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Critical Design Review

Honda Modular Packaging Capstone

ME4901.02 Spring 2022

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Background

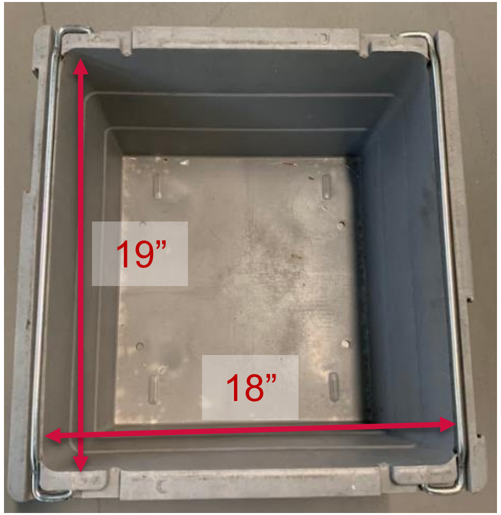
- Honda currently uses corrugated plastic dunnage to protect parts during transport to, from, and within their facilities for assembly
- This dunnage does not have a long lifespan and is expensive to produce
- The implementation of a reusable, reconfigurable, and modular system may help reduce waste and cost

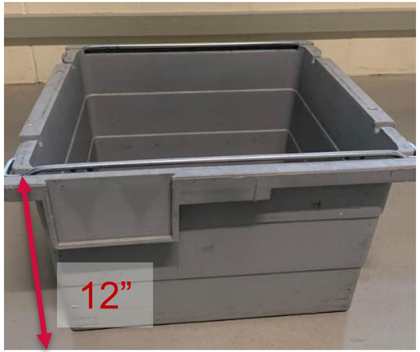
"C-Tote"

Blue corrugated plastic dunnage

Background

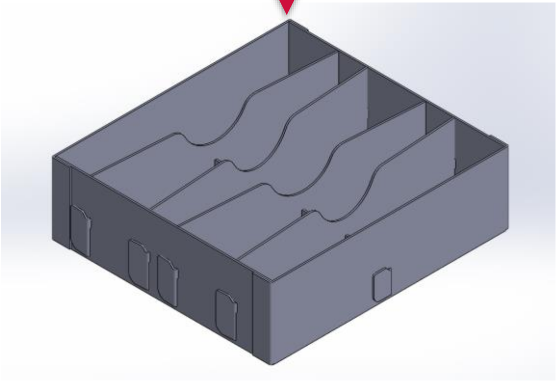
- The current design requires new dunnage to be designed and manufactured for each component
- The new corrugated plastic dunnage requires an expensive prototyping fee charged by the manufacturer
- A modular packaging system will reduce dunnage manufacturing costs via improved lifespan and adjustability to accommodate components of different sizes and shapes

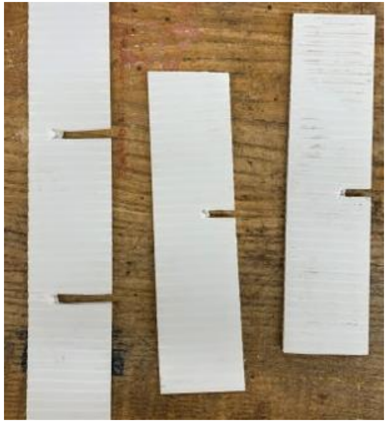




Purpose

- Develop a modular packing system that is adjustable in size
- The system prevents contained components from sustaining damage during transportation
- Less waste will be produced from custom corrugated plastic dunnage
- The system will be able to accommodate parts of multiple sizes, reducing the need for storage of custom dunnage
- The system will collapse when not in use, reducing space needed for dunnage storage





Approach

- Honda desires a dunnage pack that is both reusable and reconfigurable to contain parts of different sizes

- Team began by analyzing geometry, material properties, and mechanisms possible for creating a modular cell pack using corrugated plastic

- Dividers and layered dunnage packs were initially thought of being the module that can be adjusted or swapped out

Objectives & Metrics

Objective	Metric	Values: Excellent	Good	Okay	Poor / Fail
Increase minimum usage period	Years in service the product can withstand	5 years	3-4 years	1-2 years	<1 year
Increase flexibility of packaging	Number of possible configurations	Infinite number of configurations	50+ discrete configurations	25-49 discrete configurations	<25 configurations
Minimize space dunnage takes up in collapsed form	Volume	< 1 ft^3	1-2 ft^3	2-3 ft^3	> 3 ft^3
Minimize number of tools required to adjust compartments	Number of tools	0	1	1	2

Scope

In Scope:

- Develop a concept design of a modular packaging system
- Complete detailed design and proof of concept prototype of the modular packaging system
- Dynamic Testing
- Shaker Table Testing

Out of Scope:

- Professionally manufactured dunnage prototype (Will be completed by Honda's dunnage manufacturer, PrimeX for future mass production)

Deliverables:

- Prototype modular packaging product
- Testing Reports
- Prototype Drawing
- Prototype BOM
- Prototype User Manual

Functionality and Requirements

ID	STATUS	IMPORTANCE	TYPE	REQUIREMENT DISCRIPTION	UNIT OF MEASURE	MARGINAL (TARGET) VALUE	IDEAL (OJBECTIVE) VALUE
S3	ON TRACK	HIGH	FUNCTIONAL / PERFORMANCE	The user be able to adjust comaprtment sizes	N/A	N/A	N/A
S5	ON TRACK	MED	FUNCTIONAL / PERFORMANCE	The user should be able to store multiple layers of components inside the container	Layers	1	3
S6	ON TRACK	HIGH	FUNCTIONAL / PERFORMANCE	The user should not be able to remove internal compartments/dividers	N/A	N/A	N/A
S14	ON TRACK	MED	FUNCTIONAL / PERF	User should be able to collapse dunnage when not in use	N/A	N/A	N/A

Project Management

Budget

BUDGET (BY PHASE)		PROJECT NAME: Honda Modular Packaging	COHORT: AU2021					
LV	**Approval Status**	**Category and Item**	**Item Notes**	**Quantity**	**Budget**	**Actual**	**Receipt #**	**Purchaser**
1		PROBLEM DEFINTION		NA	NA	NA	NA	NA
		Travel- Tour at Honda MAP		1	$50.00	$48.00		Jacob
		⇑ Do Not Delete - Click this line for insert Above ⇑						
1		CONCEPT DEVELOPMENT		NA	NA	NA	NA	NA
		Corrugated plastic for material selection		1	$25.00	$22.00		Cade
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1		PRELIMINARY DESIGN		NA	NA	NA	NA	NA
		3D Printer filament for divider clips		1	$20.00	$19.00		Jacob
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1		FABRICATION, ASSEMBLY, AND INTEGRATION		NA	NA	NA	NA	NA
		First ABS purchase (Iterations 1 and 2)		1	$200.00	$138.00		Noah
		Second ABS purchase (Iterations 3 and 4)		1	$200.00	$143.00		Noah
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1		FULL SYSTEM TESTING AND EVALATION		NA	NA	NA	NA	NA
		Simulated parts for shaker table/dynamic testing		1	$20.00	$19.00		Jacob
		Paint marker for number/lettering dividers		1	$7.00	$6.00		Noah
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1		PROJECT CLOSEOUT		NA	NA	NA	NA	NA
		Travel- Closeout meeting at Honda MAP		1	$50.00	$48.00		Jacob
	Total				**$572.00**	**$443.00**		

Main Risks

RISK TABLE	PROJECT NAME: Honda Modular Packaging	COHORT: AU2021				
Risk ID	**Area / Subsystem**	**Description of Risk**	**Impact (1-5)**	**Likelihood (1-5)**	**Rating**	**Status / Mitigation**
3	Failure	Material mechanically fails due to stress (normal or shear)	5	1	5	10-20-2021: Analysis will be performed to make sure that the materials used can withstand the stresses to which they are exposed 11-29-2021: Solid plastic such as PVC or HDPE will be used instead of corrugated plastic (Likelihood: 5->3) 2-11-2022: Deflection analysis and FEA were performed to determine how much how much stress and deflection the dividers will experience (Likelihood: 3->2) 3-21-2022: Retaining clips have quickly become the largest area of concern for mechanical failure. Multiple have broken in the same place after use. (Likelihood: 2->4) 4-6-2022: Problem with mechanical failure in retaining clips has been resolved via thickening and the addition or a radius. No other areas have shown signs of mechanical failure. (Likelihood: 4->1)
7	Compartments	Compartment size will be difficult to adjust	5	1	5	10-20-2021: Product will be designed to be adjustable without tools Compartments will be adjusted using a pin (Likelihood: 3->2) 1-20-2022: Dunnage will be reconfigurable and held in place with clips (Likelihood: 2->1) 3-25-2022: Dunnage will be reconfigurable but held in place by hooks and slots.
8	Weight	Product is too heavy to be practical according to Honda rules and standards	5	1	5	10-20-2021: Lightweight materials will be used where possible 11-29-1021: Plastic thickness will be minimized in order to reduce weight (Likelihood: 5->3) 2-7-2022: Material analysis performed, including 2D density calculations (Likelihood: 5->2) 3-10-2022: The dunnage has been confirmed to be light enough to remain below the weight limit with multiple layers (Likelihood: 2->1)
9	Lifetime	Product lasts less than 5 years	3	4	12	10-20-2021: Durable materials will be used 11-29-2021: Hard plastic will be used as opposed to corrugated plastic (Likelihood: 5->4)

Schedule

Date	Goal(s)	Description
3/3/2022	Laser cut in-house prototype	Fabrication of the components of modular packaging prototype
3/4/2022	Design review with PrimeX	Reviewing the design with PrimeX to identify the potential manufacturing problems of the design
3/9/2022	Complete fabrication of first prototype	Original prototype was complete and assembled
3/14/2022	Second iteration of prototype manufactured	An iteration similar to the original prototype, but with a different joining method used on the border corners was complete
3/25/2022	Third iteration of prototype manufactured	A third iteration of the team’s prototype that does not utilize any divider clips was manufactured
4/11/2022	Fourth iteration of prototype manufactured	A fourth iteration corrected a bad dimension on one of the dividers and introduced a new retaining clip design
4/12/2022	Shaker table test date	Original date planned for shaker table testing
4/13/2022	Functional Demonstration	Final product demonstration
4/18/2022	Dynamic testing performed	Substitute test since shaker table test was not possible

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Design Decisions

Concept Generation

Individual Brainstorming

- With the requirements in mind, individual ideas and concepts were evaluated and initially combined to best suit functionality goals
- The most pressing requirements were modularity, ability to store components safely, and weight reduction

Sharing and Evaluating Ideas

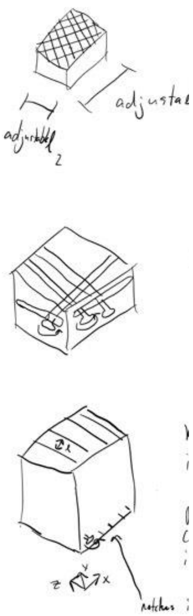
- Morph chart was used to organize functionality and solutions. Subsystems were evaluated utilizing pairwise comparison chart.
- The team worked with Honda engineering to determine strategies for accomplishing functionality

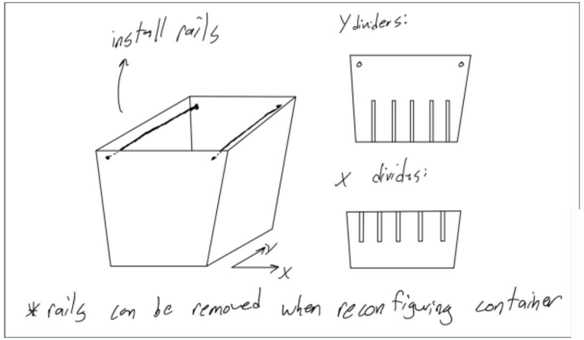
Designing for Manufacturability

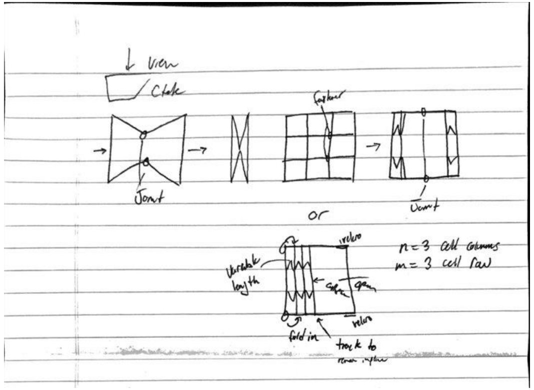
- The dunnage, when used in industry, is mass produced
- Ease of manufacturing, component uniformity, and ultimately cost reduction

