



Stochastic Simulation of Crash Structures

Paul Wood

Materials Characterisation and Simulation Project

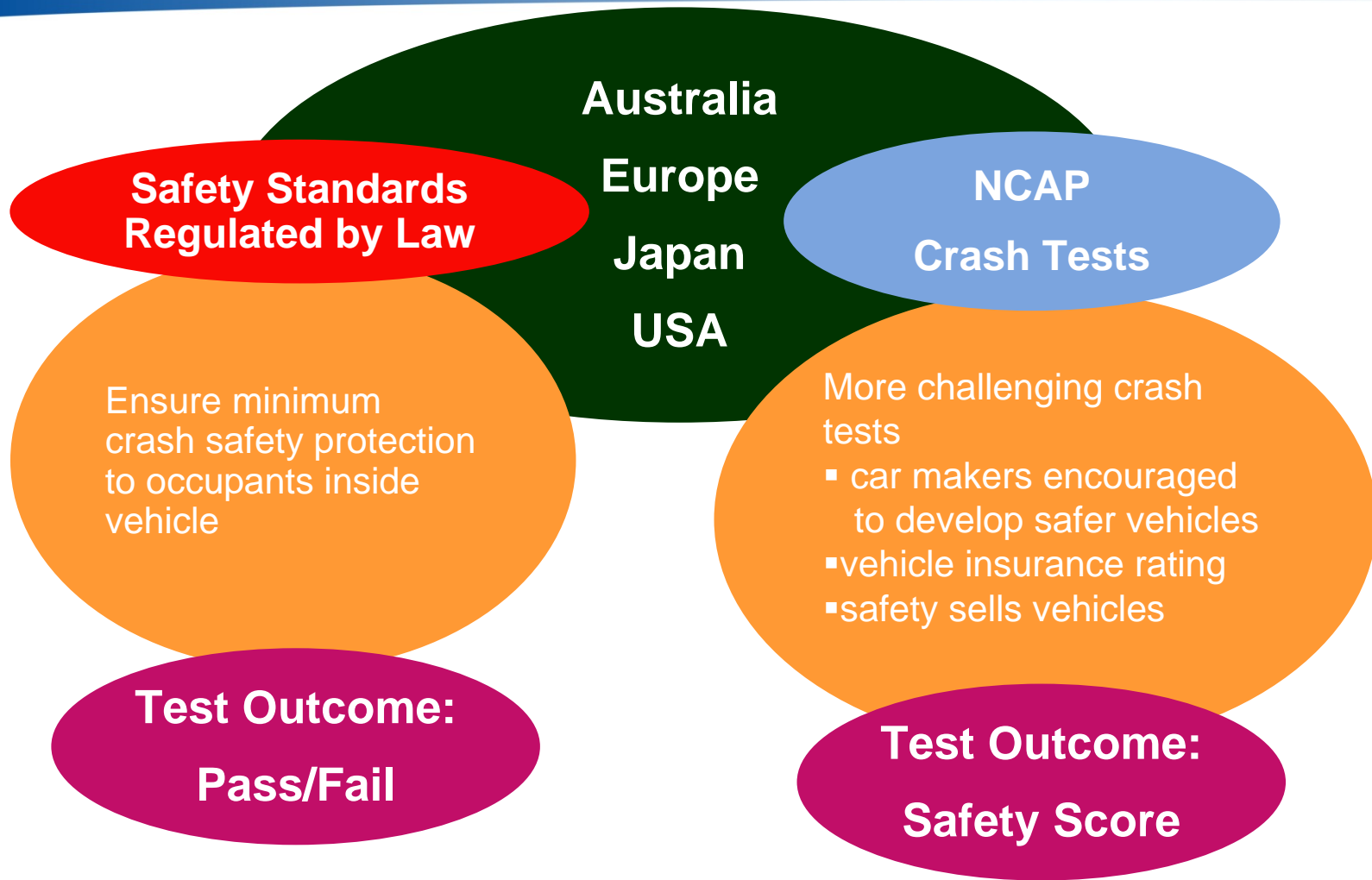




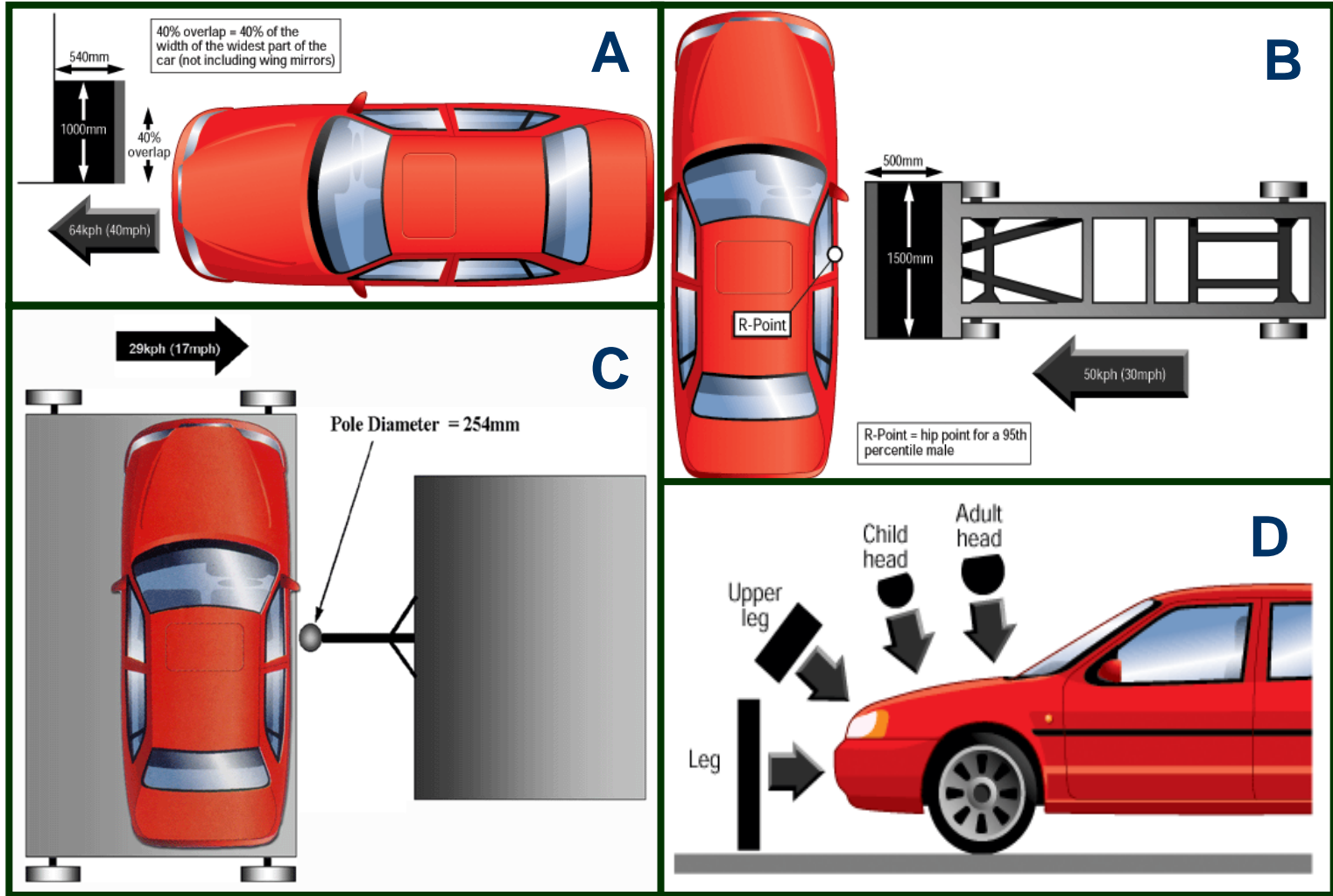
Project Partners



Crash Test Requirements



NCAP Crash Test Procedures



NCAP Crash Test Drivers



-  Good
-  Adequate
-  Marginal
-  Weak
-  Poor



Test dummies for front and side impact contain sensing equipment to measure forces, accelerations and displacements during crash tests

