



CEN/TC 158/WG 11
Headforms and test methods

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Size J Polyurethane Headform Cellbond ATD Prototype - rev 2

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Polyurethane (PU) Head Form prototype for helmet testing (size J)

July 2017 rev.2

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Impacting on Safety
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This report describes the size J head form prototype in semi rigid urethane for shock absorption and penetration tests, with falling headform/helmet assembly off board and with DTS SLICE NANO data acquisition system and the following sensors:

Prototype V1:

- NAP $\delta a\omega$ (Nine accelerometer array package – method to obtain 6DOF head kinematics using 3-2-2-2 nine accelerometers configuration)

Prototype V2

- Coplanar $\delta a\omega$ Six accelerometers + three ARS configuration.
- TOTAL 9 channels



BS EN 960:2006 design requirements (section 3.1.1):

The headforms shall be made of metal and, together with any means for their support, shall exhibit no resonance below a frequency of 2000 Hz.

Full headforms shall have the following characteristics:

- a) *The centre of gravity shall be located within a 10 mm radius point G on the central vertical axis;*
- b) *A facility for attaching an accelerometer shall be incorporated such that, with the headform in any angular orientation, the respective sensitive axes of the accelerometer shall pass within 10 mm of point G;*
- c) *The appropriate mass, if specified in Table 1.*

Three-quarter headforms shall have the following characteristics:

- i) *The centre of gravity shall be located within a 10 mm radius of point A on the central vertical axis;*
- ii) *A facility for attaching an accelerometer shall be incorporated within the headform or its means of support, such that, with the headform in any angular orientation, the respective sensitive axes of the accelerometer shall pass within 10 mm of point A.*



Modifications to the BS EN 960:2006 design requirements (section 3.1.1) within the current design:

- a) *Material used FD-70 semi rigid urethane;*
- b) *Centre of gravity reference location according to HIII 5th drawing package.*
- c) *Mass equation taken from Tom Connor's technical paper.*

$$\text{Mass (kg)} = 0.23C(\text{cm}) - 9.3$$

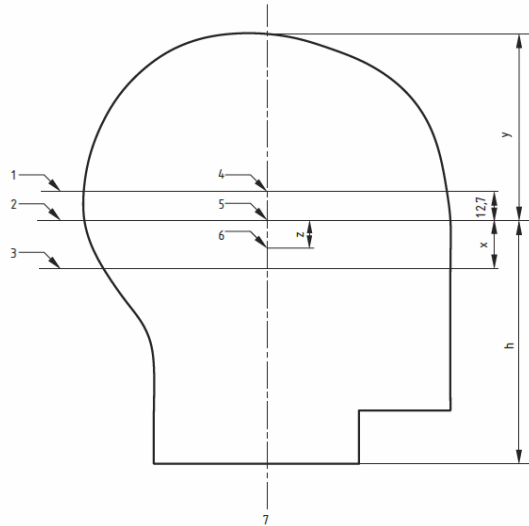
Where *C* is the head circumference in cm.

Mass tolerance unknown



EN 960:2006 (E)

EN 960:2006 (E)



Section on vertical longitudinal plane

Key

- 1 AA' plane
- 2 reference plane
- 3 basic plane
- 4 point A
- 5 point R
- 6 point G
- 7 central vertical axis

Figure 1 — Principal planes and reference points of a headform

Table 1 — Dimensions for Figure 1 and headform masses

Size designation	h (mm)	x (mm)	y (mm)	z (mm)	Mass (g)
445	108,5	21,0	81,7	9,9	
455	110,6	21,5	83,3	10,1	1 970 ± 75
465	112,7	22,0	84,8	10,4	
475	114,8	22,5	86,4	10,6	
485	116,9	23,0	88,0	10,8	
495	119,0	23,5	89,7	11,1	3 100 ± 100
505	121,1	24,0	91,2	11,3	
515	123,2	24,5	92,7	11,5	
525	125,3	25,0	94,5	11,7	
535	127,4	25,5	96,0	11,9	4 100 ± 120
545	129,5	26,0	97,5	12,1	
555	131,6	26,5	99,1	12,3	
565	133,7	27,0	100,8	12,5	
575	135,8	27,5	102,4	12,7	4 700 ± 140
585	137,9	28,0	103,9	12,9	
595	140,0	28,5	105,4	13,1	
605	142,1	29,0	107,2	13,3	5 600 ± 160
615	144,2	29,5	108,7	13,5	
625	146,3	30,0	110,2	13,7	6 100 ± 180
635	148,4	30,5	111,8	13,9	
645	150,5	31,0	113,5	14,1	