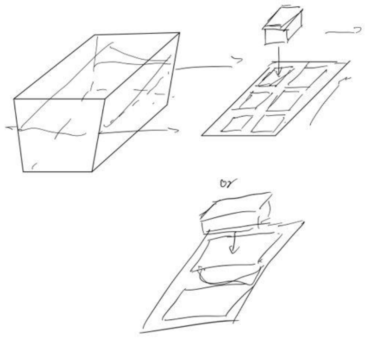
Concept Generation

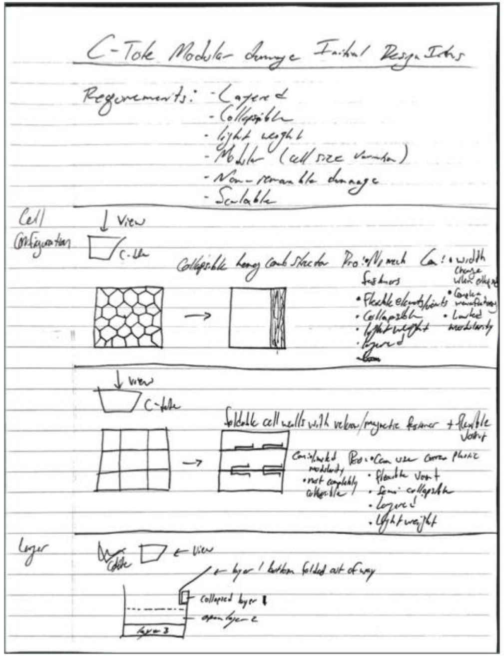
Individual Brainstorming





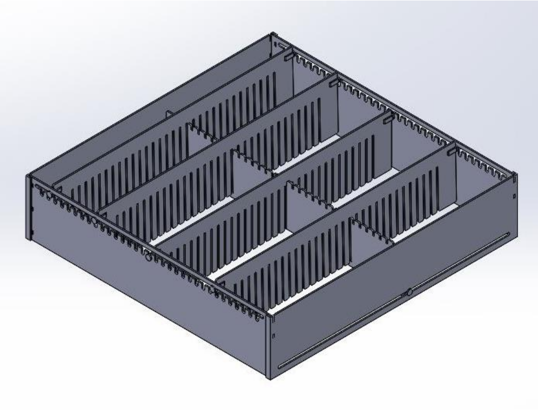


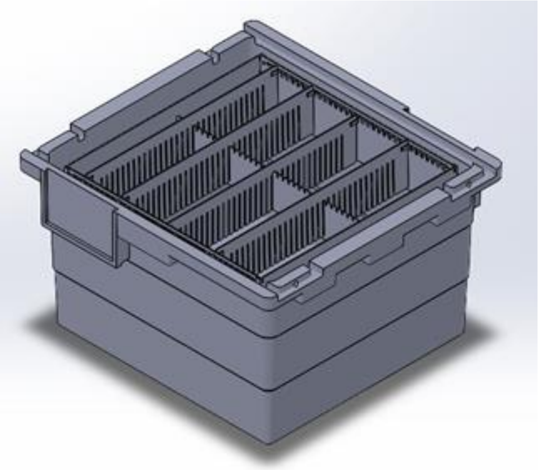




Initial Concept

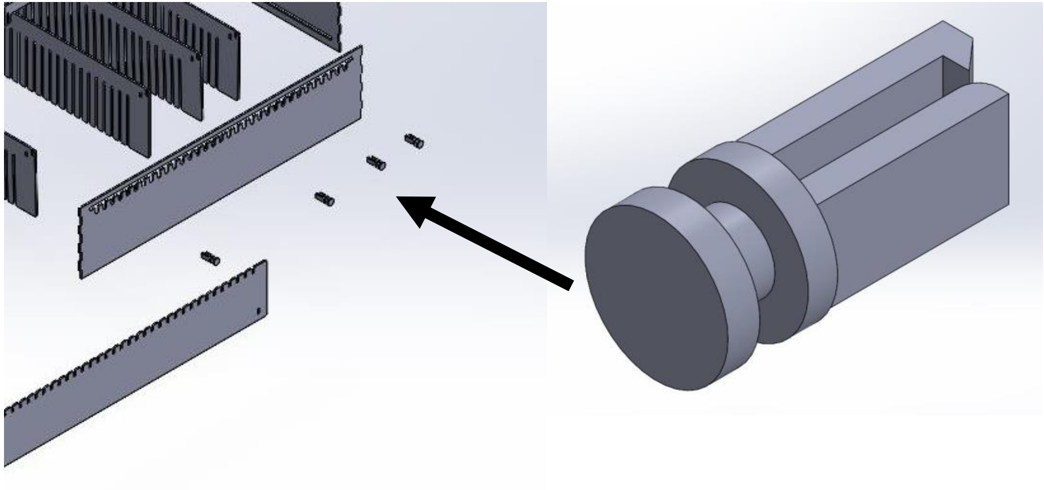
- This design consisted of slotted dividers made of rigid plastic
- The dividers mesh with each other to form a matrix that can be adjusted to many discrete sizes
- The dividers along one axis are held in place by clips that fit into notches on the edge of the dunnage and travels in a slot
- Difficult to manipulate and adjust the dividers- too many complex interactions with tight tolerances to maintain rigidity
- Reference Test 2 detailed in following slides for additional reason to change

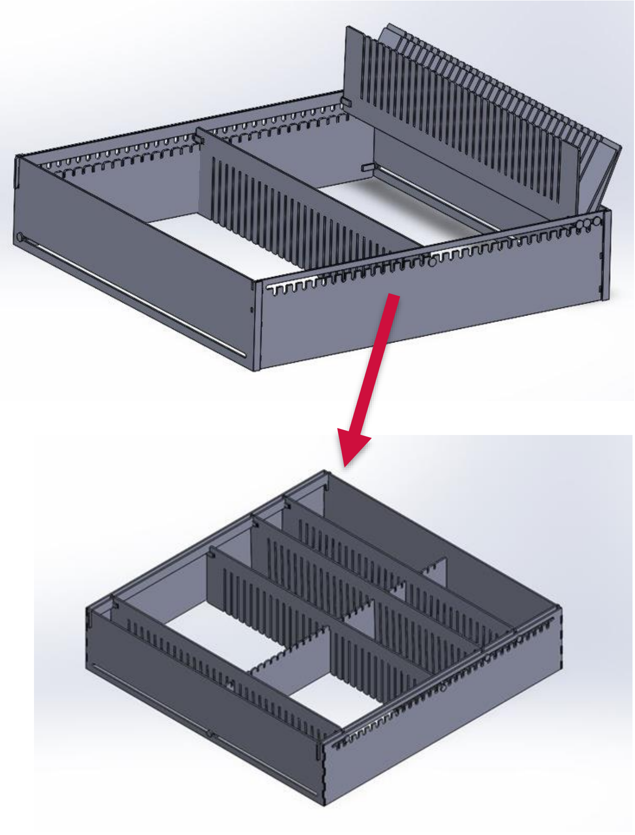




Initial Concept

- Dividers can be rotated and slid along a track to change their position and allow access to lower layers in the tote
- Takes too much time and struggle to access lower layers





Design Changes

- Lap joint at dunnage wall corner intersection replaced by hook-in-slot
  1. Maintains rigidity of outer wall better than glued lap joint
  2. Does not require glue or other fastener, reducing number of parts required within the dunnage
- Retainer clip, used in securing dividers in place, was updated multiple times as failure at base of clip was very common
  1. Clip each end tapered to further reduce stress at base
  2. Clip at each end lengthened to allow for larger deflection at tip, reducing stress at base to remove from pack
- Divider clip dimensions increased to allow for 3D printer error tolerance
  1. Increases ease of use allowing for clip to slide along track better
  2. Allows for better contact between clip portion and the connected divider
- Rotating divider clip eliminated and replaced with hook-in-slot system to maintain rigidity of dividers
  1. Manipulation of rotating divider system deemed too difficult and meticulous
  2. Hook-in-slot allows for dunnage to be reconfigured, but not on the fly on the assembly line without removing dividers from pack
  3. This change led to the development of the final prototype

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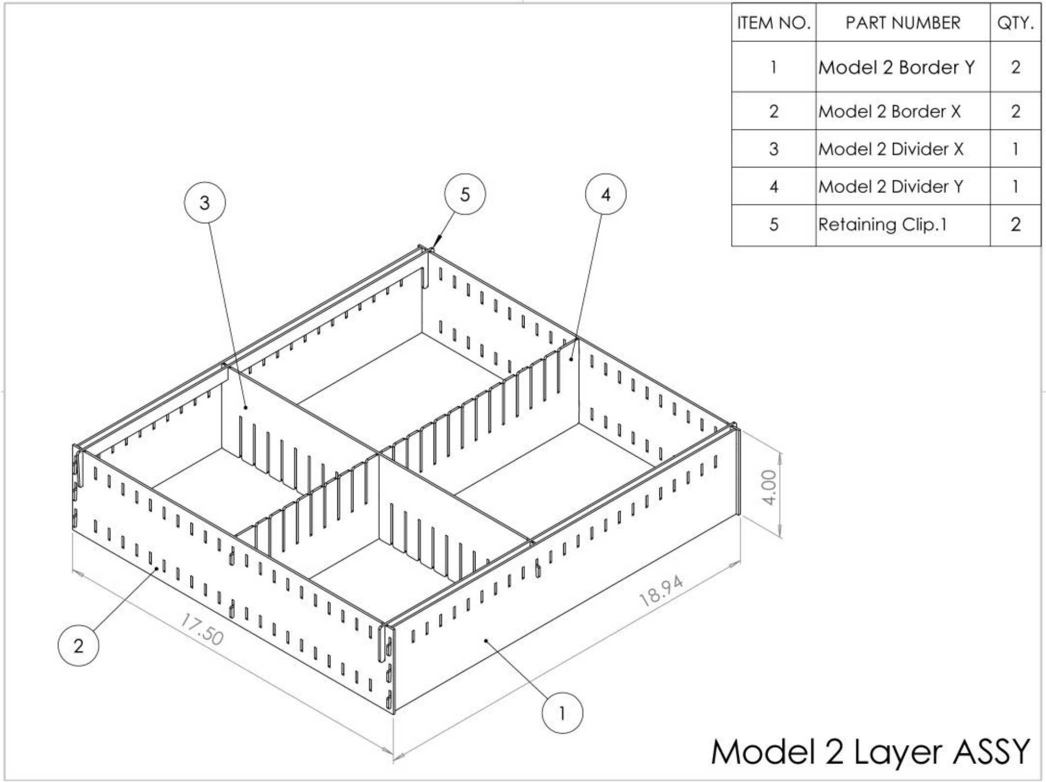
Design Documentation

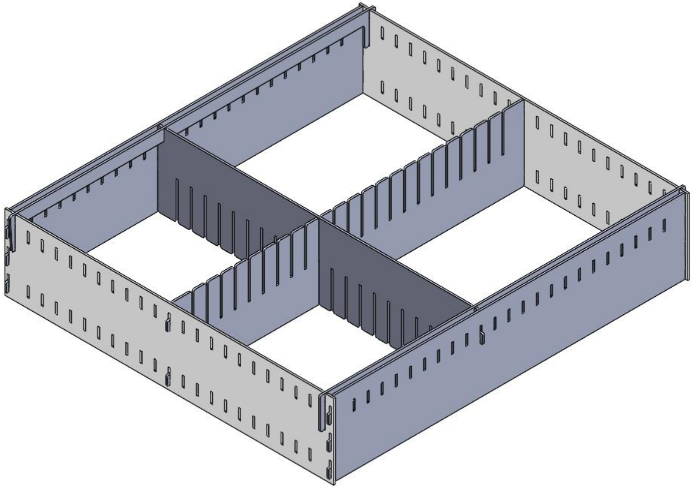
Assembly Drawing

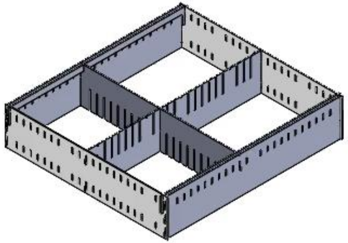
- Single Layer Assembly Drawing
  - Overall Dimensions
  - All Layer Components
- Excluding
  - C Tote
  - Foam Shims
  - Layer Divider



ITEM NO.	PART NUMBER	QTY.
1	Model 2 Border Y	2
2	Model 2 Border X	2
3	Model 2 Divider X	1
4	Model 2 Divider Y	1
5	Retaining Clip.1	2

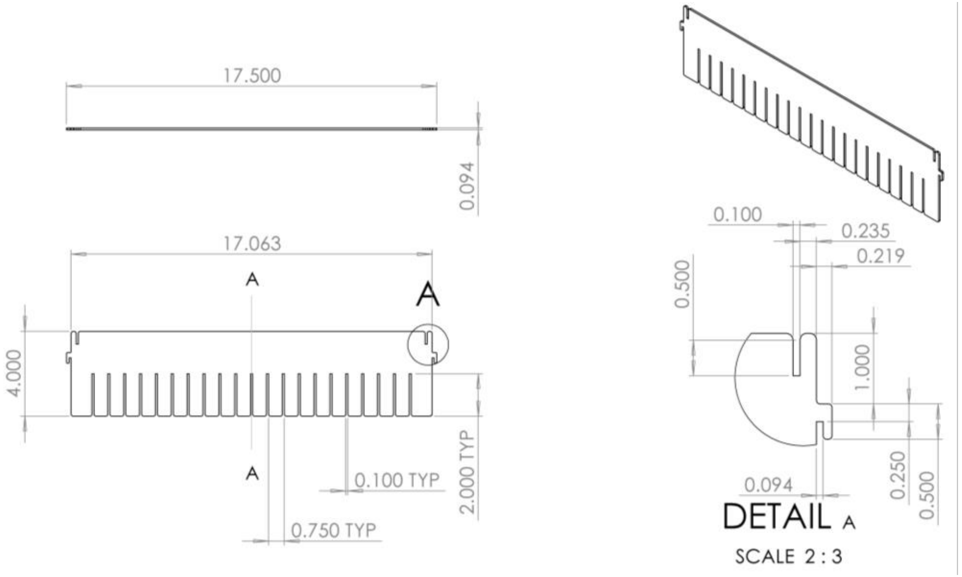
Assembly Exploded View





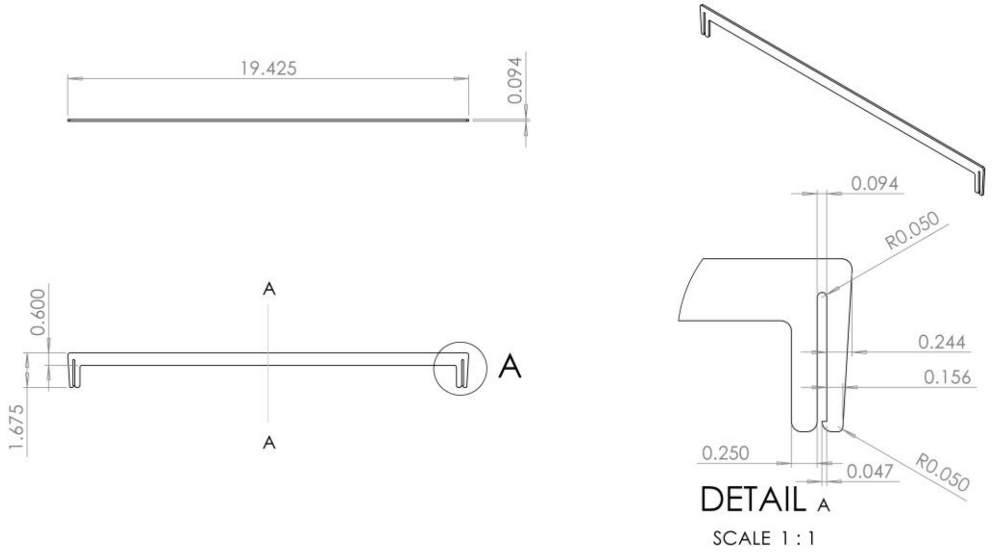
Notable Individual Part Drawing

- Important Aspects of Design
  - Well fitted slot sizes for ease of assembly
  - Retaining clip slot allows for retention in layer
  - Incorporates allowance of CO2 laser overburn and kerf
  - Hook designed to fit easily into the slots of mating components



