Army Research Laboratory Underbody Blast Design Challenge

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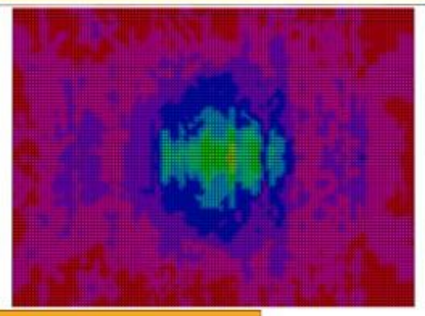
Problem Statement

- The design must optimize areal density (*AD*) and total thickness (*t*) while reducing deflection (*D*) from a buried blast
- The areal density must be less than 2.99 [g/cm2] and the thickness must be less than 20.6 [mm]
- The design must be 0.213 [m] long and 0.120 [m] wide

$$Score = 5 \cdot [D - 16.9(AD)^{-1.15}] + [20.6 - t]$$



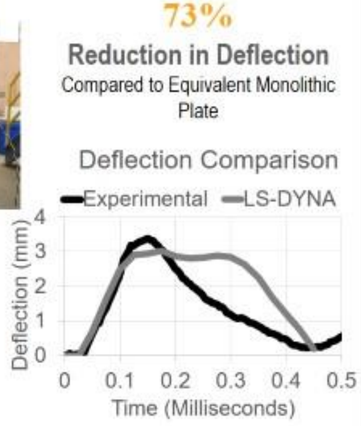
Physical Testing

1st Prototype

- ARL conducted testing in January 2021
- Deflection: 3.38 [mm]
- Score: 22 points

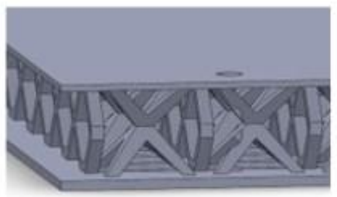
73%
Reduction in Deflection
Compared to Equivalent Monolithic Plate

20%
Reduction in Acceleration
Between Top and Bottom Plates

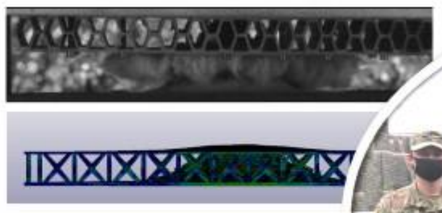


2nd Prototype

- ARL testing in late April 2021
- Redesigned for proper manufacturing



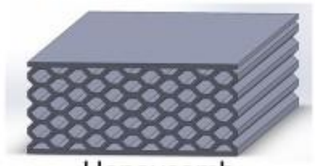
Multiple Redesigns
Decreased complexity to enable 3D Printing



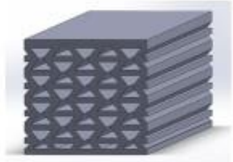
Preliminary Design

1st Prototype

- Designs focused on Honeycomb, Truss and Auxetic Structures



Honeycomb



Auxetic

Truss

2nd Prototype

- Design focused on a sacrificial core utilizing complex cellular patter
- LS-DYNA used to optimize areal density

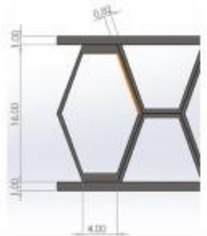
0.5 [mm] Short/Narrow

0.75 [mm] Thick

Detailed Design

1st Prototype

- Areal Density: 2.08 [g/cm2]
- Thickness: 18 [mm]
- Projected Score: 22 points



$5000 Print Cost
27 Hour Print Duration

2nd Prototype

- Areal Density: 1.82 [g/cm2]
- Thickness: 16.5 [mm]
- Projected Score: 24.2 points

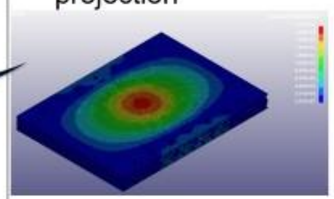
13%
Reduction in Areal Density
Between Prototypes

CME Facebook

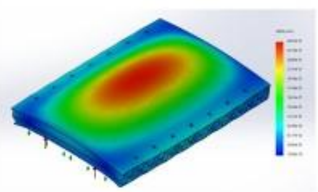
Simulation and Analysis

1st Prototype

- SolidWorks used to evaluate initial designs using Pressure Simulation
- LS-DYNA provided basic initial deflection projection



LS-DYNA



SOLIDWORKS

2nd Prototype

- LS-DYNA refined and used to compare deflections among complex designs

Design		Height [mm]	Areal Density [g/cm^2]	Predicted Deflection [mm]	Predicted Score
1st Prototype		18	2.1	3.40	22
Honeycomb	Thick	18	1.0	4.6	62
	Standard	18	0.98	6.3	59
	Short	12	0.94	4.8	76
	Narrow	10	1.0	6.9	60
	Stacked	16	1.4	6.0	33
	Thickest	16	1.9	4.5	23
Auxetic	1	8	1.3	8.0	34
	2	8	1.3	4.2	57
	3	10	1.3	3.5	57
2nd Prototype		16.5	1.7	4.9	24