Table A.14 — Spherical coordinates for full headform size 575

1 - 575		Angle H												
		0	15	30	45	60	75	90	105	120	135	150	165	180
Angle V above	90	102,3	102,3	102,3	102,3	102,3	102,3	102,3	102,3	102,3	102,3	102,3	102,3	102,3
	80	101,0	101,0	100,9	101,0	101,3	101,6	101,7	102,0	102,7	103,1	103,8	103,8	104,0
	70	100,5	100,5	100,5	100,6	100,5	100,3	100,5	101,3	102,6	104,1	105,2	105,4	105,4
	60	101,3	101,3	101,3	100,6	99,2	98,3	98,5	99,7	101,7	104,2	106,1	106,3	106,2
	50	102,5	102,6	102,5	100,2	97,2	95,6	95,6	97,3	100,0	103,3	106,1	106,2	106,1
	40	103,2	103,1	102,9	98,7	94,4	92,1	92,0	94,1	97,6	101,6	105,2	105,4	105,4
	30	102,6	102,5	101,7	96,1	90,8	88,1	88,0	90,4	94,4	99,1	103,5	104,2	104,4
	20	101,3	100,7	99,3	92,8	87,0	84,1	83,9	86,6	90,8	96,1	101,3	102,7	103,2
	10	100,3	99,2	97,0	89,7	83,8	80,8	80,5	83,3	87,5	93,0	98,8	101,3	101,9
Reference plane	0	100,8	99,2	95,8	88,1	82,4	79,4	79,1	81,7	86,0	91,3	96,8	100,0	100,8
Angle V below	10	102,3	101,3	95,9	86,1	78,8	76,2	76,3	78,6	82,3	88,0	92,6	95,9	96,4
	20	107,2	108,2	98,4	88,1	79,9	76,2	73,3	75,9	79,3	84,2	88,5	91,4	92,1
	30	116,3	117,6	102,6	90,8	83,7	80,4	73,5	75,4	78,8	83,6	87,6	89,6	88,9
	40	131,5	132,9	112,7	98,9	90,3	83,0	78,4	79,4	82,0	85,7	88,4	89,6	88,4
	46	145,0	146,6	119,5	106,0	97,0	87,6	84,3	85,2	86,9	89,6	91,3	92,4	91,9
	50	139,2	139,2	124,0	110,7	103,3	93,4	90,1	91,2	92,3	94,5	95,6	96,8	97,0
	52	135,4	135,2	124,0	112,8	107,1	96,8	93,6	94,9	95,9	97,8	98,8	100,0	100,6
	55	130,2	129,9	122,1	112,6	106,9	101,8	100,1	101,7	102,6	104,3	105,1	106,7	107,6
	60	123,0	122,4	119,8	111,6	113,2	113,8	114,6	116,7	117,9	119,6	120,7	122,7	124,0
	65	127,2	126,9	127,6	129,2	133,7	134,3	135,8	138,3	139,7	141,9	143,1	145,4	146,6

V = Vertical angle above or below the reference plane
 H = Angle of vertical slice, measured in horizontal plane, from front of mid-sagittal plane

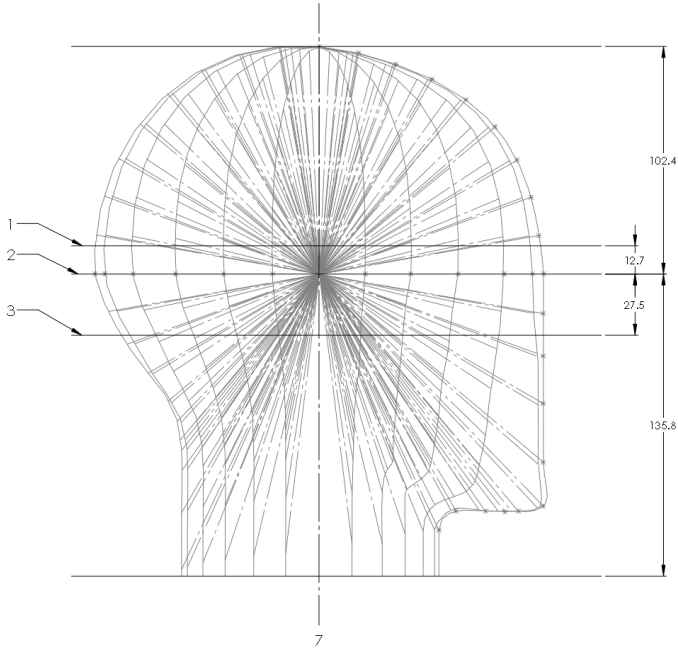
Angles in degrees, to be measured with an uncertainty of measurement not exceeding $\pm 0,2^\circ$.
 Radii in mm, with a tolerance of $\pm 0,5\%$ and measured with an uncertainty of measurement not exceeding 0,1 mm.

