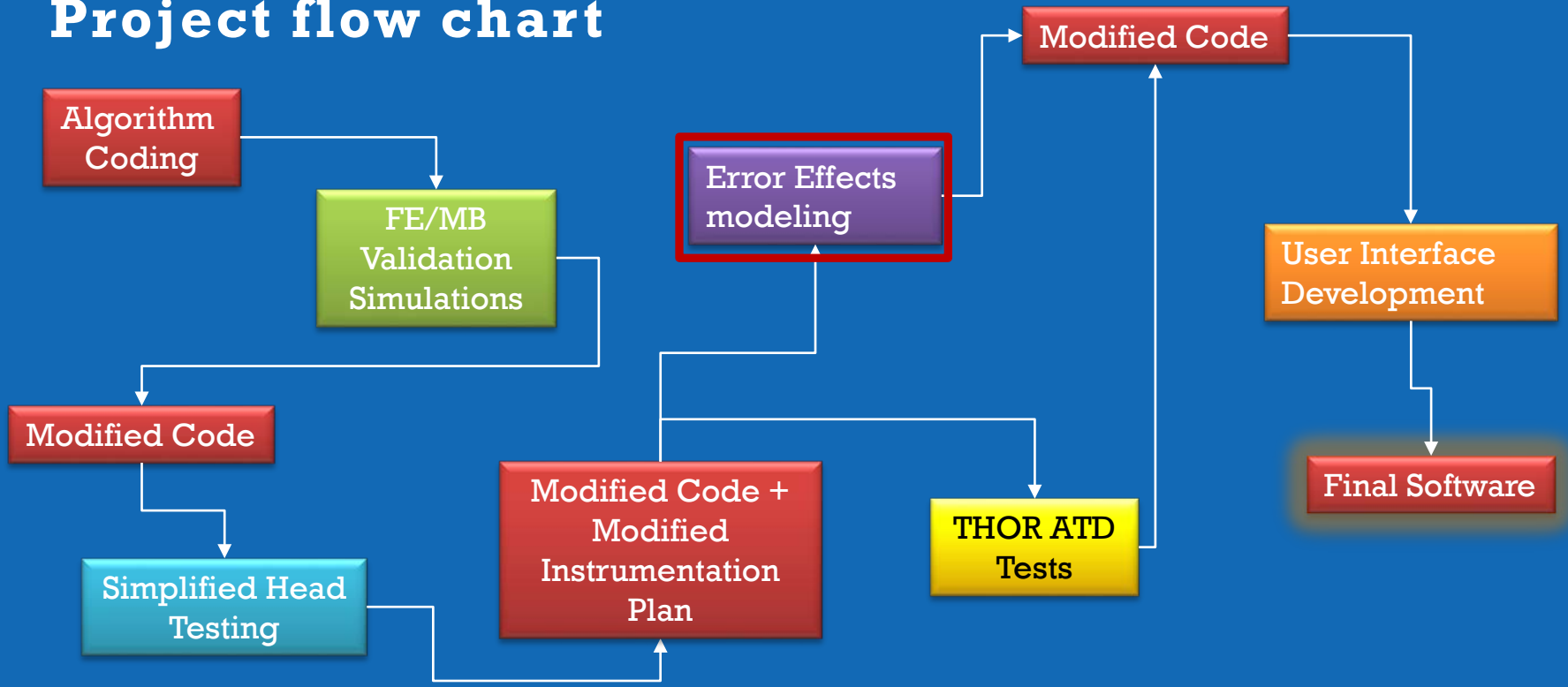
THOR ATD tests



Head Impact at 116-120 ms

Error:
Absolute Error (Vicon-Calculated)

Project flow chart



Error Effects Modeling

Errors considered:

- Initial orientation
- Initial position
- Noise level
- Sensitivity error (multiplicative error)
- Debias error (offset error)

