



University of Cincinnati

**PACE Industrial Design and Engineering
Invitational Competition**

Chevy/GMC Truck/SUV Center Console

Fall 2007



OVERVIEW

AGENDA

Overview

Activities
Benchmarking
Team Building

Technology

Industrial Design
Engineering

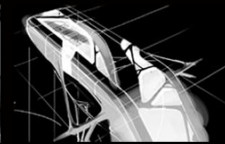
Family

Industrial Design
Engineering

Business

Industrial Design
Engineering

Questions



TIMELINE

10 week (one quarter) long project

OVERVIEW

Brainstorming Activities

9-19

School Starts

NX Training Begins

Form 3 Teams

9-24

Benchmark and vehicle comparison analysis begins

10-1

Features Explored

10-8

Surveys Conducted

10-15

Features Chosen

10-22

Analyze Survey Results

10-29

Field Trip
October 26, 2007
GM Moraine Plant

Feature Details

11-5

11-12

Prepare For Final Presentation

11-19

11-26

Final Presentation

12-7

School Ends

Team Makeup
Industrial Design
Mechanical Engineering



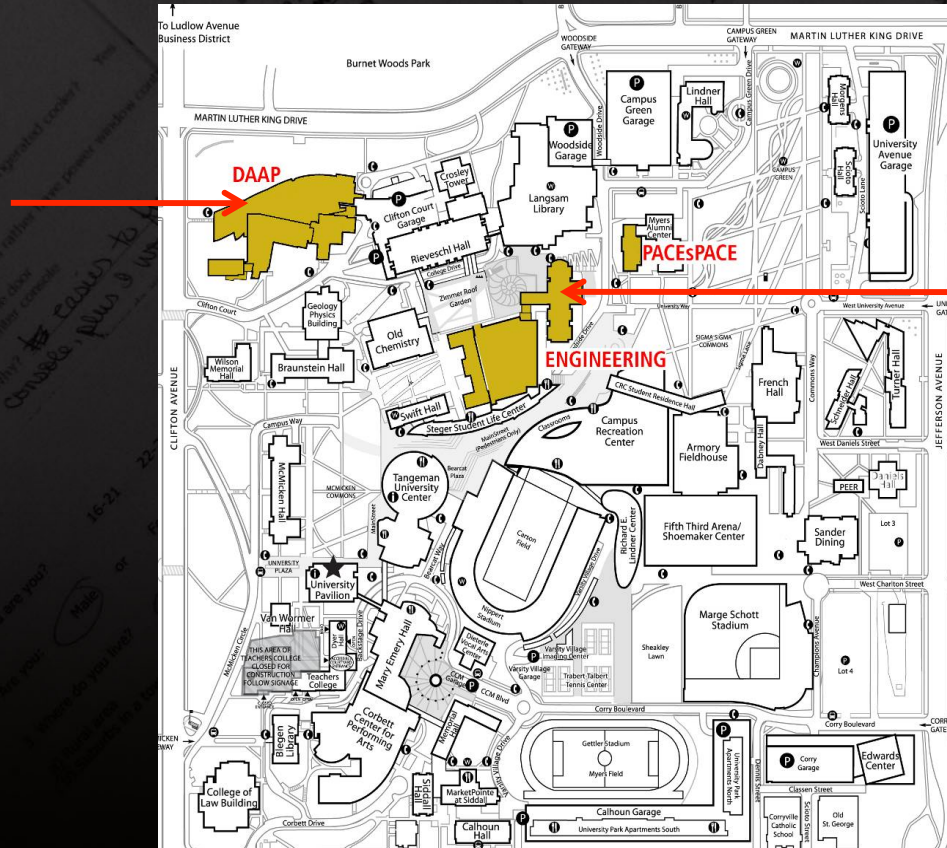
Faculty Members

OVERVIEW



Brigid O'Kane
Professor of Industrial Design

College of Design,
Architecture, Art, and
Planning
School of Design



Sam Anand
Professor of Mechanical Engineering

College of
Engineering

UC West Campus



One Big Team in Three Categories

OVERVIEW

ID = Industrial Design
ME = Mechanical Engineering

Technology



Family



Business



Collaborative Activities

OVERVIEW

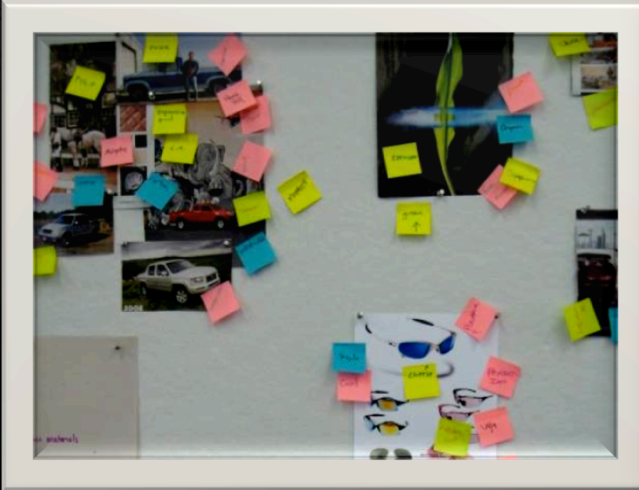
Brain Storming



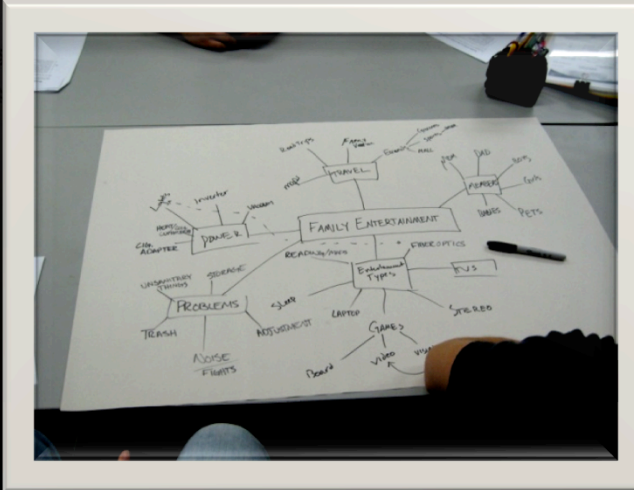
Mind Mapping



Brain Storming Results



Mind Mapping Results



OVERVIEW

FAMILY ENTERTAINMENT

TRAVEL

- Family Vacation
- Road Trips
- Maps
- Errands
- Grocery
- Sports - Soccer
- Mall

POWER

- Vacuum
- Inverter
- Hot/Cool Cup Holder
- Light Adapter
- Lights

MEMBERS

- Mom
- Dad
- Boys
- Girls
- Babies
- Pets

ENTERTAINMENT TYPES

- Fiber optics
- Sleep
- Laptop
- Games
- Board
- Video
- Reading/Maps
- TVs
- Stereo
- Visual - I-Spy

PROBLEMS

- Unsanitary Things
- Storage
- Trash
- Noise
- Fighting Kids
- Adjustment



OVERVIEW

TECHNOLOGY

TOUCH SCREEN (LARGE)

Fingerprint
Lock mechanism

Hidden as trim

Controls

UNIVERSIAL

Storage

Seating

UTILITY

Water Dispenser

Hot/Cool
Cup holder

PERSONAL COMFORT

INTERFACE

TRANSFORMATION

Personalization
(Customization)

SECURITY

Finger Print

CONNECTIVITY

USB

Wi-Fi

Bluetooth

PERSONAL ELECTRONICS

PDA

MP3

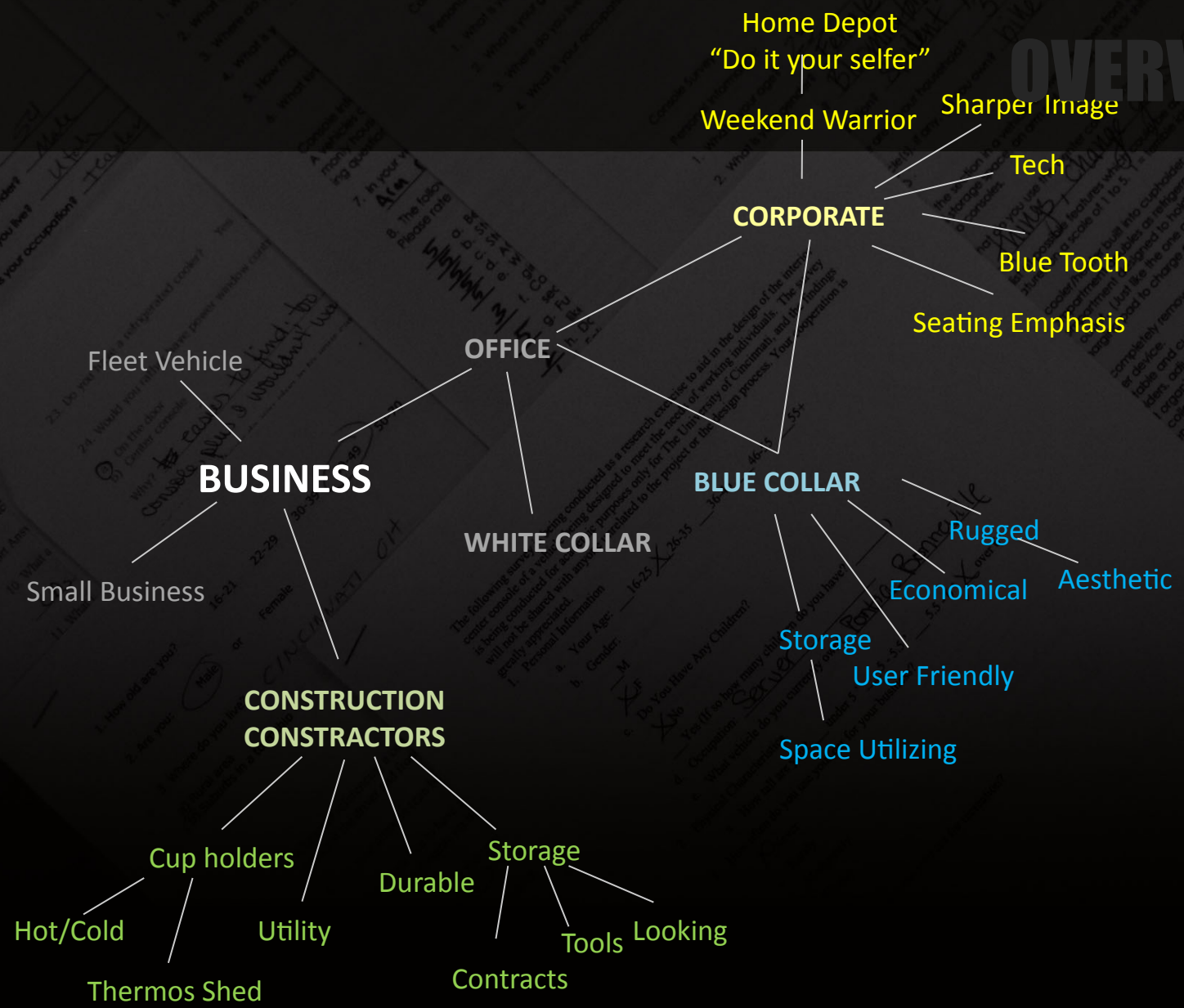
COMPUTERS

Dock

Documents

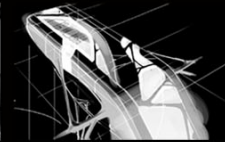


OVERVIEW



OVERVIEW

Weekly Collaborative Meetings



Benchmarking Study

Competitive analysis results from dealership visits

OVERVIEW

FORD
F150



CHEVROLET
TAHOE



TOYOTA
FJ CRUISER



LINCOLN
MARK LT



CHEVROLET
SILVERADO



CHEVROLET

CHEVY
TAHOE



CHEVROLET

NISSAN
MURANO



TOYOTA
LAND CRUISER



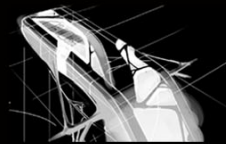
GM Moraine Plant Field Trip

October 26, 2007

OVERVIEW



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Moraine Assembly New Models

<http://www.chevrolet.com/trailblazer/photogallery/>



2001-present **Chevrolet TrailBlazer**



2001-present **GMC Envoy**



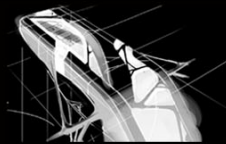
2004 – Present **GMC Envoy Denali**



GM Moraine Plant Handout

OVERVIEW

Balancing Center Console Design Requirements	Piece Cost	Investment Cost	Buildability - DFM (Assembly & Mfg.)	Part Proliferation/Build Combinations	Labor Impact (Attachment Design)	Assembly Plant Tooling	Error Proofing	Ergonomic Concerns	Vehicle Integration	Mass	Safety	Serviceability
Appearance												
Styling	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Color & Material Selection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Brand & Trim Level Uniqueness	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Function												
Cup Holders	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Storage	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Emergency Brake	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gear Shift	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Option Content	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Interface to IP & its functions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Quality												
Interior Fit & Finish	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Squeak & Rattle	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Harmony	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reliability												
Material Durability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Validation Requirements-Functional & Environmental	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓



OVERVIEW

Survey Overview



The Survey

Total number of respondents: 327

OVERVIEW

Student Name	Number of Respondents
Jonathan Wicks	31
Thomas Gernetzke	31
Bradley Smith	31
Laura Reilly	31
Andrew Kreyenhagen	31
Curtis Wilson	32
Clay Mastin	30
Lukas Yates	46
Ryan Wohleber	33
Jason Fuller	31