The jaw line shall be radiused along its length with a nominal 5 mm radius. The base of the neck shall be squared off perpendicular to the central vertical axis.

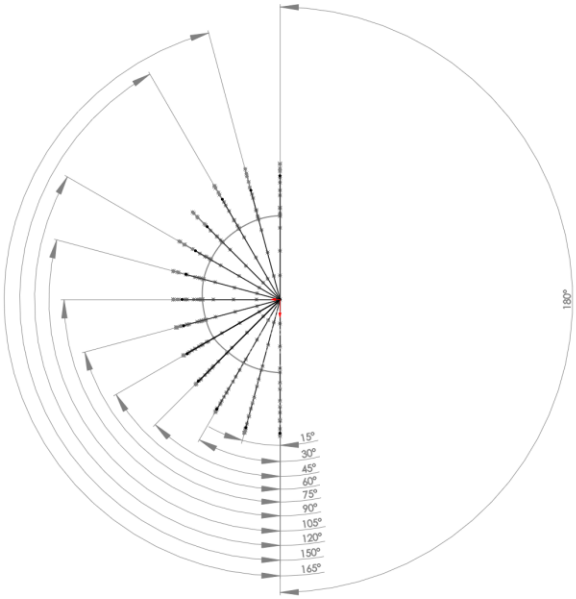
NOTE The surface corresponding to the radii shown in *italics* lies below the jaw line.



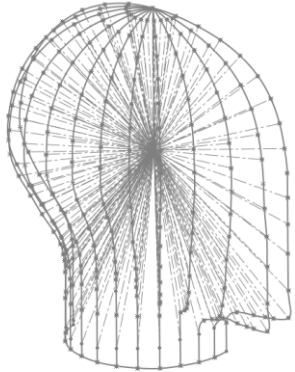
Design process of the headform



LEFT VIEW



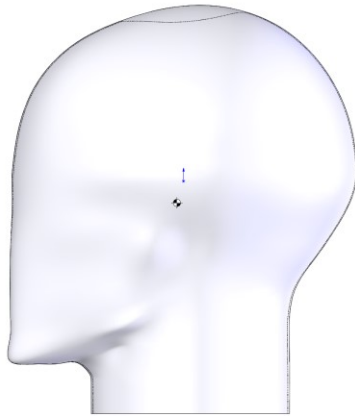
TOP VIEW



ISOMETRIC VIEW



Headform jaws modified to a smother shape



BS EN960:2006 Standard

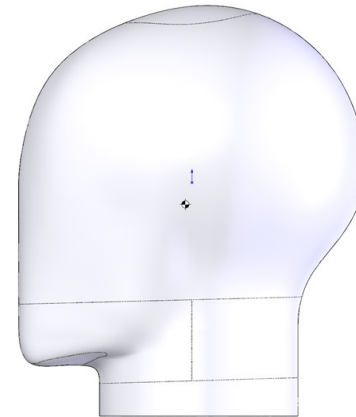
Mass = 4899.82 grams

Centre of mass: (millimetres)

X = 0.00
Y = -12.66
Z = -3.65

MOI (kg cm²)

I_{xx} = 160.24
I_{yy} = 230.77
I_{zz} = 271.69



BS EN960:2006 Modified

Mass = 4875.30 grams

Centre of mass: (millimetres)