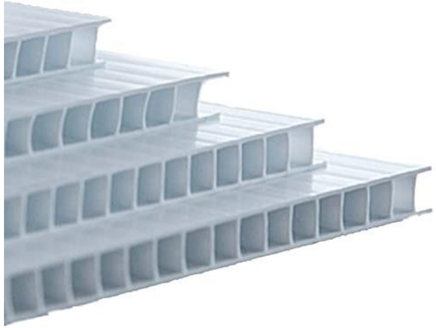
Notable Individual Part Drawing

- Important Aspects of Design
  - Securely clips to 3/32 ABS
  - Ensures fit in slots
  - Tapered clip to allow for easy bending
  - Round edges to reduce stress concentrations

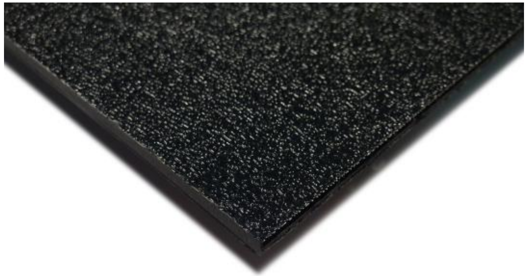


Purchased Parts – Raw Materials

- 4mm corrugated plastic sign board for separating cell pack layers (1)
- 3/32" ABS extruded sheet stock for laser cutting the dividers and retaining clip (2)
- Expanded polyethylene foam used for shimming cell pack within tote



(1)



(2)

Bill of Materials per Cell Pack Layer

Part Name	Material	Quantity
Divider X	3/32” ABS	1-6
Divider Y	3/32” ABS	1-6
Border X	3/32” ABS	2
Border Y	3/32” ABS	2
Border Z	4 mm Corrugated Plastic	1
Retaining Clip	3/32” ABS	2
Foam Shims	Polyethylene Foam	12

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Detailed Engineering Analysis

Engineering Analysis

- The majority of the analysis performed by the team on this project pertained to material selection
- This analysis consisted of three main sections:

    1. Weight/planar density analysis
    2. Deflection analysis
    3. FEA analysis of dividers

Weight Analysis

- Several thicknesses and materials were considered for the dividers that provide most of the dunnage’s function
- Dimensions and weights of available materials were measured in order to determine the planar density of those plastics
- Main purpose was to work towards the objective of reducing weight

Type	Material	Length (ft)	Width (ft)	Thickness (ft)	Weight (lb)	Density (lb/ft^3)	Area Density (lb/ft^2)
1/16 ABS	ABS	2	1	0.005208333	0.616	59.136	0.308
3/32 ABS	ABS	2	1	0.0078125	0.979	61.776	0.4895
1/8 ABS	ABS	2	1	0.010416667	1.342	64.416	0.671
1/16 Acrylic	Acrylic	2	1	0.005208333	0.736	70.656	0.368
5/64 Acrylic	Acrylic	2	1	0.006510417	0.99	76.032	0.495
3/32 Acrylic	Acrylic	2	1	0.0078125	1.124	71.936	0.562
7/64 Acrylic	Acrylic	2	1	0.009114583	1.506	82.61485714	0.753
1/8 Acrylic	Acrylic	2	1	0.010416667	1.592	76.416	0.796
4 mm Corrugated Plastic	coroplast	2	1.5	4 mm	0.444		0.148
bubble x	bub-x	1	1	2.6 mm	0.156		0.156

Deflection Analysis

- The dividers were modeled as a beam between two hinges with a single load in the center
- The magnitude of the load was modeled as two different values as can be seen below
- Performed in order to reduce weight, while still meeting the requirement of protecting the components from sustaining any damage

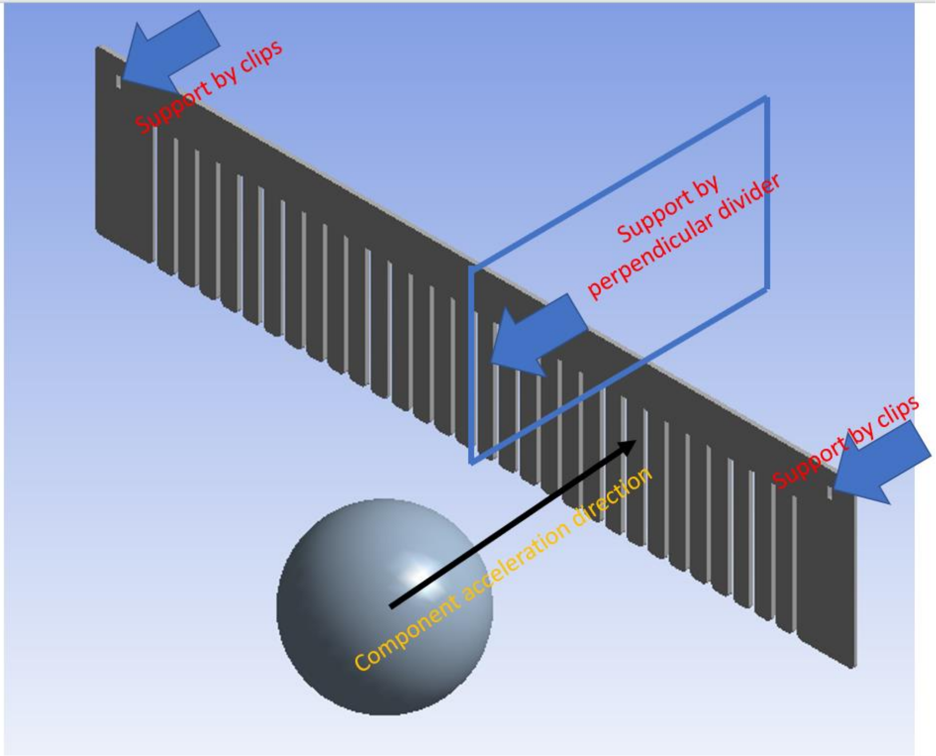
Material	Elastic Modulus (psi)	Thickness (in)	Moment of Inertia (in^4)	Braking Force Deflection (in)	Centripetal Force Deflection (in)
1/16" ABS	1.60E+05	0.06250	2.54E-04	0.9258	2.6684
3/32" ABS	1.60E+05	0.09375	8.58E-04	0.2743	0.7906
1/8" ABS	1.60E+05	0.12500	2.03E-03	0.1157	0.3336
1/16" Acrylic	4.00E+05	0.06250	2.54E-04	0.3703	1.0674
3/32" Acrylic	4.00E+05	0.09375	8.58E-04	0.1097	0.3163
1/8" Acrylic	4.00E+05	0.12500	2.03E-03	0.0463	0.1334

Starting Speed (mph):	65
Stopping Distance (ft):	525
Turn Speed (mph):	15
Turn Radius (ft):	19.4
Part Weight (lb):	3.444
Active Divider Length (in):	12.5

Deceleration (ft/s^2):	8.65566531
Braking Force (lb):	0.925779855
Centripetal Force (lb):	2.668401034
Part Mass (lbm):	0.106956522

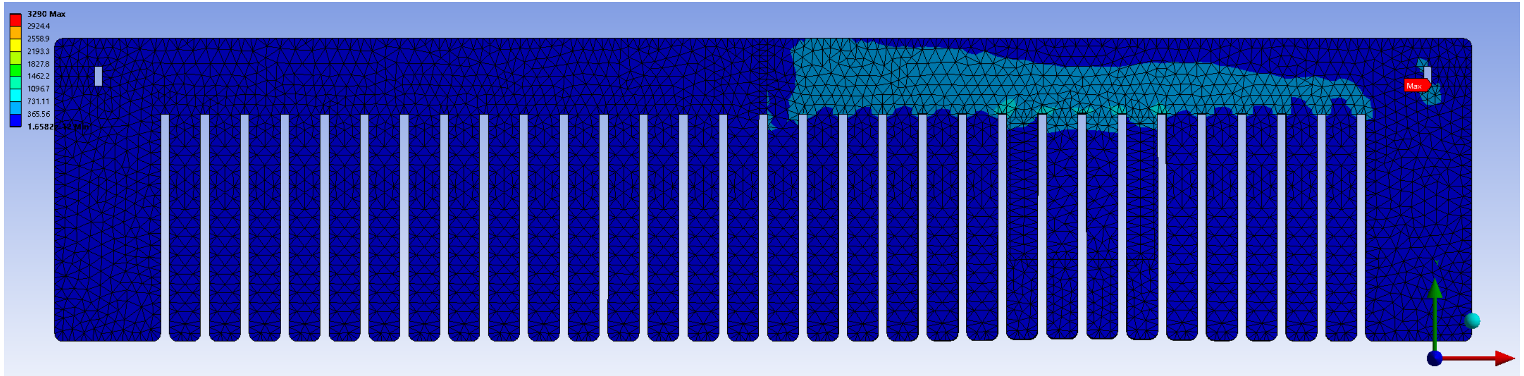
FEA Analysis

- The team also conducted the finite element analysis on the design using Ansys.
- The boundary condition for the analysis based on the worst condition the design would experience: a block weighted 5 lb. hit the center of the wall of the packaging system with a configuration of 4 cells during a sudden brake on a truck. The truck decelerates from 65mph to 0 mph in 525ft.