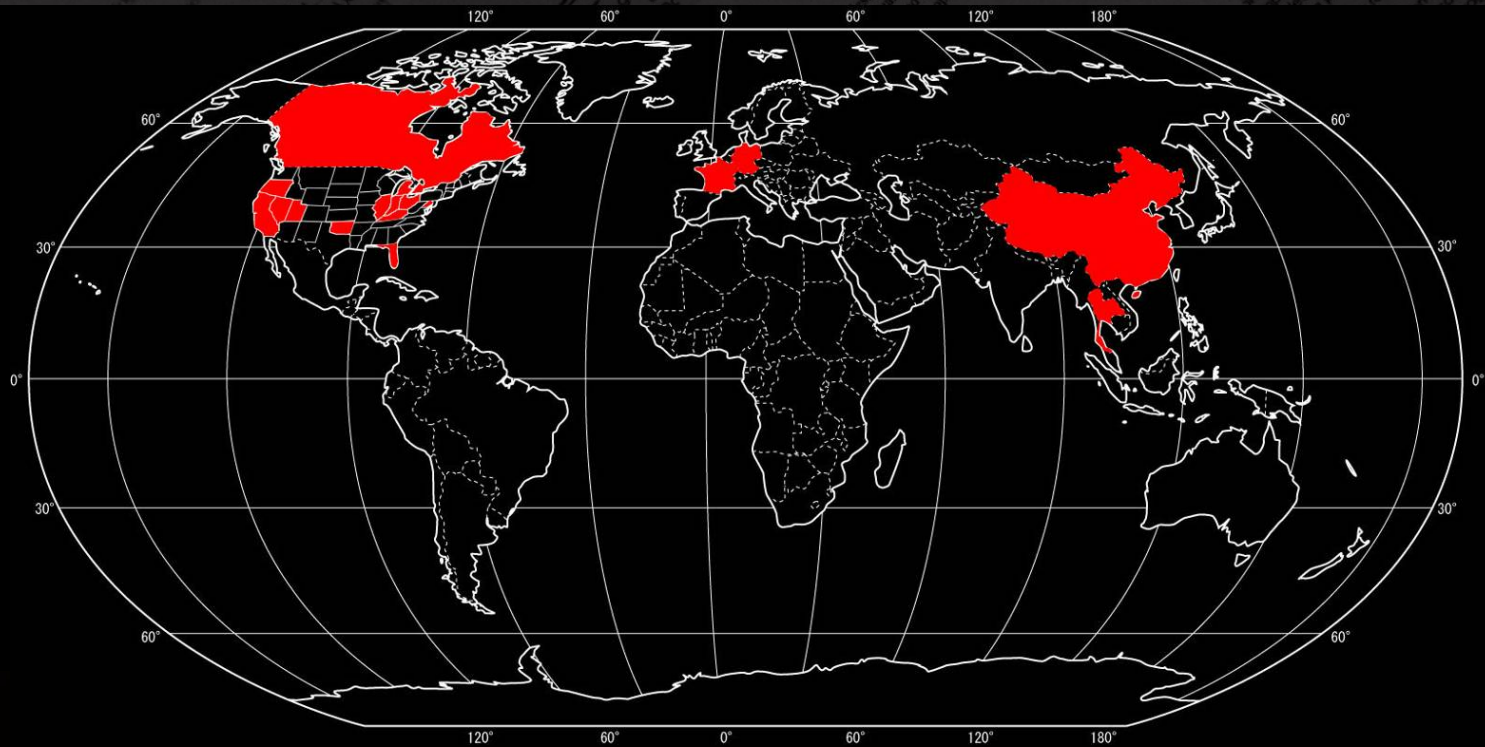
Survey Samples

6 countries surveyed

OVERVIEW

France
Germany
Canada

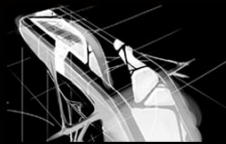
China
Thailand
USA (12 states)



Sample of Features from Surveys

OVERVIEW

- Phone Charger
- Contact Solution
- Cologne
- Hand Sanitizer
- Check Book
- Letters
- Bank Slips
- CDs
- Pens
- Post-Its
- Note Paper
- Cell Phone
- Gum
- Change
- Tools
- Sun Glasses
- Cassette Tapes
- Condoms
- Personal Razors
- Deodorant
- Map
- Keys
- Gloves
- Comb
- Cleaning Wipes
- iPod
- Hair Clips
- Insurance Information
- Vehicle Registration
- Tire Pressure Gauge
- Drinks
- FM Transmitter
- Cigarettes
- Napkins / Tissues
- Purse / Bag
- Writing Tools
- Harmonica
- Ice
- Medical Pack
- Bottles, Pacifier
- Toys for Kids
- Sketch Book
- Lotion
- Air Freshener
- Cosmetics
- Garbage
- Money / Coin holder
- Food (Snacks)
- Mints
- Lighter
- Radar Detector



OVERVIEW

Usability of console

Storage: 98%

Best full size truck (score 1-6)

GM: 5.53
Ford: 4.33
Chrysler: 3.50
Toyota: 3.37
Nissan: 2.09
Honda: 1.78

Recyclability concerns

Very important: 74%

Note: 96% would pay 5% more for a vehicle with recycled materials.

GPS

74% wanted GPS



TECHNOLOGY

Tom Gernetzke
Co-Captain: Technology
Major: Industrial Design



TECHNOLOGY

Technology



Clay Mastin

Ryan Wohleber

Tom Gernetzke

Phil Weckesser

Ben Stayton

CONNECTS TO
CHAIR BACK



Survey Results of Technology Features

TECHNOLOGY

86% wanted AC/DC power outlet

52% wanted personal computing (music, scheduling, etc.)

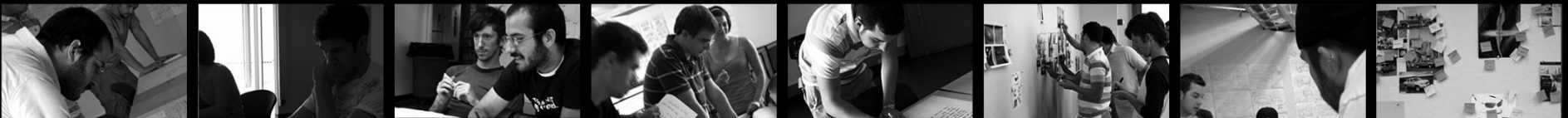
74% wanted touch screen interface for major cabin controls (temperature settings, music selection, etc.)

72% wanted removable hard drive which could be connected to a PC or truck's onboard computer (enabling easy music transfer, online CPU diagnostics, etc.)

74% wanted customizable technology

68% wanted charging pad

58% wanted cell phone interface



TECHNOLOGY

MP3 interface options should be improved

65% wanted technology integrated into console

2.5 was the average number of electronics carried in the vehicle

CONNECTS TO
CHAIR BACK

78% wanted digital storage

#1 desired feature was AC/DC power outlet



Features designed

Technology

TECHNOLOGY

Solid state removable hard drive 32 GB

Interface with existing display on the instrument panel

Small/portable device

Vehicle diagnostics

Repair estimates, fuel consumption, etc.

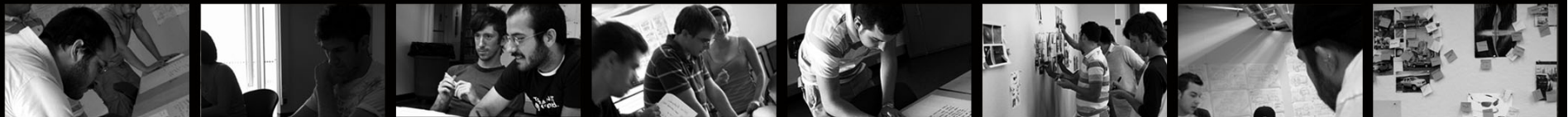
Dual Function: Interface with vehicle and personal data used with PC

Security system

Music files

AC outlet and USB interface

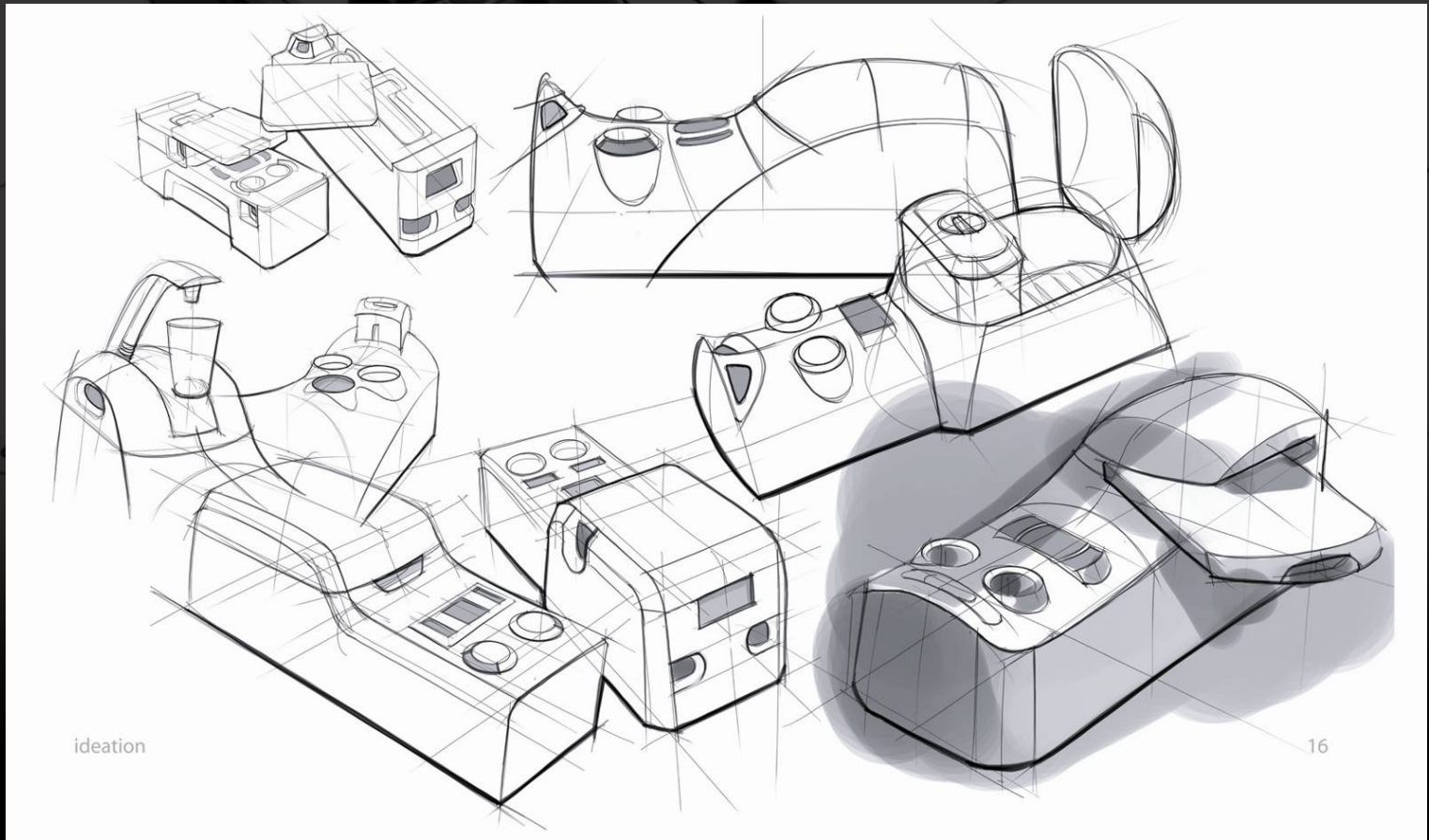
CONNECTS TO
CHAIR BACK



Industrial Design Ideation Sketches

Technology

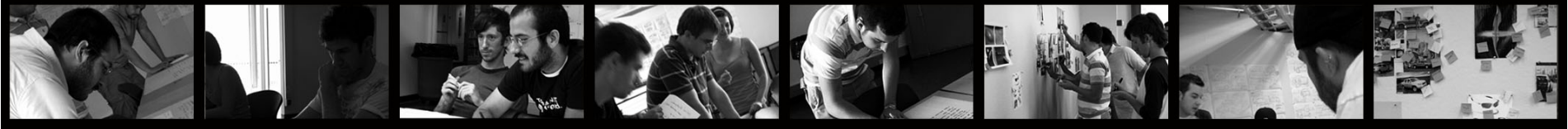
TECHNOLOGY



CONNECTS
CHAIR & BAR

ideation

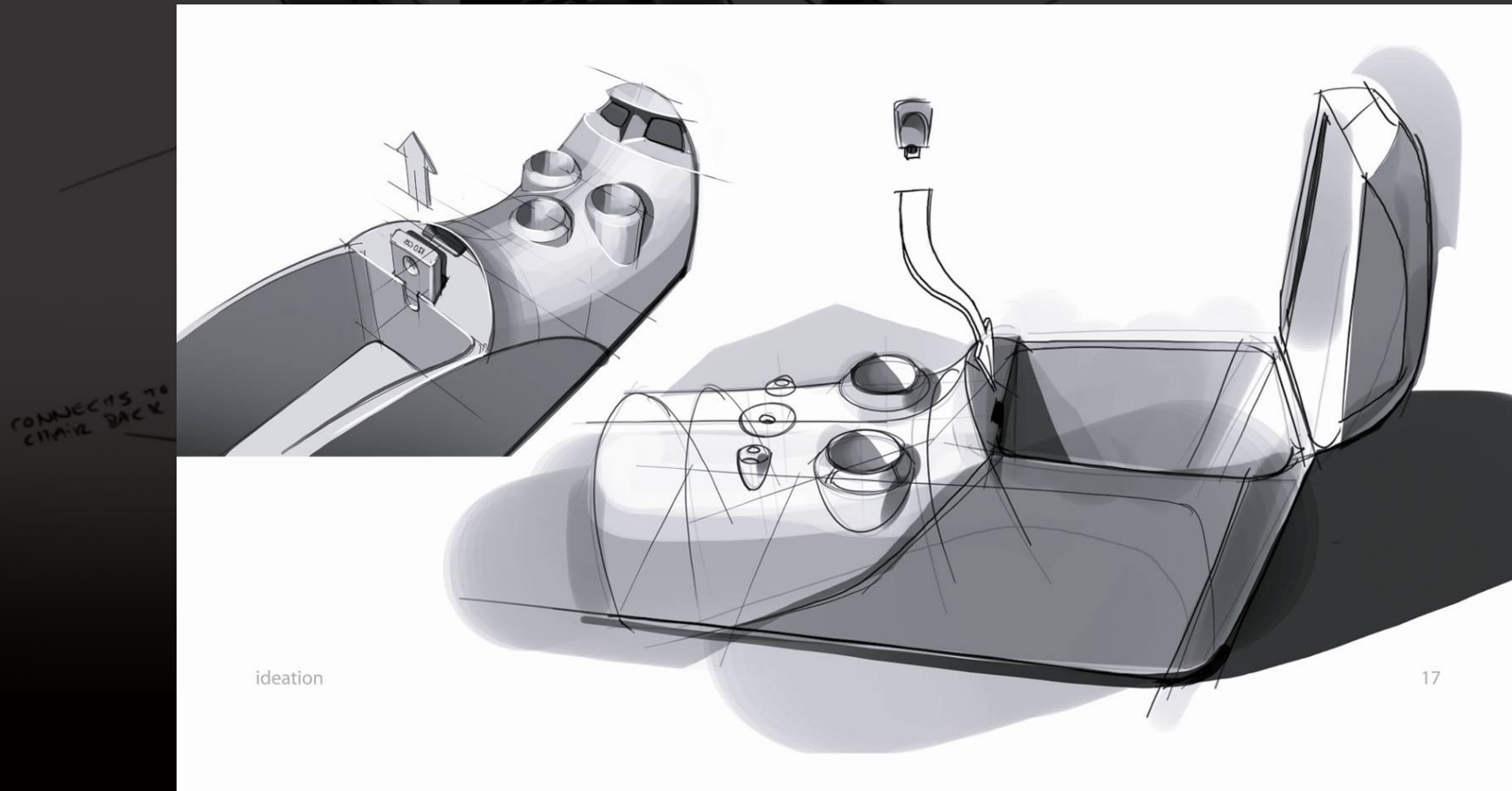
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Industrial Design Ideation Sketches