X = 0.00
Y = -12.60
Z = -3.68

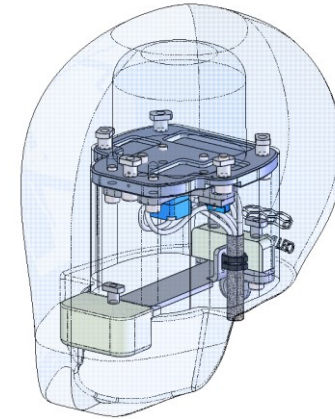
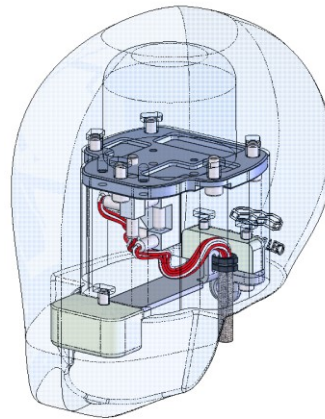
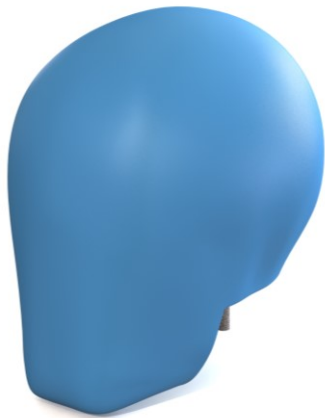
MOI (kg cm²)

I_{xx} = 158.17
I_{yy} = 229.53
I_{zz} = 269.40



Off board versions

The following pages show the off board NAP and Coplanar $\delta a \omega$ versions of the size J PU headform.

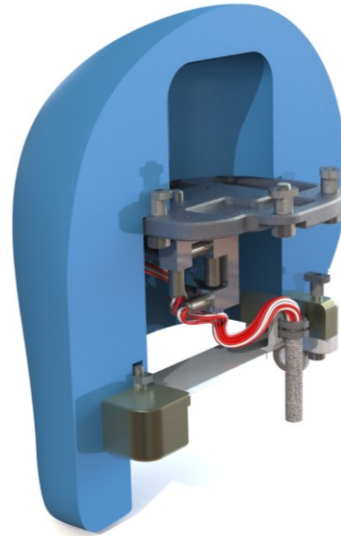
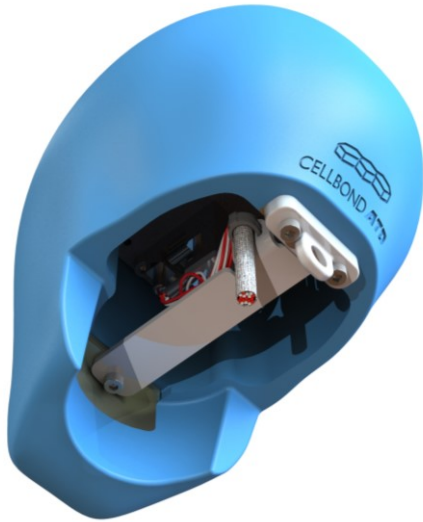


Material: FD-70

Density: 1170 kg/m³



Off board - NAP 6aω scheme



57.5 size CELLBOND Headform



Base Plate



M6 x 16 SHCS



Nine Acc. Configuration



M6 x 20 SHCS



Ballast Weight



Handle + Strain Release



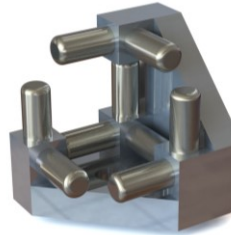
Hook Holder



M5 x 30 SHCS



M5 x 16 SHCS



¹Mass = 3913.17 grams

Centre of mass: (millimetres)

X = - 0.18

Y = 0.94

Z = - 0.08

MOI (kg cm²)

