

Vehicle Research Institute

Lyn Okse: An Electric Utility Vehicle with Off-Highway Capability

Eric Leonhardt and Paul James

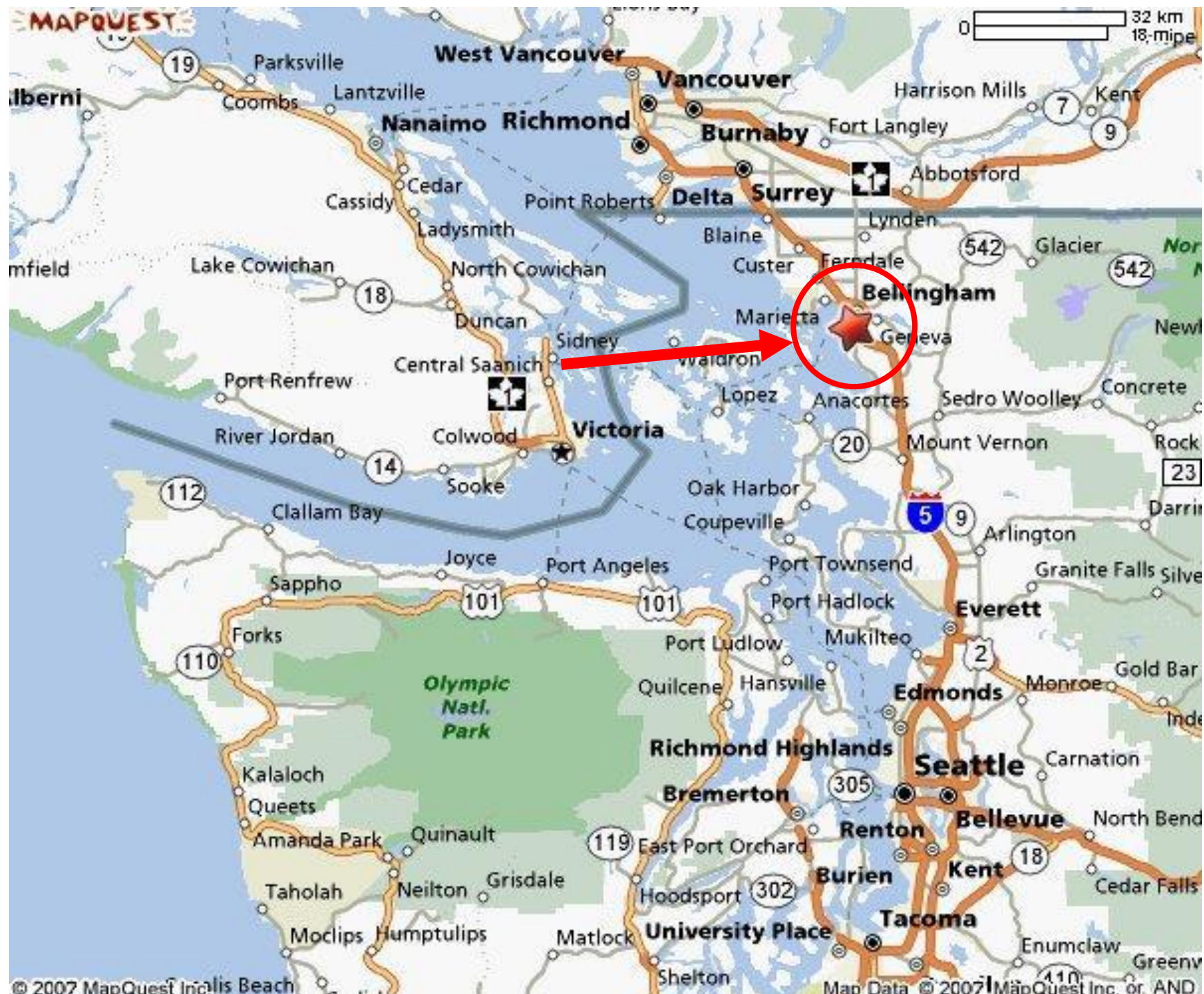
EVS29 Symposium

Montreal, Québec, Canada, June 2016





Paul James
Anthropology
Western
Washington
University





Vehicle Projects



Chelsea
Sexton after
riding in
WWU ReVolt





Outline
Problem
Benchmarking
Requirements
Design Process
Safety Targets
Material Testing
Suspension Design
Powertrain Design
Fabrication







