LANDMINE BLAST MITIGATING SEAT

SYSTEM BREAKDOWN

- **MODULAR SEAT SYSTEM**
  - **BASE SEAT**
    - Chassis
    - Backrest
    - Seat Bucket
    - Upholstery / Padding
    - Seat Belts / Harness
    - Blast Mitigation System
  - **FIXTURES**
    - Side Wall Backward Mounted
    - Side Wall Sideward Mounted
    - Roof Mounted
    - Floor Mounted
    - Adjustable Floor Mounted 1
    - Adjustable Floor Mounted 2
  - **FOOTREST**
    - Seat Mounted Footrest
  - **HEADREST**
    - Whiplash Headrest
    - Whiplash and Side Impact Headrest
  - **INTERFACES**
    - Rifle Mount

SEAT DESIGN CRITERIA - PROTECTION LEVELS OF STANAG

The table presented below appears in ANNEX B to STANAG 4569 (Edition 2). The table describes the protection levels and the corresponding blast threat.

LEVEL		GRENADE AND BLAST MINE THREAT	
4	4b	Mine Explosion under belly	10 kg (explosive mass) Blast AT Mine
	4a	Mine Explosion pressure activated under any wheel or track location	
3	3b	Mine Explosion under belly	8 kg (explosive mass) Blast AT Mine
	3a	Mine Explosion pressure activated under any wheel or track location	
2	2b	Mine Explosion under belly	6 kg (explosive mass) Blast AT Mine
	2a	Mine Explosion pressure activated under any wheel or track location	
1	Hand grenades, unexploded artillery fragmenting submunitions, and other small anti personnel explosive devices detonated anywhere under the vehicle		

SEAT DESIGN CRITERIA - REQUIRED MITIGATION LEVELS OF AEP 55 Vol. 2

In order for the occupant of the seat to survive the blast event, the following injury criteria stipulated by AEP 55, Volume 2 (Edition 1) must be complied with, namely:

- Lower Tibia Axial Compression Force*
- Dynamic Response Index (DRI_z)*
- Upper Neck Axial Compression Force
- Upper Neck Flexion and Extension Moment
- Chest Wall Velocity Predictor (CWVP) for non-auditory overpressure injuries

The table provided below presents the mandatory criteria values that appear in ANNEX E of AEP 55 Volume 2 (Edition 1).

BODY REGION	CRITERIA	TOLERANCE VALUE	SOURCE OF MITIGATION
Lower Leg	Peak lower tibia axial compression force ($-F_z$)	5.4 kN *	Seat (Footrest)
Thoraco-lumbar spine	Dynamic Response Index (DRI_z), calculated with pelvis A_z	17.7 *	Seat (BMS)
Cervical spine (neck)	Upper neck axial compression force ($-F_z$) Upper Neck Moment: Flexion ($+M_y$) Extension ($-M_y$)	4.0 kN @ 0ms, 1.1 kN @ 30 ms 190 Nm 57 Nm	Seat (BMS and potentially headrest)
Non-auditory internal organs	Chest Wall Velocity Predictor (CWVP)	3.6 m/s	Vehicle Hull

* *From significant prior experience it is known that specifically these two criteria are key to evaluate during the development testing. Most often, if these two criteria comply, the latter three follow. All the criteria would however need to be ultimately verified for a full STANAG / AEP 55 certification test.*

SEAT DESIGN CRITERIA - PROTECTION LEVELS OF STANAG 4569

In the event of a blast, the vehicle (and hence the mounted seats and their occupants) are subjected to an acceleration and resultant speed change. The aim of the Landmine Blast Mitigating Seat is to successfully limit the severity of the speed change experienced by the seat occupant to an acceptable / survivable level.

The table below presents the expected resultant speed changes based on the combination the vehicle mass and explosive mass.

VEHICLE MASS (ton)	LANDMINE MASS (kg)	EXPECTED SPEED CHANGE (m/s)	STANAG 4569 Protection Level
< 5	< 6	10	2a, 2b
5 to 10	6 to 8	8*	3a, 3b, 2a, 2b
> 10	8 to 10	6*	4a, 4b, 3a, 3b

* *The current seat design has been successfully subjected to tests with a 6 - 8 m/s speed change with a resultant DRI of less than 17.7.*

BLAST MITIGATION PRINCIPLE - SEAT STROKING

In order to successfully limit the severity of the speed change (acceleration) experienced by the seat occupant to an acceptable / survivable level during a landmine blast event, the seat needs to provide mitigation by stroking.