The measurements relate to injury criteria e.g. HIC, chest acceleration and rib displacements. A score is assigned using a star rating which is published for public viewing on NCAP websites

Example of NCAP Crash Test Results

a. Example of Low NCAP Score (c.2003)



Adult occupant rating ★★☆☆☆
Pedestrian rating ★☆☆☆☆

Test Scores:
Front 4 (25%)
Side 14 (78%)
Pedestrian 4 (11%)

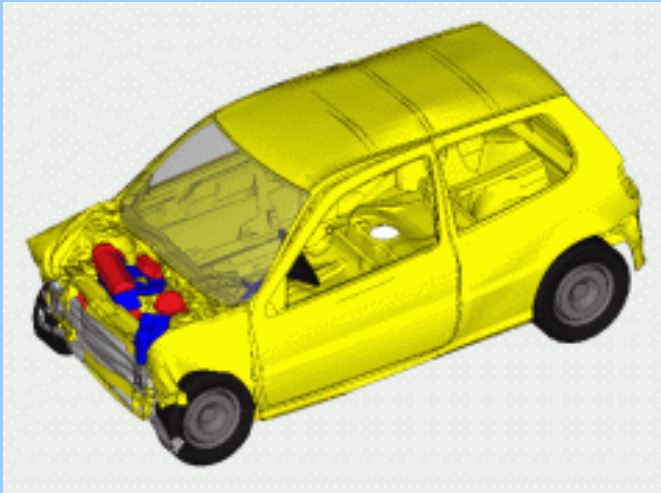
b. Example of High NCAP Score (c.2003)



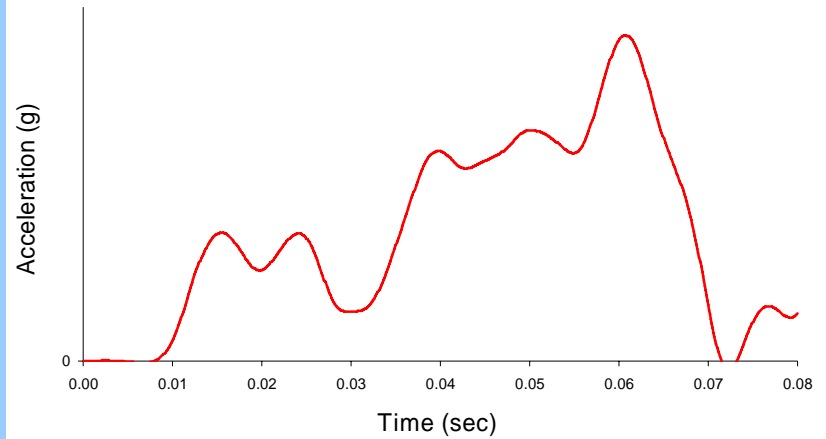
Adult occupant rating ★★★★★
Pedestrian rating ★★★☆☆

Test Scores:
Front 15 (94%)
Side 18 (100%)
Pedestrian 10 (28%)

Virtual Crash Testing



Structure Acceleration versus Time During Impact



Protection:

- Good
- Adequate
- Marginal
- Weak
- Poor



NCAP SCORE

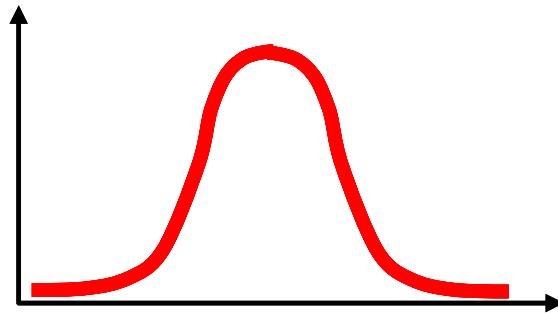
Typical Engineering Tolerances

Typical structural property and noise factors variations;

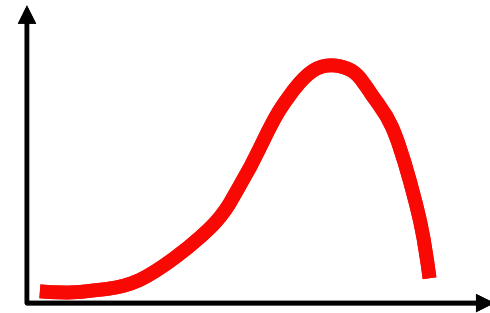
	Description	Range	Distribution Model Applied
Structural Properties	Materials	+/- 10%	Uniform?
	Gauges	+/- 10%	Uniform?
	Joints	+/- 20%	Skewed ?
	Manufacturing effects	+/- 10%	Skewed ?
Boundary Conditions	Barrier angle	+/- 1 deg	Normal
	Impact velocity	+ 3%	Normal

Modelling Variability

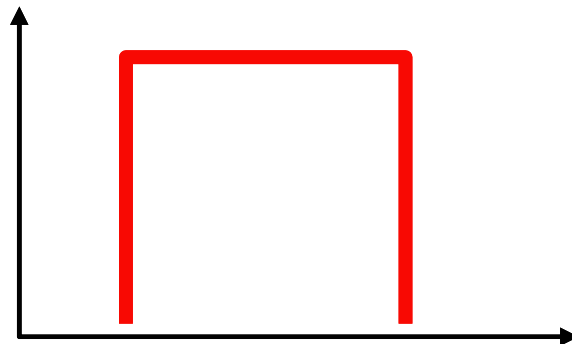
Typical parent distribution models;