Top Speed: 40 km/hr

Load: 460 kg

Range: 48 km

Power: 7 kW



e-Ride Industries EVX4 Patriot



Canadian Electric Vehicle
Might E Truck





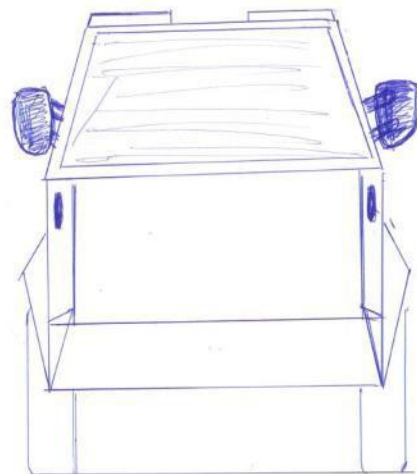
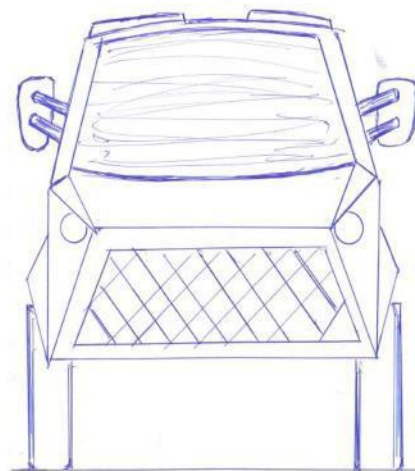
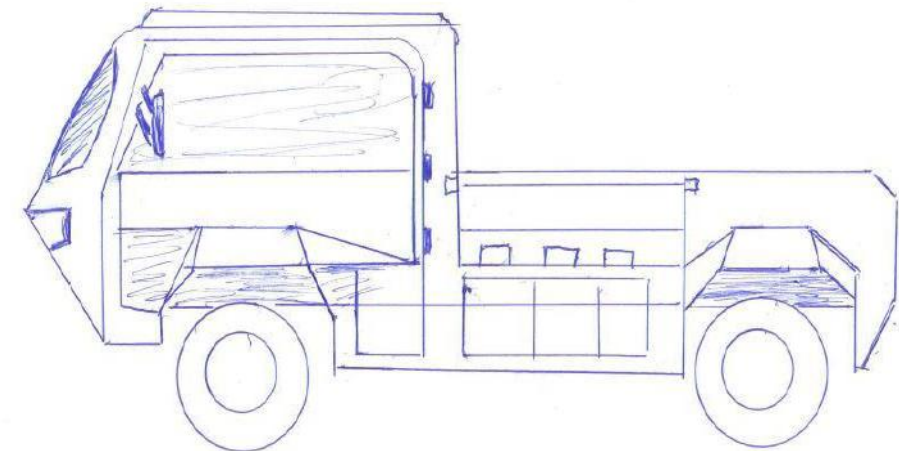
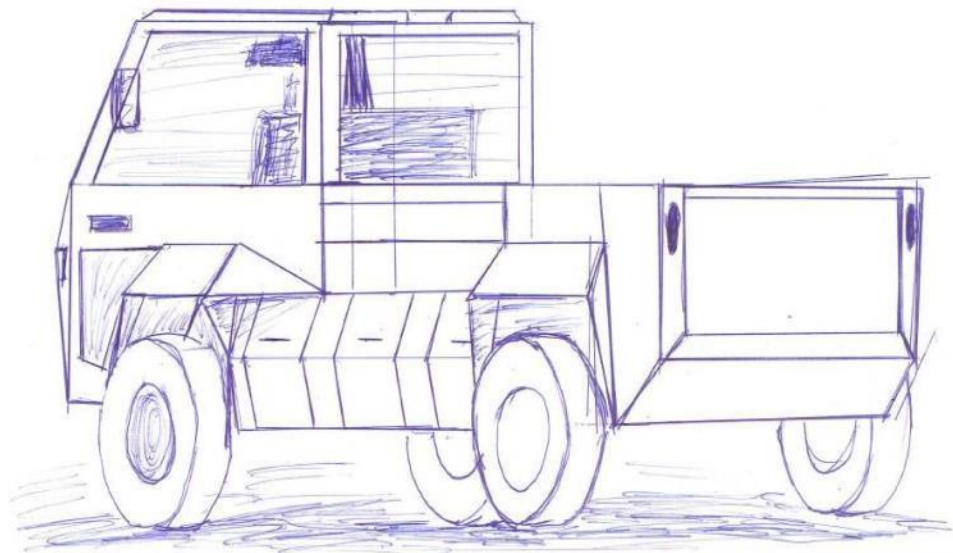
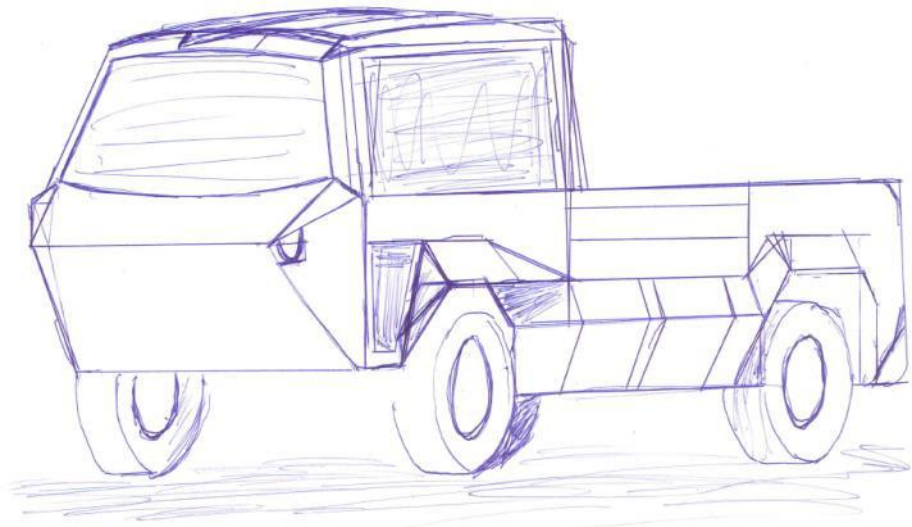
Inspiration—Jeep and Pinzgauer