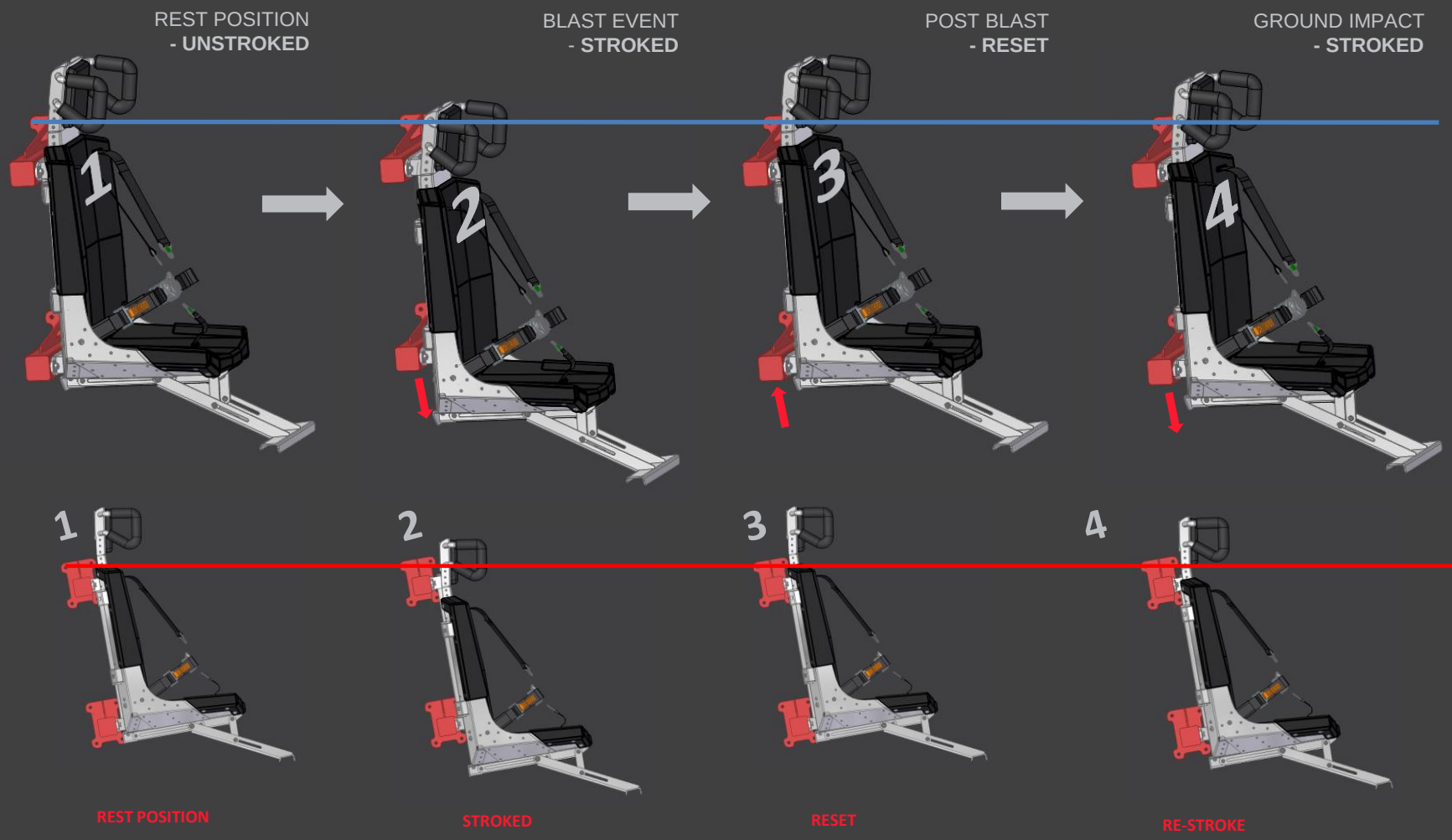
- The stroking action of the seats Blast Mitigation System (BMS) allows for the period of impact experienced by the seat to be increased, which in turn, decreases the acceleration experienced by the occupant to a survivable level

- There are in actuality two events experienced by the seat occupant during a landmine blast event:
  - The blast - the vehicle accelerates upward at an extremely high rate, rising into the air.
  - The ground impact - the vehicle returns to the ground, subjecting the occupants to a second high rate acceleration.