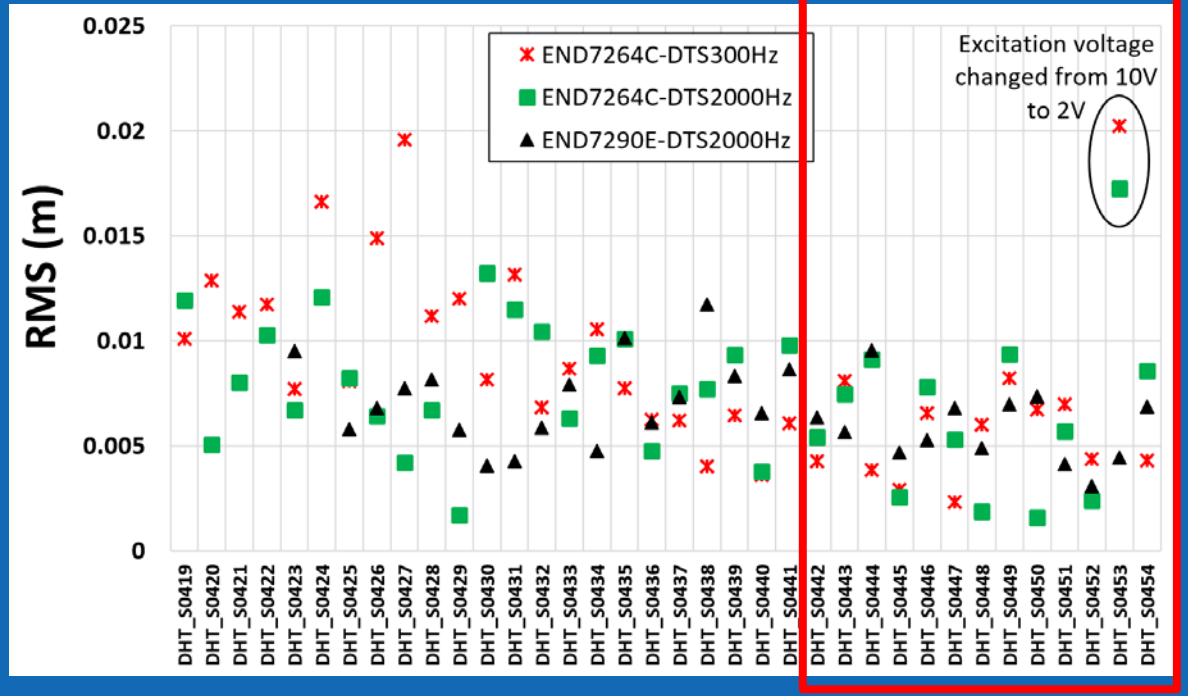
Error Effects Modeling

- Bounds identified
- Each error:
  - 15 values within the bounds
  - Spaced equally (assuming 15 values)
- Implemented one at a time (univariable analysis)
- Compared to baseline (assumed "ideal") response

