Ministry of Defence

Naval Design Partnering

de&S

DEVELOPMENT OF A SUSPENSION SEAT TEST PROTOCOL

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Position NDP High Speed Craft Development Manager

Contents

- Whole Body Vibration Measurement and Exposure
- Legacy Craft Issues
- NDP Research Solutions

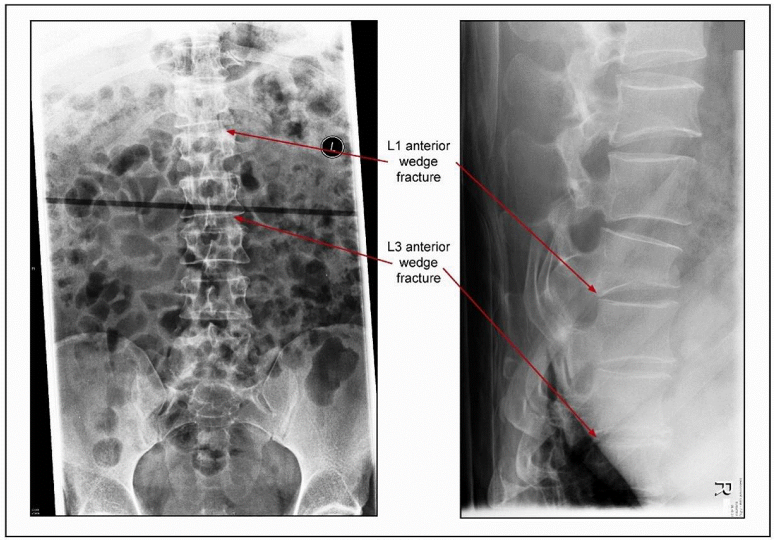
Background

- Whole Body Vibration and shock

recognised as an issue on HSC

for a number of years, believed to cause:

  - Acute injuries,
  - Long term health degradation
  - Performance loss/fatigue

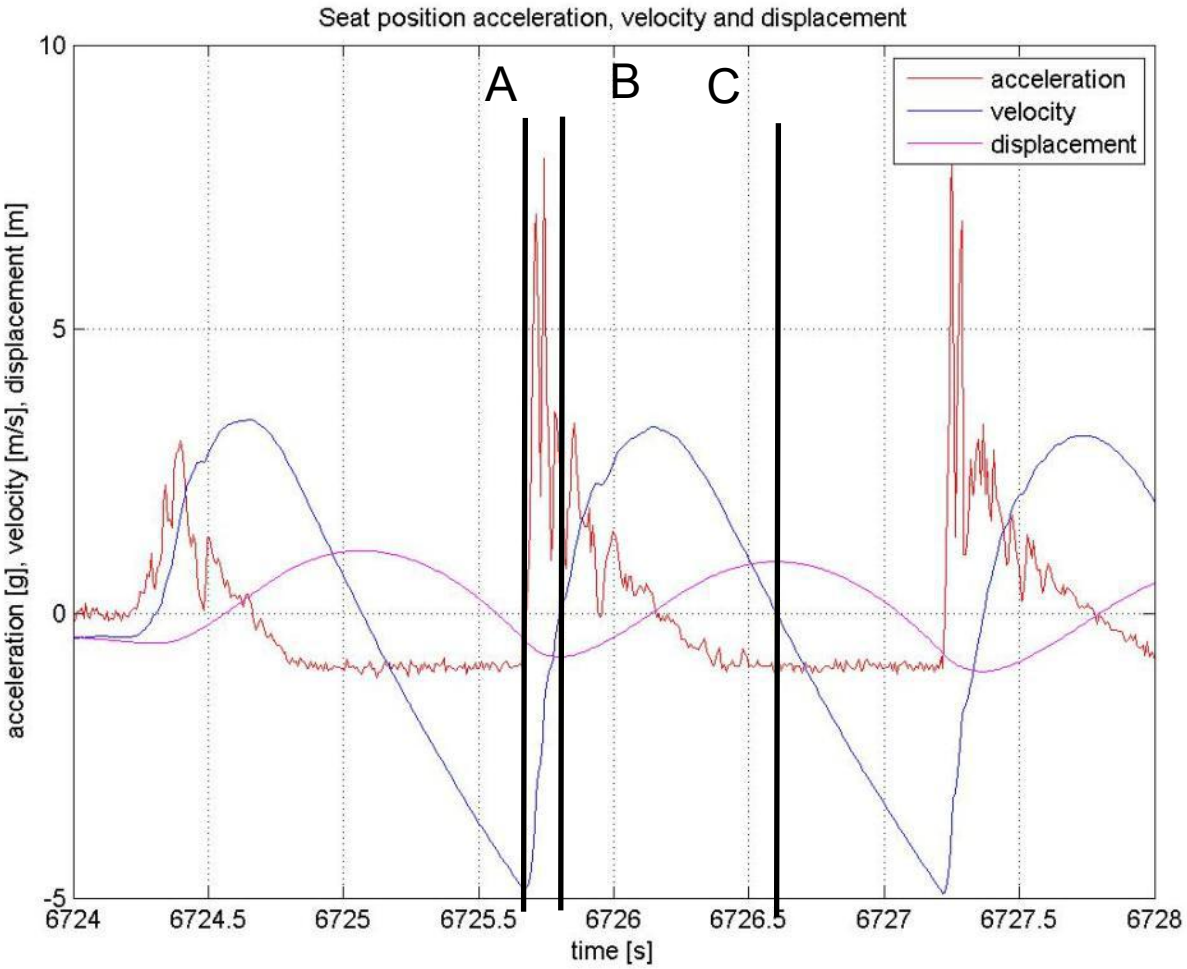


X-ray images of injury

- Legislation has placed requirements on employers and employees to act
- EU and UK Legislation places Limits on the Exposure

Measurement and Exposure

- Planing craft time histories consist of repeated shocks



Free fall ended at max downward velocity (A)

Craft still moving down: max loading phase

Displacement minima at zero velocity (after slam) (B)

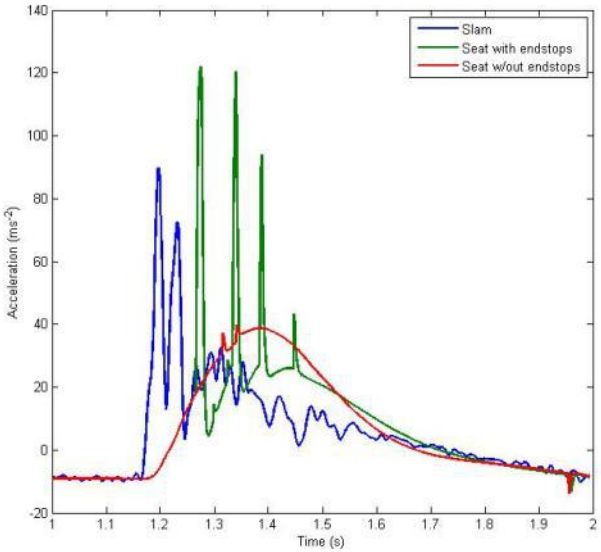
Displacement maxima at zero velocity (during free fall) (C)

Legacy Craft Issues 1

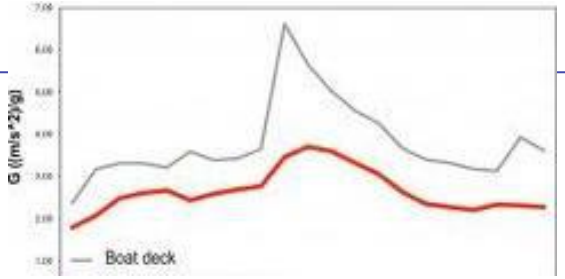
- Diversity of the fleet
- Diversity of occupants
- Available weight and space

Seat selection issues

- Lack of a test standard and hence:
  - No way of demonstrating seats are fit for purpose (safe)
  - End Stop Impacts
  - Unable to compare like with like