Technology

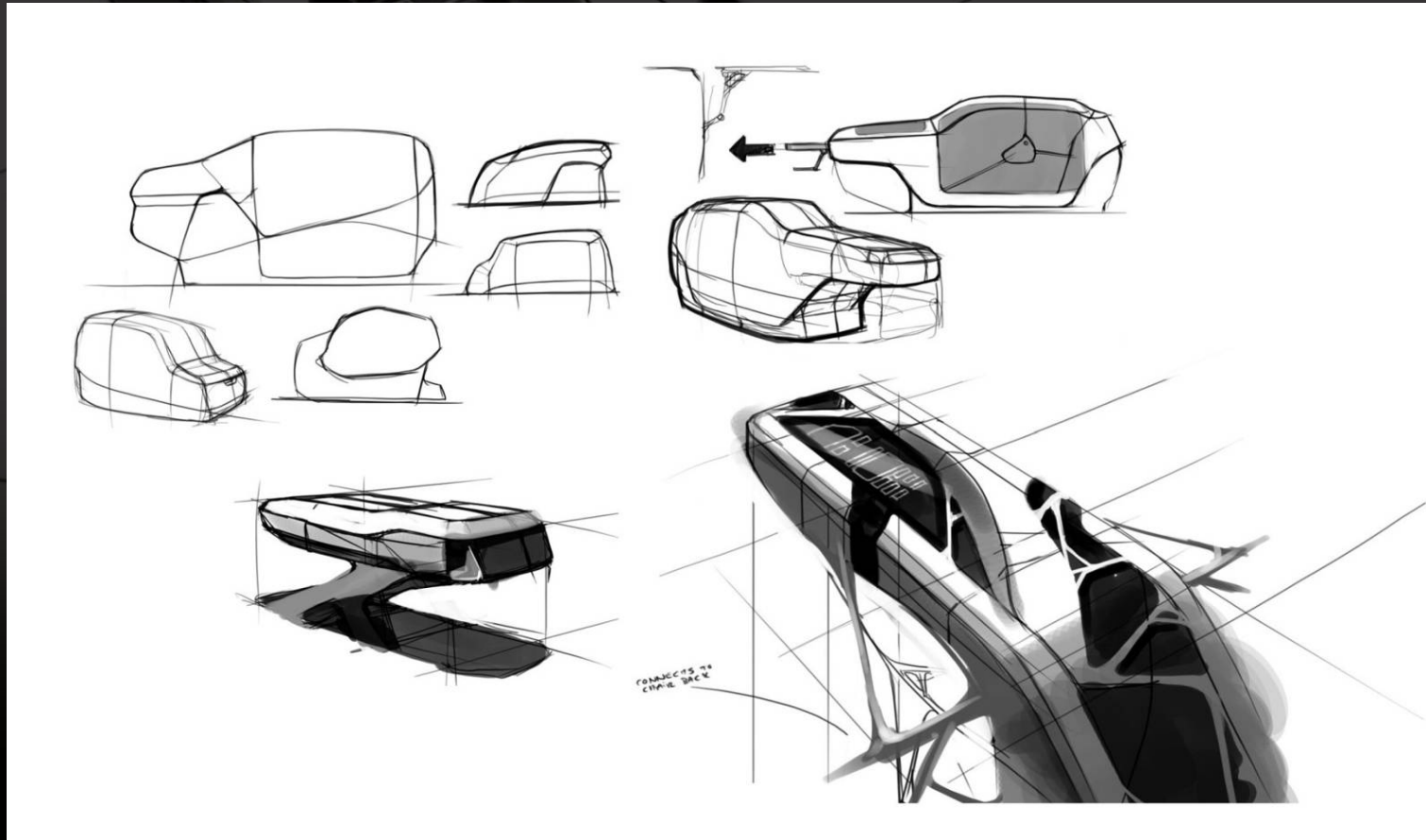
TECHNOLOGY



Industrial Design Ideation Sketches

Technology

TECHNOLOGY



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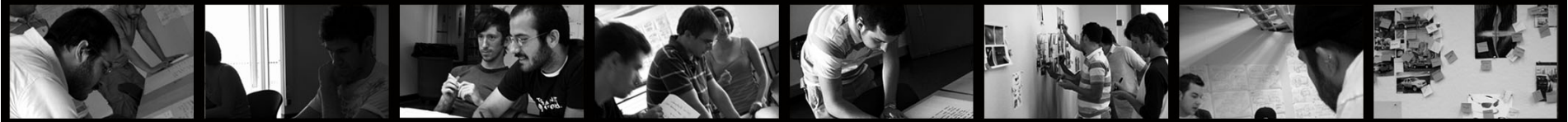
Design Proposal

TECHNOLOGY

Technology: removable solid state drive, AC outlet, and USB ports



CONNECTS TO
CHAIR BACK

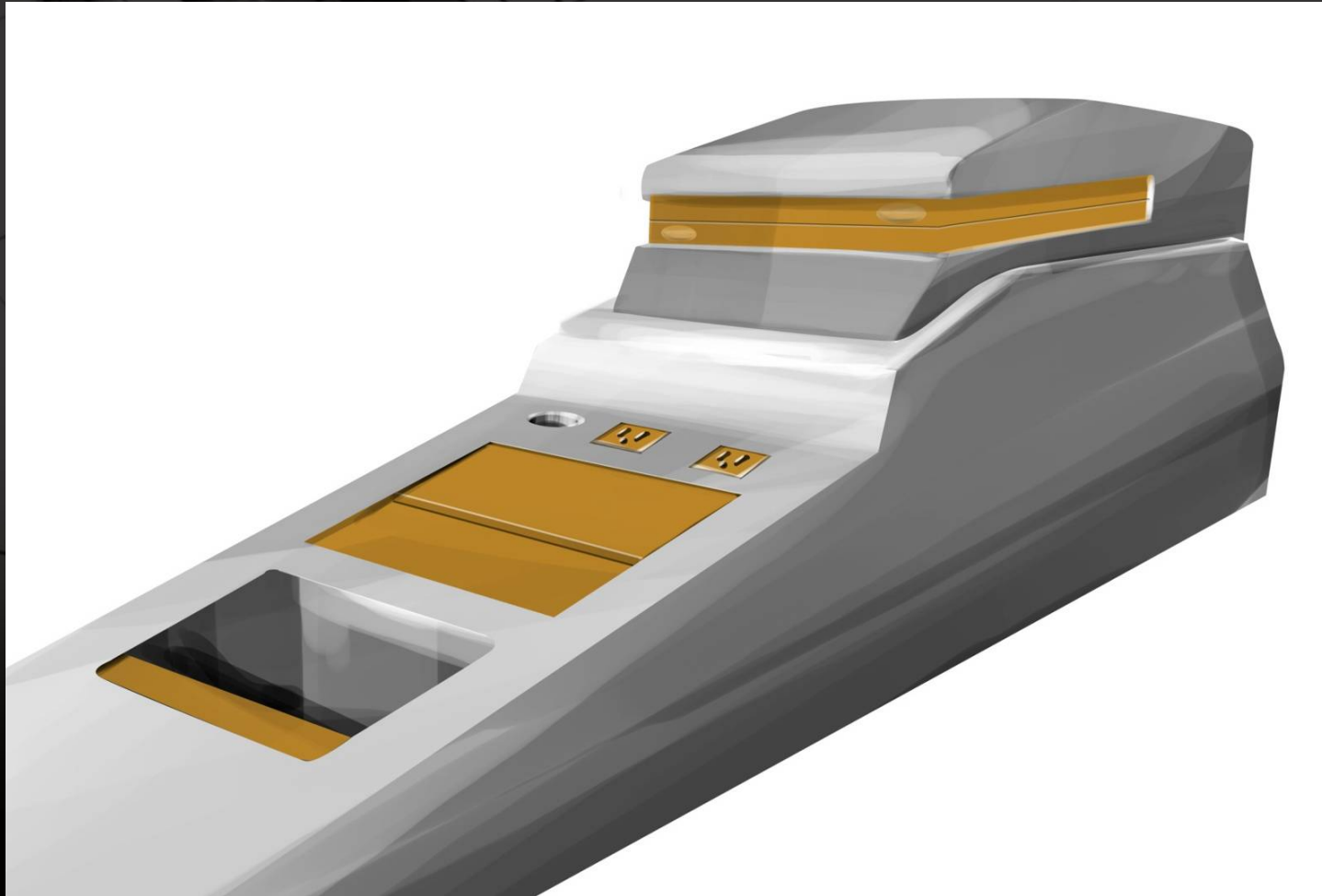


Design Proposal

Technology: removable solid state drive, AC outlet, and USB ports

TECHNOLOGY

CONNECTS TO
CHAIR BACK



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Design Proposal

Technology: removable solid state drive, AC outlet, and USB ports

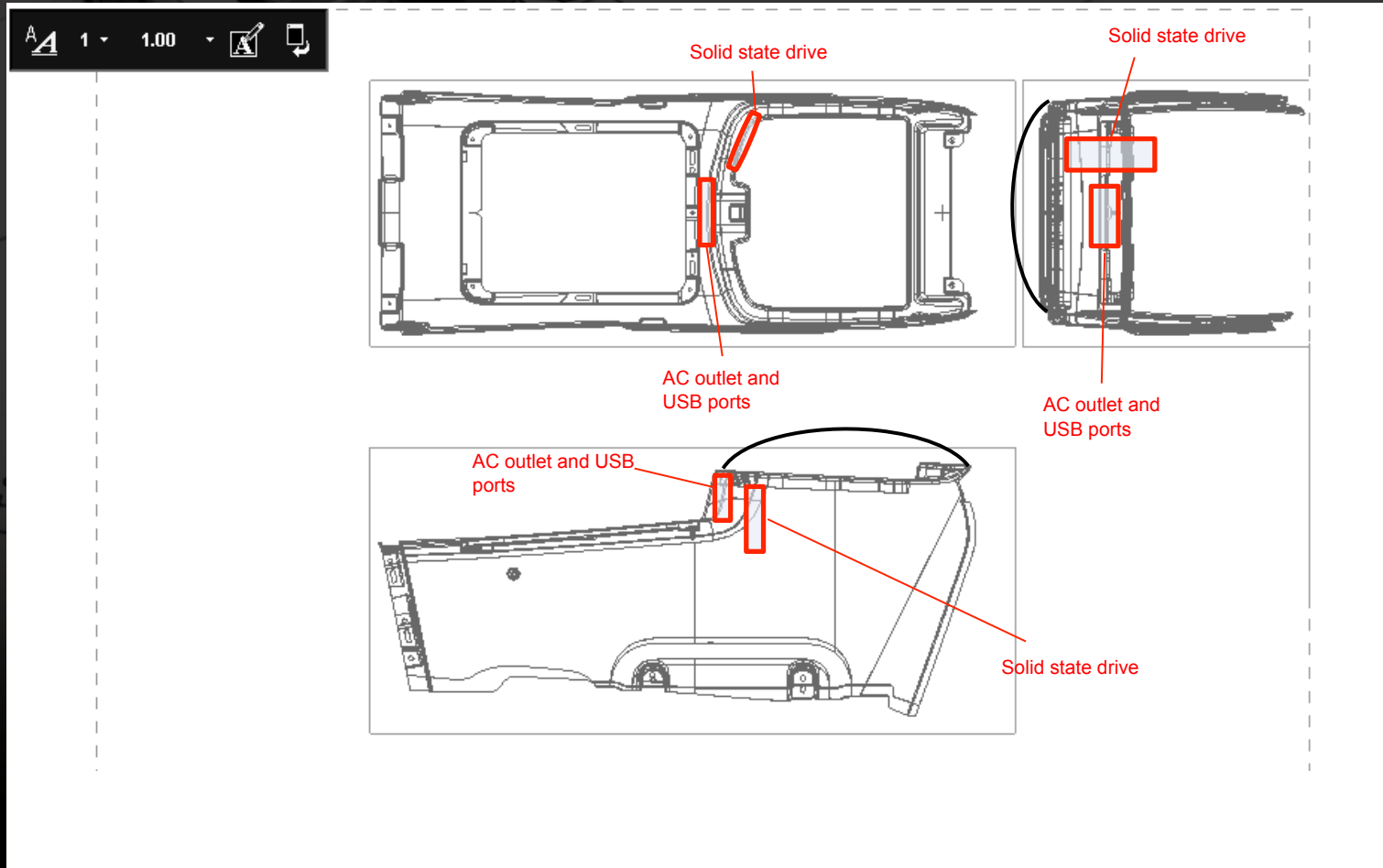
TECHNOLOGY



Feature Positioning

Technology: removable solid state drive, AC outlet, and USB ports

TECHNOLOGY



CONNECTS TO CHAIR BACK



TECHNOLOGY

Ben Stayton

Co-Captain: Technology

Major: Mechanical Engineering

CONNECTS TO
CHAIR BACK



Design Process

TECHNOLOGY

Removable hard drive restrictions

- Capacity
- Dimensions
- Portability
- Cost

32 GB

1.8" form factor

Solid state drive

Final Dimensions: 72.26 mm x 55.27 mm x 12.5 mm

CONNECTS TO
CHAIR BACK



NX5 Procedure

Technology

TECHNOLOGY

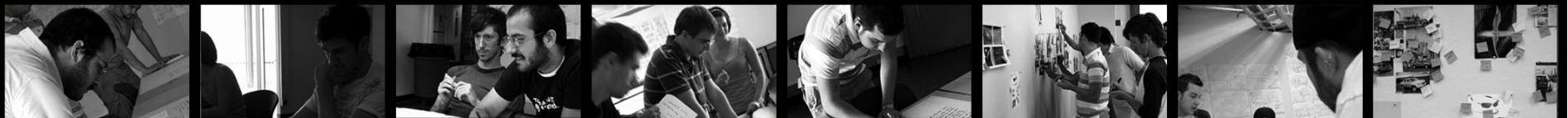
Hard disk

- Creation of housing architecture
- Additional pocket for placement
- Features
 - Removable
 - USB connectivity
 - Thumb grip
 - Modular

CONNECTS TO
CHAIR BACK

Outlet

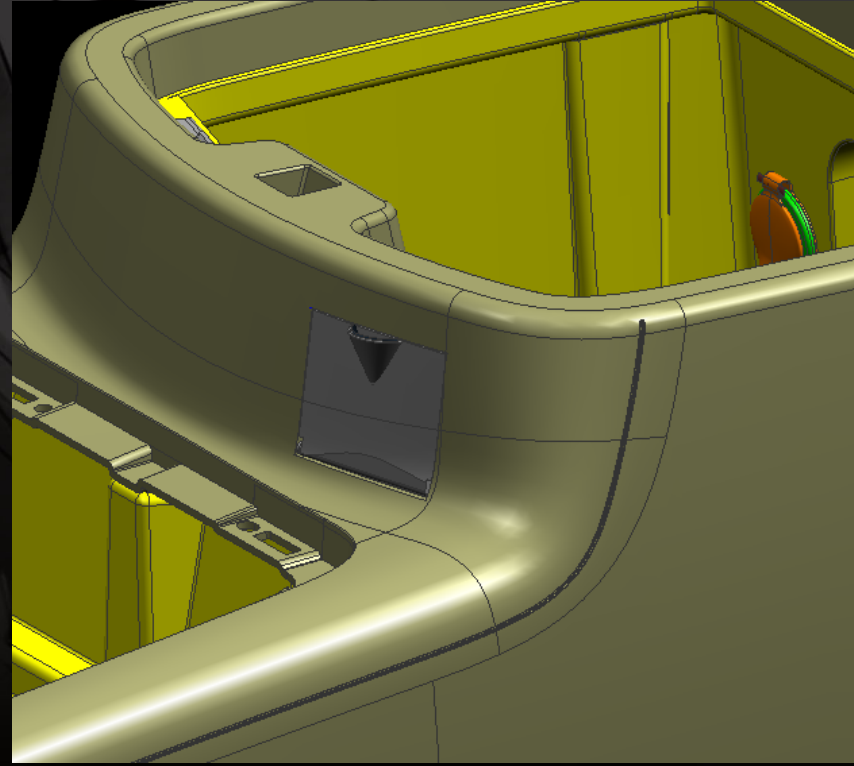
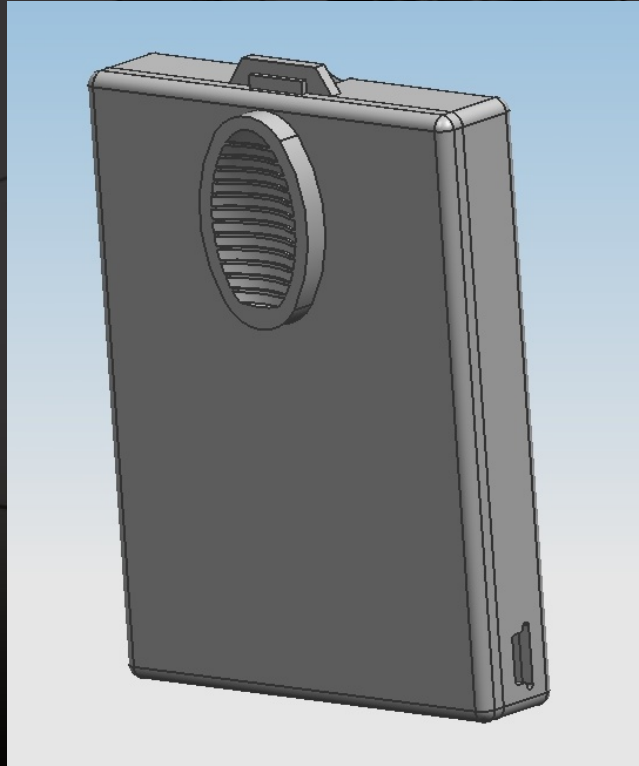
- 110-120V / 60 Hz electrical receptacle
- Additional USB ports