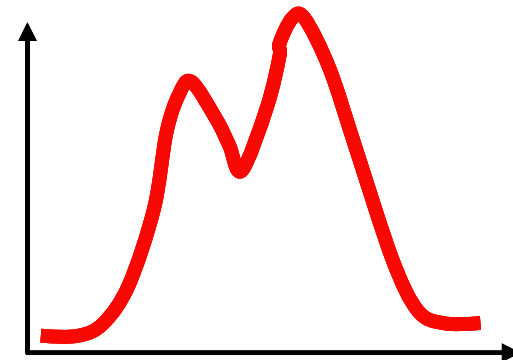
Normal Distribution



Skewed Distribution



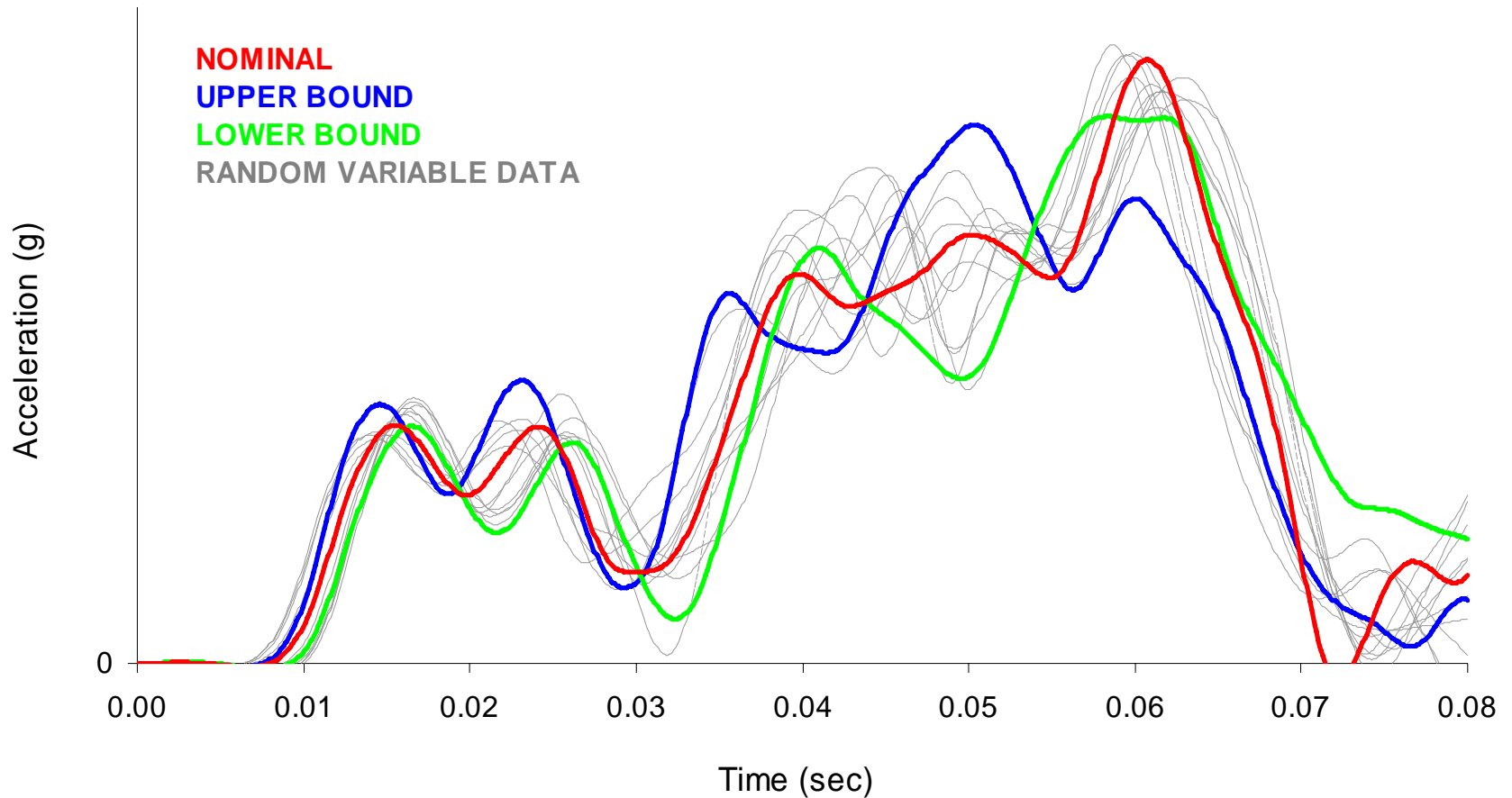
Uniform Distribution



Bi-modal Distribution

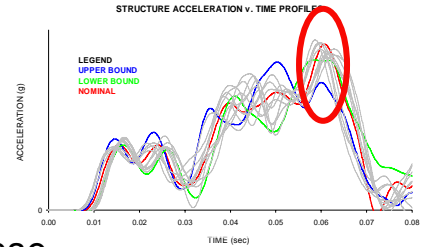
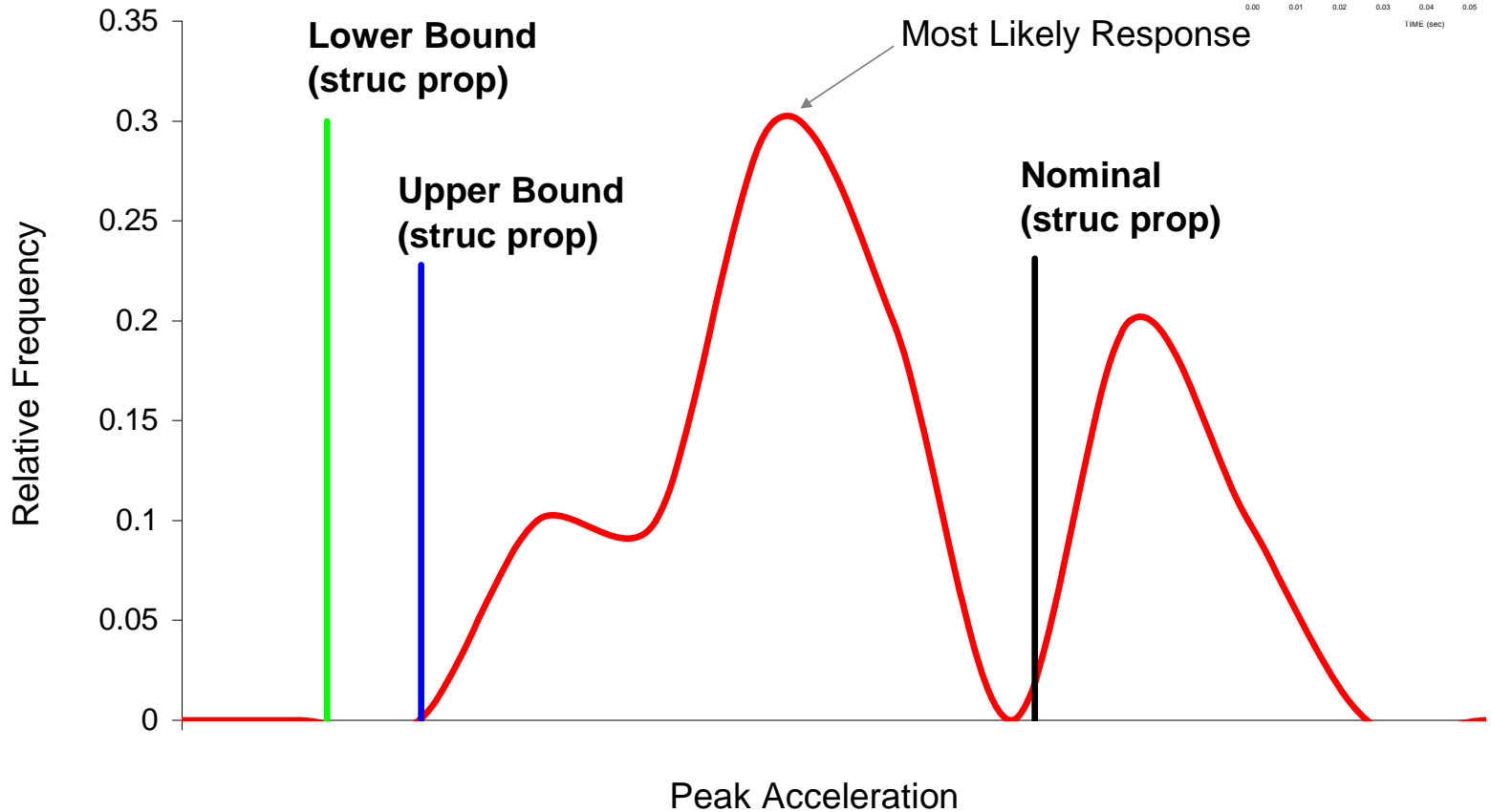
USNCAP Performance Variability