- The current BMS design provides for:
  - up to 140 mm of travel on the 1st stroke (mitigation of the blast) and,
  - up to 50 mm of travel on the 2nd stroke (mitigation of the ground impact).

The mitigation mechanism of the BMS provides resistance to the movement of the seat at a predetermined and constant force, thus controlling the rate at which the seat travels relative to the vehicle, significantly reducing the acceleration forces experienced by the seat occupant.

BLAST MITIGATION PRINCIPLE - DOUBLE STROKING MECHANISM



BLAST MITIGATION PRINCIPLE - DOUBLE STROKING MECHANISM

The high speed drop test images below illustrate the working principle of the double stroking mechanism.

REST POSITION **(UNSTROKED)**

0mm STROKE
T(0ms)*

BLAST EVENT (**STROKED)**

116mm 1st STROKE
T(0-100ms)

POST BLAST **(RESET)**

0mm STROKE
T(100-200ms)

GROUND IMPACT **(STROKED)**

35mm 2nd STROKE
T(800-900ms)

* The quoted times are cumulative from the first impact T(0) not the duration of each event.

CURRENT PRODUCT - TECHNICAL SPECIFICATIONS

Functional Specifications

Key Features:

- Double stroking blast mitigation system (BMS):
  - *Mitigation of initial blast event (1st Stroke)*
  - *Mitigation of secondary impact (2nd Stroke)*
  - *Maximum 1st stroke travel of 140 mm*
  - *Maximum 2nd stroke travel of 50 mm*
- Modular configuration with the following optional add-ons:
  - *Headrest (Whiplash and/or Side Impact)*
  - *Retractable Footrest*
  - *Equipment attachment brackets*
- Multiple seat-vehicle mounting options:
  - *Adjustable Floor Mount (e.g. Driver / Commander)*
  - *Side Mount (e.g. Gunner)*
  - *Rear Mount (e.g. Rear Crew)*
  - *Roof Mount (e.g. Rear Crew / Gunner)*
- Ergonomically designed (75 percentile male)
- Commercial, Certified, 5 Point Safety Harness
  - *Compliant with FMVSS-209*
  - *Harness / Belt configuration adjustable as per customer requirement*
- Low to Zero Maintenance (Unique Passive System)
- Optimised Weight & Cost

Physical Specifications

Key Attributes:

- Construction materials:
  - *Aluminium*
  - *Steel*
  - *Engineering Plastics*
  - *Fabric*
  - *PU Foam Padding*
  - *Nylon Webbing*

- Mass and Dimensions (seat only):
  - *Mass: 17 kg*
  - *Overall Dimensions (installed orientation – zero stroke, extended footrest, whiplash headrest):*
    - 1080 x 750 x 450 mm.
  - *Overall Dimensions (packaged orientation – headrest removed):*
    - 750 x 540 x 450 mm.

PRODUCT – PROTO1 PHOTOGRAPHS

BASE SEAT WITH FOOTREST (RETRACTED)

BASE SEAT WITH FOOTREST (EXTENDED)