NX5 Models

Technology

TECHNOLOGY



Finite Element Analysis Results

Technology

TECHNOLOGY

Solid State Drive

Parameters

- 1 Watt power generation (with a safety factor of 2.0) spread over interior faces, $1.06 \mu\text{W}/\text{mm}^2$
- Ambient temperature $20 \text{ }^\circ\text{C}$
- Initial temperature $26 \text{ }^\circ\text{C}$
- Maximum temperature of $26.17 \text{ }^\circ\text{C}$ at bottom
- Minimum temperature of $21.35 \text{ }^\circ\text{C}$ at top

CONNECTS TO
CHAIR BACK

Electrical Outlet Cover

Parameters

- 1,000N side load

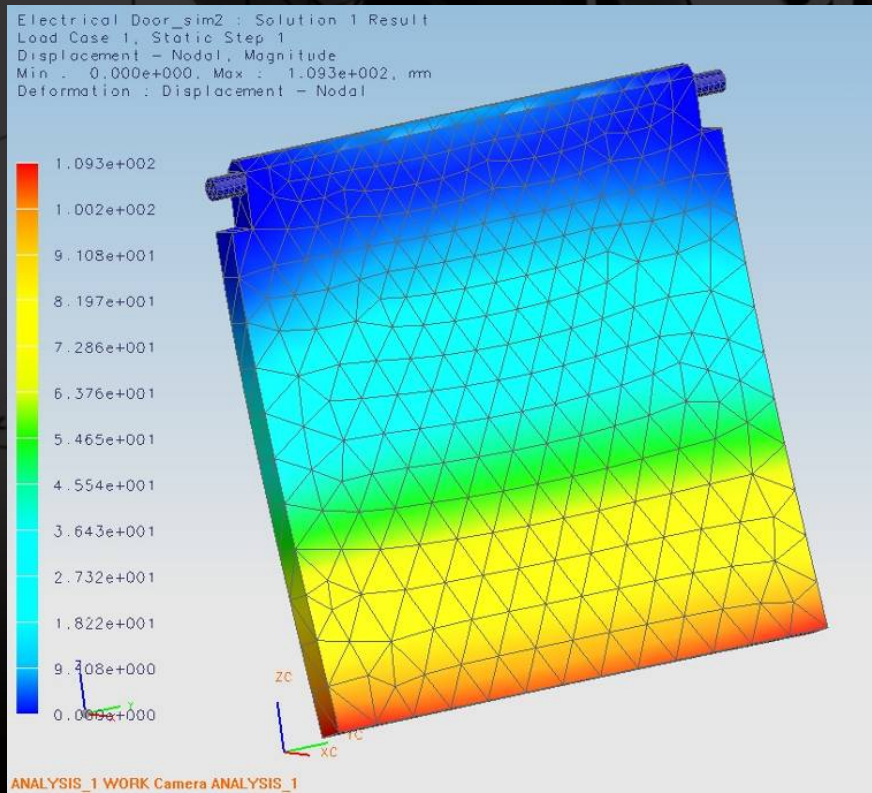


Finite Element Analysis Results

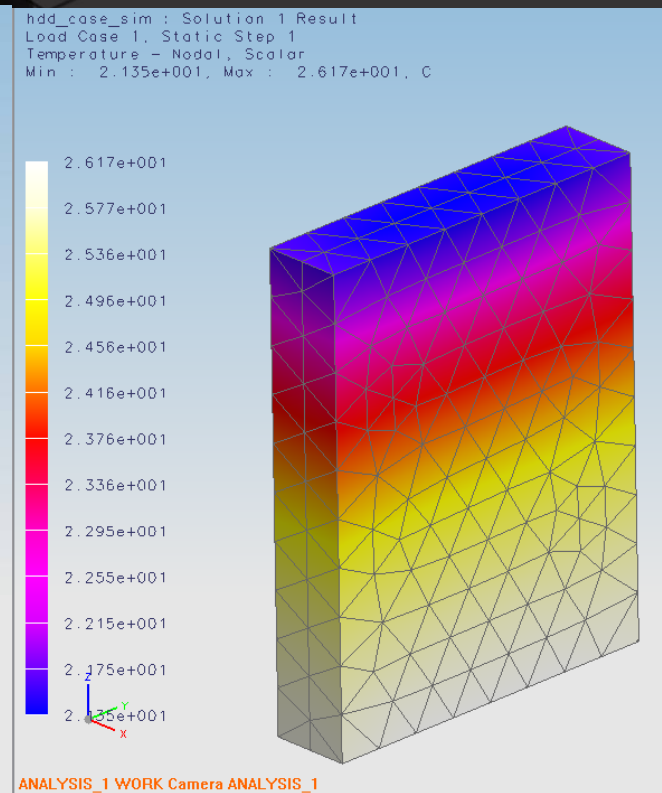
Technology

TECHNOLOGY

Electrical Door Hinge Stress



Solid State Drive Thermal Analysis



FAMILY

Jonny Wicks

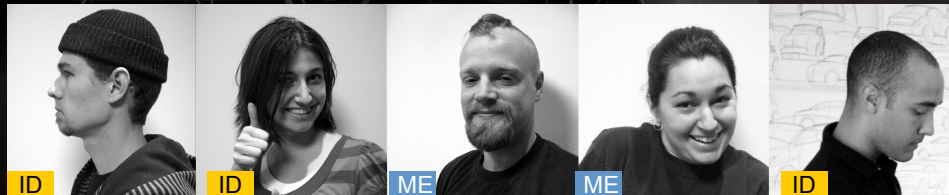
Co-Captain: Family

Major: Industrial Design

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Family



ID Jonny Wicks

ID Laura Reilly

ME Robin DeJager
-Kennedy

ME Maria Totterdale

ID Jason Fuller



Survey Results of Family Features

General comment

“The map light is hard to deal with because it’s on the rearview mirror and lights up the entire dash.”

Additional survey results

83% wanted flex light

58% wanted removable safety light



Features designed

Family

Removable LED light

- Battery-powered
- Detachable flexible neck stores in console
- Multiple intensity levels
- Flashes for distress signaling
- 0.5" maximum diameter
- Safety considerations for driver visibility etc.

Retractable LED light

- Lights for second-row passengers
- Flexible neck

Thermoelectric cup holders

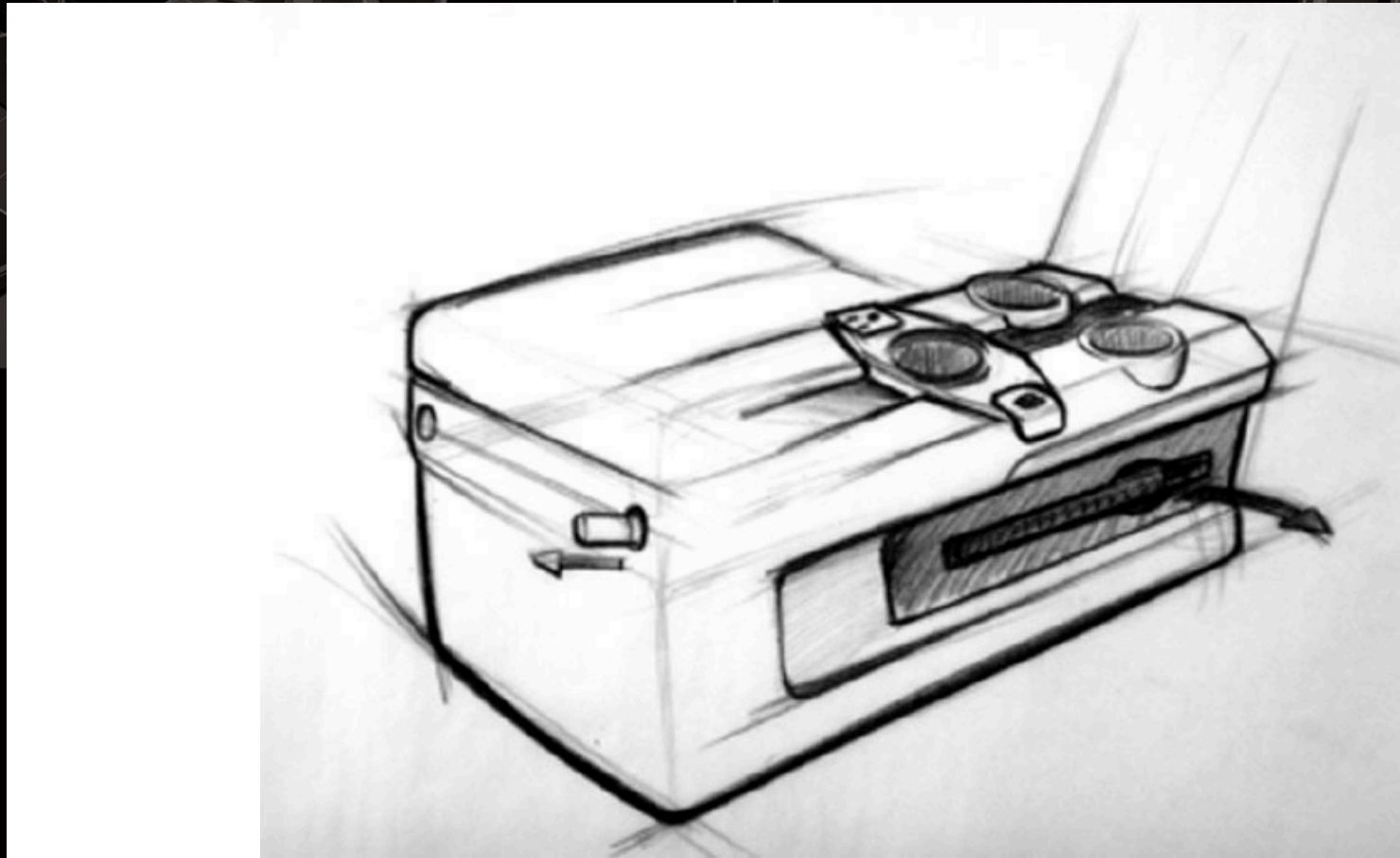
- Heat and cool beverages
- Inserts removable for cleaning