Structure Acceleration versus Time During Impact

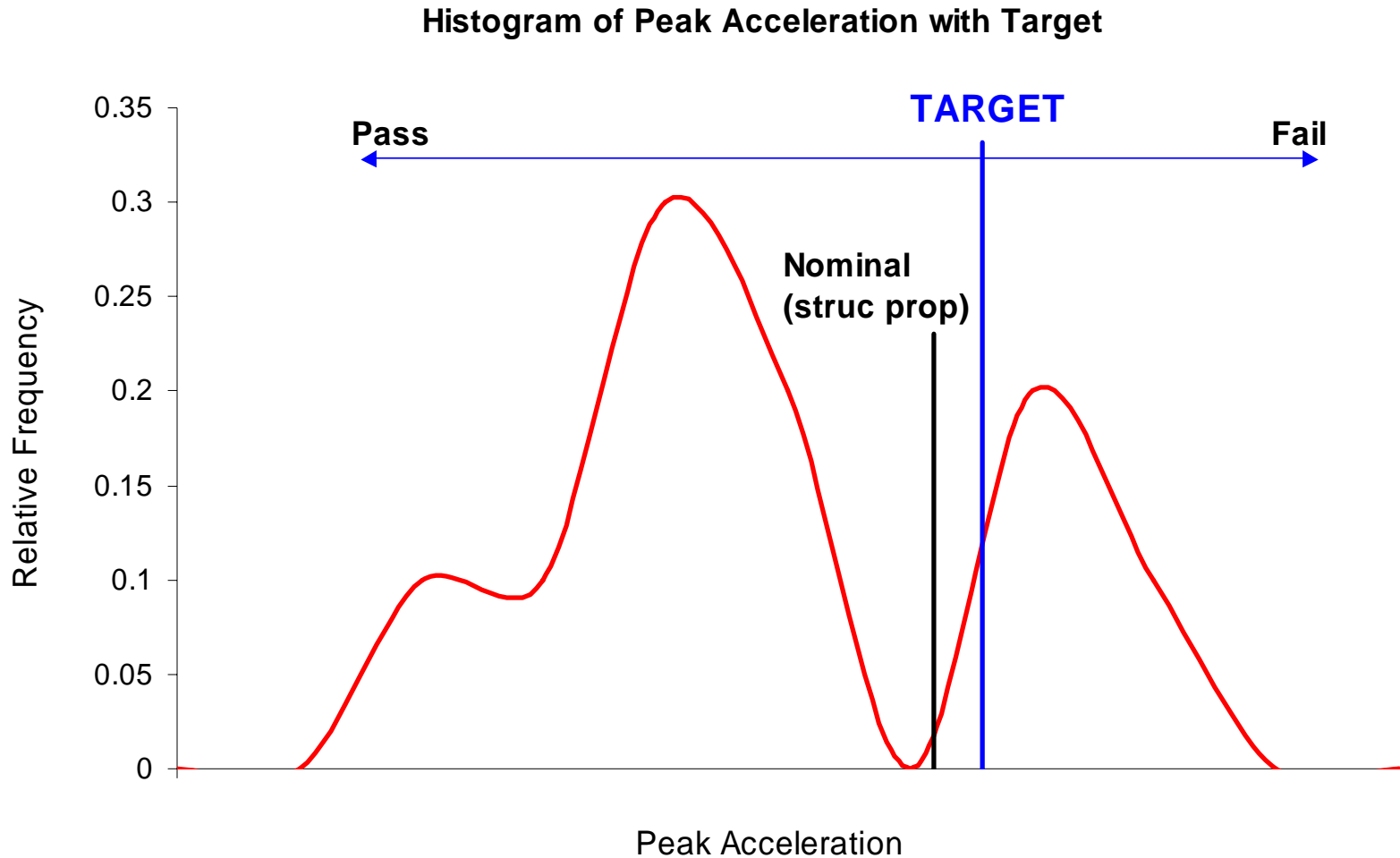


Characterising Performance Variability

Histogram of Peak Acceleration

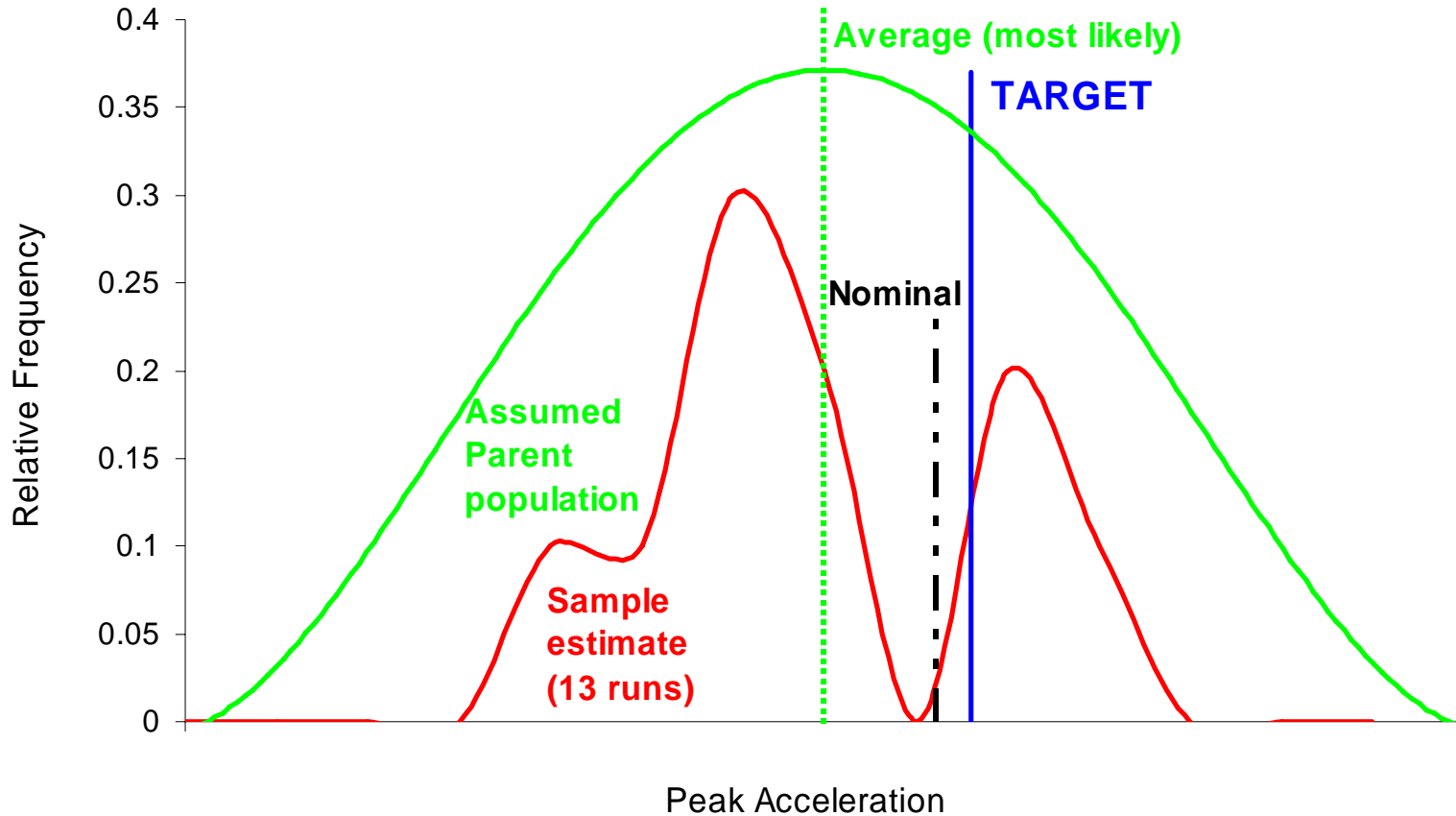


Performance Variability & Relationship to Target



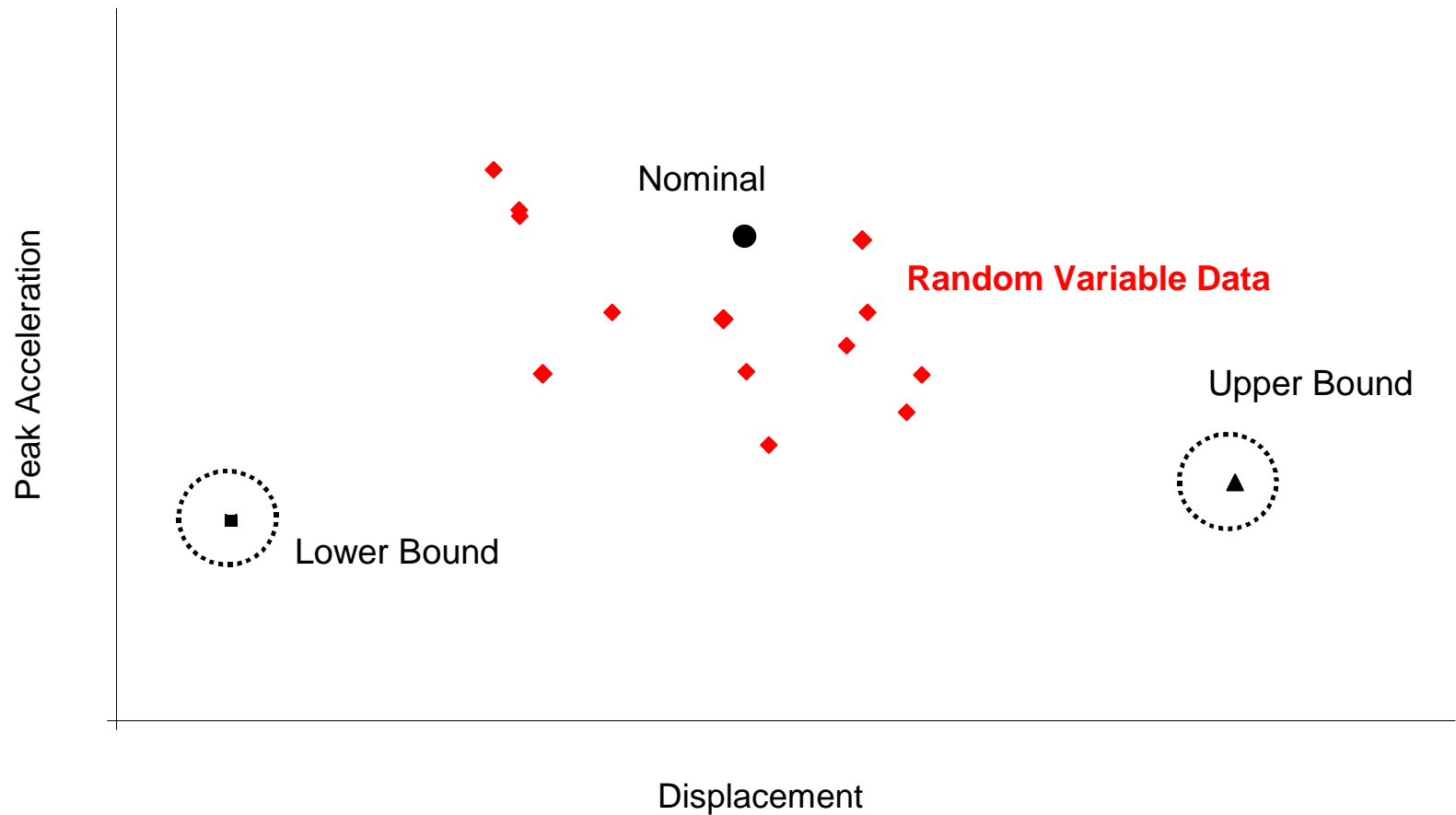
Sample Estimate of Performance Variability