CURRENT PRODUCT – PROTO 2 PHOTOGRAPHS

Base Seat

PRODUCT CONFIGURATIONS – RETRACTABLE FOOTREST

RETRACTED FOOTREST

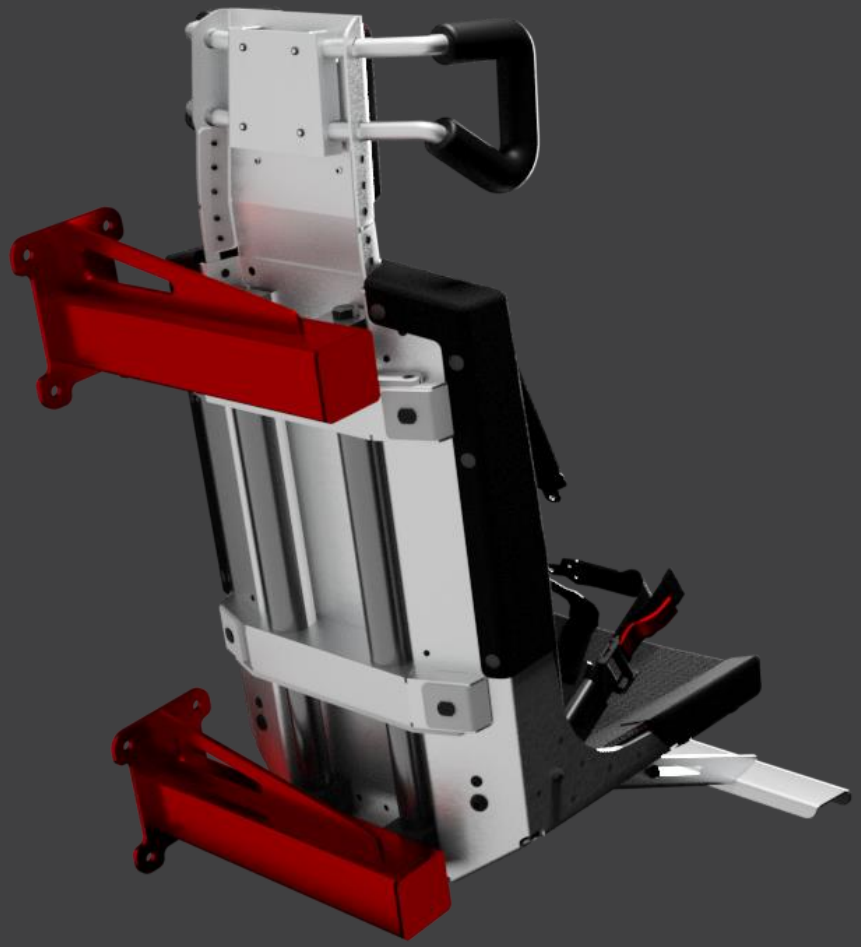
EXTENDED FOOTREST

PRODUCT CONFIGURATIONS – HEADREST OPTIONS

STANDARD HEADREST

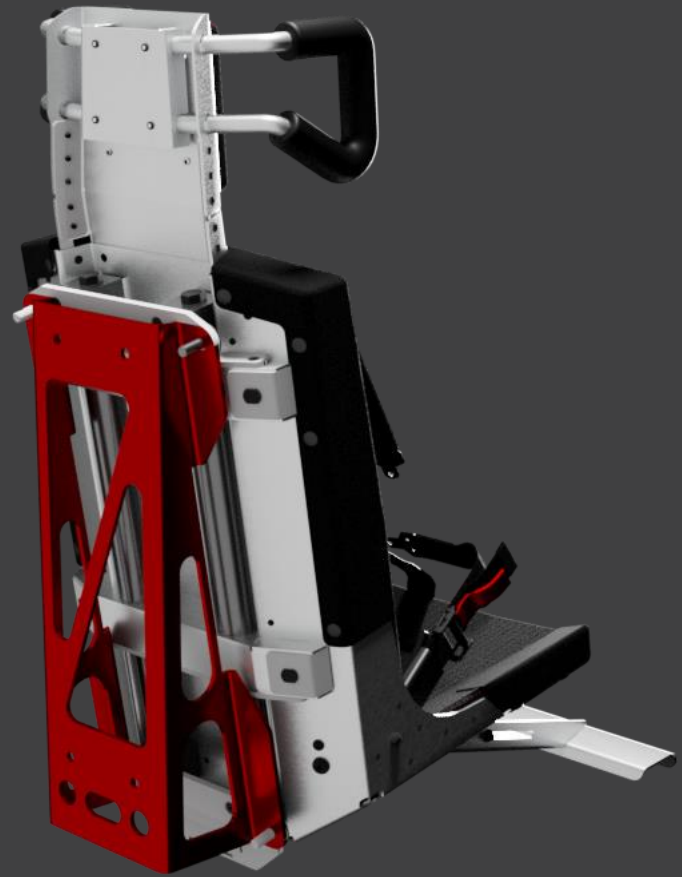
ANTI-WHIPLASH HEADREST

PRODUCT CONFIGURATIONS - GUNNER MOUNT



PRODUCT CONFIGURATIONS - FLOOR MOUNT (COMMANDER / DRIVER)