Industrial Design Ideation Sketches

Family

FAMILY



Design Proposal

Family: LED lights, thermoelectric cup holders

FAMILY



CURRENT CONSOLE + FEATURES



Design Proposal

Family: LED lights, thermoelectric cup holders

FAMILY



Design Proposal

Family: LED lights, thermoelectric cup holders

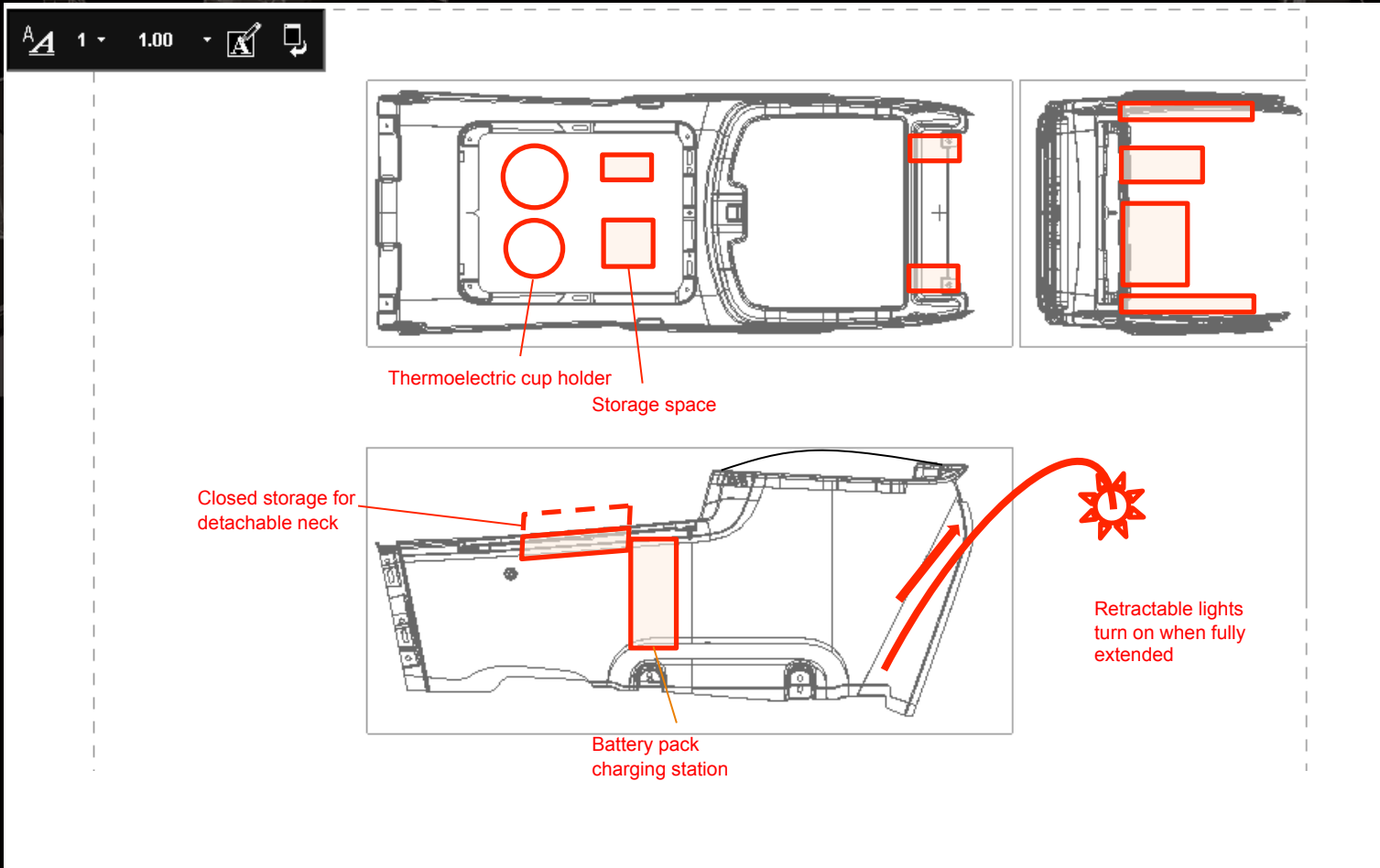
FAMILY



Family

Family: LED lights, thermoelectric cup holders

FAMILY



FAMILY

Rob DeJager-Kennedy

Co-Captain: Family

Major: Mechanical Engineering

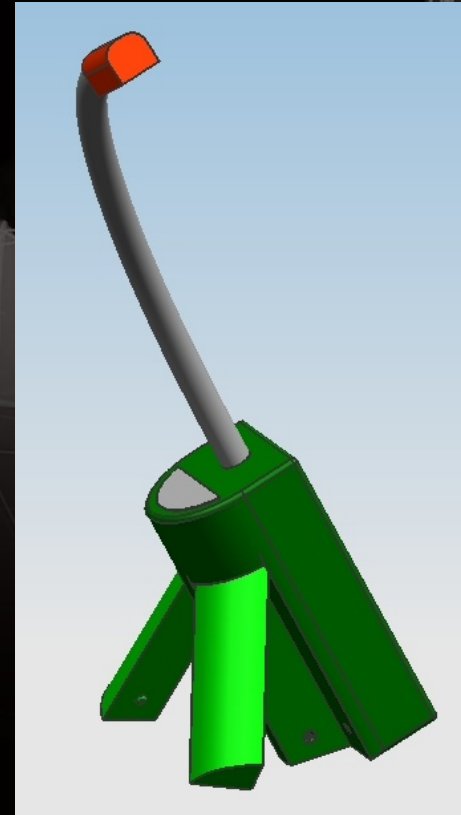
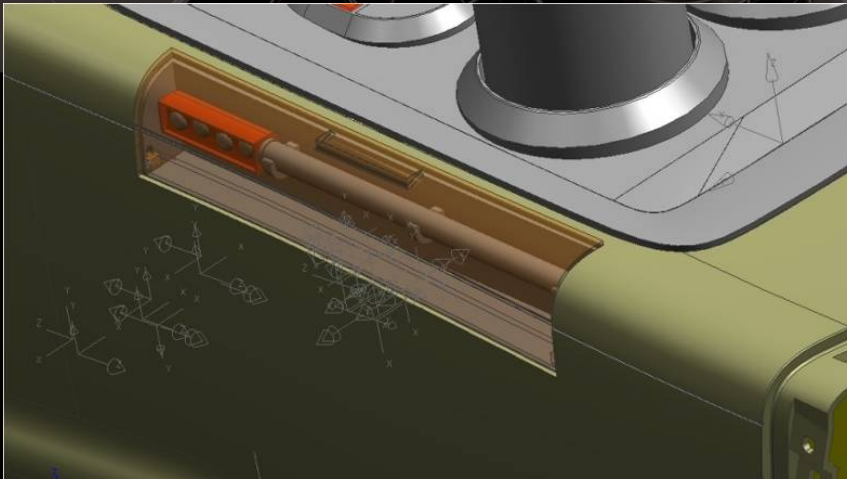


Design Process

Family

Removable Light

- Case
 - Hand-held, magnetic, freestanding
- Neck
 - Length, removable for storage
- Head
 - Geometry, LED design
- Interface with Console
 - Locking mechanism, spring release



Closed Storage for Removable Neck

- Consistent with existing geometry
- Door motion is accessible to both passenger and driver

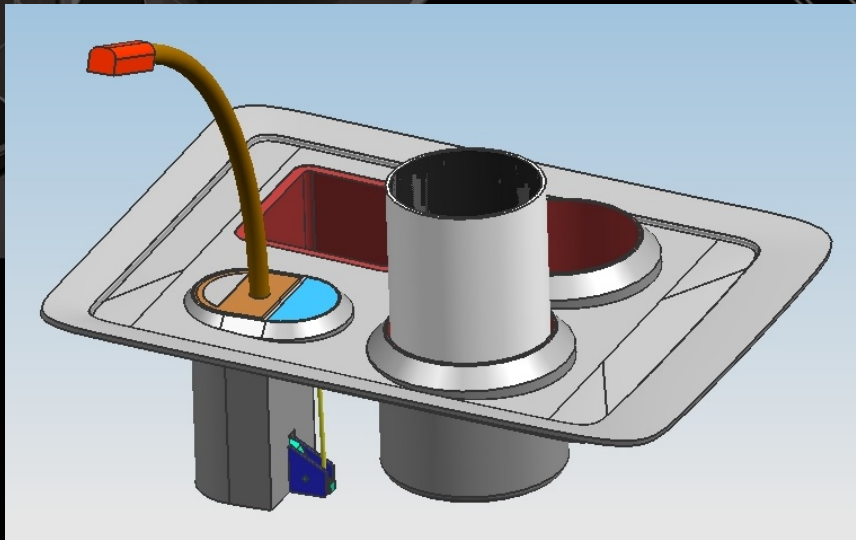


Design Process

Family

Front Console Insert Assembly

- Thermoelectric cup holders
- Incorporate features into existing space
- Positioning of features



Retractable Second Row Lighting

- Lights store flush in console
- Turn on when fully extended

FAMILY

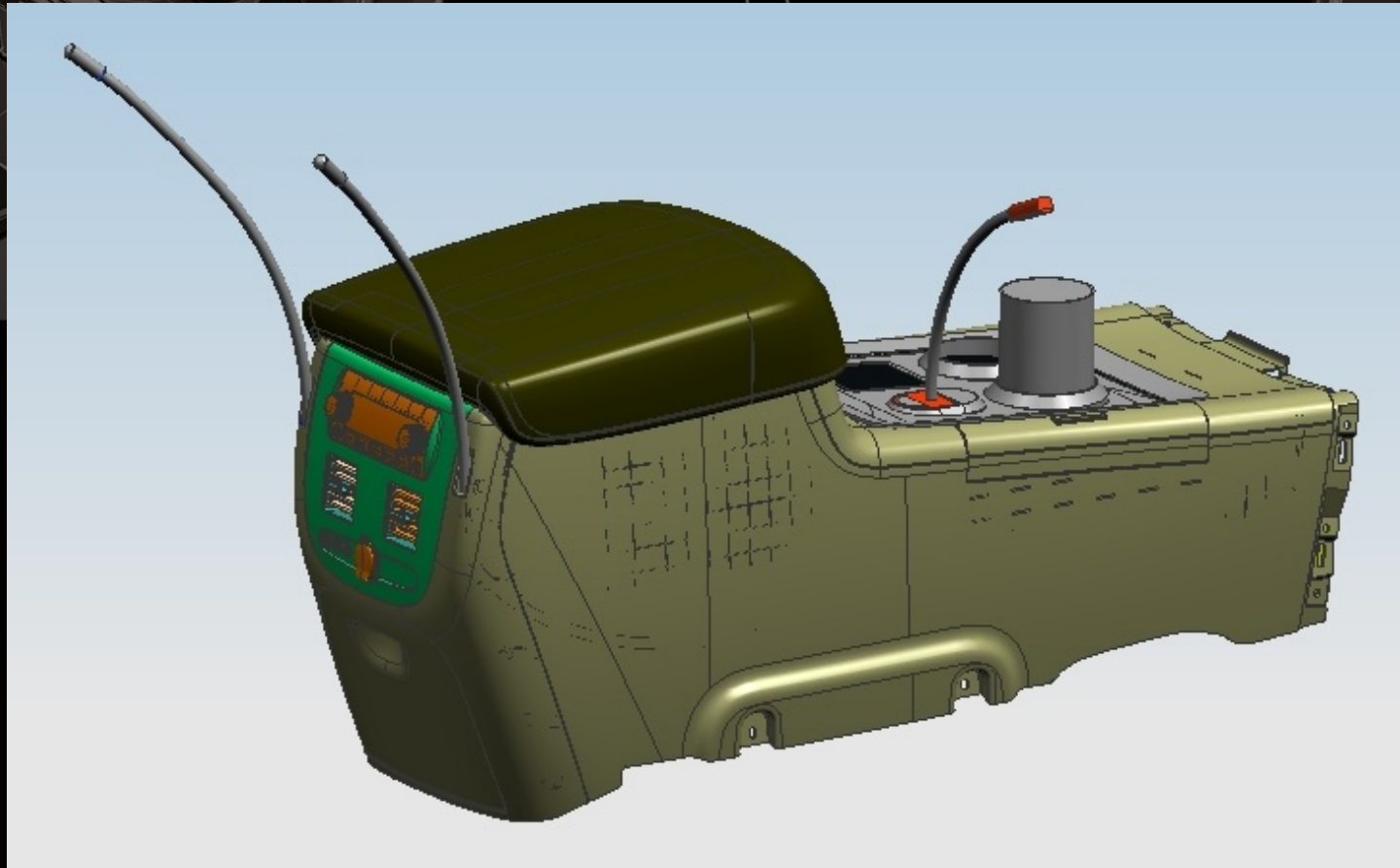


NX5 Models

Family

Overview of full assembly

FAMILY



Completed Analysis

Family

FAMILY

Light release

- 1.5 inches pop-up when released
- 3 lbf required, thus requires 2lbf/in spring
- Motion simulation performed on latch mechanism
- No interferences found

Light lid

- FEA stress analysis performed
- Used friction coefficient of 0.39 on pins

Front insert

- Overall assembly
- Exploded view/sequence



Finite Element Analysis Results

Family

Thermal heating

5 $\mu\text{W}/\text{mm}^2$ used on cup sides

10 $\mu\text{W}/\text{mm}^2$ used on coffee

21 C used as initial temperature

15 C used as ambient temperature

Minimum temperature at top and sides 13 C

Maximum temperature at bottom 53 C

Natural convection will even temperature out

Power required for thermoelectric is 0.64 Watts

Thermal Cooling

5 $\mu\text{W}/\text{mm}^2$ used on cup sides

10 $\mu\text{W}/\text{mm}^2$ used on coffee

26 C used as initial and ambient temperatures

Maximum temp at top 25 C

Minimum temp at bottom -3 C

Natural convection will even temperature out

Power required for thermoelectric is 0.96 Watts

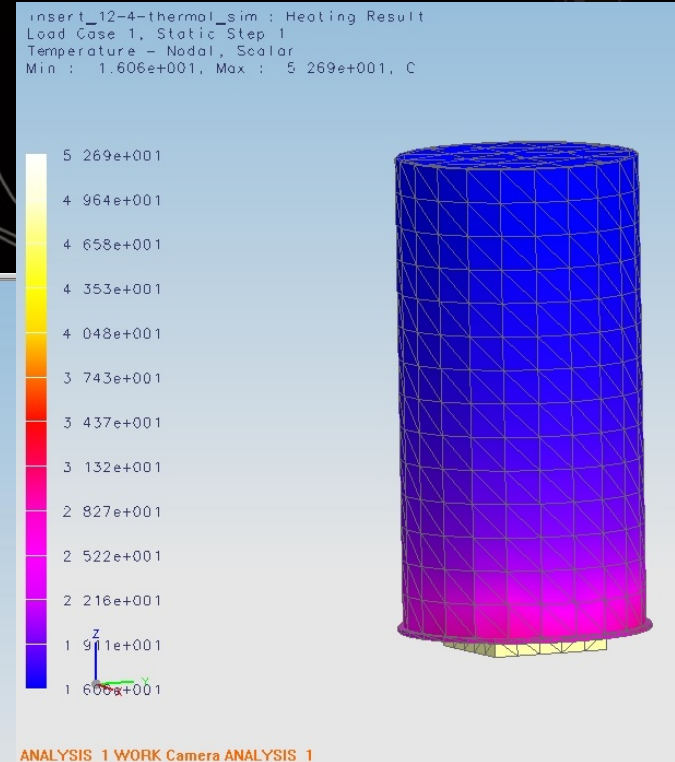
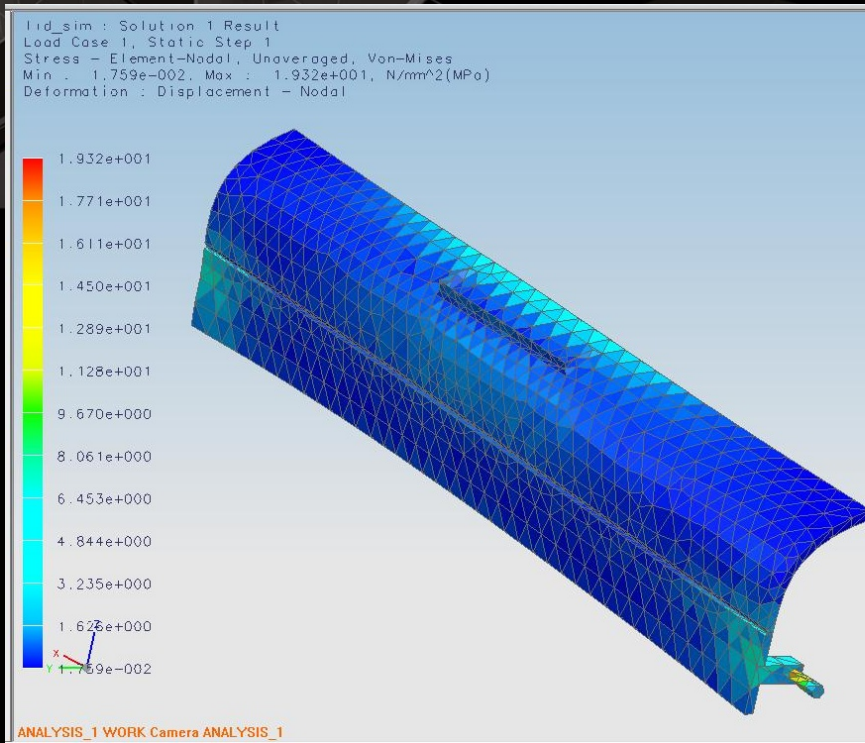
FAMILY



Finite Element Analysis Results

Family

Stress on Lid



Beverage Heating



BUSINESS

Lukas Yates

Co-Captain: Business
Major: Industrial Design

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BUSINESS

Business



Brad Smith

Jeremy Briggs

Curt Wilson

Curtis Forquer

Lukas Yates

Andrew Kreyenhagen



Survey Results of Business Features

45% thought it is important to have my computer in car

94% wanted a fold out surface to write on and/or a surface to hold a laptop computer



Features designed

BUSINESS

Business

- Retractable table slides in front of driver or passenger
- Push to open, push to close
- Soft rubber edge
- Clipboard or laptop
- Take out existing pocket in top of lid
- Translucent, lights up