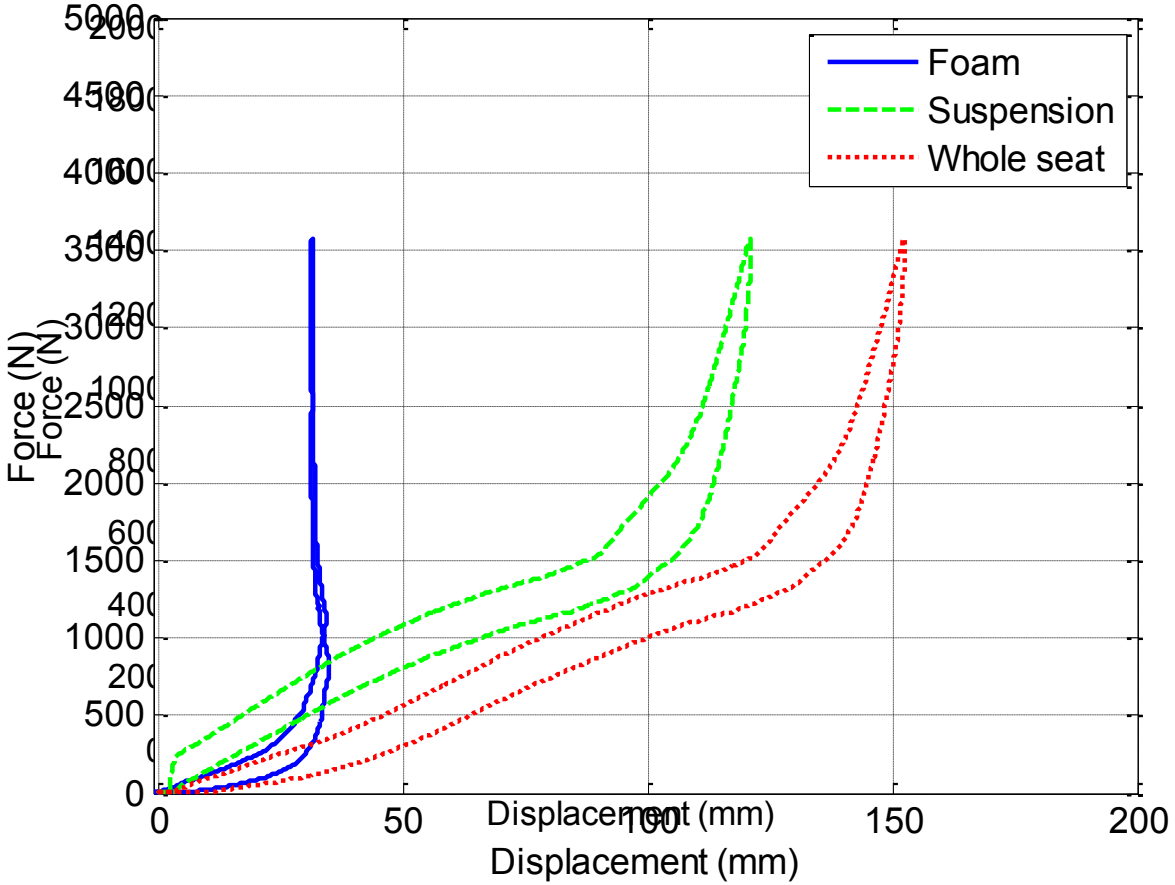
XXX - the safest seats at sea
- Scientifically proven YY % impact reduction



Test Protocol Development

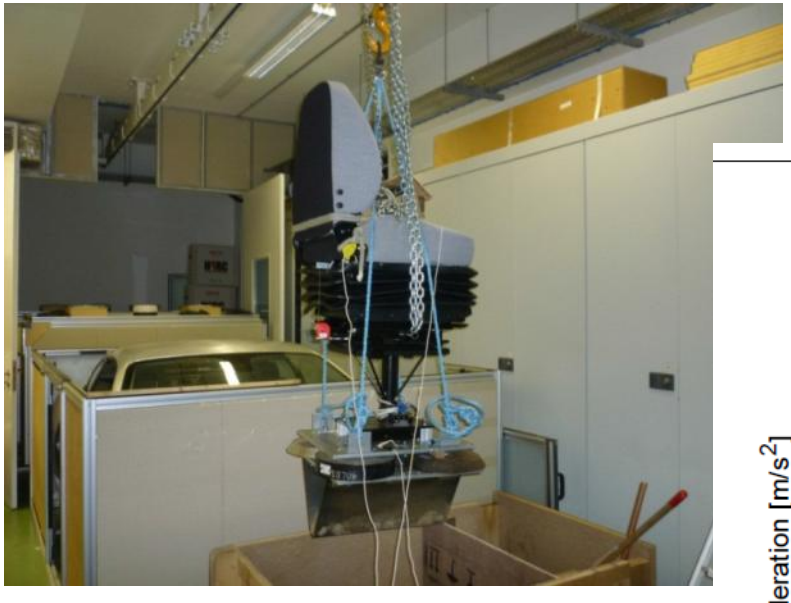
- University of Southampton Institute of Sound and Vibration Research engaged to develop test protocol and inform NDP on how to specify/assess shock mitigating seats
- Threefold process
  1. Characterisation of example seats on an indenter rig to give stiffness curves (for modelling)
  2. Testing of example seats (manned and unmanned) on 1m stroke shaker
  3. Shock testing of seats