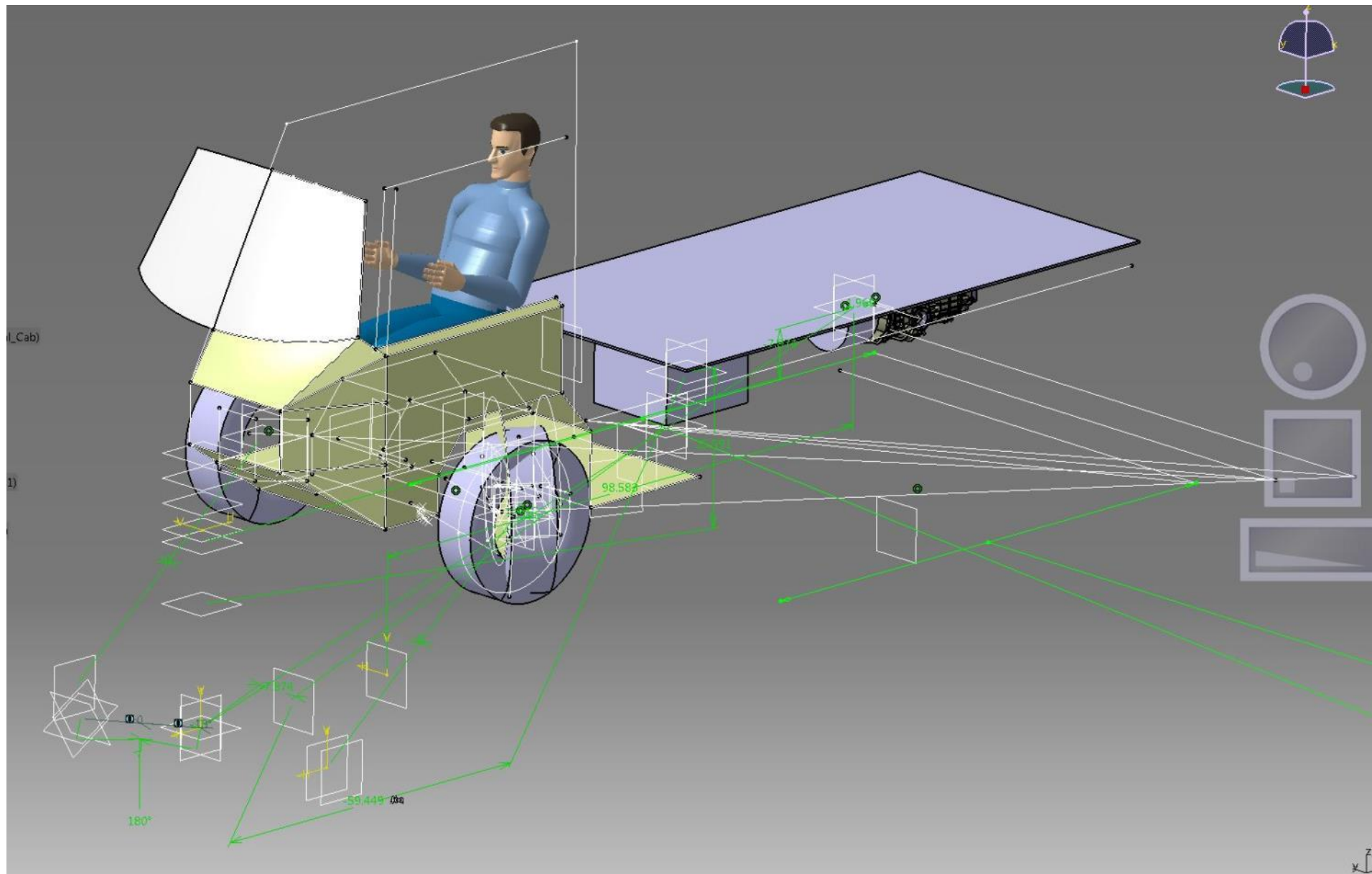
A gardener
explains
reach issues
and the
preferred
tool storage
angle during
focal follow
video
ethnography