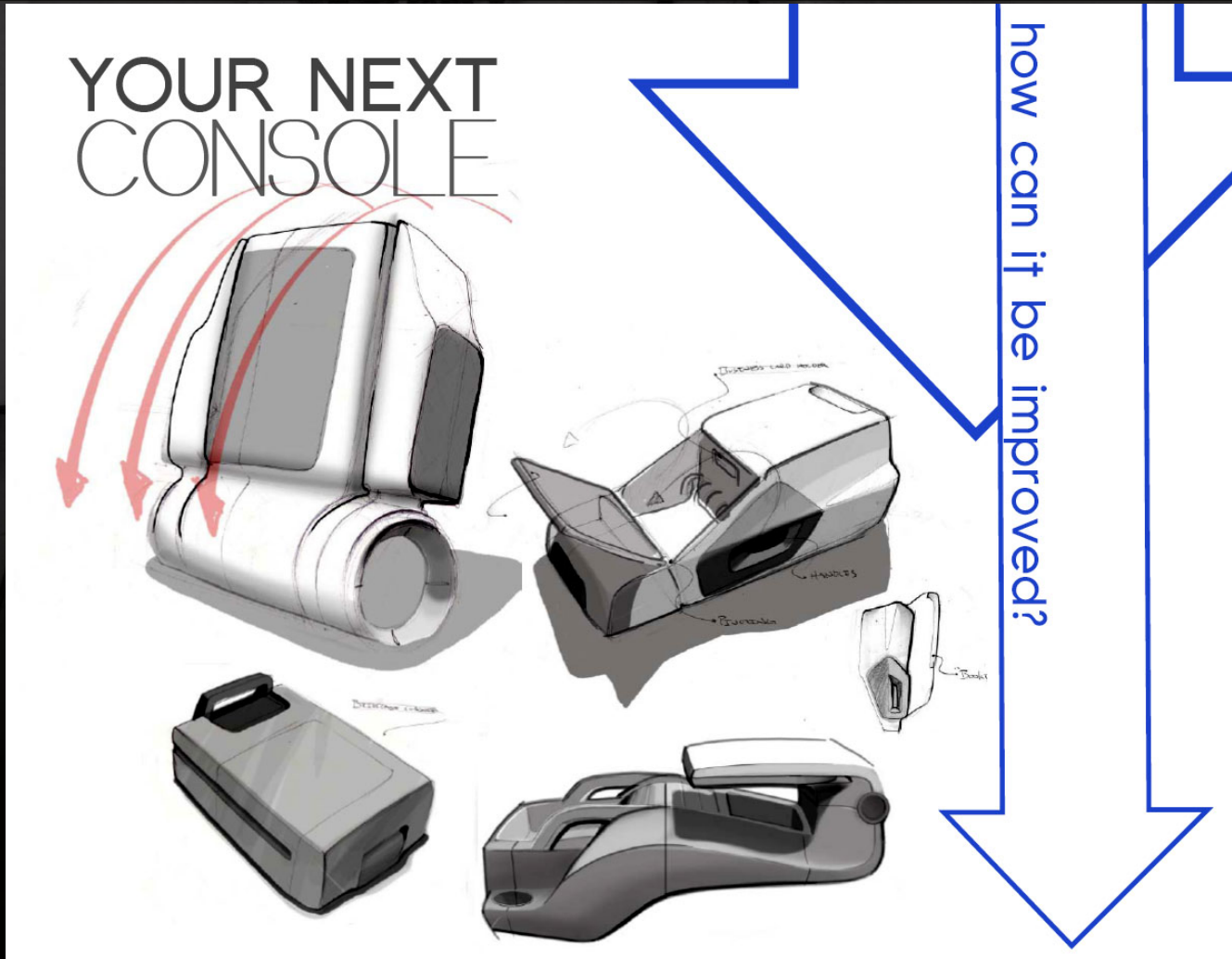
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Industrial Design Ideation Sketches

Business: In-console work surface

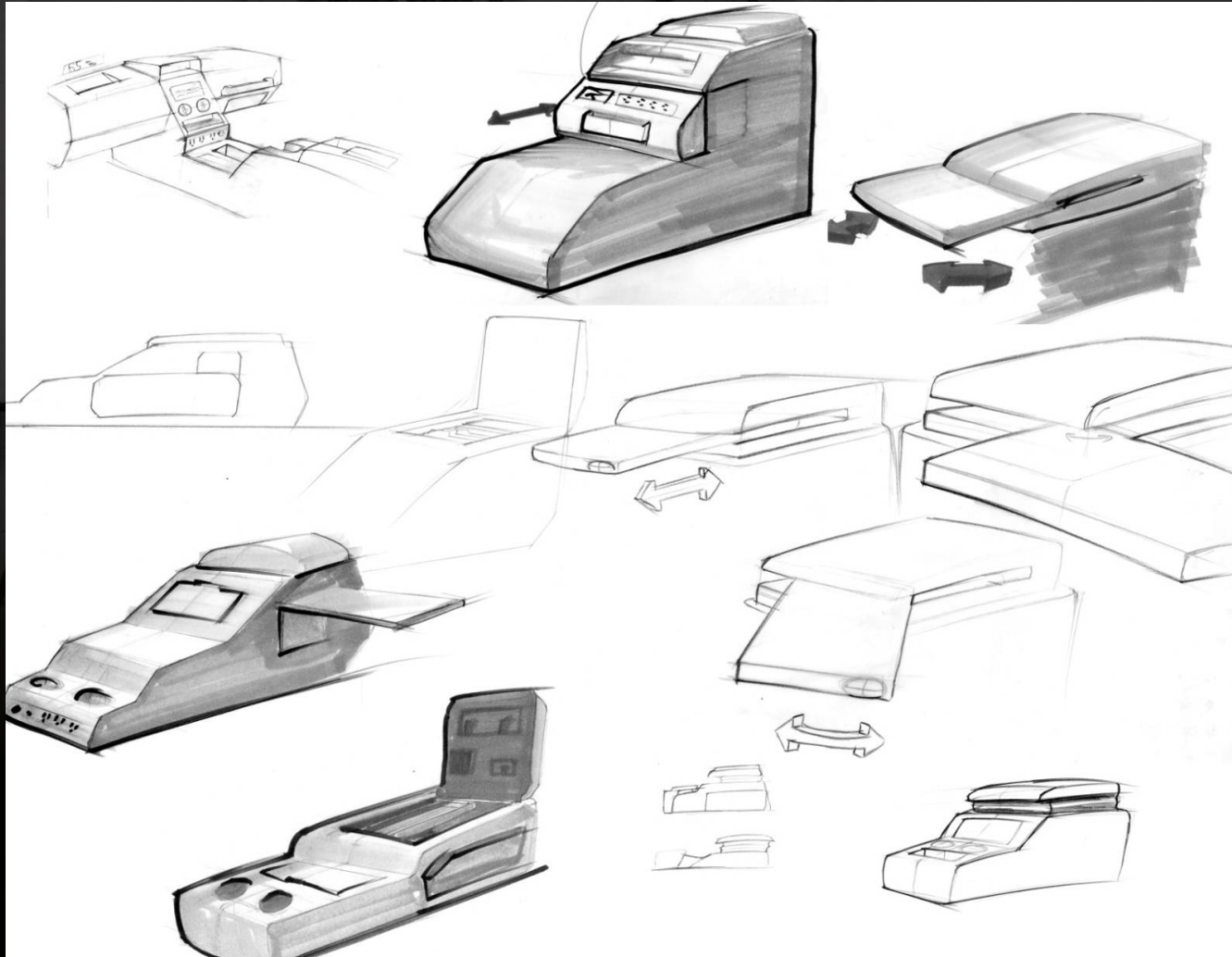
BUSINESS



Industrial Design Ideation Sketches

Business: In-console work surface

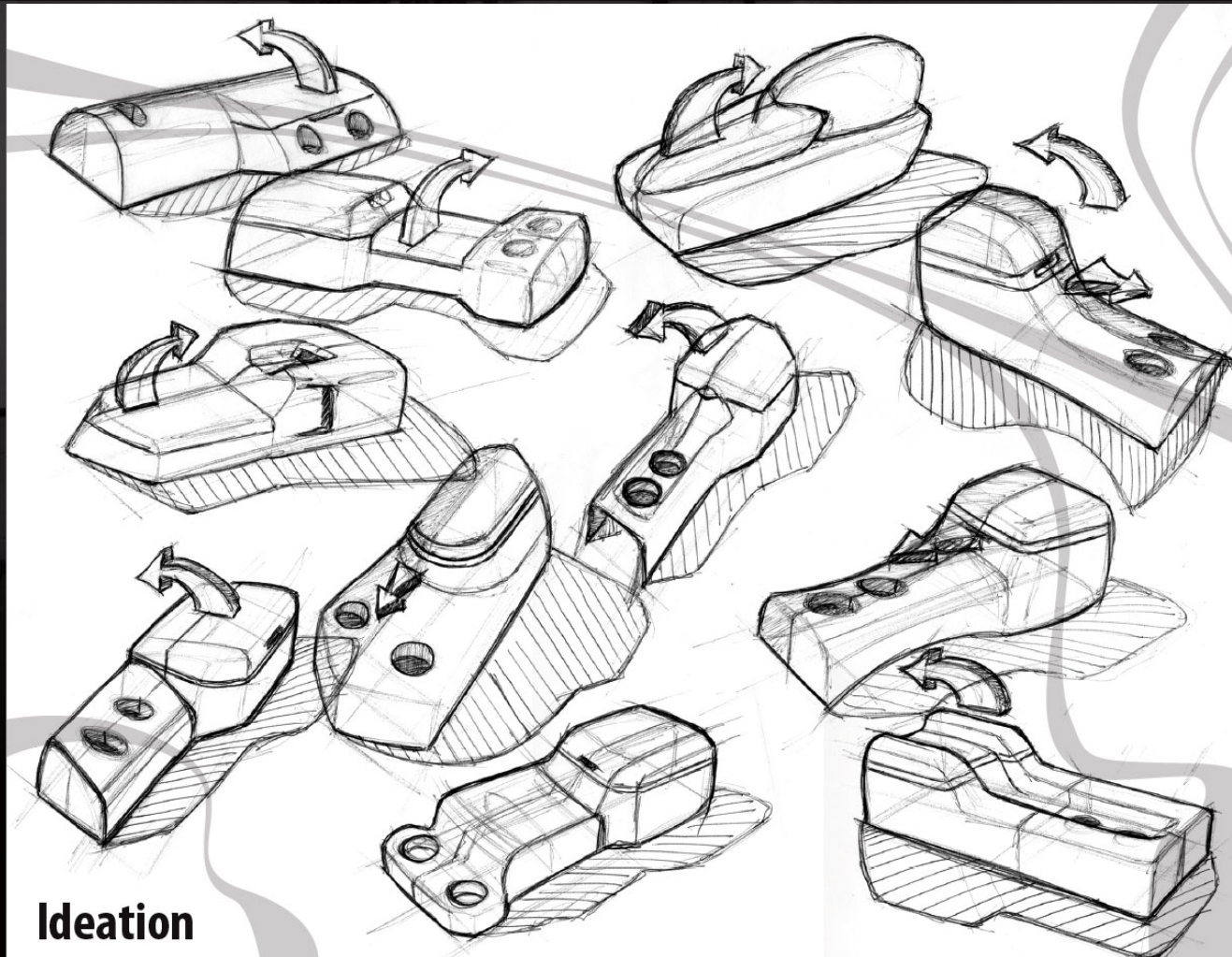
BUSINESS



Industrial Design Ideation Sketches

Business: In-console work surface

BUSINESS



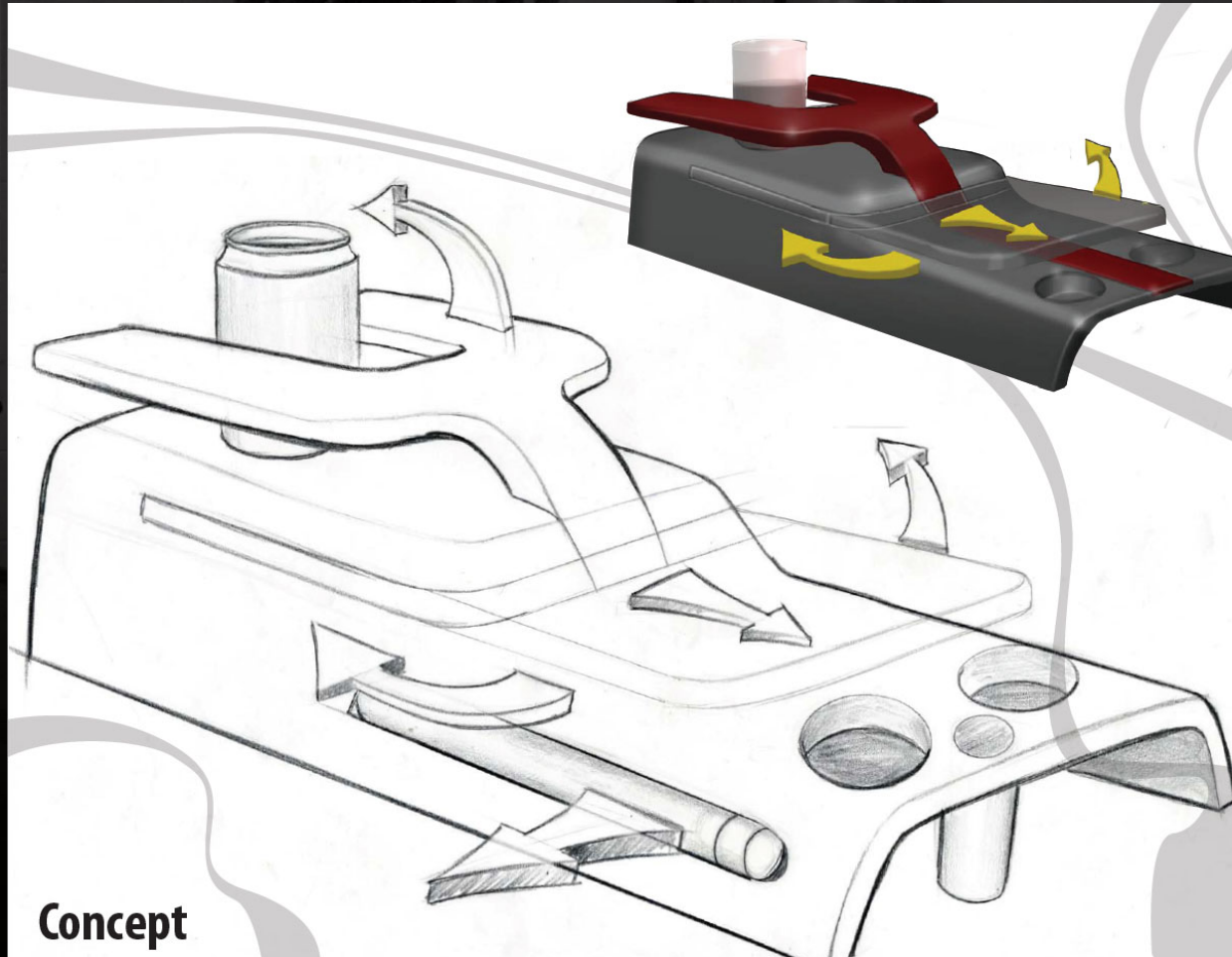
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Industrial Design Ideation Sketches