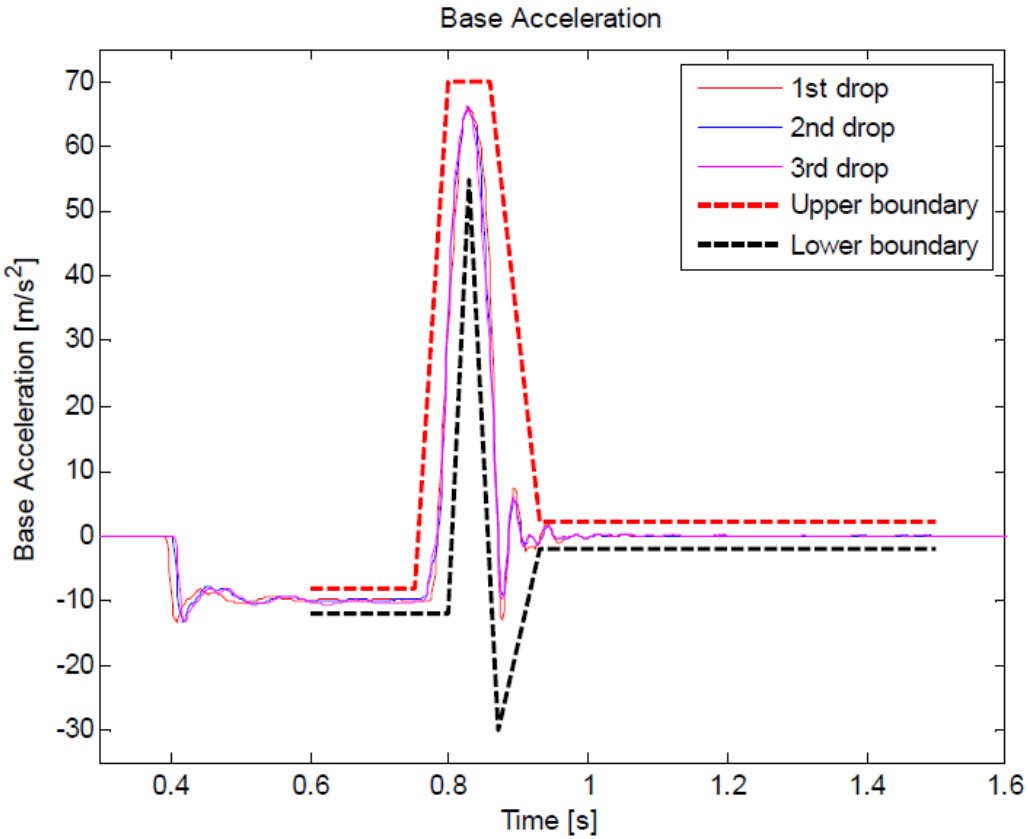
Example of in service seat



Load-deflection curves of the Pacific 24 In service seat

ISVR Drop test protocol





Initial Seat testing results

- ISVR delivery of seat test results
- Hypothesis: All seats will give similar SEAT Values
  - Mature market
  - Minimal number of parameter (k_{seat}, c_{seat}, m_{seat}, length of travel)
  - Reasonably straightforward problem?

Initial results

Manufacturer	Model	SEAT Value (VDV ratio) suspension frame	SEAT Value (seat base to seat surface)
-	Pac 24 seat	-	1.94
A	1	0.75	1.08
B	2	1.75	2.2
C	3	0.72	0.94
D	4	0.63	0.79
E	5	1.3	1.27
F	6	1.19	1.37
G	7	1.43	1.76
H	8	0.71	1.04
C	9	0.73	1.19
I	10	1.03	1.16
I	10-a	0.91	1.12
D	11	0.66	0.86

Outcomes

Cushions have a big effect!

Manufacturer	Model	Base VDV	SEAT Value (VDV ratio) on suspension frame	SEAT Value (seat base to seat surface)
		20.95	X	1.63*X

Would expect this to be 1 (ie a rigid seat)

This shows 94% worse than nothing

Results indicate that no cushion would be the best solution- from a WBV perspective

Example of an HF issue

Users unlikely to accept this

Outcomes

Shows significant differences between seats (so a useful test)

Shows benefits of seats compared with baseline.