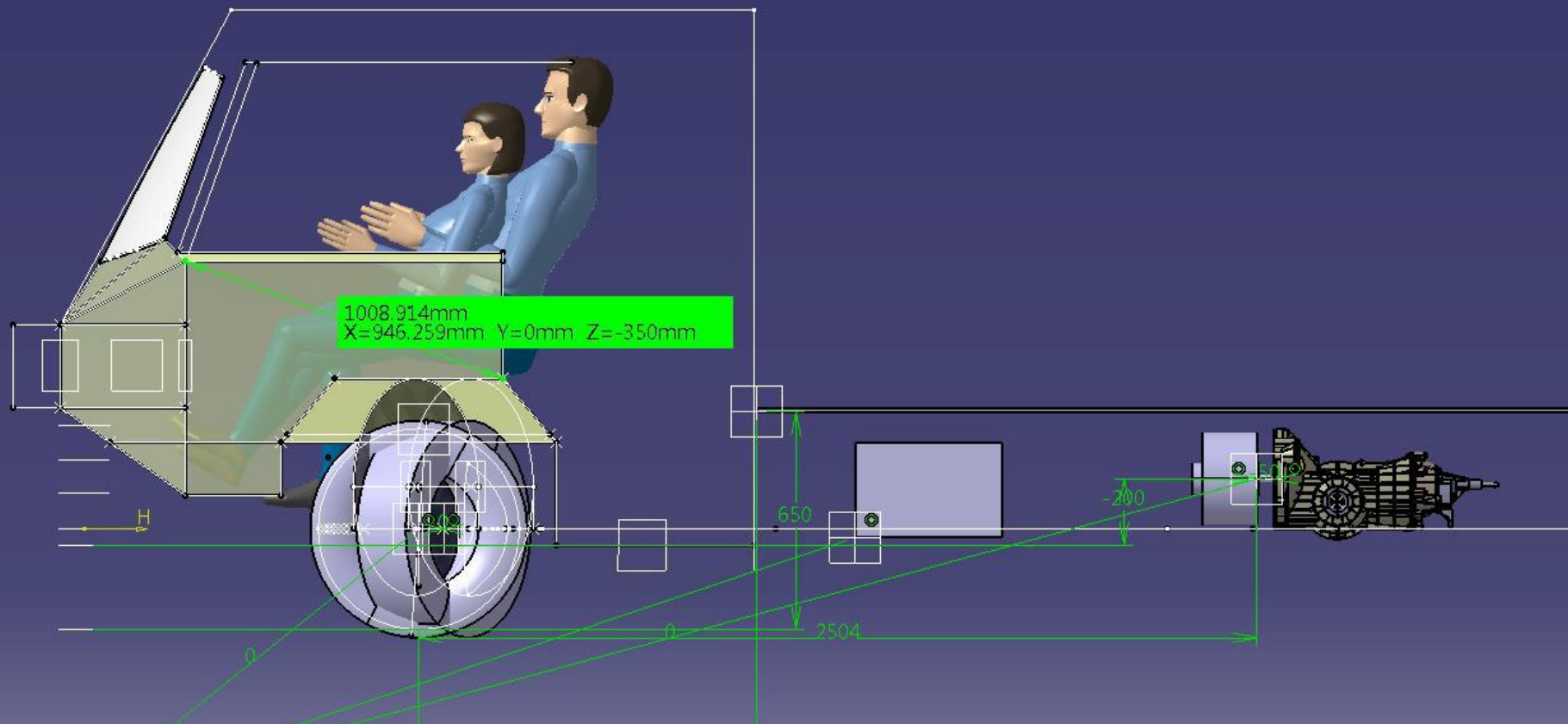


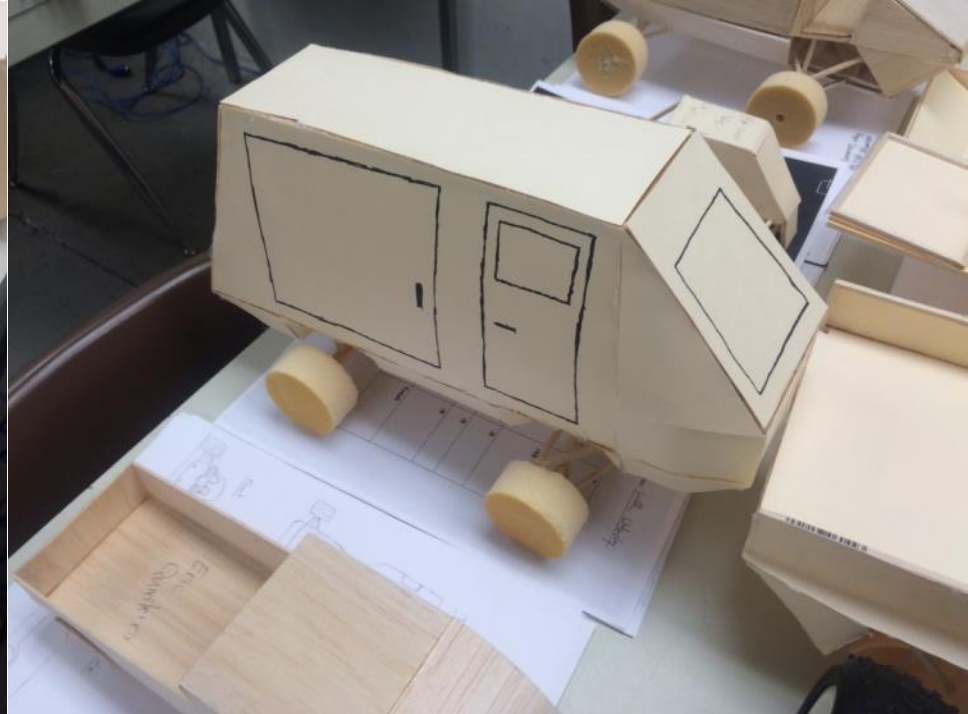
Requirements

- Overall Chassis width of 1524 mm max
- Packaging to Accommodate a North American 95th percentile male and a 5th percentile female
- 227 kg payload
- Bed 1219 mm x 2438 (4ft x 8ft Plywood)
- Range 64.4 km (Tax Benefit)
- Max Gross Vehicle Weight: 1124 kg (Legal limit for Low Speed or NEV)
- Fully enclosed cab
- More space in the cab
- Integrated lockable exterior storage
- Fully enclosed and compartmentalized battery and powertrain mounting
- Engaging exterior design
- Ground Clearance 255 mm
- Maneuverability













Storage and Ergonomics

Two exterior storage storage boxes per side

1000 mm

390 mm

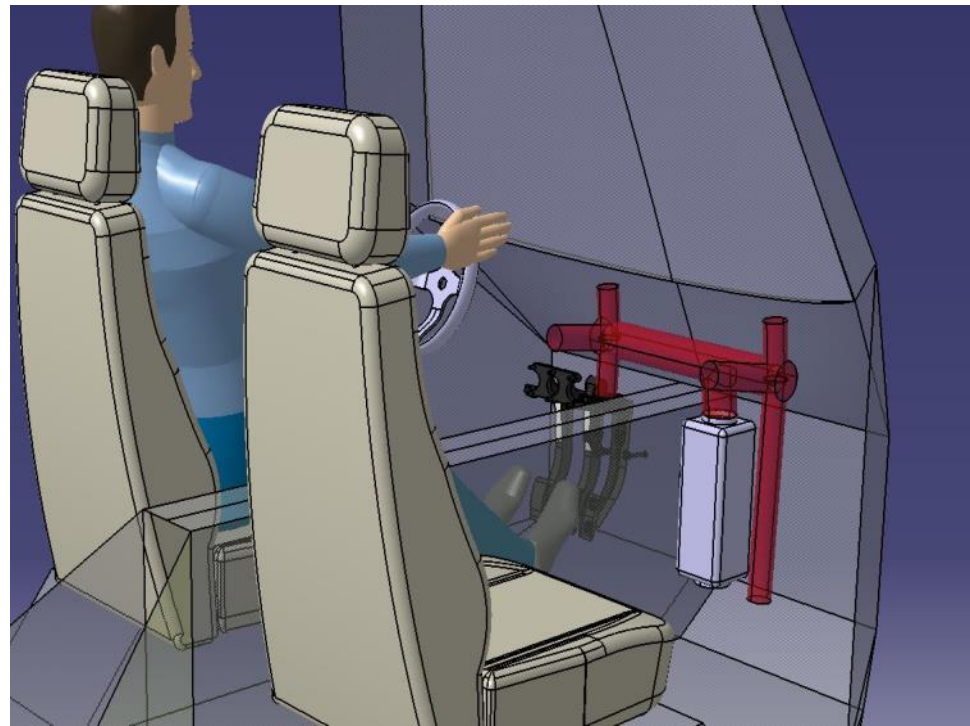
Built mockup for testing of opening methods