PRODUCT CONFIGURATIONS - REAR MOUNT (CREW)



PRODUCT CONFIGURATIONS - ROOF MOUNT (CREW)

DEVELOPMENT TESTING & EVALUATION - METHODOLOGY

DROP TEST RIG

The drop test rig is used in the design and qualification of seats in armoured cars, and the evaluation of occupant injury criteria. A seat with test dummy is hoisted and then dropped from a calibrated height, so as to replicate the severity of the land mine blast in question. The test rig has been used to successfully qualify seat installations in numerous armoured cars, and to design and test a stroking seat mechanism for mitigating injuries in extreme blasts. Sensors on the test rig provide speed and acceleration data of each individual drop test.

TEST DUMMY

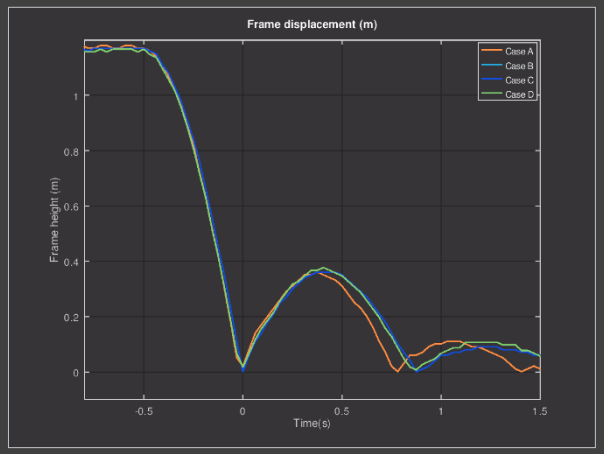
The test dummy is a replica of the commonly used and accepted Hybrid III crash test dummy. The similarity in performance of Bronberg Dynamic's test dummy compared to the Hybrid III has been verified. Data gathered from the dummy's sensors is used to evaluate the seat performance against the design criteria.

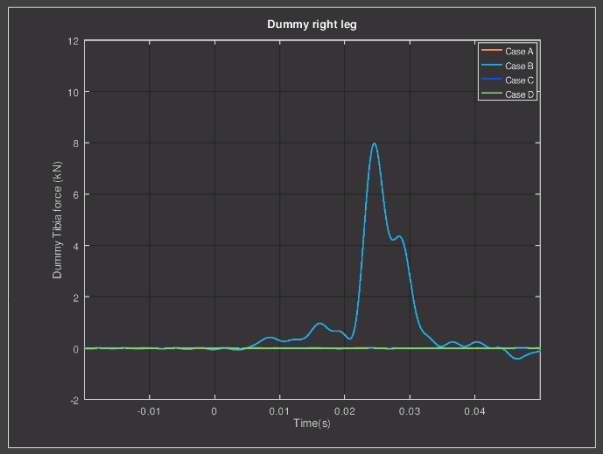
The above method of testing provides the repeatable and controllable test conditions, crucial to successful and cost effective development testing & evaluation.