Best seats achieve SEAT values of 0.63 – 0.69 (on the frame) or 0.79 on the cushion

$$T{\downarrow}2 = T{\downarrow}1\ [SEAT{\downarrow}1\ /SEAT{\downarrow}2\ ]{\uparrow}4$$

This means time to VDV limit values increases significantly

ie $[1/0.66\ ]{\uparrow}4 = 5.3$ or comparing seats $[1.94/0.79\ ]{\uparrow}4 = 36.4$

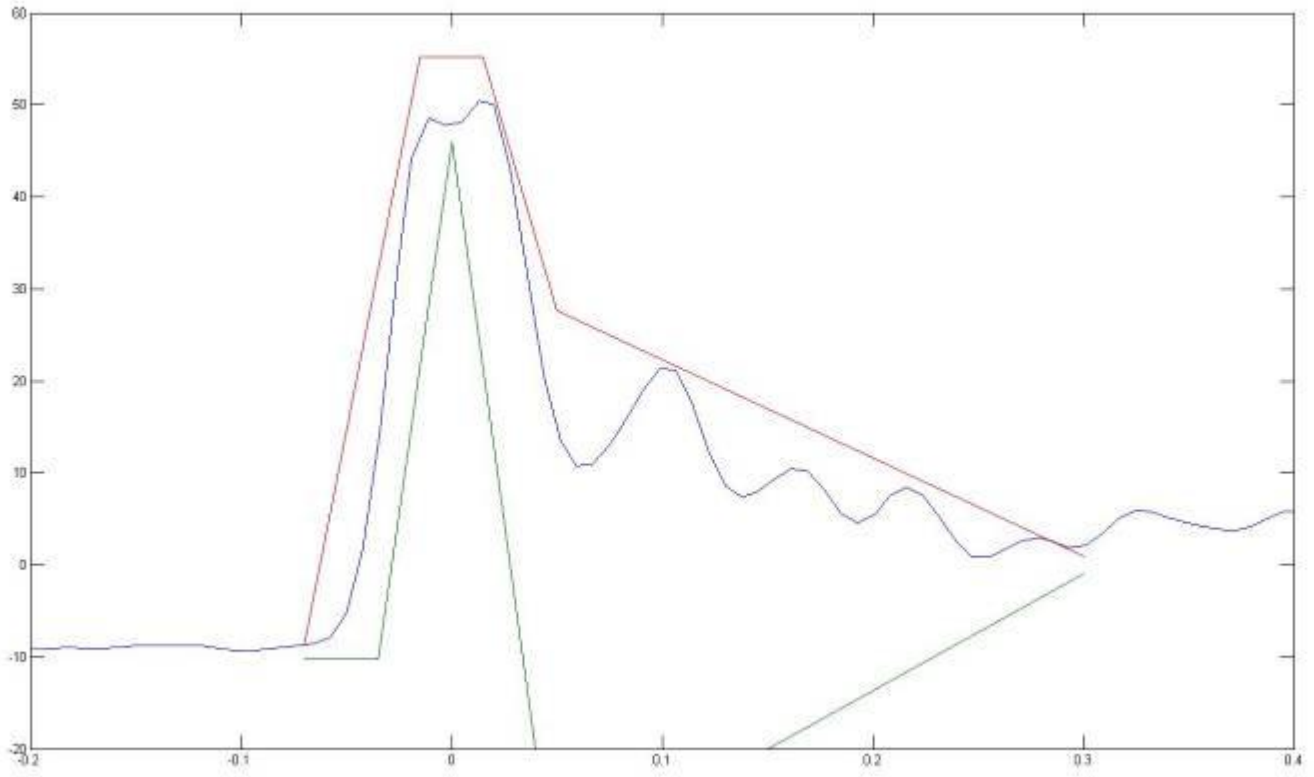
NDP Development

- NDP undertook ~300 drops using a number of seats to test:
  - Drop Height (the main test variable – other variables were usually tested over a range of drop heights, from 0.05m to 1.05m)
  - Wedge Apex angle
  - Occupant mass (generally sandbags, varied from 0kg to ~100kg)
  - Load Position on the Seat (varying the position of the load on the seat fore and aft)
  - Dropping Table Mass (varied from 64kg to 201kg)
  - Sand Angle (horizontal, tilted forwards, tilted aft, tilted sideways)
  - Hang Angle (horizontal, tilted forwards, tilted aft, tilted sideways)
  - Bomb Release Type (2 bomb releases were tested)