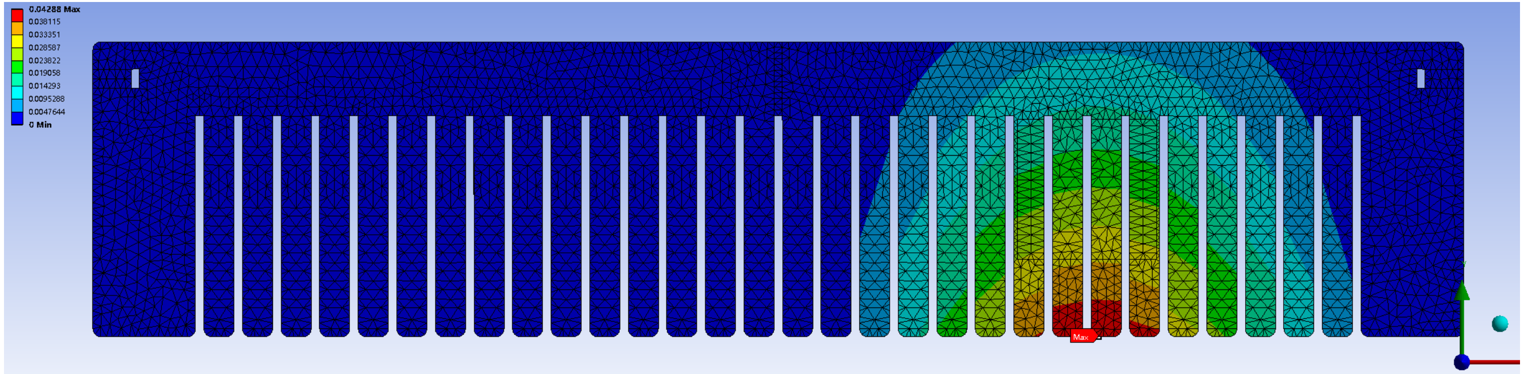


FEA Analysis on Divider

Von-Mises Stress: 3290psi

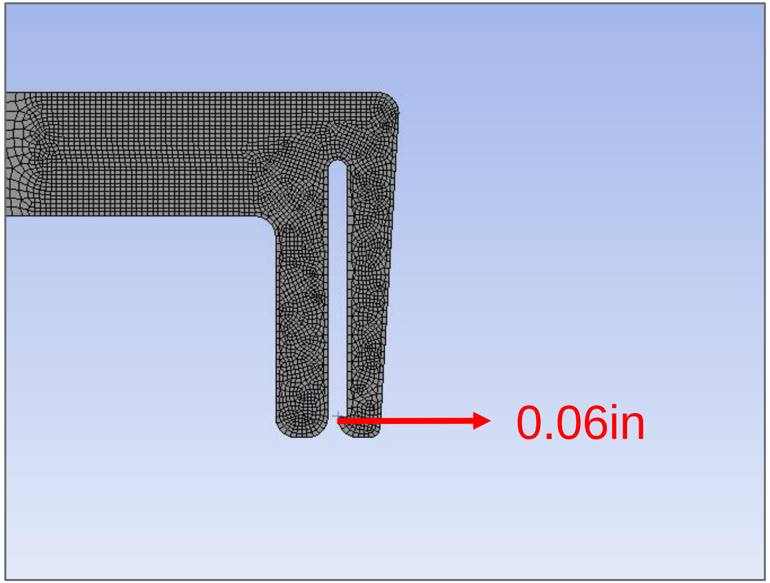


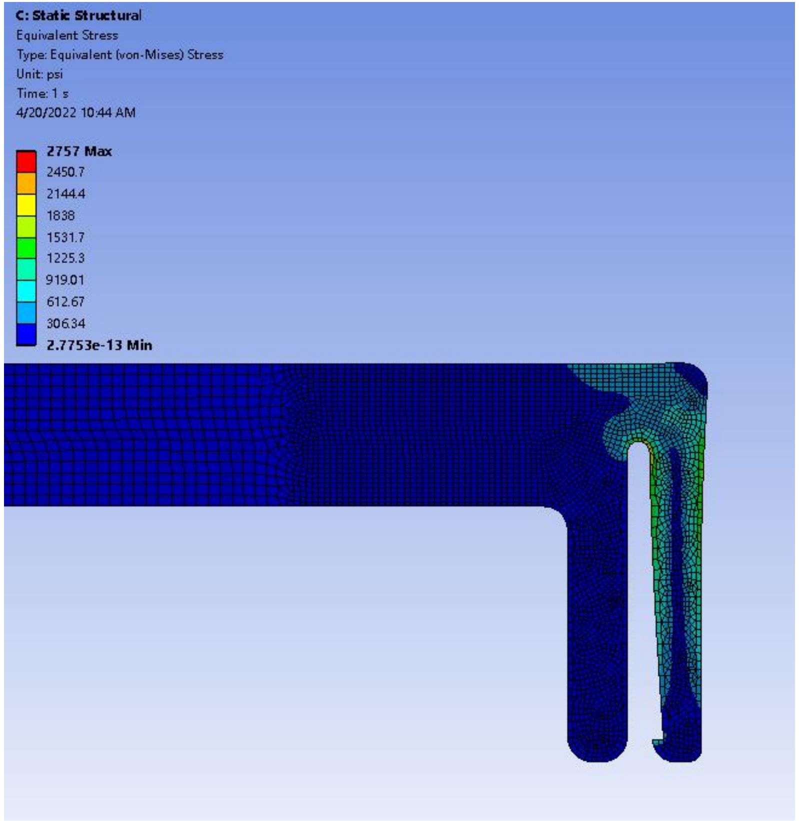
Deflection: 0.4288in



FEA Analysis on Clips

Von-Mises 2757 PSI, Safety Factor 1.45





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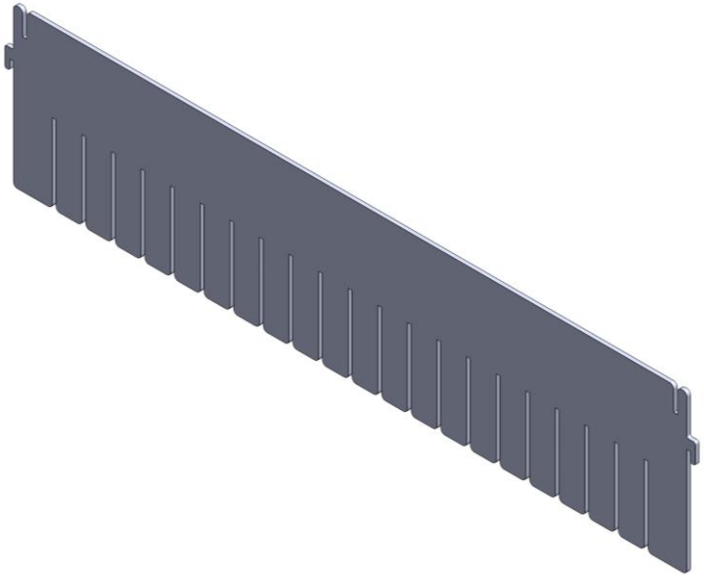
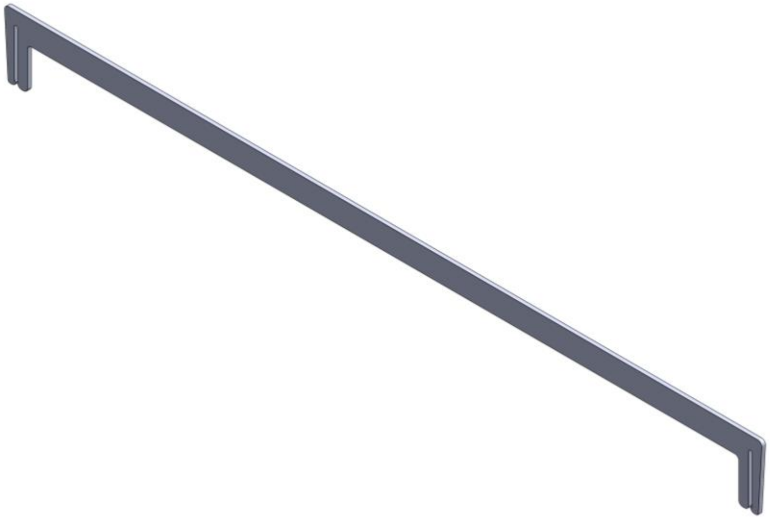
Manufacturing Plan

Manufacturing Plan for Laser Cut Component Fabrication

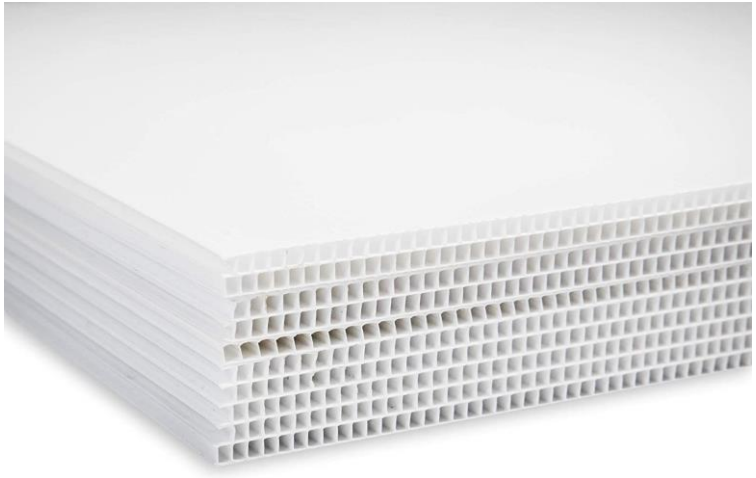
- Material: 3/32 ABS Sheet Stock
- Machines: In-house Epilog 75 W CO2 Laser





Manufacturing Plan for Razor Cut Component Fabrication

- Material: 4mm Corrugated Plastic
- Machines: Foot Shear
- Scoring Bends: Razor Blade



Potential Risks and Mitigations For Manufacturing Plan

Potential Risks	Mitigation Strategy
Interstate ABS sheet stock for production cuts differently from Primex ABS used in mockup test phase	Assess cut quality before manufacturing components and adjust dimensions accordingly
Retaining clip breaking when being forced on	Modify the retaining clip to be more durable and clearly define any limitations in the use manual
Semi-permanent layer dividers made from corrugated plastic being hard to install or work with	Have precut/scored corrugated plastic before gluing and velcroing in place

Manufacturing Plan Schedule

Component Fabrication Process	Completion Date
Laser Cut Dividers	4/14/22
Razor Cut Corrugated Plastic	4/17/22
Razor Cut Foam Shims	4/17/22

Assembly/Integration Process	Completion Date
Layer System	4/19/22
Final Assembly in Tote	4/19/22

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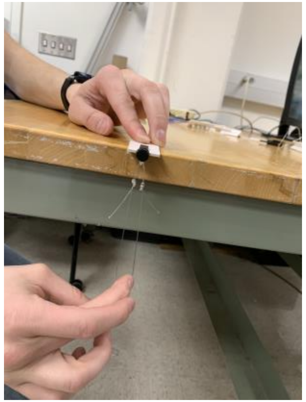
Testing and Evaluation

Test #1 – Retaining Clip Strength Test

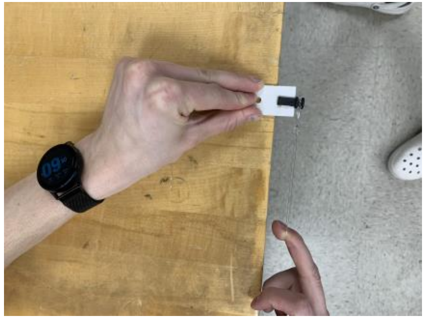
- The retaining clips will experience vertical loading while performing their function of maintaining divider position
- To ensure that the clips do not come off during use, the amount of force that one clip can withstand was measured
- A test-cut clip was tied to a bolt on one end and a fish scale on the other
- The scale was pulled until the clip came unattached
- Goal was for the clips to hold 7.5 lb
- Average force was 11.64 lb

Test #2 – Divider Clip Strength Test

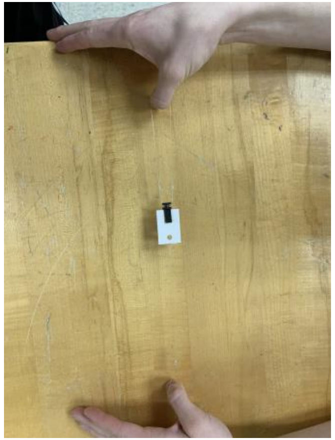
- This test was performed in a similar way to the first test, but in 3 different load cases
- Load case 2 met the requirement barely- noticed this was a common issue when manipulating dunnage in the initial concept prototype, clip would pop off if under a load like this case.



Load Case 1-
Required: 5 lb
Actual: 16.5 lb



Load Case 2-
Required: 3 lb
Actual: 4.4 lb



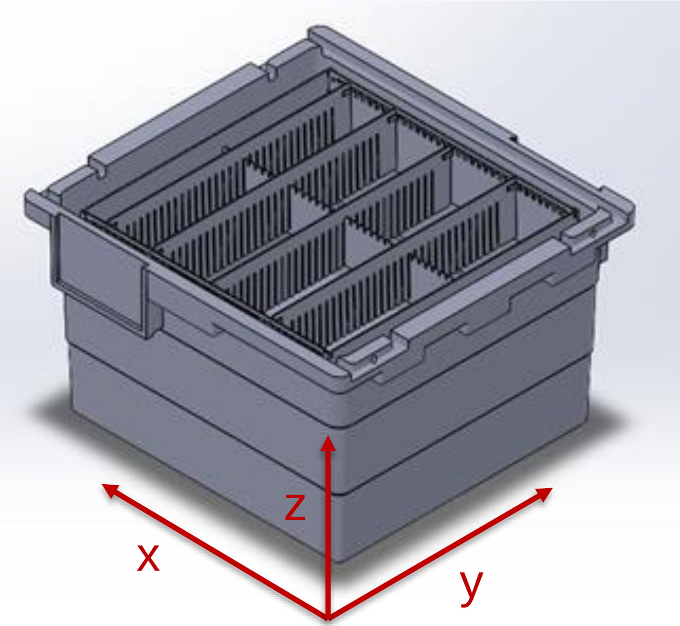
Load Case 3-
Required: 10 lb
Actual: 18.5 lb

Test Plan #3 – Shaker Table Test

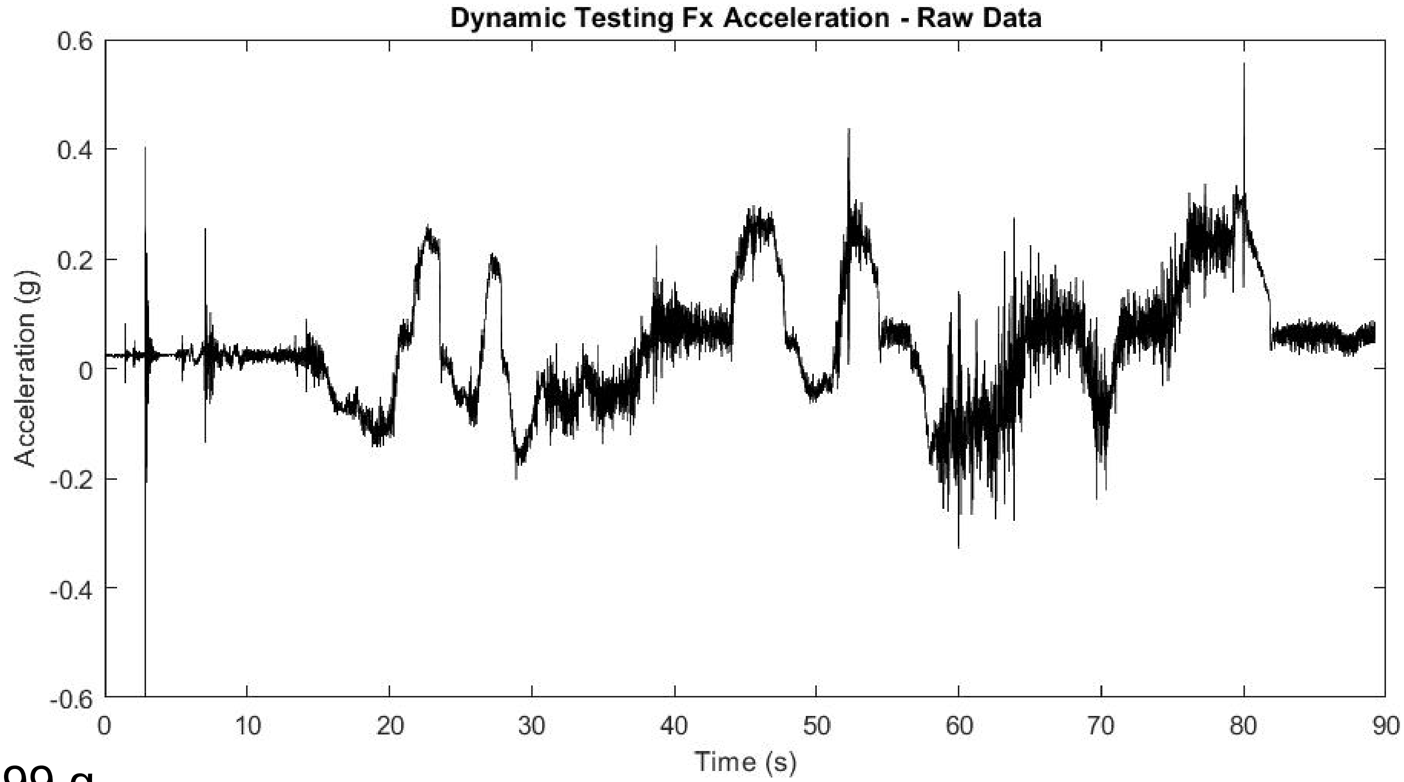
- **Not yet performed**
- Requested by Honda at the beginning of the project
- Main purpose is to validate against requirement S1 – that the user should be able to transport components without them sustaining damage
- Representative parts will be placed inside the dunnage and the system placed on a shaker table
- Honda cannot give exact criteria for testing, but recommends referencing ASTM and ISTA testing standards for packaging (ASTM-D999)
- Through research on ASTM-D999 the team found that 0.25 g from 2-100 Hz were appropriate
- **Test cannot be completed due to time constraints and oversight of risk mitigation**

Test #4 – Dynamic Testing

- Test suggested by Honda
- Representative parts are placed within the dunnage in the C-tote
- C tote placed in truck of vehicle
- Vehicle transports packaging and subjects packaging to varying accelerations
- Test will highlight any sensitive weak points in packaging but does not test for long term fatigue failure
- Accelerations experienced will me measured and logged with an accelerometer
- Also validates against requirement S1