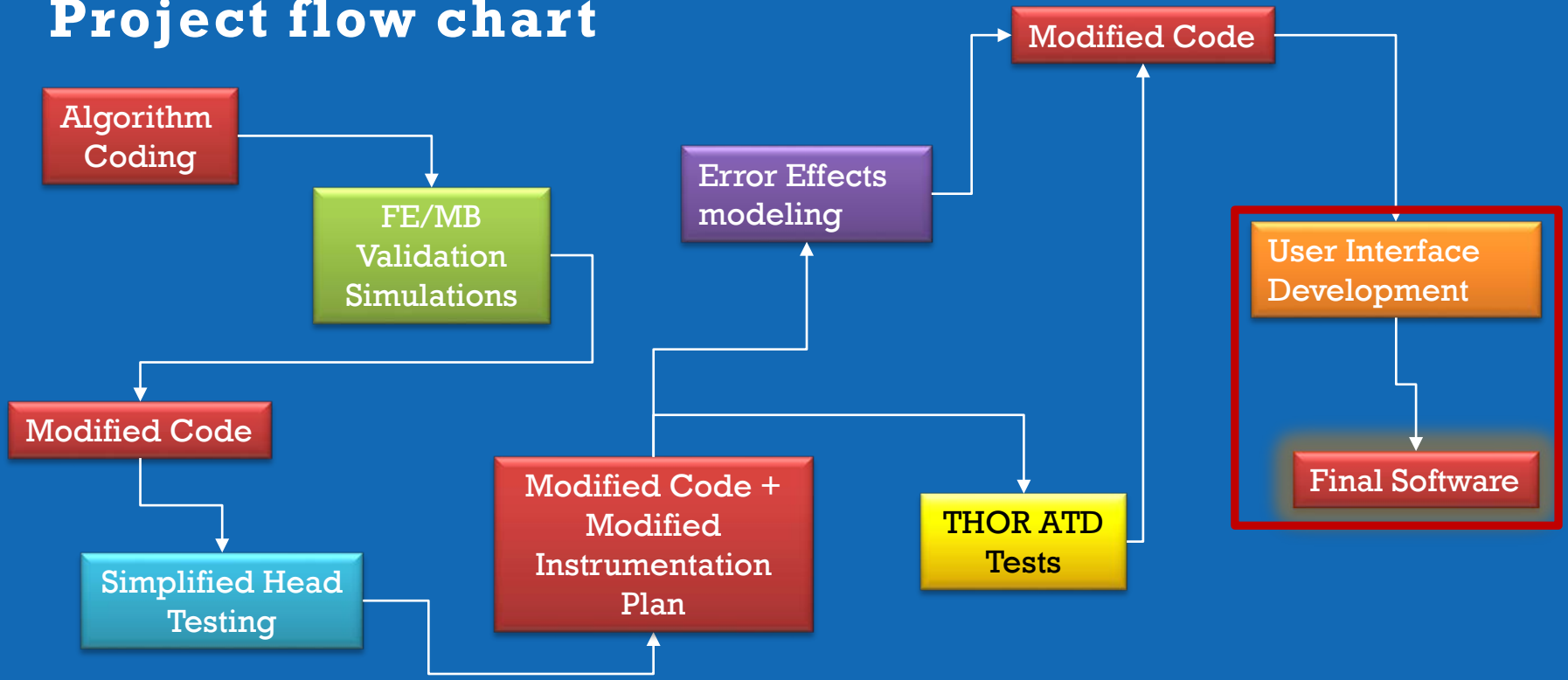
Error Effects Modeling

Error hierarchy	Error type	Max difference after 250ms (mm)
1.	ACC Debias	**750** (for debias error of 2g)
2.	ARS Debias	**210** (for debias error of 50deg/s)
3.	ACC sensitivity	**50** (for sensitivity error of 4%)
4.	Orient	**30** (for Yaw error of 1deg)
5.	ACC Noise	**17** (for noise scaled up)
6.	ARS Noise	**6.6** (for noise scaled up)
7.	ARS sensitivity	**6.4** (for sensitivity error of 1%)
8.	ACC CG location	**4.5** (for ACC CG location error of 1mm)
9.	Head CG initial location	**2.5** (for ACC CG location error of 2.5mm)