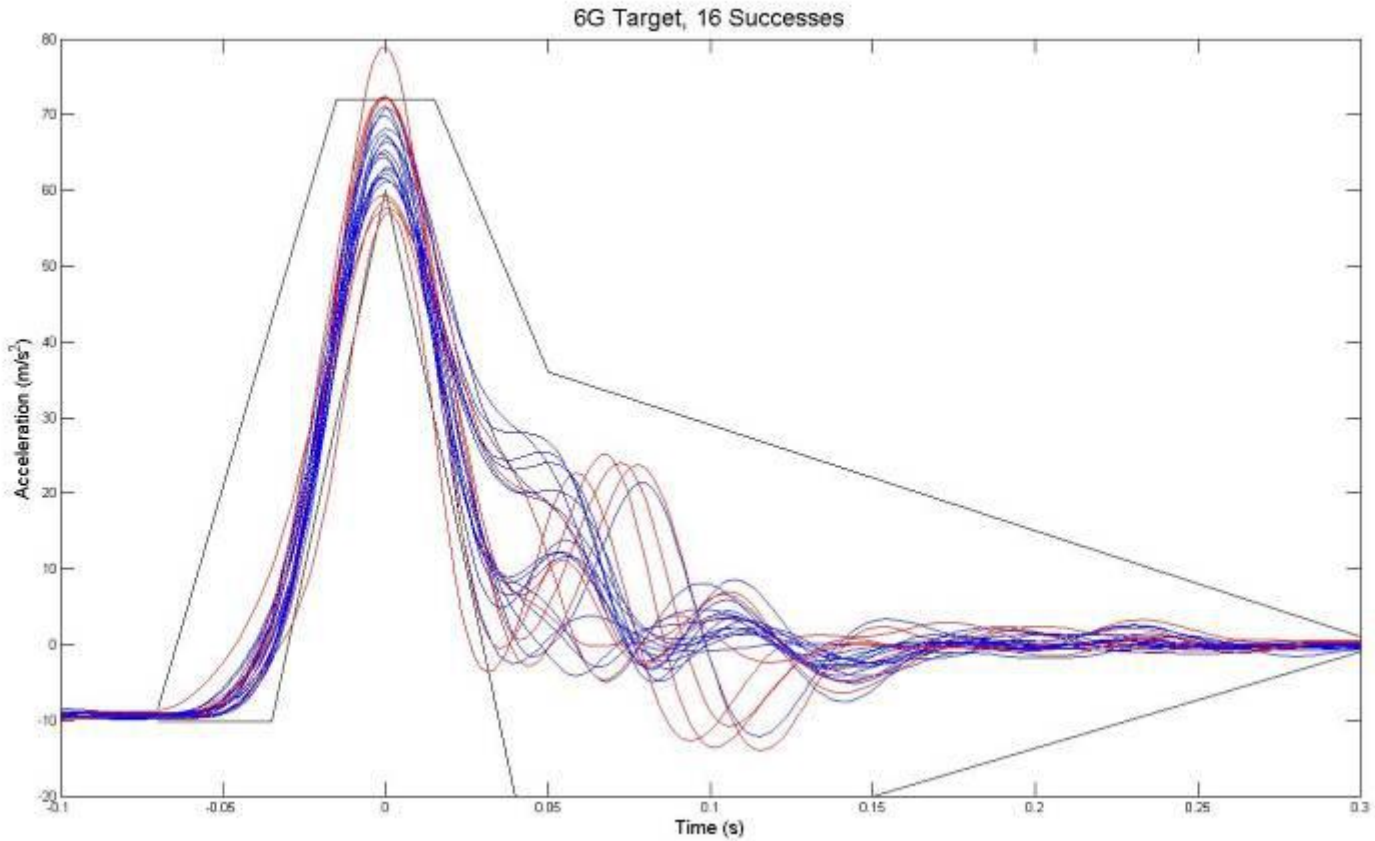
Protocol shape

- Based on shock input envelopes
  - If input fits within envelope test is valid
  - Envelope defined based on peak value shocked
- Methodology is not prescribed, drop test in informative annex