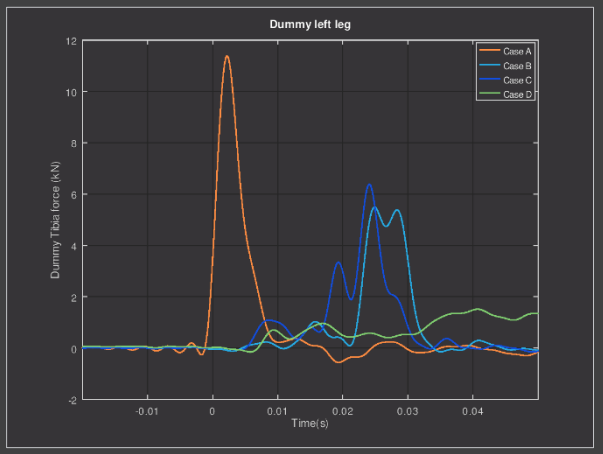
TEST & EVALUATION

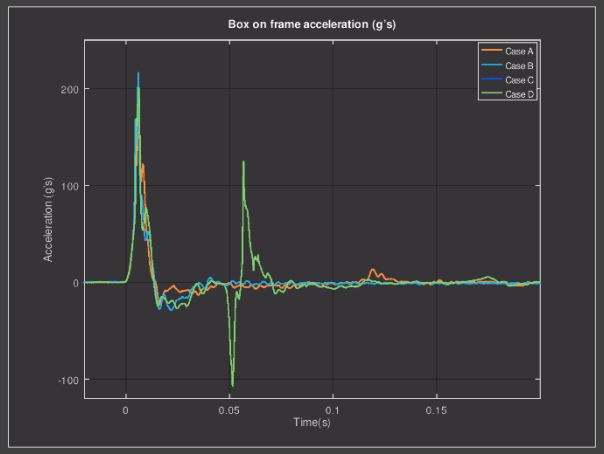
TEST & EVALUATION - INITIAL DEVELOPMENT TEST DATA

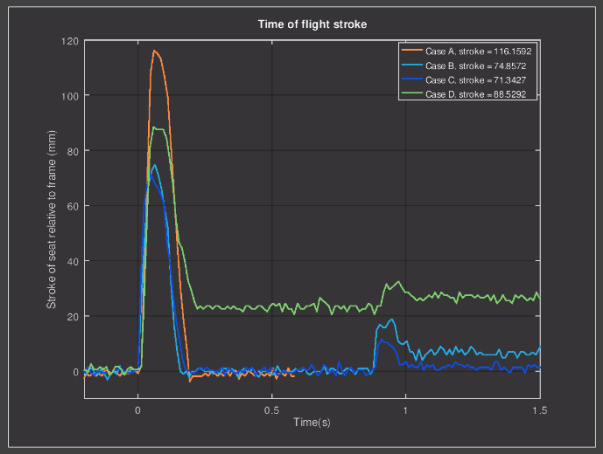
Shown below are plots of the actual test data gathered from the Drop Test Rig and Test Dummy on the current seat prototype over a total of four 7m/s drop tests (1150 mm Drop Height).