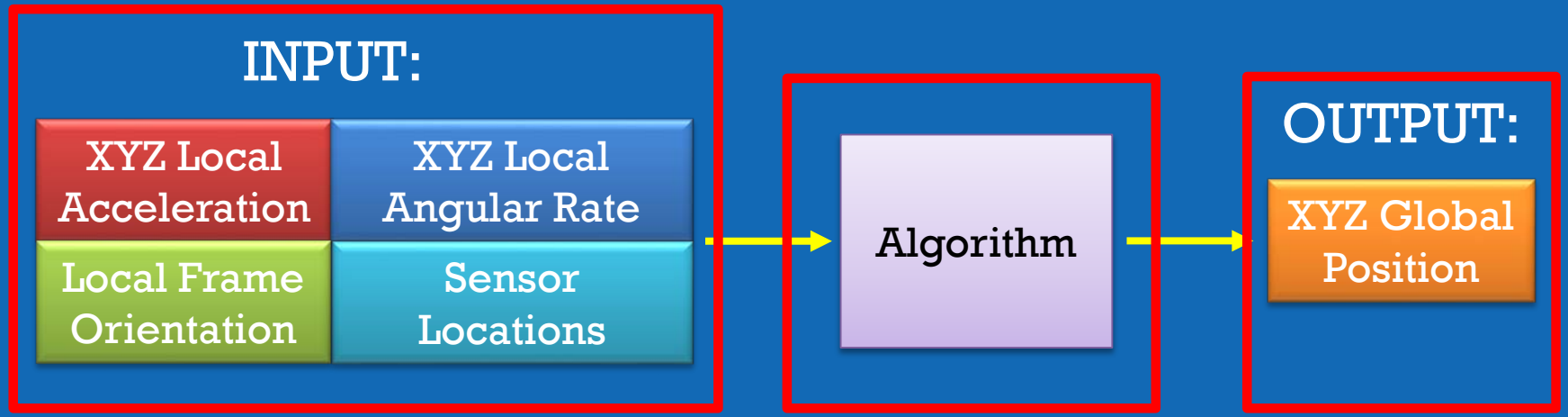
Error Effects Modeling



Project flow chart



Final software

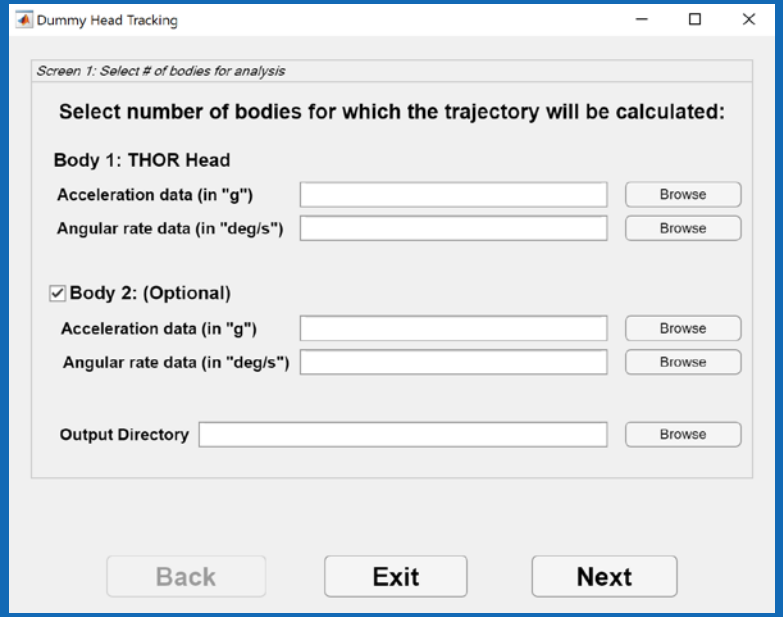


Graphical User Interface

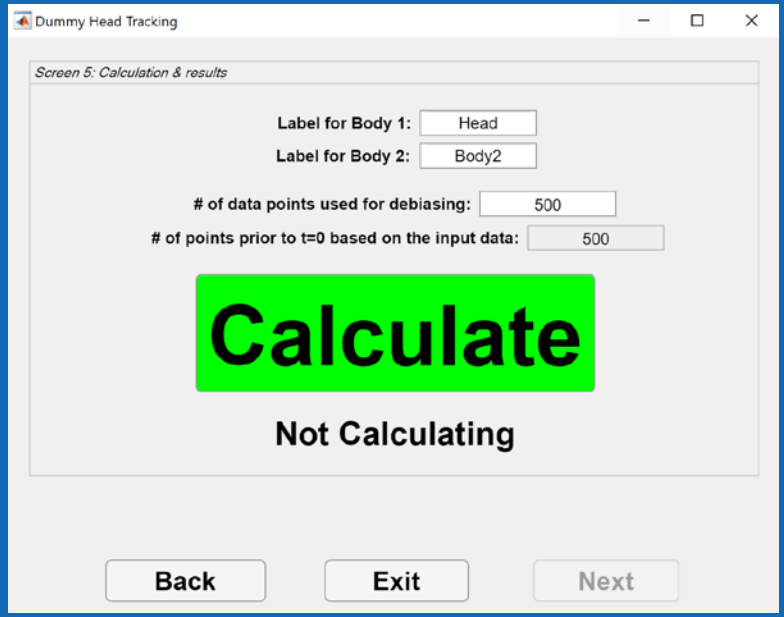
Backend code (MATLAB based)

*.xlsx files (Acc, Vel, Pos, Check, Orientation)

Graphical User Interface



First screen

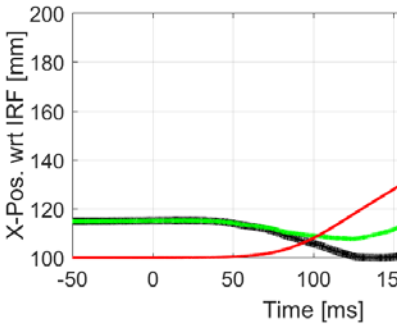


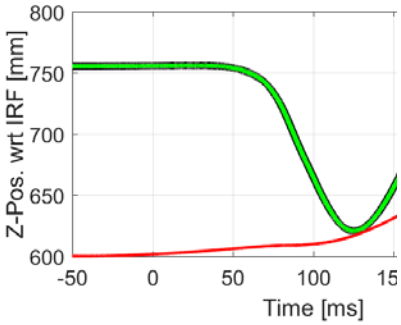
Last screen

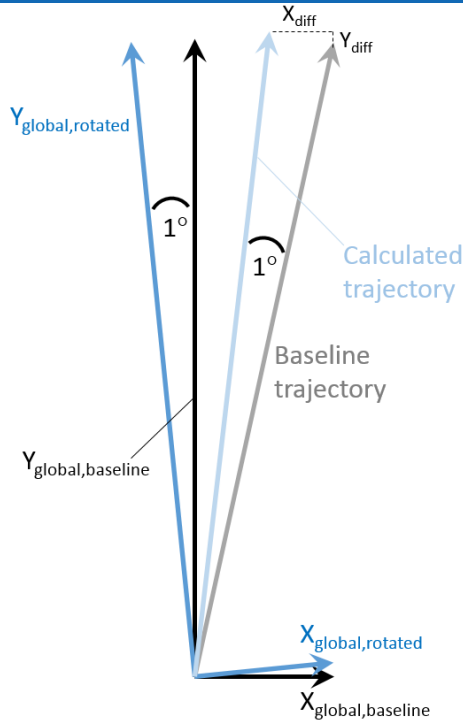
NHTSA

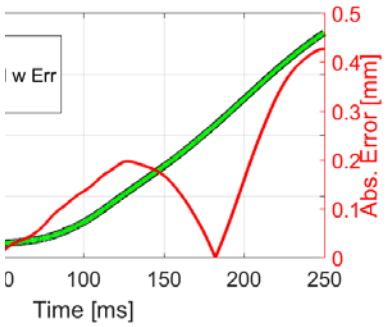
Thank you for your attention

DUMMY HEAD MOTION TRACKING IN CRASH TESTS WITH STANDARD SENSORS









off from initial

ic:

.8 mm

= 4.3 mm