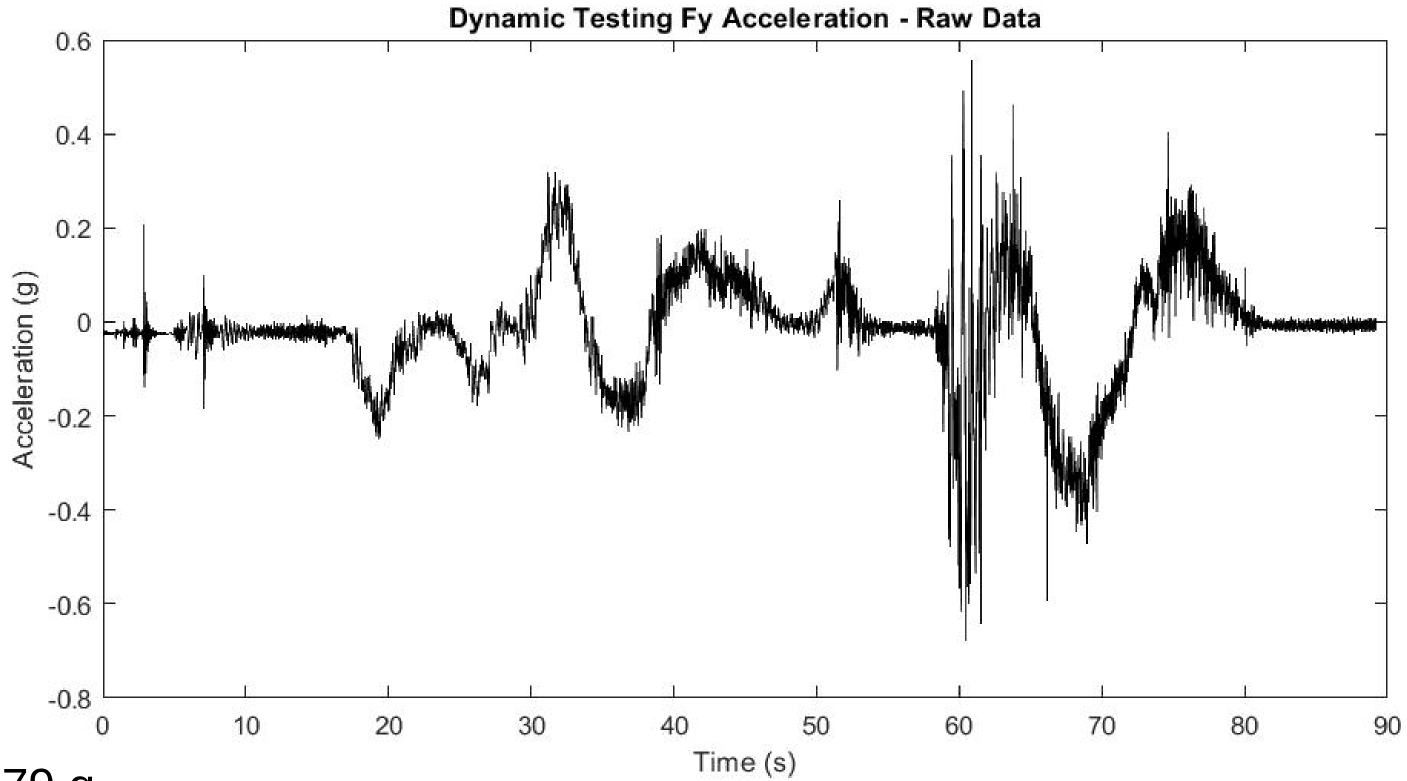


Test #4 – Dynamic Testing – Longitudinal Acceleration



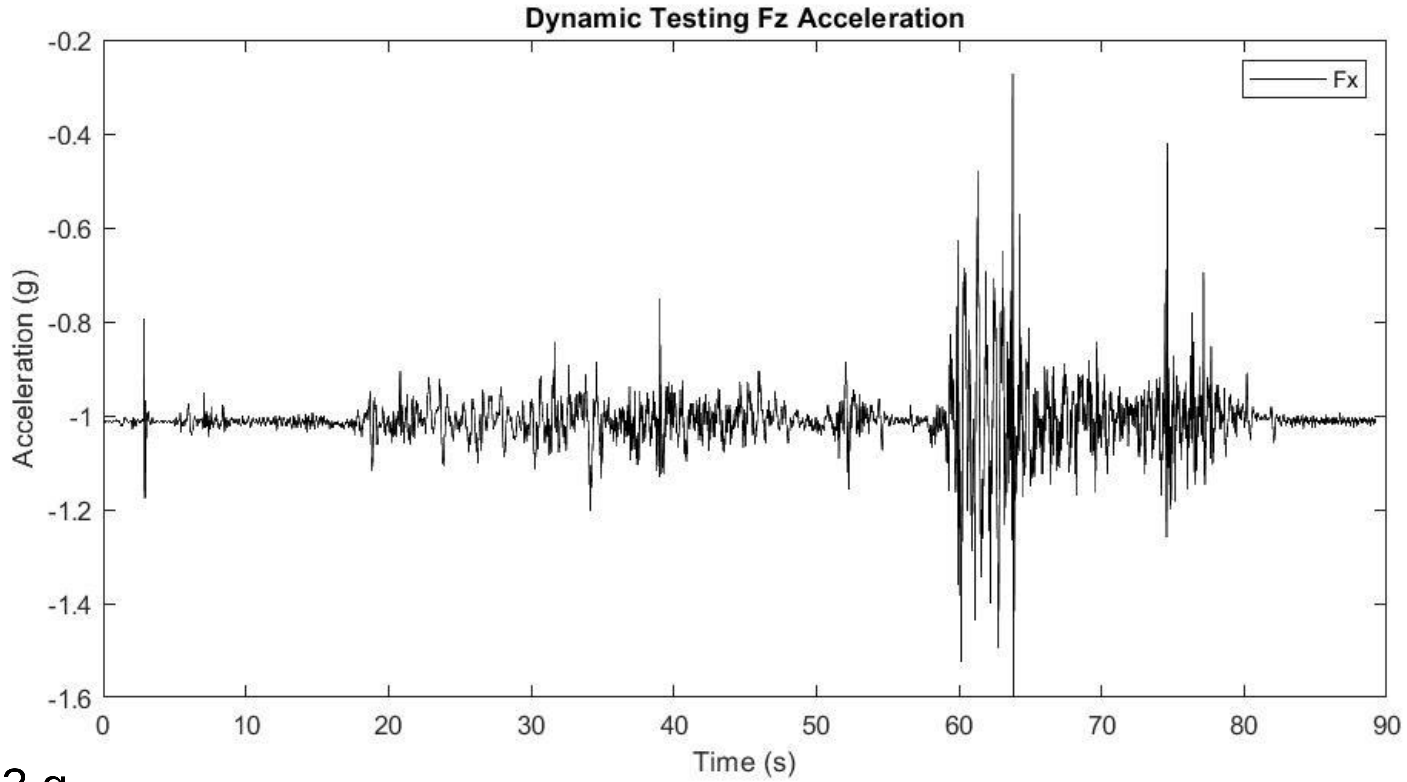
Max = 0.599 g

Test #4 – Dynamic Testing – Lateral Acceleration



Max = 0.679 g

Test #4 – Dynamic Testing – Vertical Acceleration



Max = 2.03 g

Test #4 – Dynamic Testing Results

Before

After

Dynamic testing yielded no visible damage to the dunnage or the parts. Parts contained in dunnage were significantly displaced within each cell, but all remained within their designated cell. Desired results were achieved except for significant part displacement

Verification and Validation

- Tests 1 and 2 were performed to evaluate the ability to create a clip from ABS that can effectively attach to a sheet of ABS. Important to project development, but do not verify/validate any specific requirement.
- Tests 3 and 4 both served the same purpose in validating that the main stakeholder requirement was met
- Once the final iteration of the prototype was complete, each requirement was verified/validated one at a time and each objective's success was measured according to its metric

Verification and Validation

- For most requirements, it was a simple yes or no
- There were only two stakeholder requirements and two system requirements that required further evaluation:

L1	S4	ON TRACK	HIGH	LOGISTICAL	F1	Compartments are collapsable and container fits well with other containers	ft^3	1	2	TEST
U1	S2	ON TRACK	HIGH	USABILITY		Container weight with parts	lbs	30	30	TEST

S4	ON TRACK	HIGH	LOGISTICAL	The user should be able to easily store the containers	ft^3	2	1	TEST
S2	ON TRACK	HIGH	SAFETY	The user should be able to lift container without injury	lb	30	30	TEST

- Collapsed Volume: 0.214 ft^3
- Single Layer Dunnage Weight without Tote: 1.91 lb

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Conclusions and Recommendations

Conclusions

- Requirements were able to be mostly or wholly met, highlighting a few key requirements below

The modular dunnage can be:

1. Theoretically reused for an extended period of time
2. Reconfigured to accept multiple shapes and size
3. Collapsed to allow for efficient storage with a 96% reduction in volume

The modular dunnage can be improved by:

1. Increasing number of configurations
2. Allowing for long vertically oriented parts in tote
3. Redesign slot indexing to improve ease of assembly
4. Modify the retaining clip to latch more securely and have reduced deflection

Key Lessons Learned

- Multiple specific stakeholder requirements can make determining system requirements and design decisions difficult
- Testing of whole systems should be planned well in advance
- Justifying design decisions and changes are important to understand improvements over previous designs

Overall Performance

- The team is mostly satisfied with the outcomes of the project
- Most requirements were fully met, but the design can be greatly improved upon and refined to better suit the purpose of the modular dunnage
- The team is satisfied with design effort and decisions
- By maintaining a focus on simplicity of manufacturing, the team was able to make educated critical design decisions to develop a system that is very inexpensive to produce
- The team could have improved by broadening manufacturing methods as PrimeX does not need to be only dunnage manufacturer

Recommendations for Future Work

1. Explore the use of injection molded parts or different material dunnage

- Allows for more complex shapes of dunnage, allowing for new methods of moving and securing dividers
- Different material could yield better fatigue life properties for critically components like the retaining clip

2. Use of temporary fastening methods in corrugated plastic dunnage

- Corrugated plastic is being fastened to one side of the dunnage to be a semi-permanent layer divider
- Could investigate sonic welding the permanent side and varying the attachment side to be velcro

3. Improve retaining clip

- Make retaining clip out of a different material that handles bending and fatigue loading better than ABS
- The ABS retaining clips had many failures during initial development due to the fatigue loading and large deflection of being clipped over another sheet
- Possibly even change how the clip attaches to the borders to improve logevity

Questions

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Appendices

Appendix A: Objectives & Metrics

Objective	Metric	Values: Excellent	Good	Okay	Poor / Fail
Increase minimum usage period	Years in service the product can withstand	5 years	3-4 years	1-2 years	<1 year
Maximize flexibility of packaging	Number of possible configurations	Infinite number of configurations	50+ discrete configurations	25-49 discrete configurations	<25 configurations
Minimize space dunnage takes up in collapsed form	Volume	< 1 ft^3	1-2 ft^3	2-3 ft^3	> 3 ft^3
Minimize number of tools required to adjust compartments	Number of tools	0	1	1	2

Appendix B: Stakeholders Requirements Table

#REF!

ID	STATUS	IMPORTANCE	TYPE	REQUIREMENT DISCRIPTION	UNIT OF MEASURE	MARGINAL (TARGET) VALUE	IDEAL (OJBECTIVE) VALUE	METHOLD OF VALIDATION
S1	ON TRACK	HIGH	SAFETY	The user should be able to transport components without them sustaining damage	N/A	N/A	N/A	TEST
S2	ON TRACK	HIGH	SAFETY	The user should be able to lift container without injury	lb	30	30	TEST
S3	ON TRACK	HIGH	FUNCTIONAL / PERFORMANCE	The user be able to adjust comaprtment sizes	N/A	N/A	N/A	DEMONSTRATION
S4	ON TRACK	HIGH	LOGISTICAL	The user should be able to easily store the containers	ft^3	2	1	TEST
S5	ON TRACK	MED	FUNCTIONAL / PERFORMANCE	The user should be able to store multiple layers of components inside the container	Layers	1	3	DEMONSTRATION
S6	ON TRACK	HIGH	FUNCTIONAL / PERFORMANCE	The user should not be able to remove internal compartments/dividers	N/A	N/A	N/A	DEMONSTRATION
S7	ON TRACK	LOW	DEPLOYMENT	The user should experience a seamless transition during the implementation of the new packaging system	N/A	N/A	N/A	ANALYSIS
S8	ON TRACK	HIGH	USABILITY	The user needs to be able to access components quickly and easily	N/A	N/A	N/A	DEMONSTRATION
S9	ON TRACK	MED	RELIABILITY	The user needs the container to last a minimum of 5 years	Years	5	7	ANALYSIS
S10	ON TRACK	MED	TRAINING	The user needs to be able to manipulate cell storage system without extensive training	Training time (in hours)	1	0.5	DEMONSTRATION
S11	ON TRACK	MED	INTERFACE	The user is unable to discard individual cells	N/A	N/A	N/A	DEMONSTRATION
S12	ON TRACK	MED	INTERFACE	User is able to fit existing components in modular cell system in C-crate	N/A	N/A	N/A	TEST
S13	ON TRACK	LOW	USABILITY	User should not need tools to adjust packaging	N/A	N/A	N/A	DEMONSTRATION
S14	ON TRACK	MED	FUNCTIONAL / PER	User should be able to collapse dunnage when not in use	N/A	N/A	N/A	DEMONSTRATION

Appendix C: Systems Requirements Table

#REF!