Ixx = 114.63

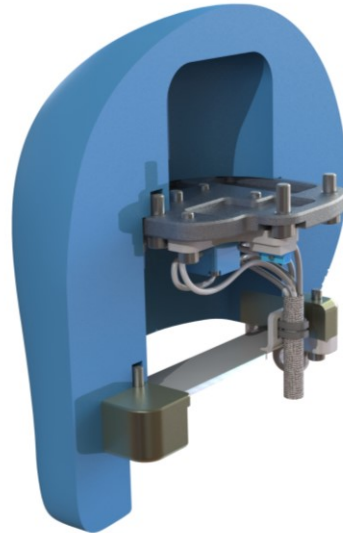
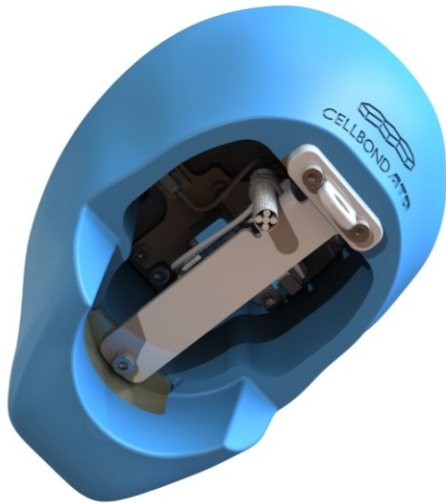
Iyy = 182.00

Izz = 199.58

¹ Target Mass 3925 grams, tolerance unknown.



Off board - COPLANAR 6a ω scheme



57.5 size CELLBOND Headform



Base Plate



Coplanar Configuration



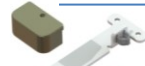
M5 x 16 SHCS



M6 x 16 SHCS



Ballast Weight



Handle + Strain Release



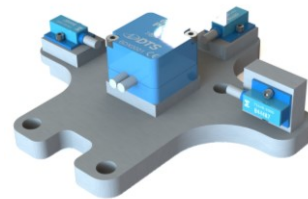
Hook Holder



M5 x 30 SHCS



M5 x 16 SHCS



1 x Coplanar Mounting Block
3 x 7264B Accelerometer
1 x 6DX Pro Accelerometer

¹Mass = 3940.79 grams
Centre of mass: (millimetres)
X = - 0.09
Y = 1.16
Z = - 0.13

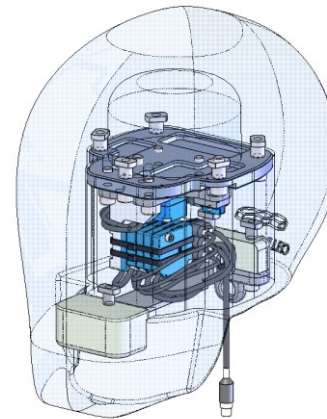
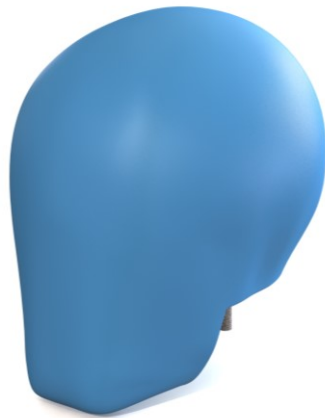
MOI (kg cm²)
I_{xx} = 114.68
I_{yy} = 182.31
I_{zz} = 199.58

¹ Target Mass 3925 grams, tolerance unknown.



On board version – Coplanar $\delta a \omega$ scheme

The following pages show the installed positions of the DAS components and details of the connecting leads and plugs to the sensors.

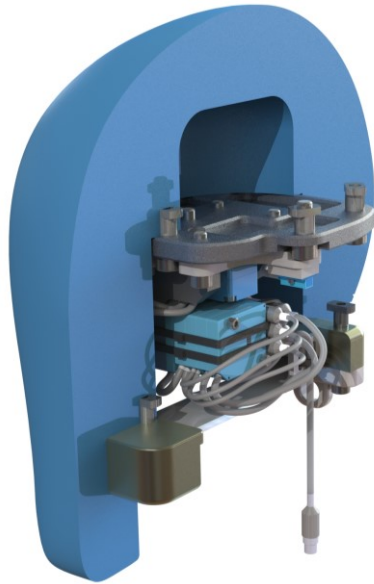


Material: FD-70

Density: 1170 kg/m³



On board - COPLANAR 6a ω CONFIGURATION



¹Mass = 3944.51 grams

Centre of mass: (millimetres)