Histogram Comparing Sample Estimate and Parent Population



Univariate v. Bivariate

Bivariate - Maximum Acceleration v. Crash Displacement



Investigate Suitability of Structural Design Metric

Define random variables in crash structure

Submit to CAE

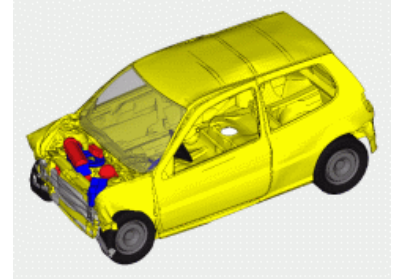
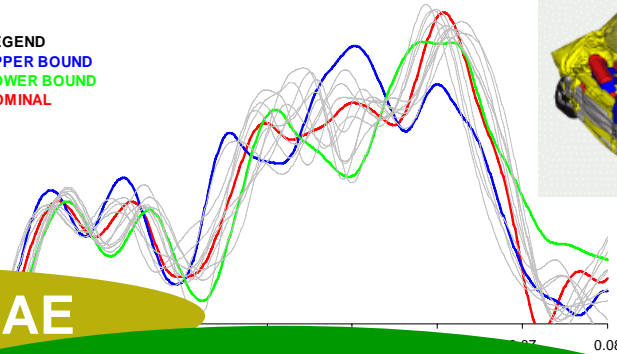
Output from CAE