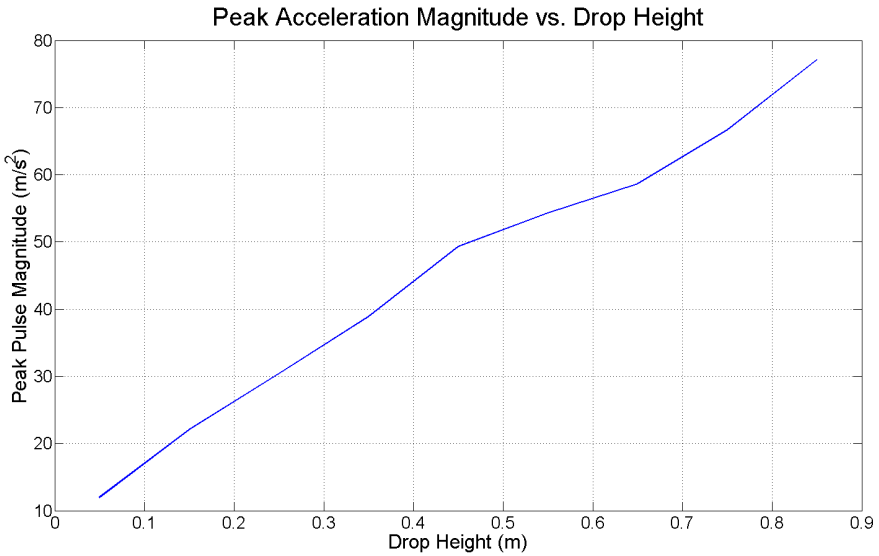
Output- Real world shocks

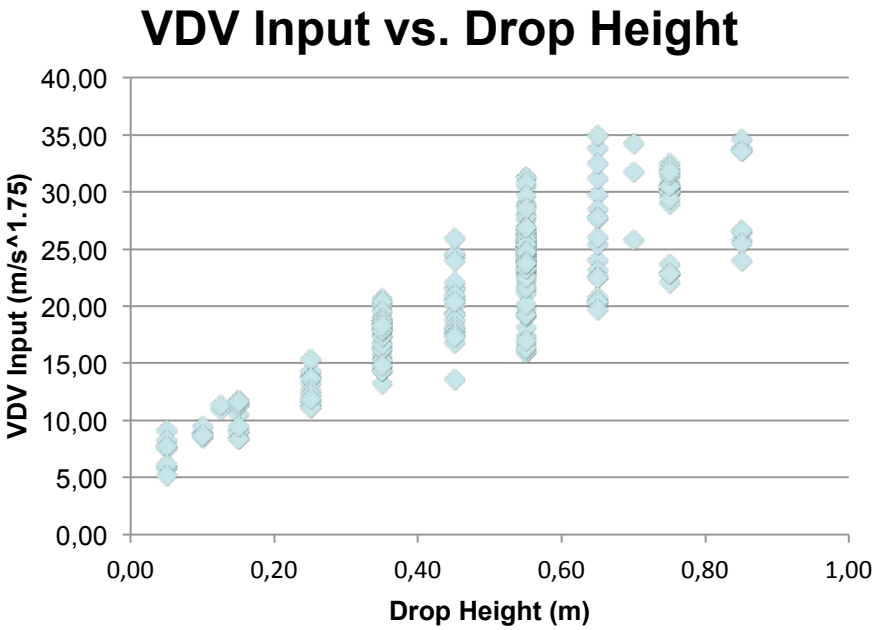


Output


6G Target, 16 Successes
Acceleration (m/s²)
Time (s)
80
70
60
50
40
30
20
10
0
-10
-20
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3