X = - 0.30

Y = 0.86

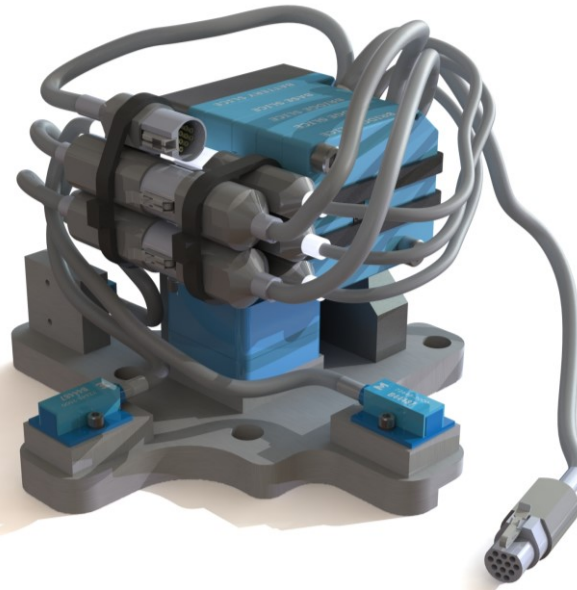
Z = 0.51

MOI (kg cm²)

I_{xx} = 116.23

I_{yy} = 182.82

I_{zz} = 203.46

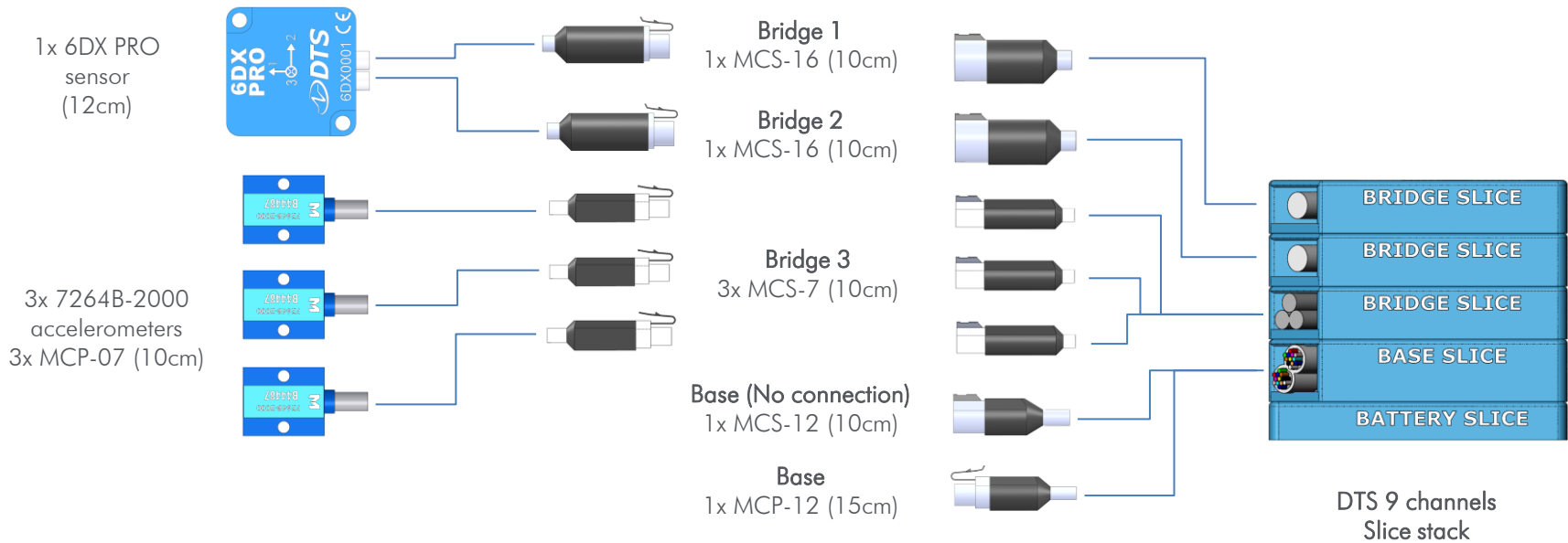


- 1 x Coplanar Mounting Block
 - 3 x 7264B Accelerometer
 - 1 x 6DX Pro Accelerometer
 - 1 x DTS Battery Slice (Nano)
 - 1 x DTS Base Slice (Nano)
 - 2 x 16 pin DTS Bridge Slice (Nano)
 - 1 x 7 pin DTS Bridge Sline (Nano)
- Total = 9 channels**

¹ Target Mass 3925 grams, tolerance unknown.



Installation Arrangement



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