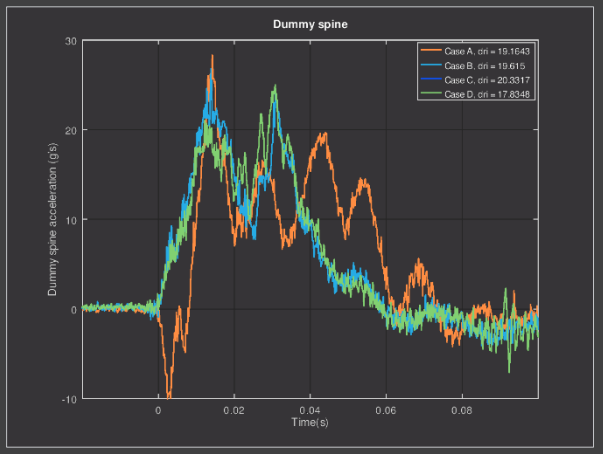










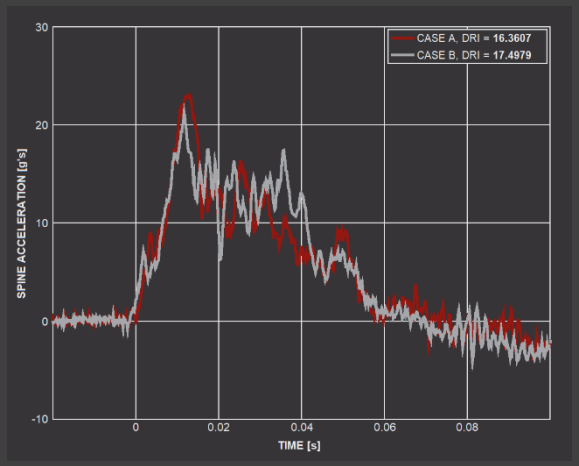


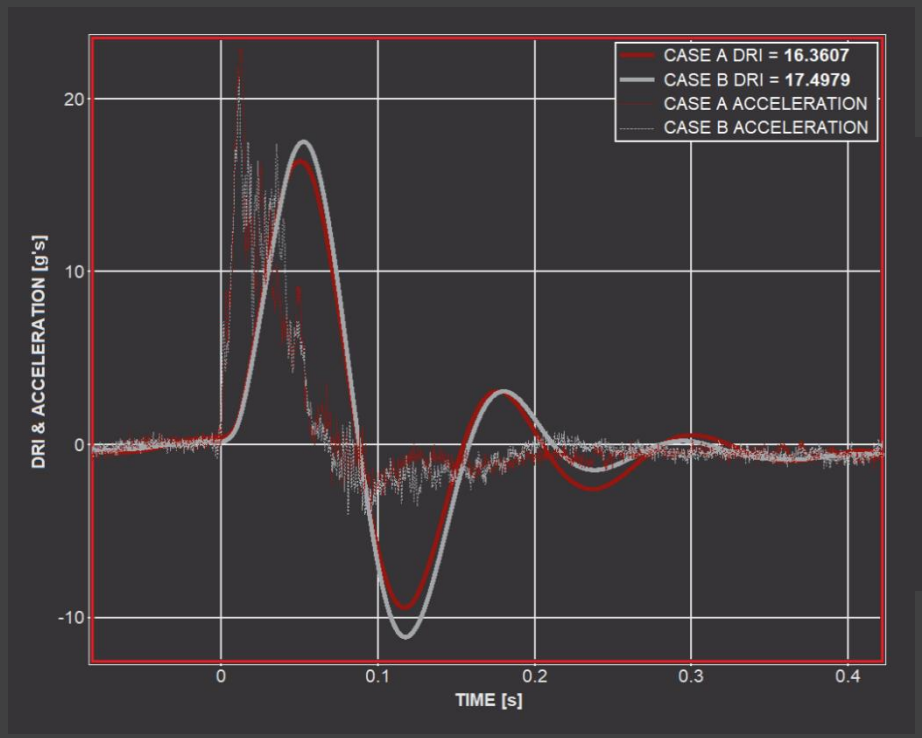
TEST & EVALUATION - LATEST TEST DATA

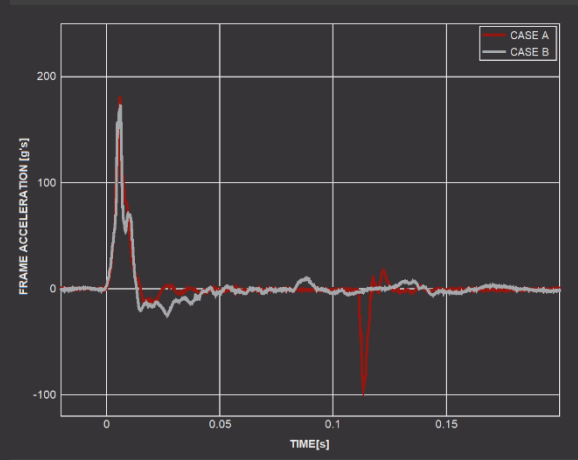
Performance & Results

Development Testing & Qualification performed via drop testing

- Drop tests resulting in a 6 m/s speed change as would be expected during a 8 kg landmine blast under a vehicle of >10 Tons. [STANAG 4569 Protection Levels 4a, 4b, 3a & 3b].
- (Dynamic Response Index) **DRI_z values of less than 17.7** achieved in compliance with STANAG / AEP 55 requirements.







PRODUCT STATUS & CONCLUDING DEVELOPMENT

- Significant amount of product testing performed thus far
  - Seat Bucket - 14 Drop Tests
  - Blast Mitigation System - 8 Drop Tests
  - Full System (Seat Bucket, BMS & Footrest - 10 Drop Tests
- Concept successfully proven with STANAG / AEP 55 compliant results


pronex


pronex