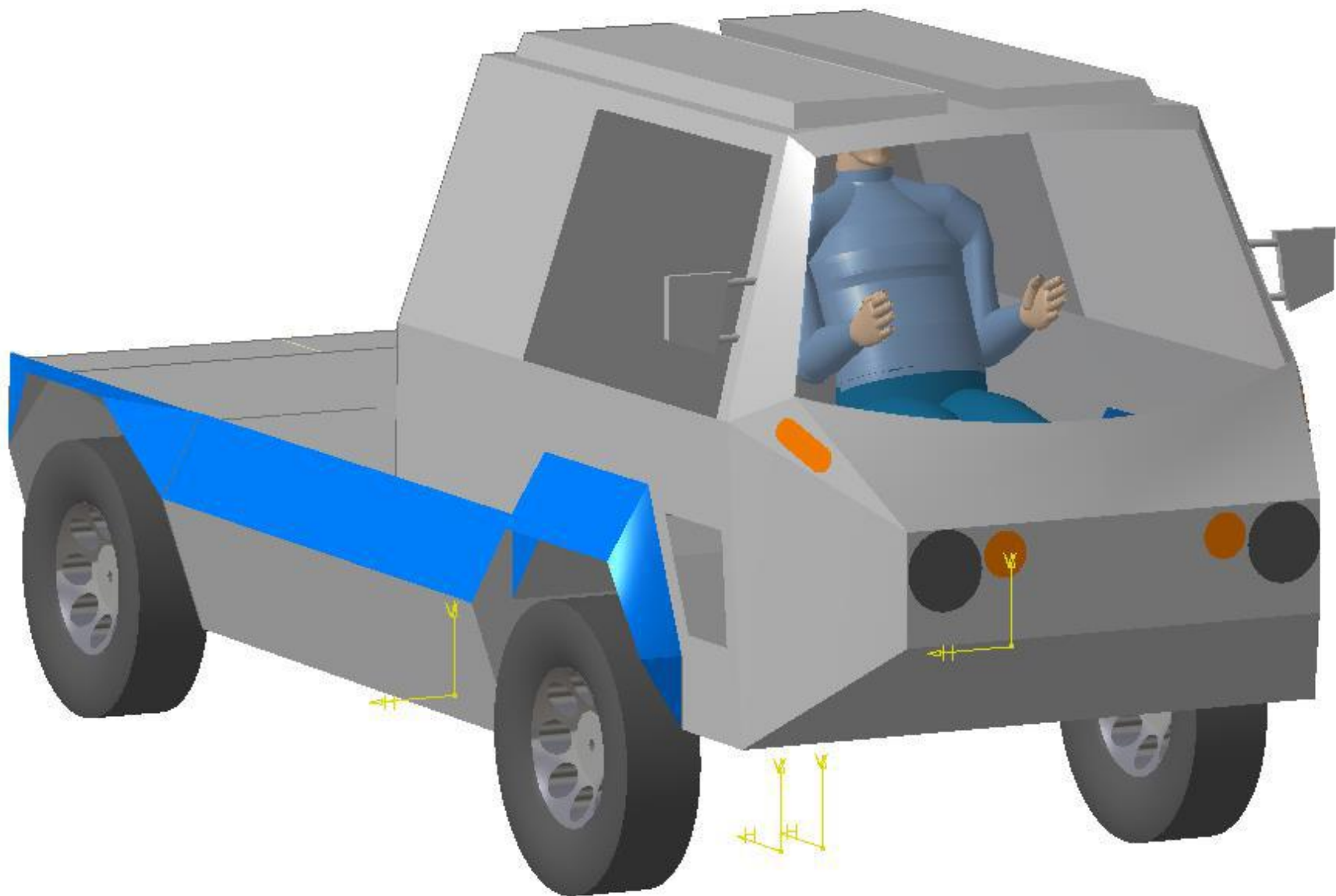


Heating

- Webasto Air Top 2000 ST
- Gasoline heater
- ~2.8 liters per hour at maximum load
- Front/rear windshield, passenger, cab
- 6,824 BTU/hr (2 kW)

Required 1.75 kW (35°F change)

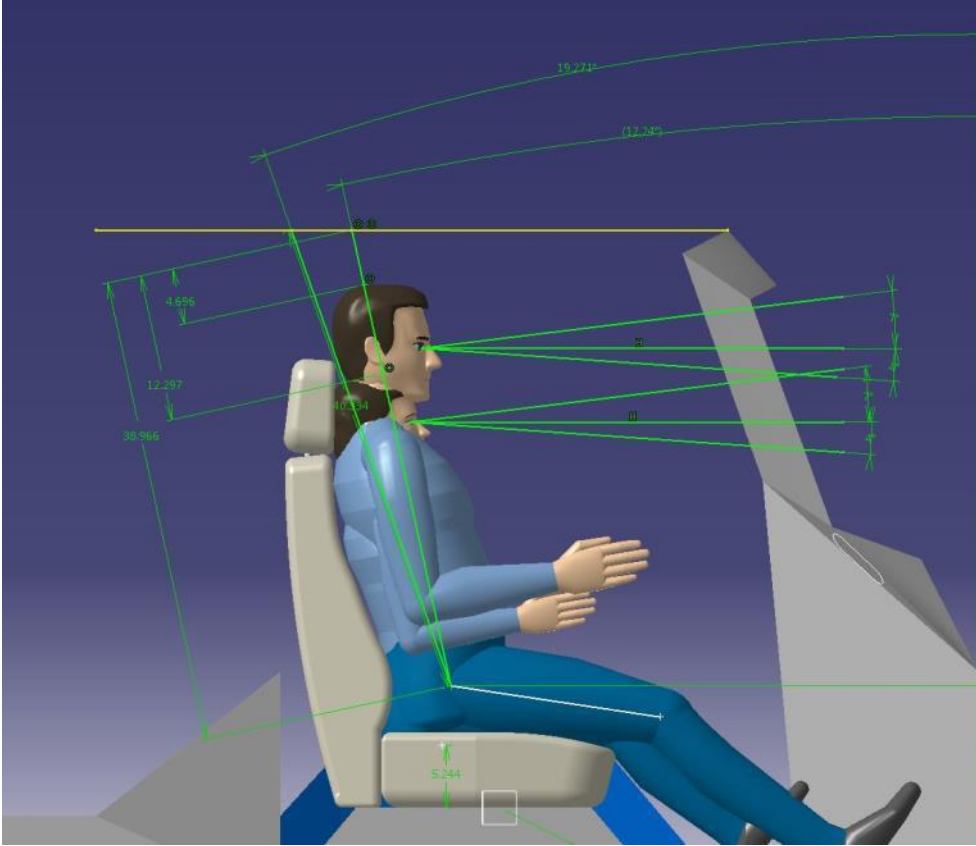
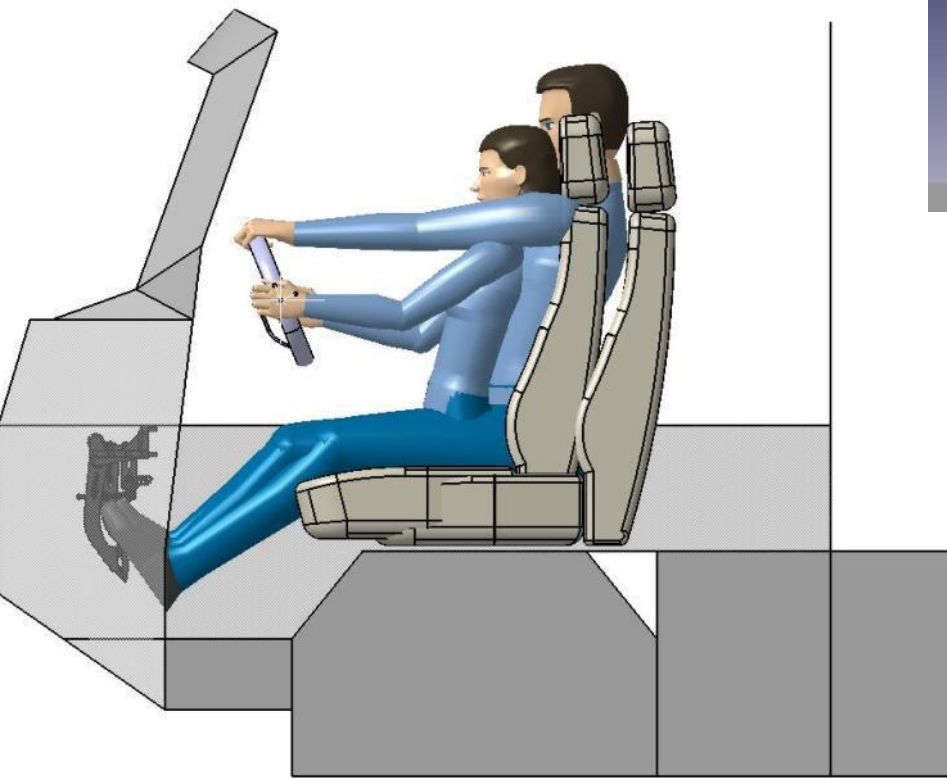