Input to occupant model

Output from occupant model

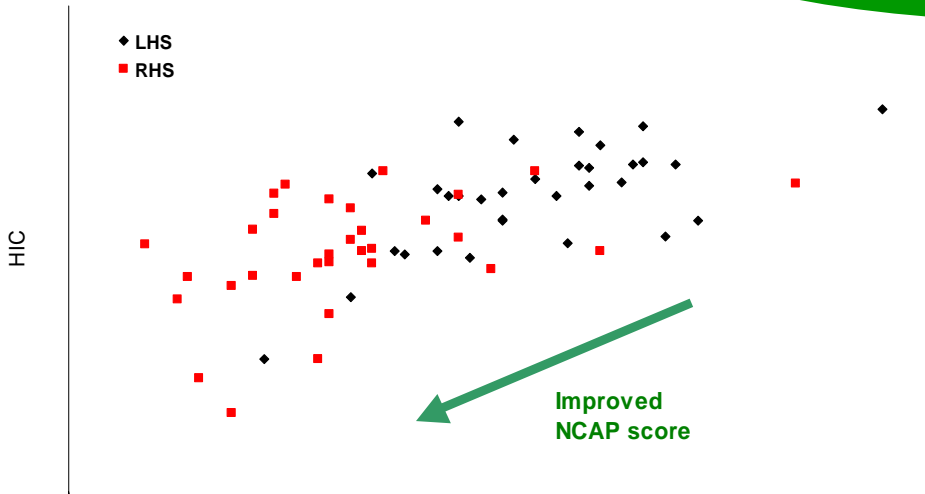
STRUCTURE ACCELERATION v. TIME PROFILES

LEGEND
 UPPER BOUND
 LOWER BOUND
 NOMINAL



RESPONSE FROM DRIVER & PASSENGER

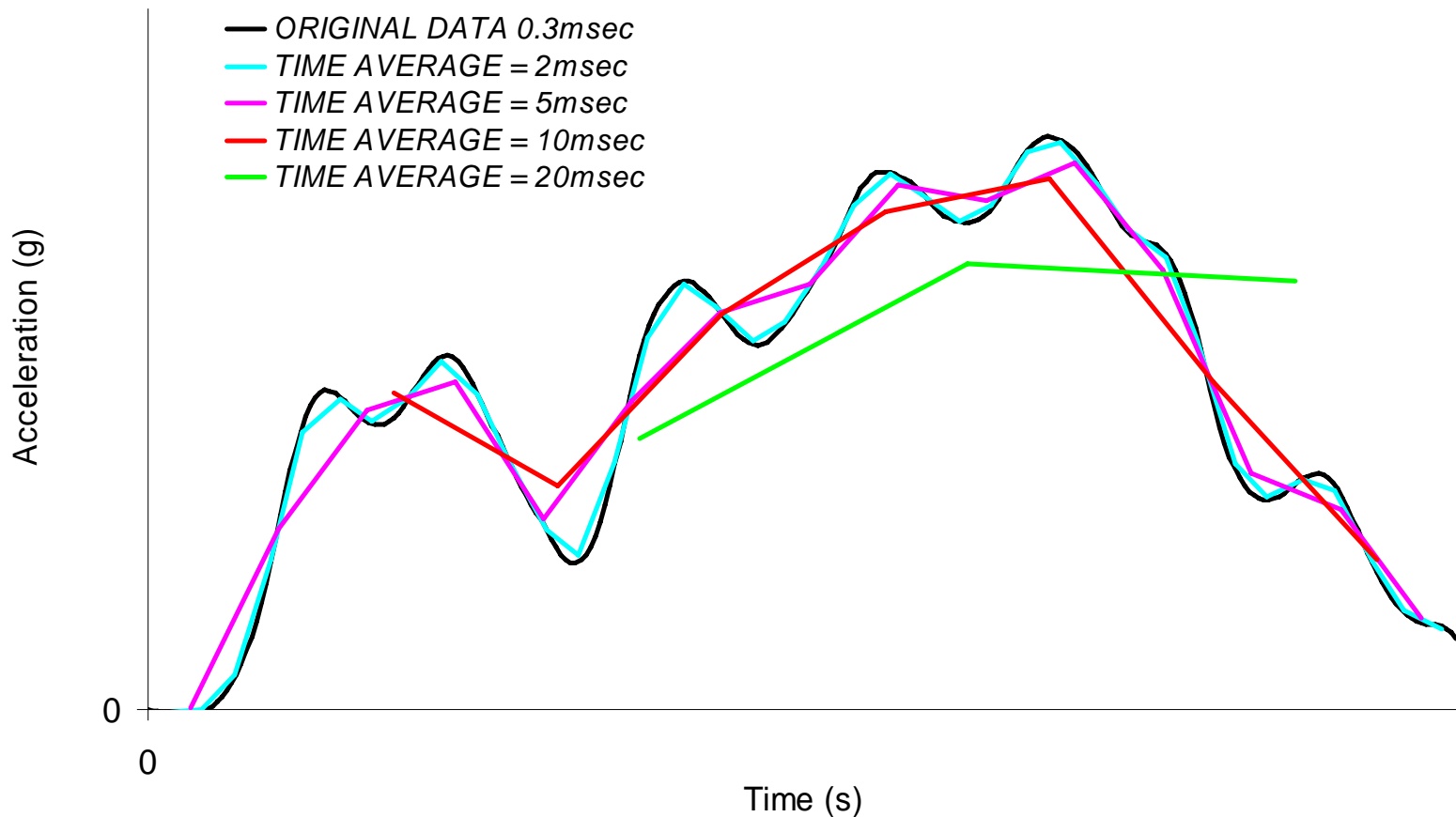
◆ LHS
 ■ RHS



CHEST ACCELERATION (g)