Business: In-console work surface

BUSINESS



Concept



Design Proposal

Business: In-console work surface

BUSINESS



Design Proposal

Business: In-console work surface

BUSINESS



Design Proposal

Business: In-console work surface

BUSINESS



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BUSINESS

Jeremy Briggs

Co-Captain: Business

Major: Mechanical Engineering

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Design Process

Business

BUSINESS

- Size – working with existing lid
- Placement – existing parts that need modified
- Rail types
 - Telescoping -> Double Telescoping
 - Lateral PTFE bearings
- Position Locking
- Push to open / push to close latch
- Table design – ergonomic hand groove underneath, front contour, pencil holder, rubber lip
- FEA Analysis
 - Assumptions
 - One-dimensional stress (materials) (uniform force)
 - Asymmetric force

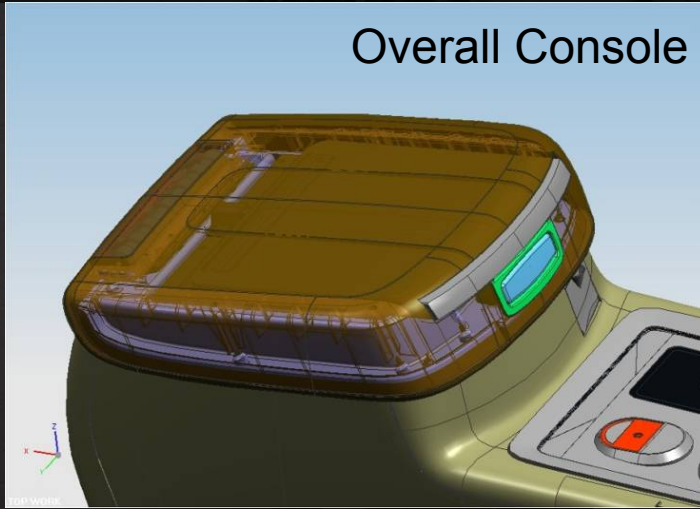


NX5 Procedure

Business

BUSINESS

Overall Console



Lid Assembly

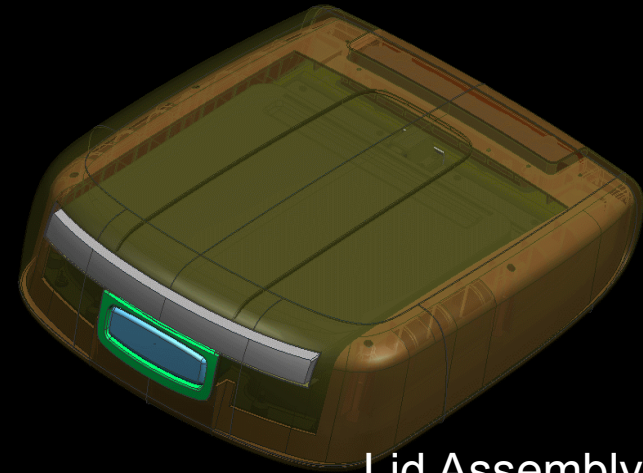
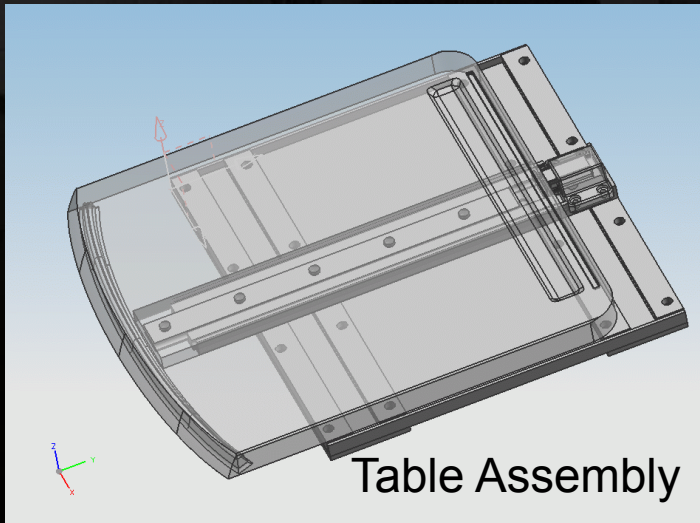


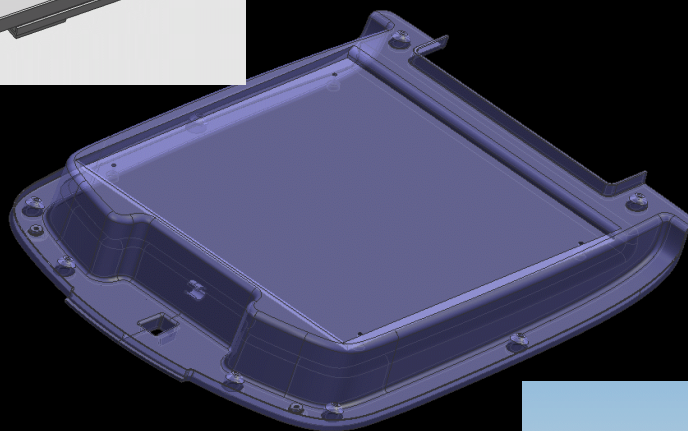
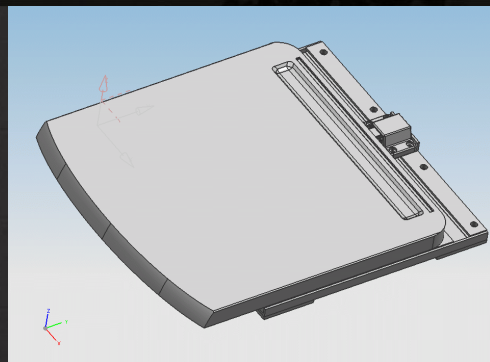
Table Assembly



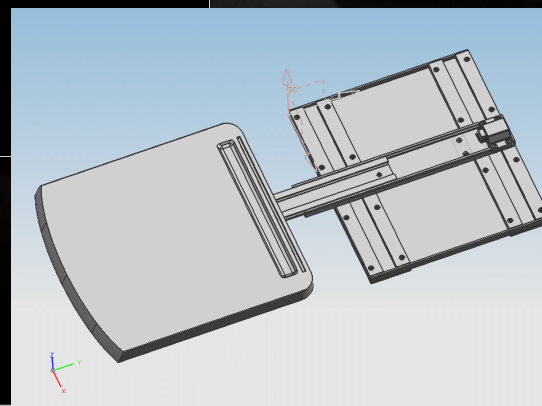
NX5 Modeling

Business

BUSINESS



TFR-ISO WORK Camera Isometric



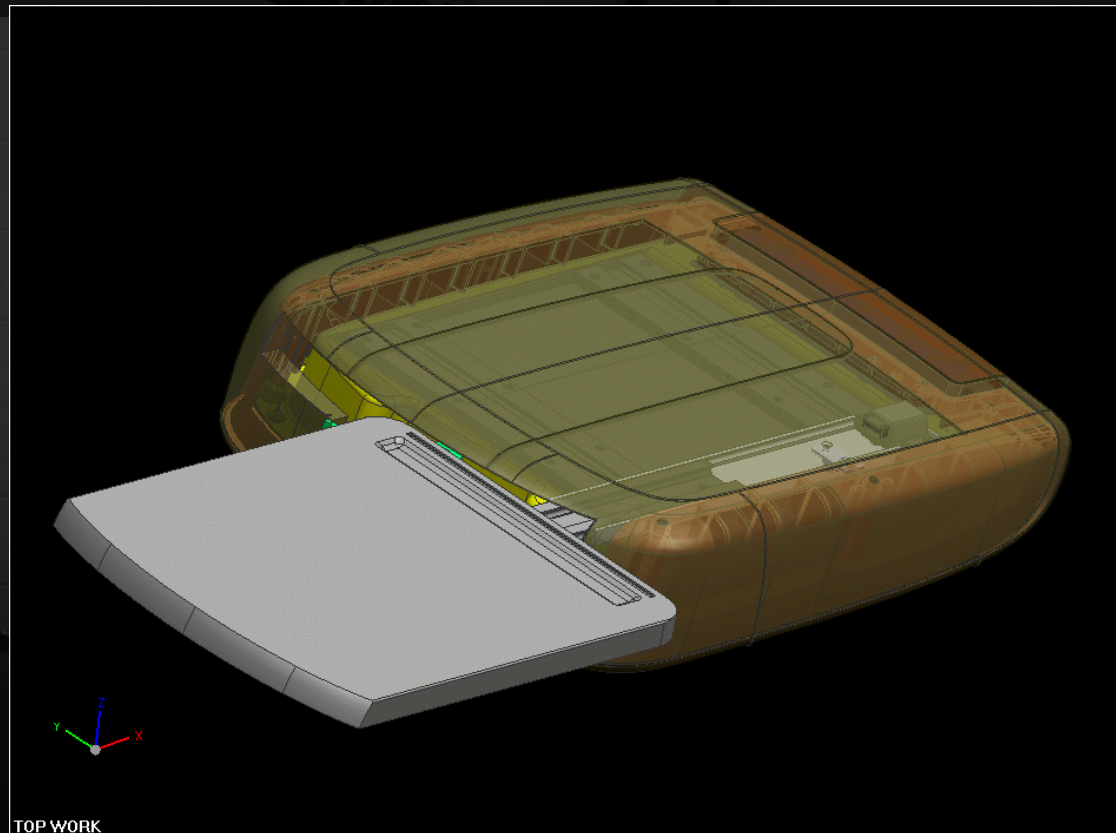
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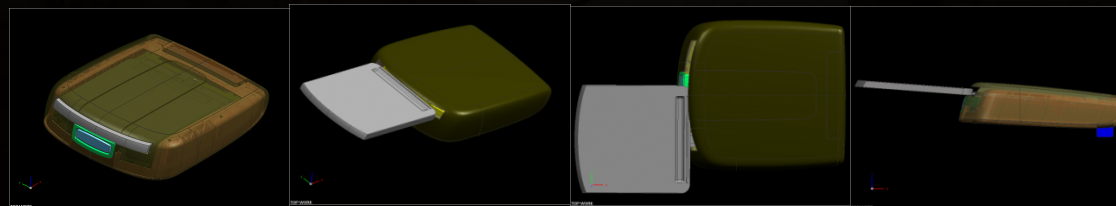
Motion Analysis

Business

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TOP WORK



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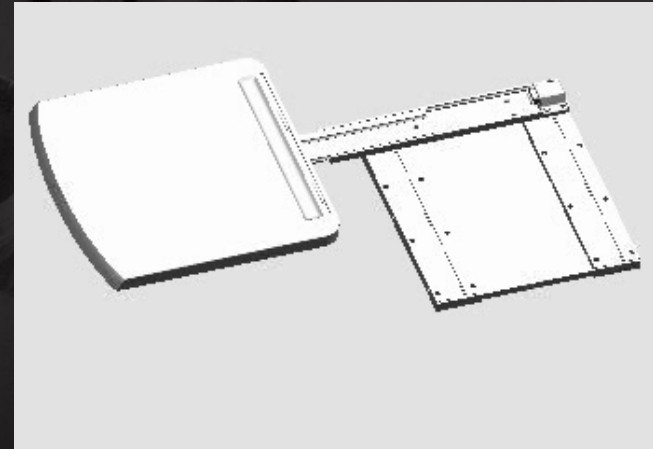
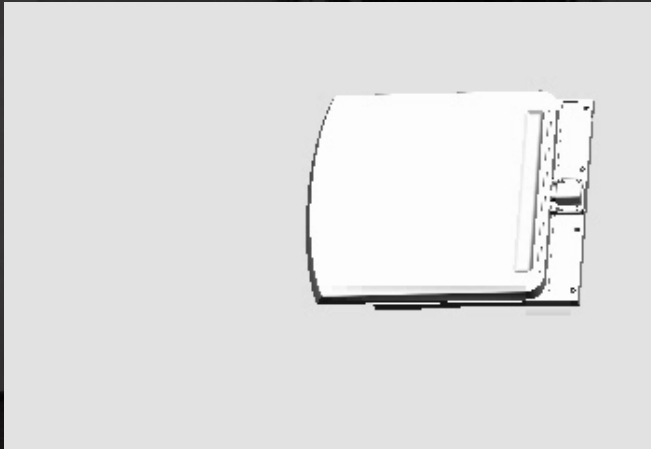


Motion Analysis

Business

Videos of table sliding motion

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Analyzed parameters of existing model interior



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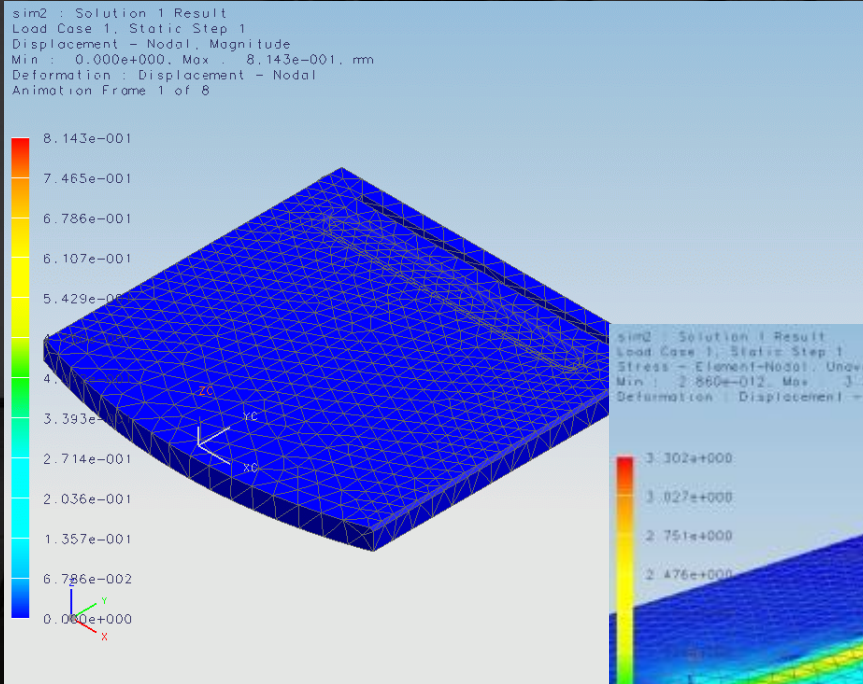


Finite Element Analysis

Business

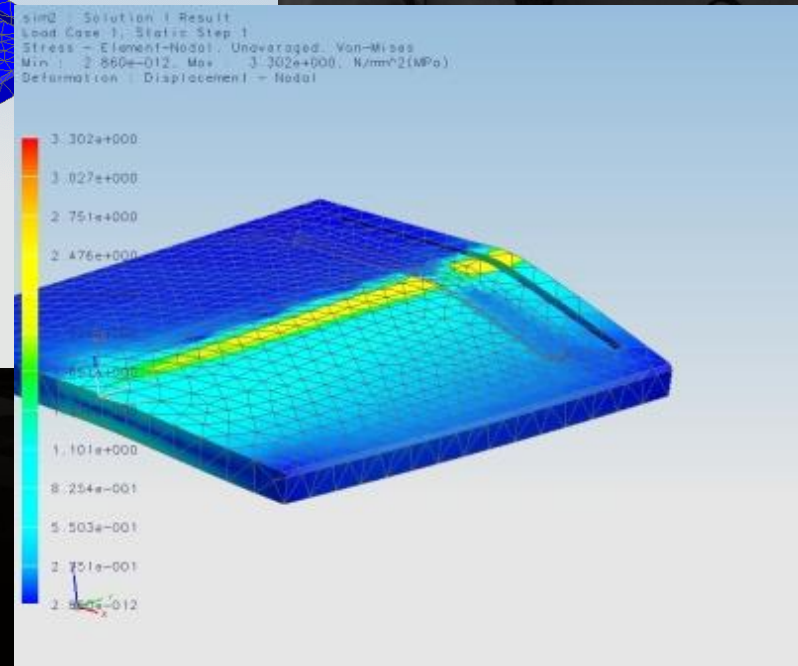
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Polypropylene Table Analysis – Asymmetric Loading