Accommodate
5th percentile female
95th percentile male

150mm seat travel

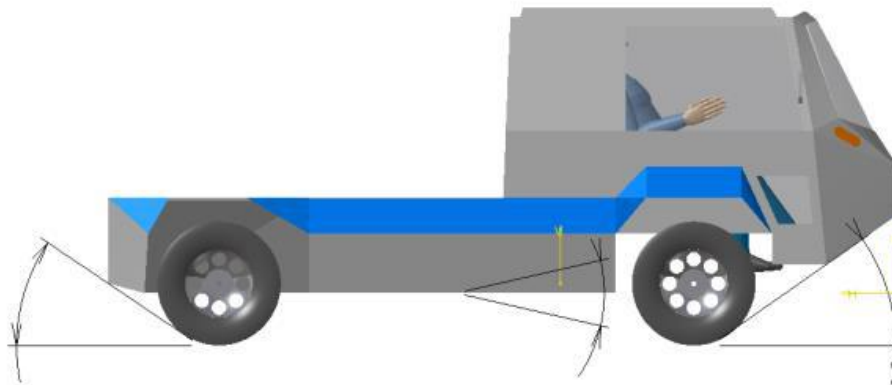
22° steering wheel angle



Challenge: Visibility!
5th percentile female
95th percentile male

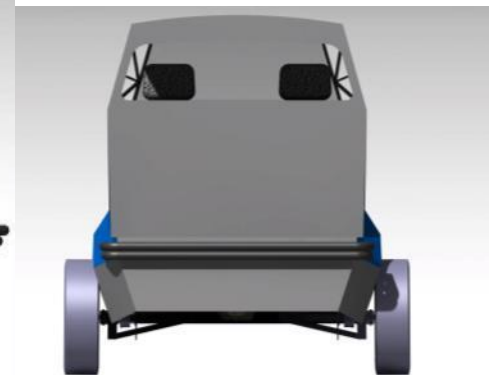
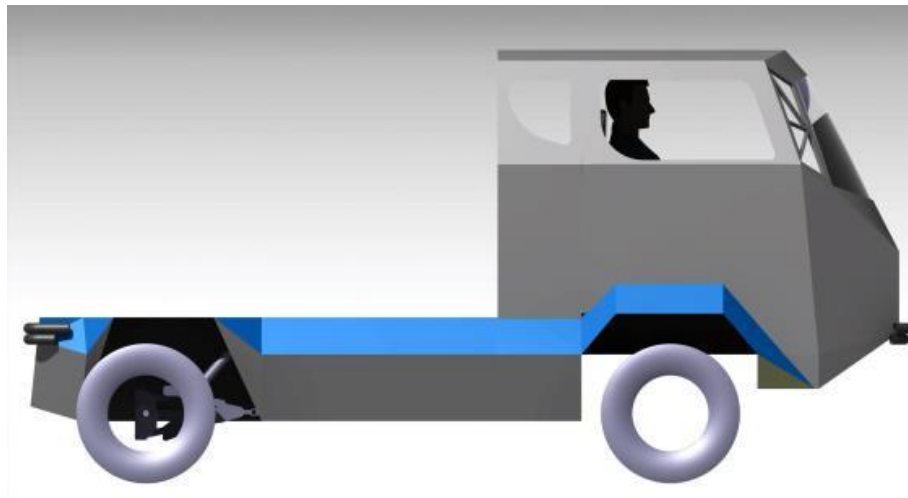
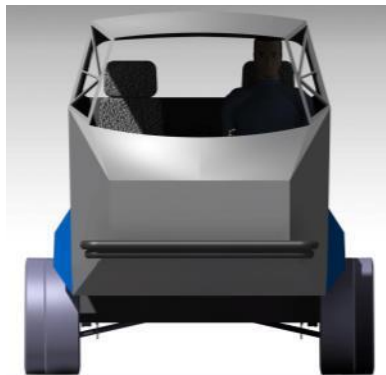
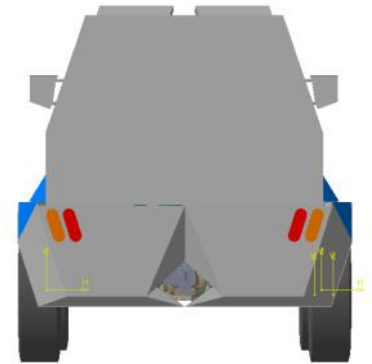