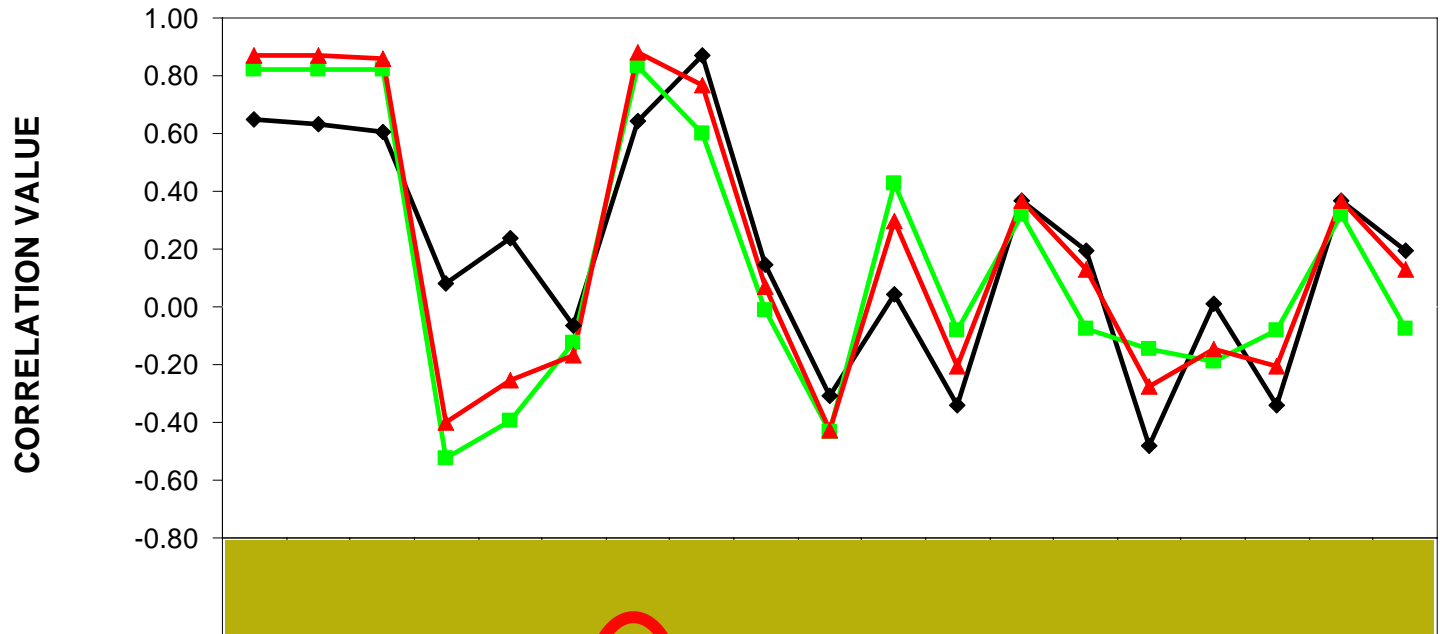
Characterise Structural Performance

CHARACTERISING STRUCTURAL ACCELERATION BY TIME AVERAGES



Validate New Structural Design Metric

CORRELATION BETWEEN OCCUPANT INJURY AND STRUCTURAL PERFORMANCE MEASURES

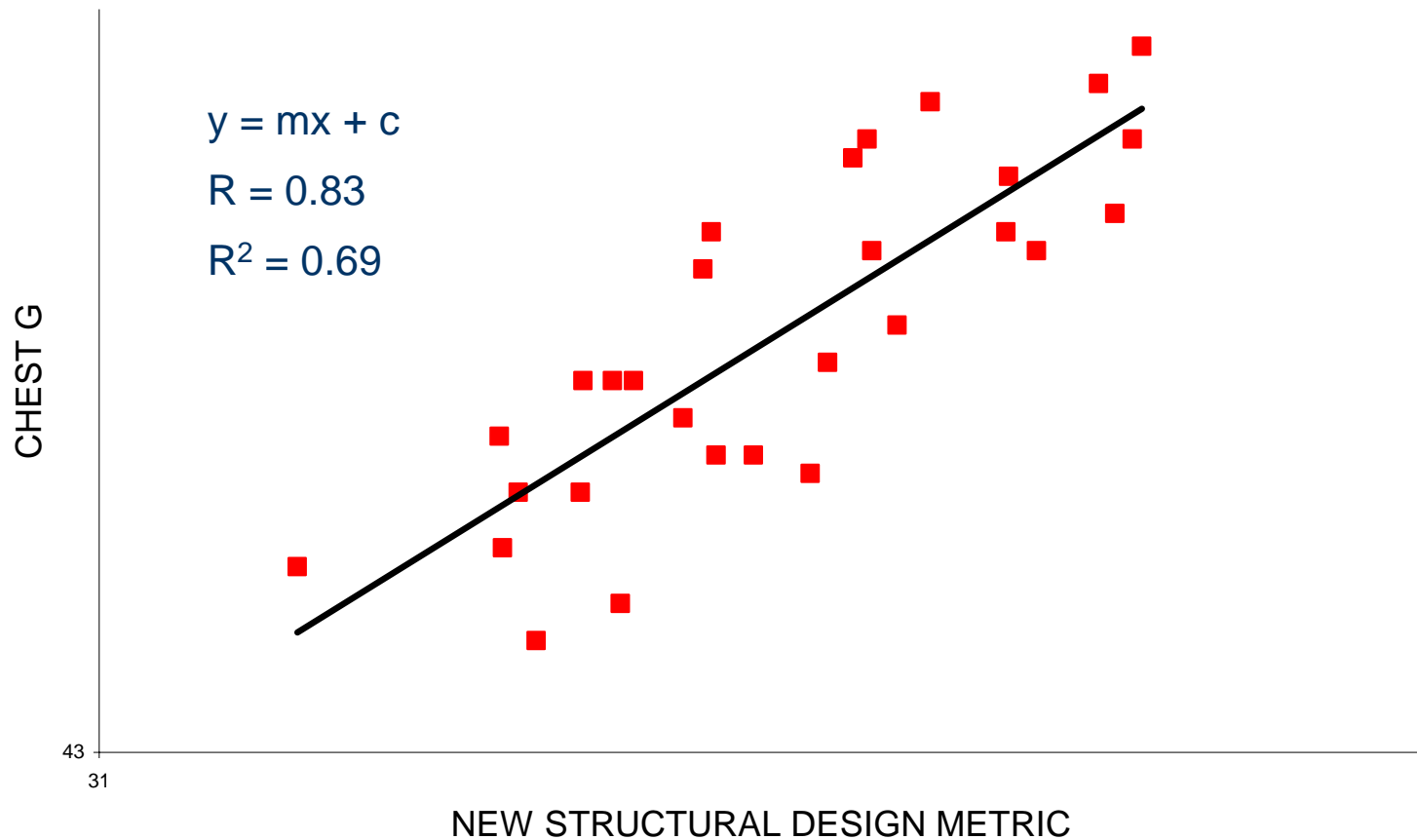


◆ LHD HIC 36.0	0.65	0.63	0.60	0.08	0.24	-0.07	0.64	0.87	0.15	-0.31	0.04	-0.34	0.37	0.19	-0.48	0.01	-0.34	0.37	0.19
■ LHD CHEST ACCEL (g)	0.82	0.82	0.82	-0.53	-0.39	-0.13	0.83	0.60	-0.01	-0.43	0.43	-0.08	0.32	-0.07	-0.15	-0.19	-0.08	0.32	-0.07
▲ LHD P.COMBI(%)	0.87	0.87	0.86	-0.40	-0.26	-0.17	0.88	0.77	0.07	-0.42	0.30	-0.21	0.37	0.13	-0.28	-0.14	-0.21	0.37	0.13

Structural Performance Measures

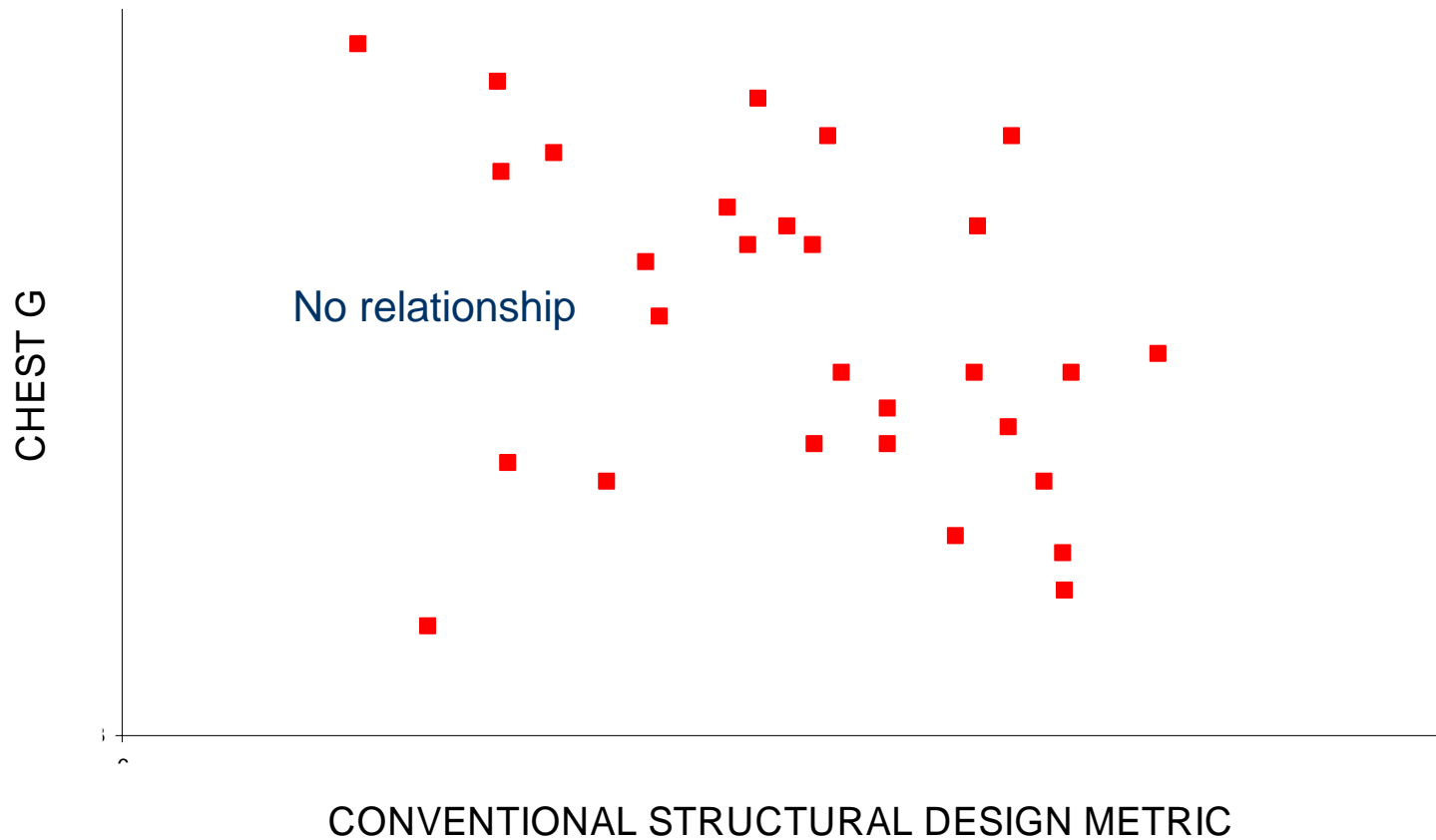
Check Sensitivity of New Structural Design Metric