ID	STAKEHOLDER REQUIREMENT ID	STATUS	IMPORTANTCE	TYPE	RELATED FXN(S)	REQUIREMENT DESCRIPTION	UNIT OF MEASURE	MARGINAL (TARGET) VALUE	IDEAL (OJBECTIVE) VALUE	METHOD OF VERIFICATION
U1	S2	ON TRACK	HIGH	USABILITY		Container weight with parts	lbs	30	30	TEST
F1	S3	ON TRACK	HIGH	FUNCTIONAL		Compartments are adjustable to provide varying cell sizes				DEMONSTRATION
L1	S4	ON TRACK	HIGH	LOGISTICAL	F1	Compartments are collapsable and container fits well with other containers	ft^2	1	2	TEST
MS1	S5	ON TRACK	MED	MODE AND/OR STATES REQUIREMENTS	F1	Cell divider levels are layered horizontally within crate	#	1	3	INSPECTION
I1	S6/S11	ON TRACK	HIGH	INTERFACE		Dividers are nonremovable				TEST
I2	S10	ON TRACK	MED	INTERFACE		Dividers and cells are easily configurable				TEST
F2	S7/S12	ON TRACK	HIGH	FUNCTIONAL		System is integrated into the C crate which is already part of the existing system				INSPECTION
U2	S8	ON TRACK	HIGH	USABILITY		Parts easily accessable	N/A	N/A	N/A	DEMONSTRATION
P1	S9	ON TRACK	HIGH	PERFORMANCE		Lasting 5 years	Years	5	7	TEST
U3	S13	ON TRACK	MED	USABILITY		System does not require tools to adjust	Tools	1	0	DEMONSTRATION
F3	S14	ON TRACK	MED	FUNCTIONAL		The dunnage within the tote is able to fold into itself				DEMONSTRATION

Appendix D: Concept Generation & Evaluation

- Document component, subsystem, and system level concept generation and evaluation process.
- Document the evaluation process in detail including each step of the screening and evaluation process.
- Ensure tools such as PCC, Morph Charts, and Decision Matrices are correctly applied.

Concept Evaluation- Pair Wise Comparison

PAIR WISE COMPARISON PROJECT NAME: Honda Modular Packaging COHORT: AU2021

	INFINITELY ADJUSTABLE	PORTABILITY	DURABILITY	ERGONOMIC	COLLAPSIBLITY	PROTECTION	SPACE EFFICIENCY	DIVIDER STABILITY	USABILITY	AESTHETICS	ROW TOTAL	WEIGHT
INFINITELY ADJUSTABLE	X	5	5	10	10	0.2	5	1	5	10	51.2	17%
PORTABILITY	0.2	X	0.2	1	1	0.1	5	0.1	5	10	22.6	8%
DURABILITY	0.2	5	X	10	1	0.2	1	1	5	10	33.4	11%
ERGONOMIC	0.1	1	0.1	X	0.1	0.1	1	0.2	1	10	13.6	5%
COLLAPSIBLITY	0.1	1	1	10	X	0.2	5	1	5	10	33.3	11%
PROTECTION	5	10	5	10	5	X	10	10	10	10	75	25%
SPACE EFFICIENCY	0.2	0.2	1	1	0.2	0.1	X	0.2	5	10	17.9	6%
DIVIDER STABILITY	1	10	1	5	1	0.1	5	X	5	10	38.1	13%
USABILITY	0.2	0.2	1	1	0.2	0.1	0.2	0.2	X	10	13.1	4%
AESTHETICS	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	X	0.9	0%
COLUMN TOTAL	7.1	32.5	14.4	48.1	18.6	1.2	32.3	13.8	41.1	90	299.1	

MORPH CHART PROJECT NAME: Honda Modular Packaging COHORT: AU2021

	MEANS 1	MEANS 2	MEANS 3	MEANS 4	MEANS 5
Contains Components	Pouches	Cubic/Rectangular cell	Net	Other Prismatic Cell	Wedge between deforable solid
Collapsible Cell Pack	Rails	Flexible elements	Hinges	Telescopic	Compressible
Protect Components	Lined Corrugated Plastic	Fabric Pouch	Foam Insert/Dividers	Rigid Dividers	Plain Corrugated Plastic
Cells Adjusts in Size	Stretch	Slide	Fold	Pivot	
Maintains Shape of Cell Pack	Tab/Slot	Velcro	Magnet	Clip	Threaded Fastener

DECISION MATRIX	PROJECT NAME: Honda Modular Packaging	COHORT: AU2021										
	Weights		Foldable Dividers		Rails and Fabric Pouches		Rails and Rigid Dividers		Cylindrical Cell Pack			
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Reconfigurable (0.35)	0.35											
Cell Size Variation	0.15		6	0.9	5	0.75	8	1.2	5	0.75		
Cell Number Variation	0.20		7	1.4	8	1.6	7	1.4	4	0.8		
Robust (0.20)	0.20											
Impact Resistance	0.10		6	0.6	2	0.2	8	0.8	8	0.8		
Vibration Resistance	0.10		6	0.6	6	0.6	8	0.8	8	0.8		
Ease of Use (0.15)	0.15											
Light Weight	0.05		7	0.35	6	0.3	6	0.3	6	0.3		
Simple to Use	0.10		6	0.6	9	0.9	9	0.9	4	0.4		
Part Protection (0.30)	0.30											
Scratch Resistant	0.15		9	1.35	9	1.35	9	1.35	8	1.2		
Limited Part Mobility	0.15		7	1.05	4	0.6	9	1.35	6	0.9		
Total Weighted Score				6.85		6.3		8.1		5.95		0

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Appendix E: Sizing and Analysis

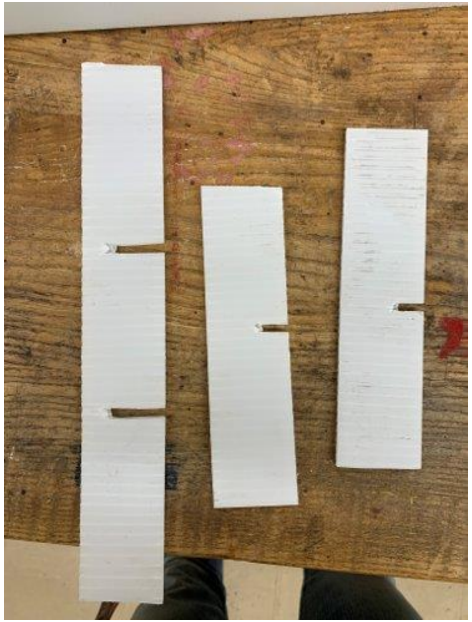
Size Analysis performed by Chris using Honda’s software for optimizing rectangular cell sizes (zoom in to read)