Departure Angle = (33.98°)



Breakover Angle = (25.529°)

Approach Angle = (34.9°)



Safety Targets

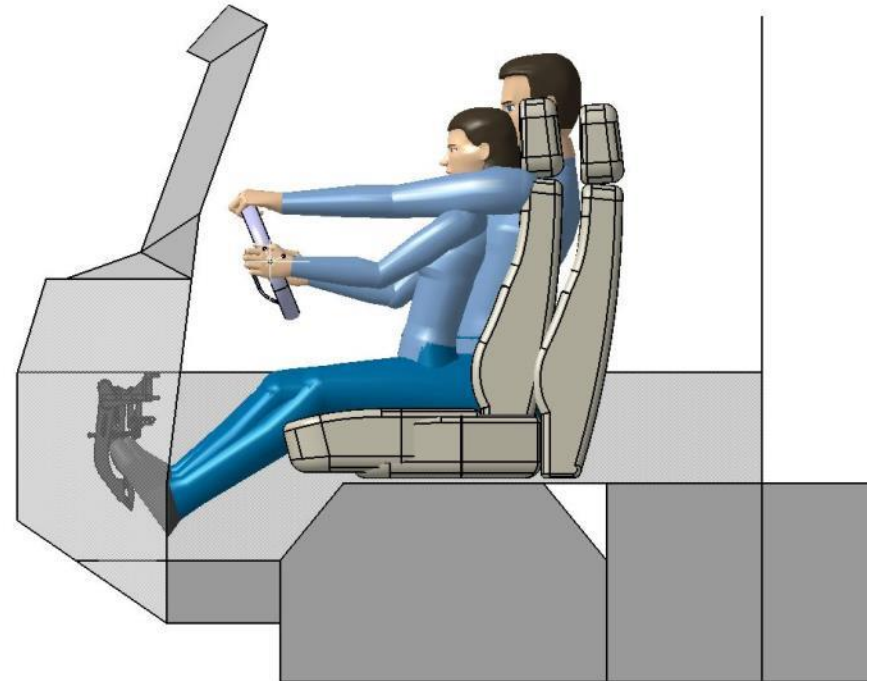
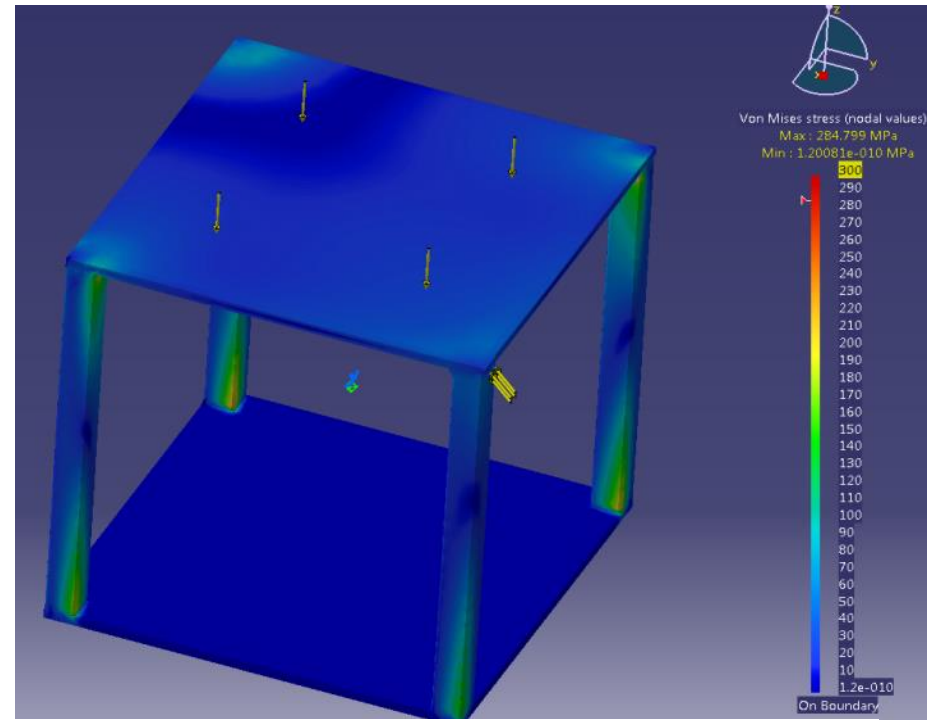
Gross Vehicle Weight Rating
1124 kg