CORRELATION BETWEEN INJURY AND NEW STRUCTURAL PERFORMANCE MEASURE



Conventional Structural Design Metric

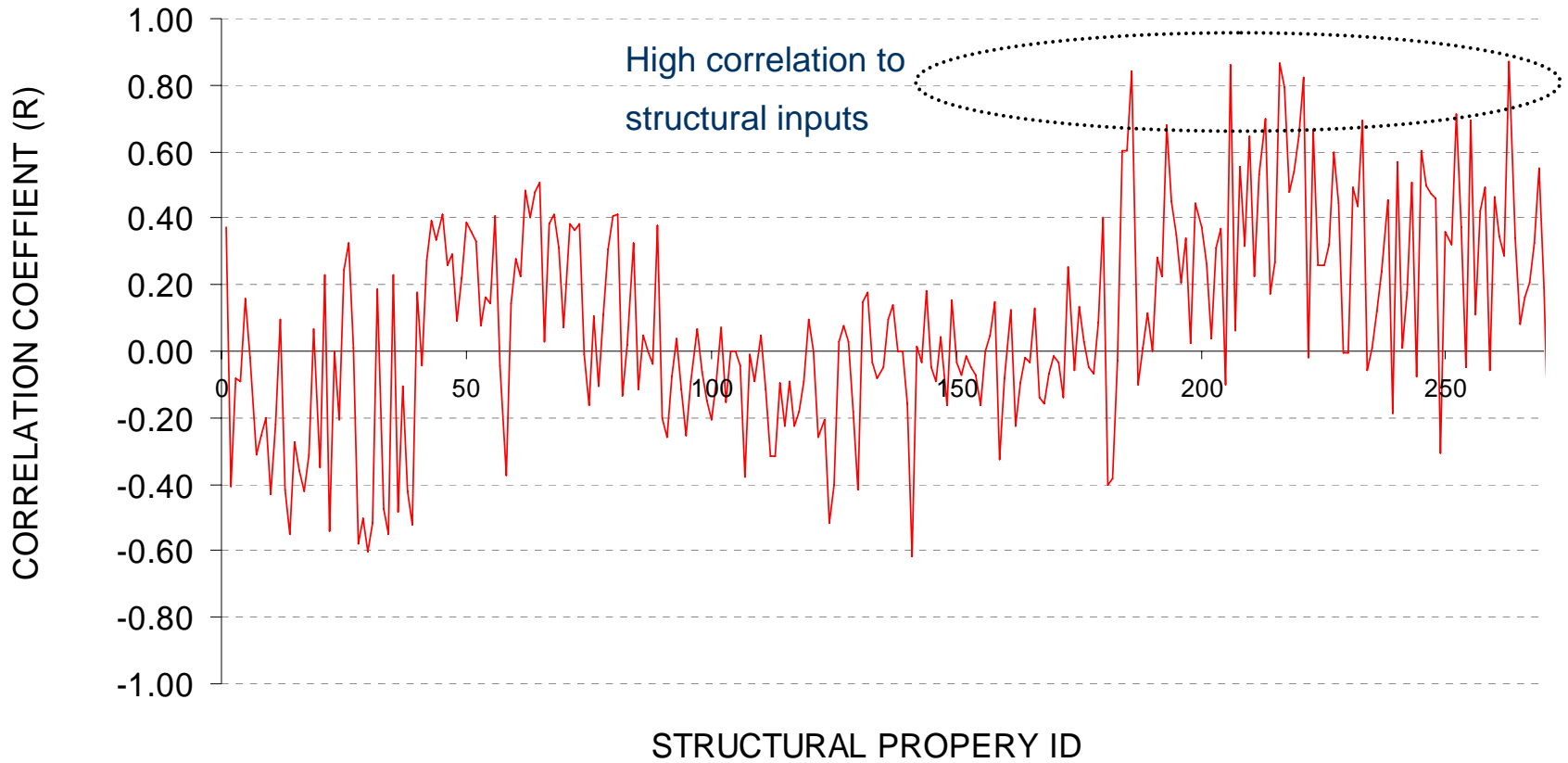
CORRELATION BETWEEN INJURY AND CONVENTIONAL STRUCTURAL PERFORMANCE MEASURE





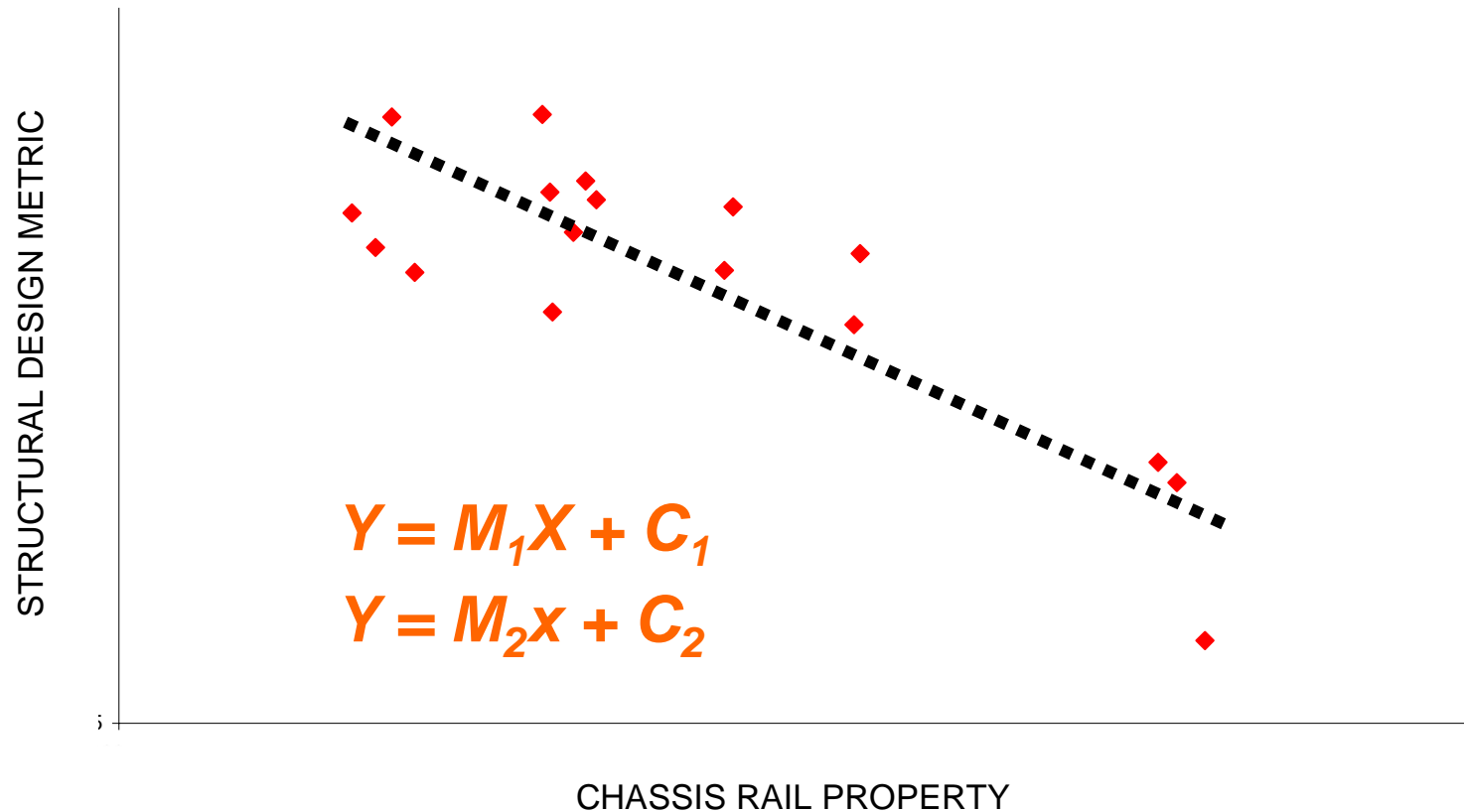
Correlation Between New Structural Design Metric and Structural Properties

Statistical Correlation Between Injury Performance Measure and Structural Crash Properties



Establish Transfer Function Between New Structural Design Metric and Structural Properties

RELATIONSHIP BETWEEN STRUCTURAL DESIGN METRIC AND STRUCTURAL PROPERTY





Establish Likely Performance Modes and Dependencies

BIVARIATE PLOT OF OP's FOR WTOL WITH DIRECTIONAL INPUT DEPENDENCIES IDENTIFIED WITHIN EACH PERFORMANCE MODE