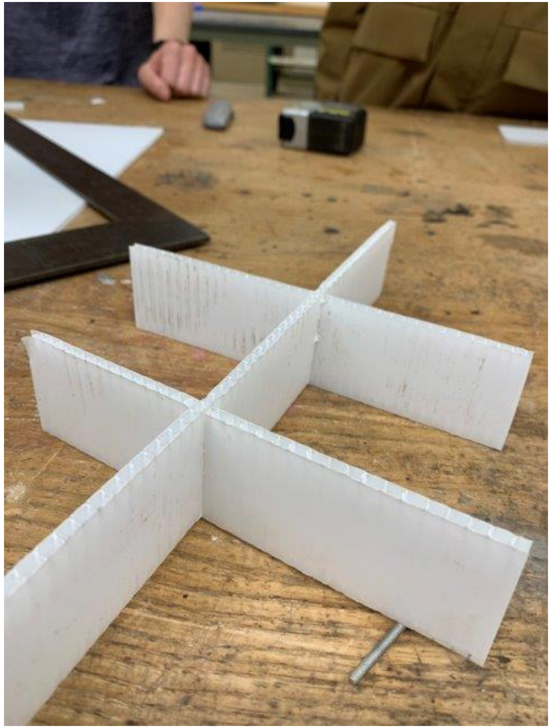
Layers	BASE 8	PART - LEN	PART - WID	PART - HEIG	PART -	CONTA	Contai	Project	PAk Ra	Best HH Co	Best HH Dens	Best HH Ori	Best Large Co	Best Large Dens	Best Large Ori	Best Overall Co	Best Overa	Best Orientati	Containers per Tra	Current Propo	ODI Container	ODI Pro	Differe	Is Bene	
3	1739130B	7.3	6.4	5.3	0.970034	C	12	NEW	BR				A1	60	Orientation 1	A1	60	Orientation 1	624	7488	104	6240	-1248	FALSE	0.833333
3	194206NH A000	13.88	4.96	2.57	0.892872	C	15	NEW	BR	C	6	Orientation 3	L4	60	Orientation 1	C	6	Orientation 3	624	9360	624	3744	-5616	FALSE	0.4
3	281006MM	4.8	3	5.3	0.793664	C	30	C/O	BR	C	20	Orientation 2	A5	60	Orientation 2	C	20	Orientation 2	624	18720	624	12480	-6240	FALSE	0.666667
3	35730/750/76030A	6.4	3.2	2.5	0.630522	C	30	NEW	BR	C	20	Orientation 1	A5	60	Orientation 1	C	20	Orientation 1	624	18720	624	12480	-6240	FALSE	0.666667
3	35730/750/76030A	5.4	2.6	2.5	0.35274	C	30	NEW	BR	C	30	Orientation 3	A5	60	Orientation 1	C	30	Orientation 3	624	18720	624	18720	0	TRUE	1
3	35730/750/76030A	4.4	2.52	2.4	0.220462	C	30	NEW	BR	C	60	Orientation 1	A5	60	Orientation 1	C	60	Orientation 1	624	18720	624	37440	18720	TRUE	2
3	3820030A	7.978	6.005	2.854	17.63698	C	15	NEW	BR				A5	60	Orientation 3	A5	60	Orientation 3	624	9360	156	9360	0	TRUE	1
3	6391030A A000	11.44	4.16	6.53	1.710787	C	10	C/O	BR				L4	60	Orientation 1	L4	60	Orientation 1	624	6240	54	3240	-3000	FALSE	0.519231
3	7114130A	11.574	4.404	1.974	0.328489	C	30	NEW	BR	C	6	Orientation 3	A5	30	Orientation 1	A5	30	Orientation 1	624	18720	156	4680	-14040	FALSE	0.25
3	7212030A	5.17	2.46	9.02	0.399037	C	15	C/O	BR	C	15	Orientation 2	A5	60	Orientation 2	C	15	Orientation 2	624	9360	624	9360	0	TRUE	1
3	7243030A	16.63	1.22	3.39	0.209439	C	30	C/O	BR	B2	15	Orientation 2	A5	15	Orientation 1	B2	15	Orientation 2	624	18720	624	9360	-9360	FALSE	0.5
3	72640,680-3A0 A000	3.2	2.5	1.1	0.02	C	20	NEW	C	C2	60	Orientation 1	A5	60	Orientation 1	C2	60	Orientation 1	624	12480	1248	74880	62400	TRUE	6
3	72640,680-3A0 A000	3.2	2.5	1.1	0.02	C	20	NEW	C	C2	60	Orientation 1	A5	60	Orientation 1	C2	60	Orientation 1	624	12480	1248	74880	62400	TRUE	6
3	7272130A	12.5	1	6	0.253532	C	30	C/O	BR	C2	6	Orientation 2	A5	30	Orientation 2	C2	6	Orientation 2	624	18720	1248	7488	-11232	FALSE	0.4
3	7293030A	16.6	0.02	3.38	0.209439	C	30	C/O	BR	B2	15	Orientation 2	A5	15	Orientation 1	B2	15	Orientation 2	624	18720	624	9360	-9360	FALSE	0.5
3	7622030A	5.95	1.88	5.95	0.110231	C	30	C/O	BR	C	20	Orientation 2	A5	60	Orientation 2	C	20	Orientation 2	624	18720	624	12480	-6240	FALSE	0.666667
3	76400-30A	9.5	4.97	2.79	0.595248	C	15	C/O	BR	C	12	Orientation 1	A5	60	Orientation 3	A5	60	Orientation 3	624	9360	156	9360	0	TRUE	1
3	76400-30A	5.272	10.142	3.35	1.146404	C	15	C/O	BR	C	6	Orientation 1	A5	60	Orientation 1	A5	60	Orientation 1	624	9360	156	9360	0	TRUE	1
3	7641030A A000	9.01	8.06	5.05	0.396832	C	15		BR				A3	60	Orientation 1	A3	60	Orientation 1	624	9360	78	4680	-4680	FALSE	0.5
3	7721530A V000	12.143	7.833	1.636	0.167551	C	30	New	BR	C	6	Orientation 3	A5	30	Orientation 1	A5	30	Orientation 1	624	18720	156	4680	-14040	FALSE	0.25
3	7730530A V000	8.3	5.939	4.288	0.11905	C	30	new	BR				A1	60	Orientation 3	A1	60	Orientation 3	624	18720	104	6240	-12480	FALSE	0.333333
3	79610 T20	2.92	13.3	3	1.080265	C	15	New	BR	C	6	Orientation 1	A5	20	Orientation 1	C	6	Orientation 1	624	9360	624	3744	-5616	FALSE	0.4
3	80316-30B	9	8.7	9	0.58	C	30	C/O	C										624	18720				TRUE	
3	83111,161-3A0 A000	13.02	9.32	3.99	0.32	C	15	C/O	C				A1	30	Orientation 3	A1	30	Orientation 3	624	9360	104	3120	-6240	FALSE	0.333333
3	83111,161-3A0 A000	13.02	9.32	3.99	0.32	C	15	C/O	C				A1	30	Orientation 3	A1	30	Orientation 3	624	9360	104	3120	-6240	FALSE	0.333333
3	8323030A A000	15.71	2.57	7.75	1.245612	C	12	C/O	BE				A5	15	Orientation 2	A5	15	Orientation 2	624	7488	156	2340	-5148	FALSE	0.3125
3	8354030A	10.4	3.26	2.5	0.330693	C	30	C/O	BR	C	6	Orientation 3	A5	60	Orientation 3	A5	60	Orientation 3	624	18720	156	9360	-9360	FALSE	0.5
3	8A420 T20 A000	7.2	6.71	2.58	0.639341	C	12	C/O	BR	C	12	Orientation 1	A5	60	Orientation 1	A5	60	Orientation 1	624	7488	156	9360	1872	TRUE	1.25
2	1739130B	7.3	6.4	5.3	0.970034	C	12	NEW	BR	C	12	Orientation 3	A5	60	Orientation 1	A5	60	Orientation 1	624	7488	156	9360	1872	TRUE	1.25
2	194206NH A000	13.88	4.96	2.57	0.892872	C	15	NEW	BR	C2	6	Orientation 3	A5	20	Orientation 3	C2	6	Orientation 3	624	9360	1248	7488	-1872	FALSE	0.8
2	281006MM	4.8	3	5.3	0.793664	C	30	C/O	BR	C	30	Orientation 1	A5	60	Orientation 1	C	30	Orientation 1	624	18720	624	18720	0	TRUE	1
2	35730/750/76030A	6.4	3.2	2.5	0.630522	C	30	NEW	BR	C2	30	Orientation 1	A5	60	Orientation 1	C2	30	Orientation 1	624	18720	1248	37440	18720	TRUE	2
2	35730/750/76030A	5.4	2.6	2.5	0.35274	C	30	NEW	BR	C2	30	Orientation 1	A5	60	Orientation 1	C2	30	Orientation 1	624	18720	1248	37440	18720	TRUE	2
2	35730/750/76030A	4.4	2.52	2.4	0.220462	C	30	NEW	BR	C2	30	Orientation 1	A5	60	Orientation 1	C2	30	Orientation 1	624	18720	1248	37440	18720	TRUE	2
2	3820030A	7.978	6.005	2.854	17.63698	C	15	NEW	BR				A1	60	Orientation 5	A1	60	Orientation 5	624	9360	104	6240	-3120	FALSE	0.666667
2	6391030A A000	11.44	4.16	6.53	1.710787	C	10	C/O	BR				A5	30	Orientation 2	A5	30	Orientation 2	624	6240	156	4680	-1560	FALSE	0.75
2	7114130A	11.574	4.404	1.974	0.328489	C	30	NEW	BR	C2	6	Orientation 3	A5	30	Orientation 1	C2	6	Orientation 3	624	18720	1248	7488	-11232	FALSE	0.4
2	7212030A	5.17	2.46	9.02	0.399037	C	15	C/O	BR	C2	12	Orientation 2	A3	60	Orientation 1	C2	12	Orientation 2	624	9360	1248	14976	5616	TRUE	1.6
2	7243030A	16.63	1.22	3.39	0.209439	C	30	C/O	BR	C	6	Orientation 3	A5	12	Orientation 1	C	6	Orientation 3	624	18720	624	3744	-14976	FALSE	0.2
2	72640,680-3A0 A000	3.2	2.5	1.1	0.02	C	20	NEW	C	C2	60	Orientation 1	A5	60	Orientation 1	C2	60	Orientation 1	624	12480	1248	74880	62400	TRUE	6
2	72640,680-3A0 A000	3.2	2.5	1.1	0.02	C	20	NEW	C	C2	60	Orientation 1	A5	60	Orientation 1	C2	60	Orientation 1	624	12480	1248	74880	62400	TRUE	6
2	7272130A	12.5	1	6	0.253532	C	30	C/O	BR	B2	12	Orientation 2	A5	30	Orientation 2	B2	12	Orientation 2	624	18720	624	7488	-11232	FALSE	0.4
2	7293030A	16.6	0.02	3.38	0.209439	C	30	C/O	BR	C	6	Orientation 3	A5	12	Orientation 1	C	6	Orientation 3	624	18720	624	3744	-14976	FALSE	0.2
2	7622030A	5.95	1.88	5.95	0.110231	C	30	C/O	BR	B2	30	Orientation 2	A5	60	Orientation 2	B2	30	Orientation 2	624	18720	624	18720	0	TRUE	1
2	76400-30A	9.5	4.97	2.79	0.595248	C	15	C/O	BR	C	6	Orientation 3	A5	30	Orientation 1	A5	30	Orientation 1	624	9360	156	4680	-4680	FALSE	0.5
2	76400-30A	5.272	10.142	3.35	1.146404	C	15	C/O	BR	C	6	Orientation 1	A3	60	Orientation 2	A3	60	Orientation 2	624	9360	78	4680	-4680	FALSE	0.5
2	7641030A A000	9.01	8.06	5.05	0.396832	C	15		BR				A5	30	Orientation 1	A5	30	Orientation 1	624	9360	156	4680	-4680	FALSE	0.5
2	7721530A V000	12.143	7.833	1.636	0.167551	C	30	New	BR	B2	12	Orientation 1	A5	30	Orientation 1	B2	12	Orientation 1	624	18720	624	7488	-11232	FALSE	0.4
2	7730530A V000	8.3	5.939	4.288	0.11905	C	30	new	BR	C	12	Orientation 3	A1	60	Orientation 5	C	12	Orientation 3	624	18720	624	7488	-11232	FALSE	0.4
2	79610 T20	2.92	13.3	3	1.080265	C	15	New	BR	C	6	Orientation 1	A5	20	Orientation 1	C	6	Orientation 1	624	9360	624	3744	-5616	FALSE	0.4
2	80316-30B	9	8.7	9	0.58	C	30	C/O	C				A1	20	Orientation 2	A1	20	Orientation 2	624	18720	104	2080	-16640	FALSE	0.111111
2	83111,161-3A0 A000	13.02	9.32	3.99	0.32	C	15	C/O	C				A5	20	Orientation 3	A5	20	Orientation 3	624	9360	156	3120	-6240	FALSE	0.333333
2	83111,161-3A0 A000	13.02	9.32	3.99	0.32	C	15	C/O	C				A5	20	Orientation 3	A5	20	Orientation 3	624	9360	156	3120	-6240	FALSE	0.333333
2	8323030A A000	15.71	2.57	7.75	1.245612	C	12	C/O	BE				A5	12	Orientation 2	A5	12	Orientation 2	624	7488	156	1872	-5616	FALSE	0.25
2	8354030A	10.4	3.26	2.5	0.330693	C	30	C/O	BR	C2	6	Orientation 3	A5	30	Orientation 1	C2	6	Orientation 3	624	18720	1248	7488	-11232	FALSE	0.4
2	8A420 T20 A000	7.2	6.71	2.58	0.639341	C	12	C/O	BR	B2	20	Orientation 1	A5	60	Orientation 1	B2	20	Orientation 1	624	7488	624	12480	4992	TRUE	1.666667
1	1739130B	7.3	6.4	5.3	0.970034	C	12	NEW	BR	B2	15	Orientation 1	A5	30	Orientation 1	B2	15	Orientation 1	624	7488	624	9360	1872	TRUE	1.25
1	194206NH A000	13.88	4.96	2.57	0.892872	C	15	NEW	BR				A1	60	Orientation 5	A1	60	Orientation 5	624	9360	104	6240	-3120	FALSE	0.666667
1	281006MM	4.8	3	5.3	0.793664	C	30	C/O	BR	B2	30	Orientation 1	A5	60	Orientation 3	C2	15	Orientation 1	624	18720	1248	18720	0	TRUE	1
1	35730/750/76030A	6.4	3.2	2.5	0.630522	C	30	NEW	BR	C	30	Orientation 5	A5	60	Orientation 3	C2	15	Orientation 1	624	18720	1248	18720	0	TRUE	1
1	35730/750/76030A	5.4	2.6	2.5	0.35274	C	30	NEW	BR	B2	60	Orientation 5	A5	60	Orientation 3	C2	30	Orientation 5	624	18720	1248	37440	18720	TRUE	2
1	35730/750/76030A	4.4	2.52	2.4	0.220462	C	30	NEW	BR	B2	60	Orientation 5	A5	60	Orientation 3	C2	30	Orientation 5	624	18720	1248	37440	18720	TRUE	2
1	3820030A	7.978	6.005	2.854	17.63698	C	15	NEW	BR				A5	60	Orientation 5	A5	60	Orientation 5	624	9360	156	9360	0	TRUE	1
1	6391030A A000	11.44	4.16	6.53	1.710787	C	10	C/O	BR	B2	6	Orientation 2	A5	30	Orientation 5	A5	30	Orientation 5	624	6240	156	4680	-1560	FALSE	0.75
1	7114130A	11.574	4.404	1.974	0.328489	C	30	NEW	BR	C	12	Orientation 5	A5	60	Orientation 5	A5	60	Orientation 5	624	18720	156	9360	-9360	FALSE	0.5
1	7212030A	5.17	2.46	9.02	0.399037	C	15	C/O	BR	C	15	Orientation 1	A5	60	Orientation 3	A5	60	Orientation 3	624	9360	156	9360	0	TRUE	1
1	7243030A	16.63	1.22	3.39	0.209439	C	30	C/O	BR				A1	60	Orientation 5	A1	60	Orientation 5	624	18720	104	6240	-12480	FALSE	0.333333
1	72640,680-3A0 A000	3.2	2.5	1.1	0.02	C	20	NEW	C	B2	60	Orientation 1	A5	60	Orientation 1	C2	60	Orientation 5	624	12480	1248	74880	62400	TRUE	6
1	72640,680-3A0 A000	3.2	2.5	1.1	0.02	C	20	NEW	C	B2	60	Orientation 1	A5	60	Orientation 1	C2	60	Orientation 5	624	12480	1248	74880	62400	TRUE	6
1	7272130A	12.5	1	6	0.253532	C	30	C/O	BR	B2	6	Orientation 2	A1	30	Orientation 5	B2	6	Orientation 2	624	18720	624	3744	-14976	FALSE	0.2
1	7293030A	16.6	0.02	3.38	0.209439	C	30	C/O	BR				A1	60	Orientation 5	A1	60	Orientation 5	624	18720	104	6240	-12480	FALSE	0.333333
1	7622030A	5.95	1.88	5.95	0.110231	C	30	C/O	BR	C	15	Orientation 1	A5	60	Orientation 3	A5	60	Orientation 3	624	18720	156	9360	-9360	FALSE	0.5
1	76400-30A	9.5	4.97	2.79	0.595248	C	15	C/O	BR	C	12	Orientation 5	A5	60	Orientation 5	A5	60	Orientation 5	624	9360	156	9360	0	TRUE	1
1	76400-30A	5.272	10.142	3.35	1.146404	C	15	C/O	BR	C	15	Orientation 2	A5	60	Orientation 4	A5	60	Orientation 4	624	9360	156	9360	0	TRUE	1
1	7641030A A000	9.01	8.06	5.05	0.396832	C	15		BR	C	6	Orientation 4	A5	20	Orientation 1	C	6	Orientation 4	624	9360	624	3744	-5616	FALSE	0.4
1	7721530A V000	12.143	7.833	1.636	0.167551	C	30	New	BR	C	6	Orientation 5	A5	20	Orientation 5	C	6	Orientation 5	624	18720	624	3744	-14976	FALSE	0.2
1	7730530A V000	8.3	5.939	4.288	0.11905	C	30	new	BR	C	12	Orientation 5	A5	30	Orientation 5	C2	6	Orientation 3	624	18720	1248	7488	-11232	FALSE	0.4
1	79610 T20	2.92	13.3	3	1.080265	C	15	New	BR				A1	60	Orientation 2	A1	60	Orientation 2	624	9360	104	6240	-3120	FALSE	0.666667
1	80316-30B	9	8.7	9	0.58	C	30	C/O	C				A5	12	Orientation 1	A5	12	Orientation 1	624	18720	156	1872	-16848	FALSE	0.1
1	83111,161-3A0 A000	13.02	9.32	3.99	0.32	C	15	C/O	C	B2	6	Orientation 1	A5	15	Orientation 2	B2	6	Orientation 1	624	9360	624	3744	-5616	FALSE	0.4
1	83111,161-3A0 A000	13.02	9.32	3.99	0.32	C	15	C/O	C	B2	6	Orientation 1	A5	15	Orientation 2	B2	6	Orientation 1	624	9360	624	3744	-5616	FALSE	0.4
1	8323030A A000	15.71	2.57	7.75	1.245612	C	12	C/O	BE				A1	20	Orientation 5	A1	20	Orientation 5	624	7488	104	2080	-5408	FALSE	0.277778
1	8354030A	10.4	3.26	2.5	0.330693	C	30	C/O	BR	C	30	Orientation 5	A5	60	Orientation 5	C	30	Orientation 5	624	18720	624	18720	0	TRUE	1
1	8A420 T20 A000	7.2	6.71	2.58	0.639341	C	12	C/O	BR	B2	10	Orientation 1	A5	60	Orientation 5	A5	60	Orientation 5	624	7488	156	9360	1872	TRUE	1.25

Appendix F: Prototyping and Testing

Rigid Dunnage fit and form test

Result: Adequate rigidity from this form of slotted connection, can be used with rigid material

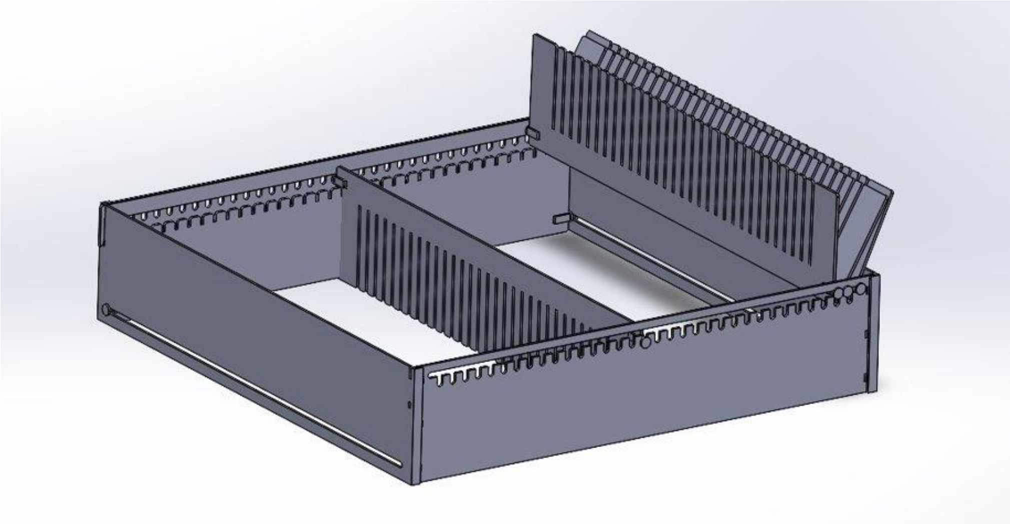




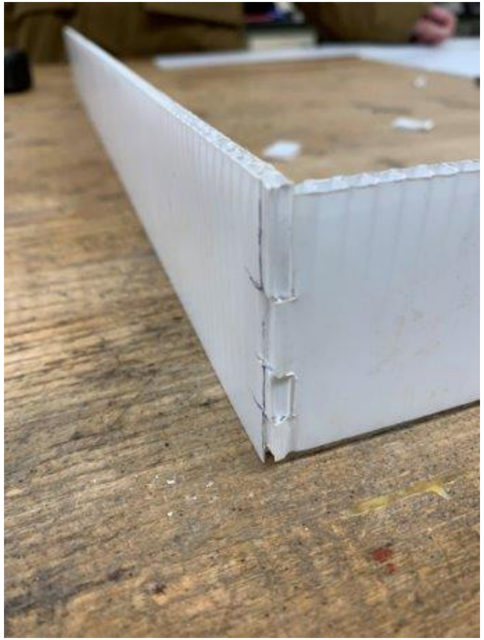
Appendix F: Prototyping and Testing

Rigid Dunnage modularity and feasibility test

Result: Concept model and initial tests show many advantages over current solution and other concepts