Displacement
animation under
asymmetric loading

Stress analysis under
asymmetric loading

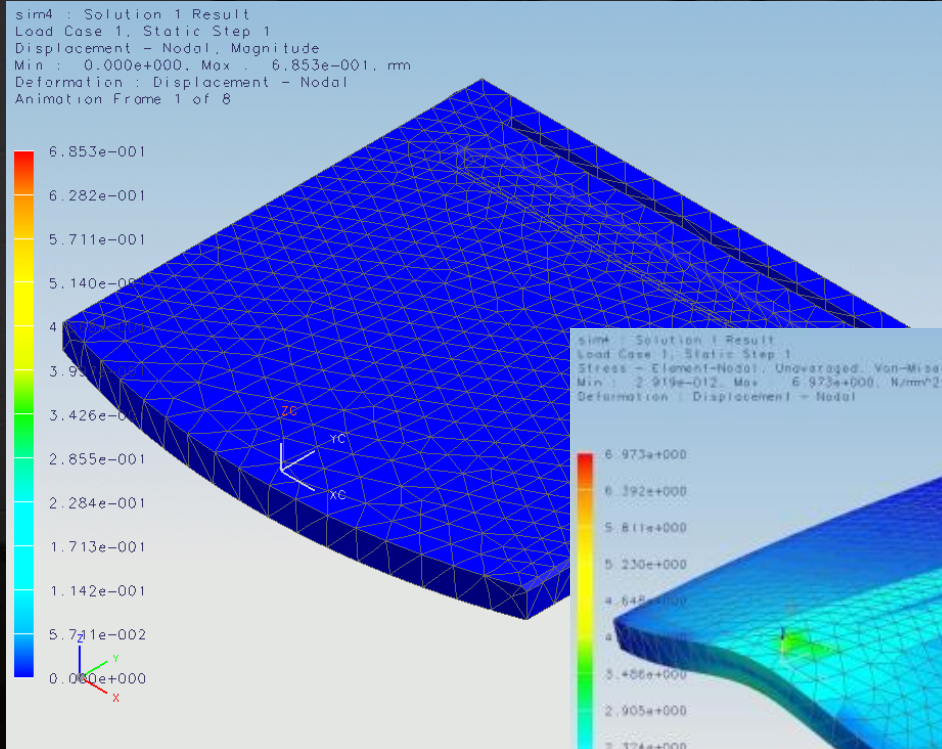


Finite Element Analysis

Business

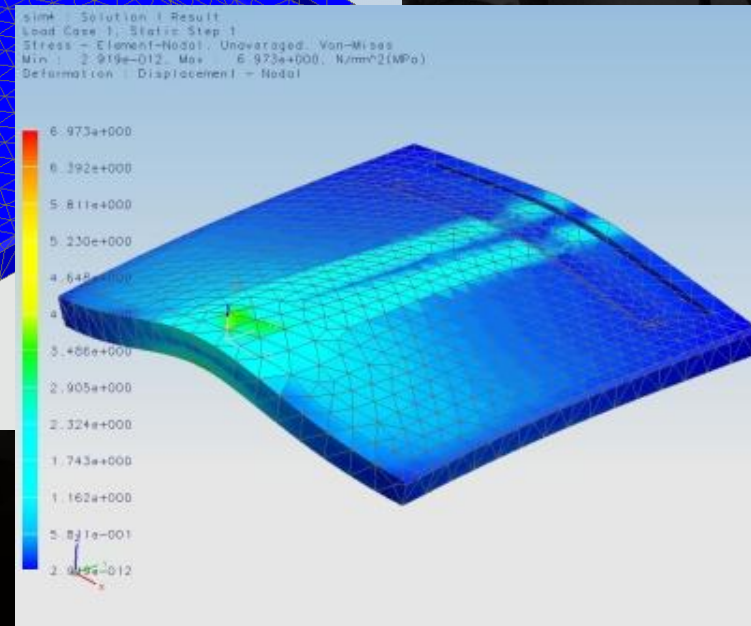
BUSINESS

Polypropylene Table Analysis – Front Loading



Displacement
animation under front
loading

Stress analysis under
front loading

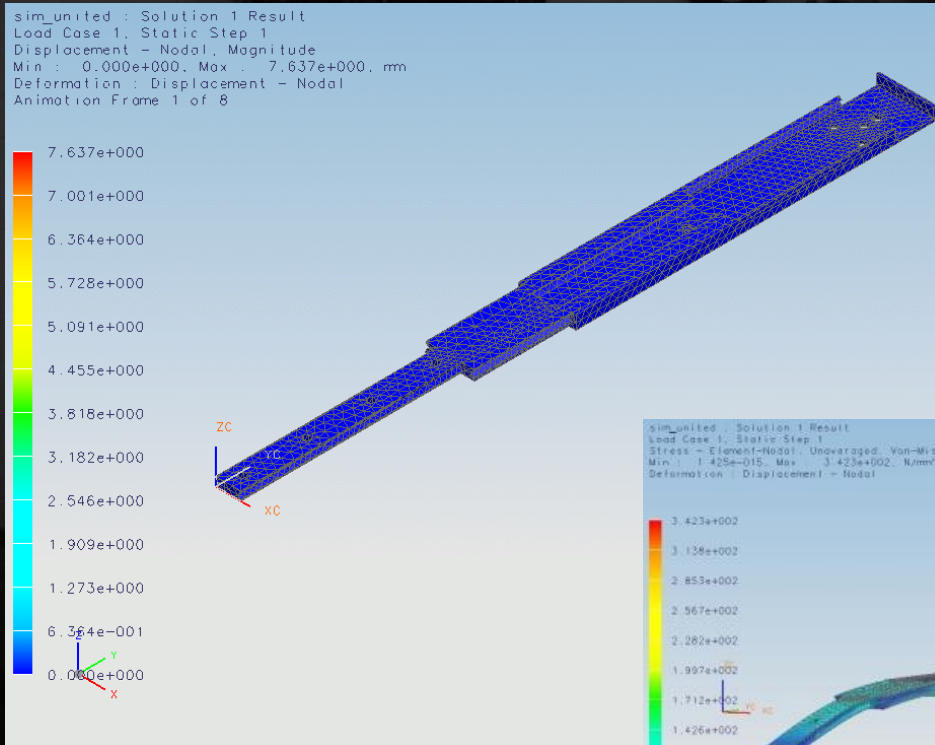


Finite Element Analysis

Business

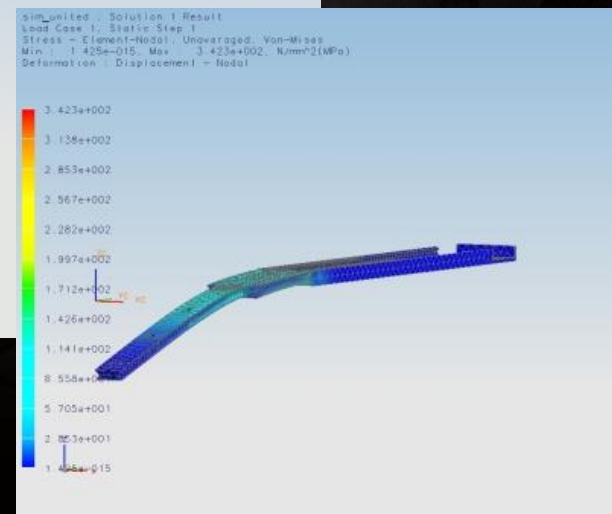
BUSINESS

Aluminum Rail Material Analysis



Displacement
animation under
distributed load

Stress analysis under
distributed load



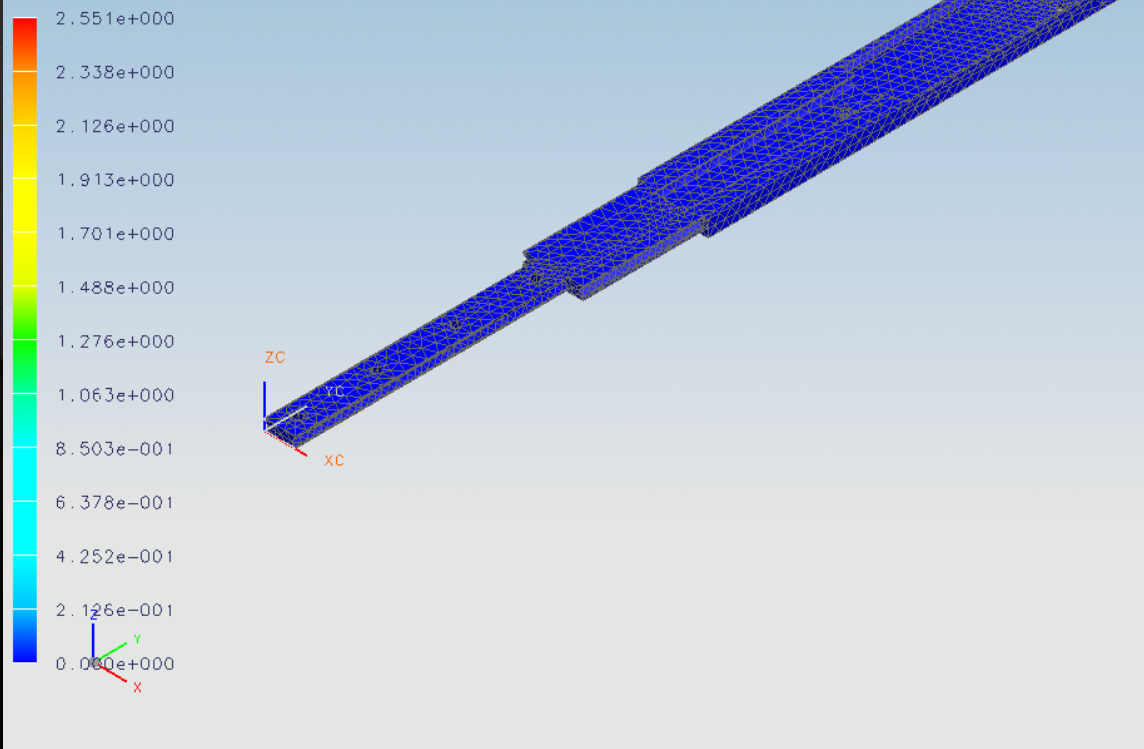
Finite Element Analysis

Business

BUSINESS

Steel Rail Material Analysis

```
sim_steal : Solution 1 Result  
Load Case 1, Static Step 1  
Displacement - Nodal, Magnitude  
Min : 0.000e+000, Max : 2.551e+000, mm  
Deformation : Displacement - Nodal  
Animation Frame 1 of 8
```



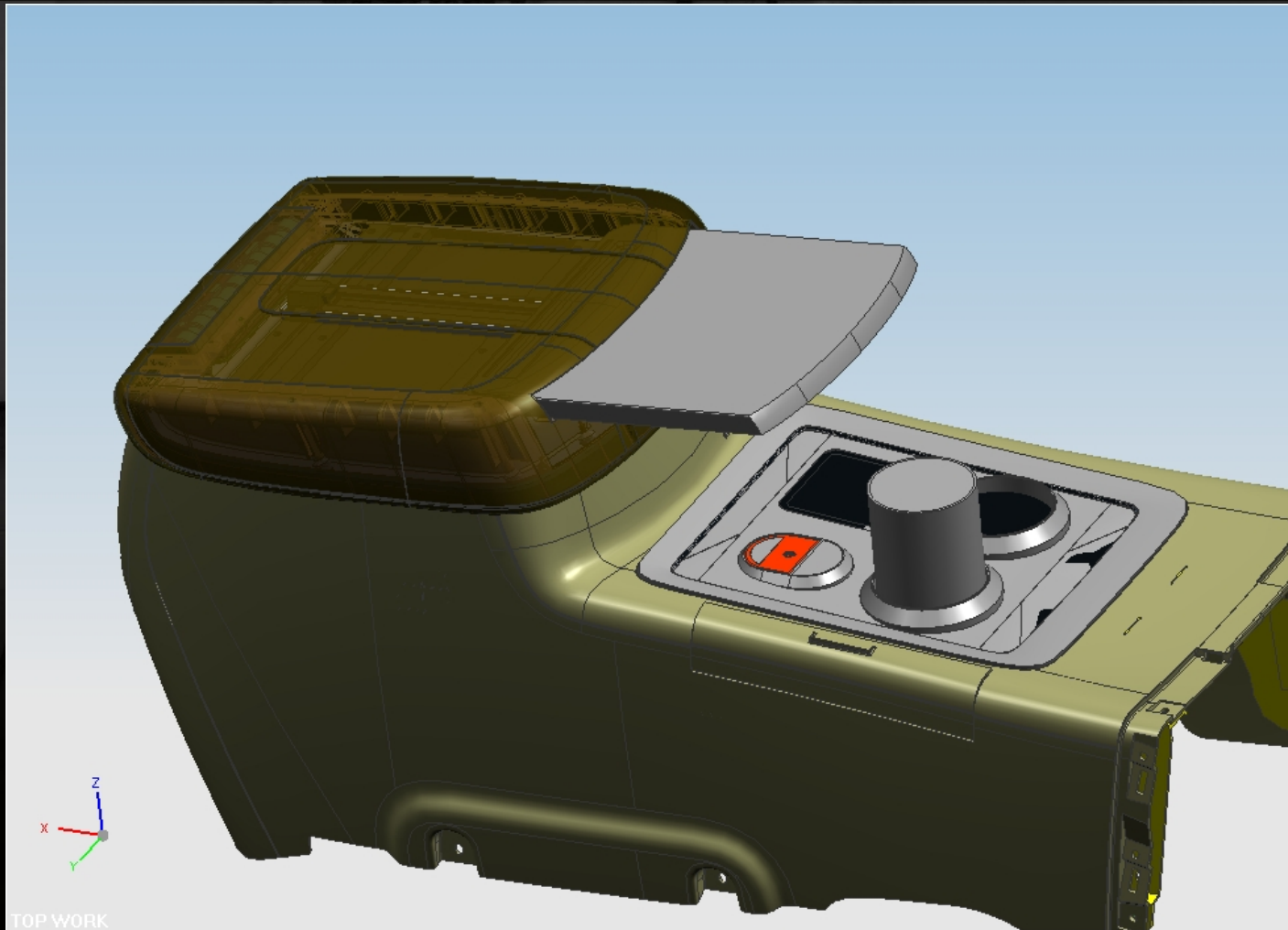
Displacement
animation under
distributed load



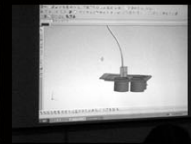
Finished Product

Business

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Overview of Final Design

- **Technology Feature**
Removable solid state drive, AC outlet, and USB ports
- **Family Feature**
LED lights with flexible necks and thermoelectric cup holders
- **Business Feature**
Push-in/push-out work surface



Thank You General Motors and PACE



Comments and Questions