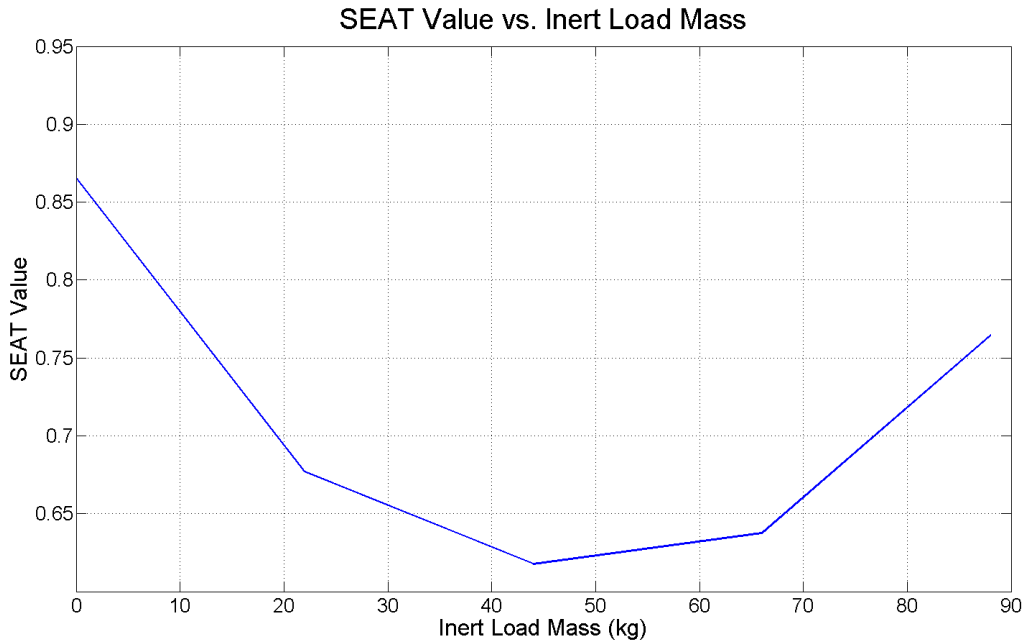
Results- Drop Height



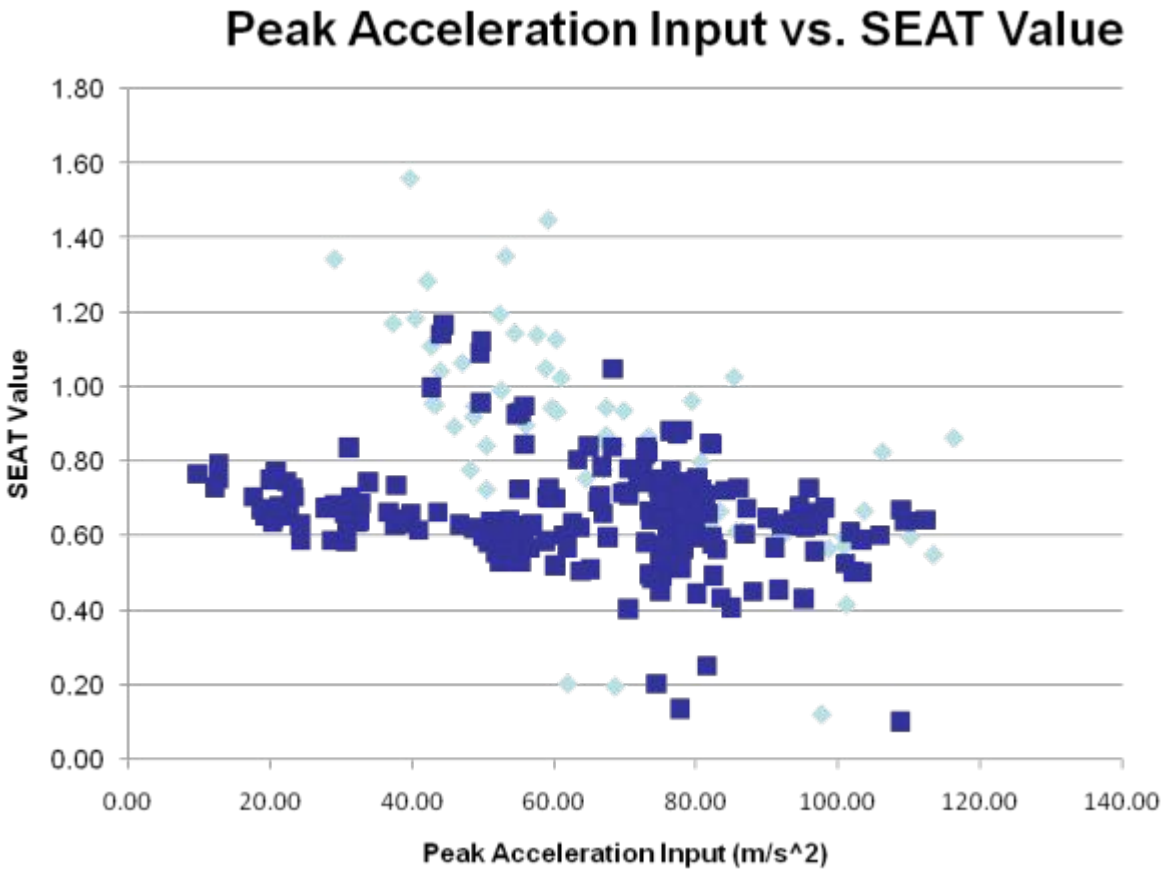


Results- Occupant mass

- Confirms need to test a range of masses
- No appreciable effect of mass location



Results- Seat Performance



Example (expanding the envelope)

Summary

- Protocol developed using indenter rig, shaker table testing, drop testing and modelling
- Large number of additional drops carried out to validate protocol
- Shocks generated representative of real world data

THANK YOU, QUESTIONS?