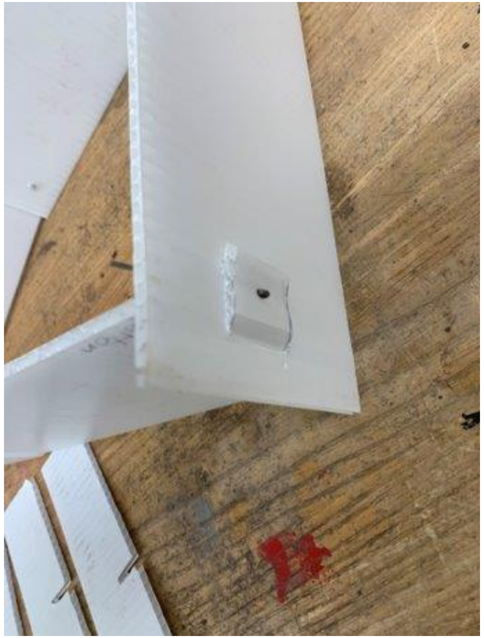


Appendix F: Prototyping and Testing



Corrugated plastic fastening test

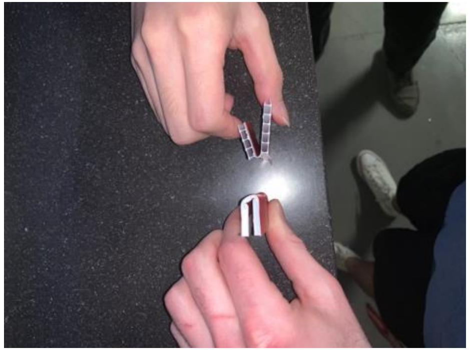
Results: limited forms of fastening, difficult to incorporate into a prototype

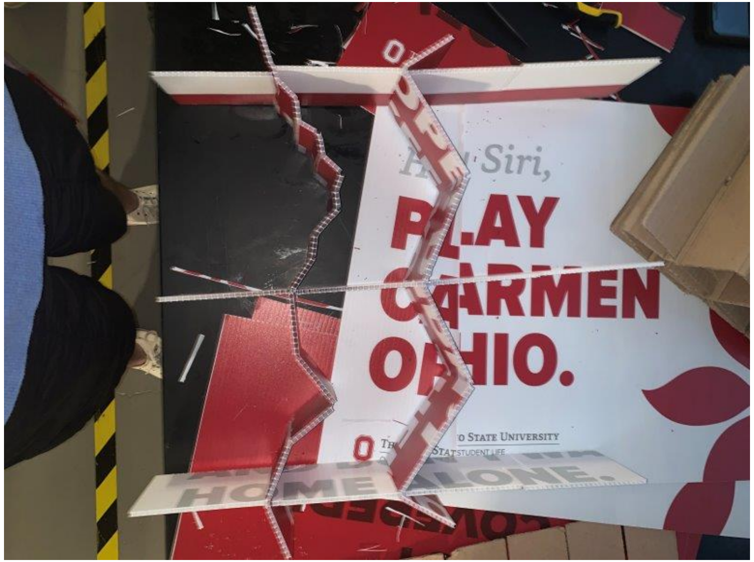


Appendix F: Prototyping and Testing

Corrugated plastic bending/geometry tests

Results: Bending isn't a reliable form of cell size adjustment for modularity





Appendix G: Risk Table

RISK TABLE	PROJECT NAME: Honda Modular Packaging	COHORT: AU2021				
Risk ID	Area / Subsystem	Description of Risk	Impact (1-5)	Likelihood (1-5)	Rating	Status / Mitigation
1	Meetings	Scheduling conflicts create limited times when all team members can meet	5	1	5	9-7-2021: Created a "when2meet" to determine the best time to have group meetings. Found multiple times a week that team is free outside of open labs.
2	Deadlines	Being unable to complete components of the project due to long lead times for parts	5	1	5	9-7-2021: Meeting multiple times a week to work on assignments.
3	Failure	Material mechanically fails due to stress (normal or shear)	5	1	5	10-20-2021: Analysis will be performed to make sure that the materials used can withstand the stresses to which they are exposed 11-29-2021: Solid plastic such as PVC or HDPE will be used instead of corrugated plastic (Likelihood: 5->3) 2-11-2022: Deflection analysis and FEA were performed to determine how much how much stress and deflection the dividers will experience (Likelihood: 3->2) 3-21-2022: Retaining clips have quickly become the largest area of concern for mechanical failure. Multiple have broken in the same place after use. (Likelihood: 2->4) 4-6-2022: Problem with mechanical failure in retaining clips has been resolved via thickening and the addition or a radius. No other areas have shown signs of mechanical failure. (Likelihood: 4->1)
4	Ergonomics	Product is uncomfortable/difficult to hold	2	1	2	10-20-2021: Product will be designed to be easy to hold 11-3-2021: Product will be designed to fit inside existing totes (Likelihood: 3->1)
5	Budget	Product is expensive to manufacture	3	1	3	10-20-2021: Product will be designed to be manufactured cost-effectively 2-28-2022: Budget and bill of materials has been monitored to maintain a low cost (Likelihood: 4->1)
6	Usability	Product is difficult to use (functions are not easily utilized)	3	1	3	10-20-2021: Product will be designed with assembly line workers' input in mind 3-10-2022: Tolerances in initial prototype are relatively tight, ease of use is not amazing. No change in likelihood, mitigation is necessary. 3-25-2022: Newer version of prototype without clips is easier to manupulate, but tolerances are still too tight. (Likelihood: 3->2) 4-18-2022: Final version of prototype has appropriate tolerances that greatly improve ease of assembly and use (Likelihood: 2->1)
7	Compartments	Compartment size will be difficult to adjust	5	1	5	10-20-2021: Product will be designed to be adjustable without tools Compartments will be adjusted using a pin (Likelihood: 3->2) 1-20-2022: Dunnage will be reconfirguarble and held in place with clips (Likelihood: 2->1)
8	Weight	Product is too heavy to be practical according to Honda rules and standards	5	1	5	10-20-2021: Lightweight materials will be used where possible 11-29-1021: Plastic thickness will be minimized in order to reduce weight (Likelihood: 5->3) 2-7-2022: Material analysis performed, including 2D density calculations (Likelihood: 5->2) 3-10-2022: The dunnage has been confirmed to be light enough to remain below the weight limit with multiple layers (Likelihood: 2->1)
9	Lifetime	Product lasts less than 5 years	3	4	12	10-20-2021: Durable materials will be used 11-29-2021: Hard plastic will be used as oppposed to corrugated plastic (Likelihood: 5->4)
10	Storage	Product takes up too much space when being stored	2	2	4	10-20-2021: Product will be designed to be collapsable 11-29-2021: Compartments will be designed to fit around other layers when dunnage is empty (Likelihood: 3->2) 3-21-2022: Product reduces volume by ~93% when stored (Likelihood: 2->1)
10	Communication	Team is unable to effectively communicate with PrimeX and exact capabilities/prices are unknown	1	5	5	1-26-2022: Team is working to get another meeting with PrimeX that will give the team a better idea of their capabilities. 2-24-2022: Team had second meeting with PrimeX rep. They informed us they can only manufacture features below 5/32". Team may not be able to manufacture a prototype through them (Likelihood: 4->5) 3-24-2022: It was decided after conversation between team and Honda representative that a professional prototype was no longer required for the course of this project (Impact: 3->1)

Appendix H: Budget

BUDGET (BY PHASE)		PROJECT NAME: Honda Modular Packaging	COHORT: AU2021					
LV	Approval Status	Category and Item	Item Notes	Quantity	Budget	Actual	Receipt #	Purchaser
1		PROBLEM DEFINTION		NA	NA	NA	NA	NA
		Travel- tour with honda and dunnage co.			$ 250.00			
		⇑ Do Not Delete - Click this line for insert Above ⇑						
1		CONCEPT DEVELOPMENT		NA	NA	NA	NA	NA
		Concept Design Laser Cut			$ 100.00			
		⇑ Do Not Delete - Click this line for insert Above ⇑						
1		PRELIMINARY DESIGN		NA	NA	NA	NA	NA
		Material selection study			$ 50.00			
		Manufacturing methods analysis			$ 100.00			
		Preliminary design verification, laser cut			$ 100.00			
		⇑ Do Not Delete - Click this line for insert Above ⇑						
1		PROTOTYPING		NA	NA	NA	NA	NA
		Prototype 1 fabrication (C tote)			$ 1,000.00			
		Prototype 2 fabrication (A-5)			$ 1,300.00			
		⇑ Do Not Delete - Click this line for insert Above ⇑						
1		TESTING		NA	NA	NA	NA	NA
		Arduino Testing Data Recorder			$ 200.00			
		⇑ Do Not Delete - Click this line for insert Above ⇑						
		N/A						
		⇑ Do Not Delete - Click this line for insert Above ⇑						
	Total				**$ 3,100.00**	**$ -**		

Appendix I: Schedule

WBS	Task Name	Duration	Start	Finish	Predecessors	% Complete
1	**Requirements Defintion**	**26 days**	**Mon 9/6/21**	**Fri 10/8/21**		**43%**
1.1	Project Kickoff	1 day	Mon 9/6/21	Mon 9/6/21		100%
1.2	Questions to ask Chris	1 day	Fri 9/24/21	Fri 9/24/21		100%
1.3	Meet with Chris at Honda	1 day	Fri 9/24/21	Fri 9/24/21		0%
1.4	Clarify Requirements	1 day	Mon 9/27/21	Mon 9/27/21	4	0%
1.5	Risk	9 days	Thu 9/16/21	Mon 9/27/21		100%
1.6	Schedule	9 days	Thu 9/16/21	Mon 9/27/21		50%
1.7	Project Charter	3 days	Mon 9/27/21	Wed 9/29/21	4	50%
1.8	Budget	3 days	Mon 9/27/21	Wed 9/29/21	4	0%
1.9	Background Research	26 days	Mon 9/6/21	Fri 10/8/21		25%
1.10	Requirements Review	1 day	Fri 10/8/21	Fri 10/8/21		0%
2	**Concept Design**	**44 days**	**Fri 10/8/21**	**Wed 12/8/21**	**1**	**0%**
2.1	Project Updates	24 days	Fri 10/8/21	Wed 11/10/21		0%
2.2	Thumbnail Sketches	3 days	Thu 10/7/21	Mon 10/11/21		0%
2.3	First Design Meeting with Chris	0 days	Sun 10/10/21	Sun 10/10/21		0%
2.4	Morph Chart	1 day	Mon 10/11/21	Mon 10/11/21		0%
2.5	Decision Matrix	1 day	Wed 10/13/21	Wed 10/13/21		0%
2.6	CAD Modeling/Early Prototyping	60 days	Fri 10/15/21	Thu 1/6/22		0%
2.7	Design Concept Review	3 days	Mon 12/6/21	Wed 12/8/21	14	0%
3	**Winter Break**	17 days	Thu 12/16/21	Fri 1/7/22		0%
4	**Preliminary Design**	**24 days**	**Mon 1/31/22**	**Thu 3/3/22**	**13**	**0%**
4.1	Project Status Updates	5 days	Mon 1/31/22	Fri 2/4/22		0%
4.2	Preliminary Design Reviews	1 day	Thu 3/3/22	Thu 3/3/22		0%
5	**Fabrication, Assembly, and Integration**	**40 days?**	**Thu 3/3/22**	**Wed 4/27/22**		**0%**
5.1	Laser Cut Prototype	2 days	Mon 3/7/22	Tue 3/8/22		0%
5.2	3D Clip Printing	2 days	Mon 3/7/22	Tue 3/8/22		0%
5.3	Prototype Assembly	1 day	Wed 3/9/22	Wed 3/9/22	29	0%
5.4	PrimeX Design Review	1 day	Thu 3/10/22	Thu 3/10/22	28	0%
5.5	Prototype Assembly	1 day?	Wed 3/9/22	Wed 3/9/22	28	0%
5.6	Second Iteration Assembly	1 day?	Mon 3/14/22	Mon 3/14/22		0%
5.7	Third Iteration Assembly	1 day?	Fri 3/25/22	Fri 3/25/22		0%
5.8	Fourth Iteration Assembly	1 day?	Mon 4/11/22	Mon 4/11/22		0%
5.9	Shaker Table Test	1 day?	Tue 4/12/22	Tue 4/12/22		0%
5.10	Functional Demonstration	1 day?	Wed 4/13/22	Wed 4/13/22		0%
5.11	Dynamic Testing	1 day?	Mon 4/18/22	Mon 4/18/22		0%
5.12	Critical Design Review	1 day	Wed 4/20/22	Wed 4/20/22	32	0%

Appendix J: BOM

	BILL OF MATERIALS	PROJECT NAME: Honda Modular Packaging	COHORT: AU2021				
	LV	PART NUMBER	DESCRIPTION	REVISION	QTY	UNIT OF MEASURE	NOTES
Line #	1	10001100	ASSEMBLY 1	A	1	EACH	
1	2	10001100	Upper Track Cell Pack Wall	A	2	EACH	
2	2	10001101	Lower Track Cell Pack wall	A	2	EACH	
3	2	10001102	Upper Divider	A	1-33	EACH	
4	2	10001103	Lower Divider	A	1-34	EACH	
5	2	10001104	Divider Slide Clip	A	4-134	EACH	
6	2	10001105	Dicider Retainer Clip	A	2	EACH	
7	2	10001106	Cell Pack Retainer Clip	A	2	EACH	
8	2	10001107	Layer Divider	A	1	EACH	

Appendix K: Concept Generation and Brainstorming