Front Impact: 20 G or 196 m/s²

Force: ~240 kN

Target Roof Rollover:
3 G or 29 m/s²

Force: ~1824 N



Validation Testing with Aluminum Honeycomb Panels



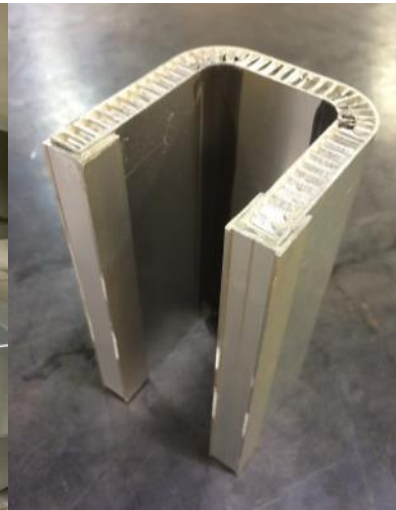
**Machining
panels**



**Tensile
test**



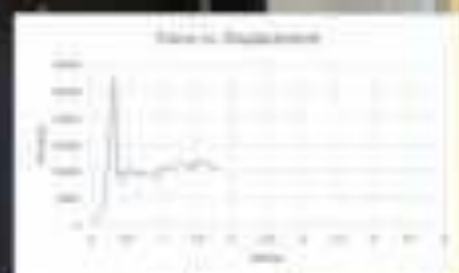
Bend test



U-Panel



T-Panel



Suspension Goals

Low cost

Off the shelf parts to minimize
fabrication and maintenance
costs

Suspension Travel: 300 mm
127 mm Bump
178 mm Droop

Steering Angle: 55°

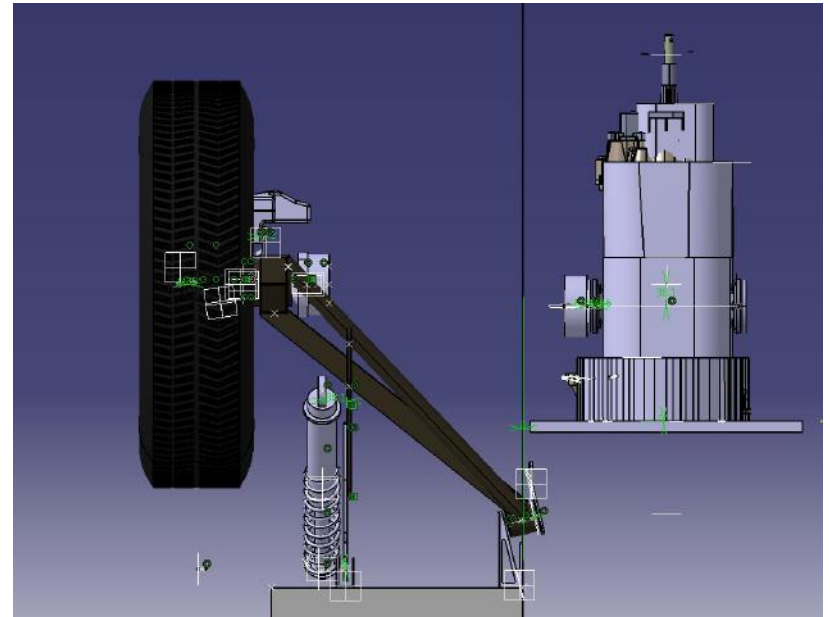
Ground Clearance: 255 mm

Tough: 7G $\sim 70 \text{ m/s}^2$ Bump

Minimal toe change in bump and
droop



<http://www.appletreeauto.com/TRAILING-ARM-KIT-FOR-930-and-091-TA3X3930-091/>



Front Results: Independent Short Long A-arms

Allows for good control of wheel movement
Roll center at 100 mm

~457 mm long control arms

Minimize front track

Reduces articulation of bushings and ball joints

275 mm total travel

Easily drive over curbs

0.06° Toe Change

1° toe change in bump and droop

Rear Results: Semi-trailing arm
independent suspension

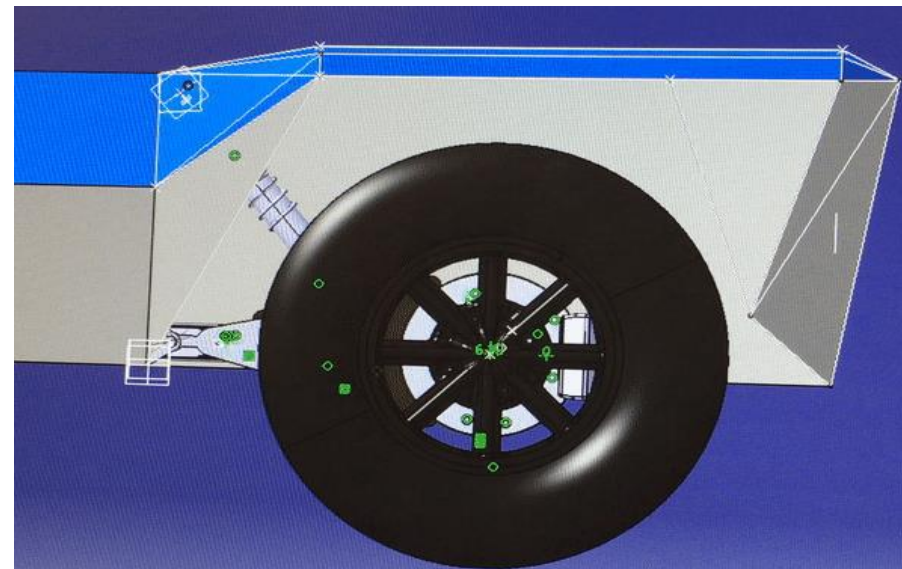
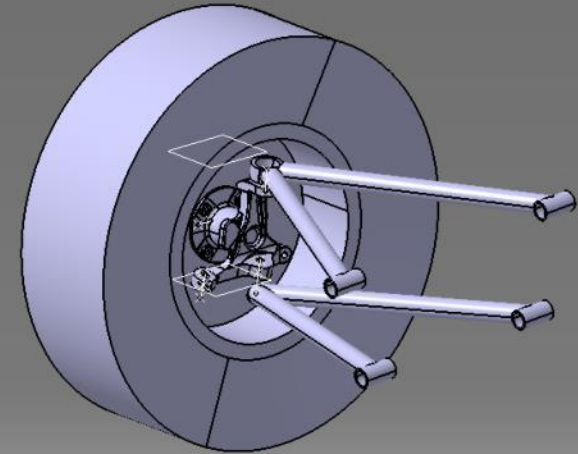
Durable, compatible with transaxle

275 mm total travel

312 mm Clearance

1636 mm track width (100 mm wider)

2337 mm wheelbase



Transaxle

- Volkswagen 091 Bus
- Limited Slip Differential
- Mated to upgraded VW Bus clutch assembly
- High Torque Capacity
- High Low-Speed Thrust



Electric Drivetrain

System Goals:

- 30kW Power Output -
- 65 km range (Tax incentive)
- 10kWh battery pack
- Hill Climb



Electric Powertrain Output

Motor Output: up to 60kW (80hp) and 240 Nm (177 lb-ft) torque

Speed	Continuous			Peak		
	Thrust	Acceleration		Thrust	Acceleration	
kph	N	g	m/s ²	N	g	
21.5	7,647	0.96	9.4	14,709	1.84	18.0
39.4	4,166	0.52	5.1	8,016	1	9.8
56.1	2,931	0.37	3.6	5,645	0.71	7.0
95.7	1,719	0.22	2.2	3,309	0.41	4.0

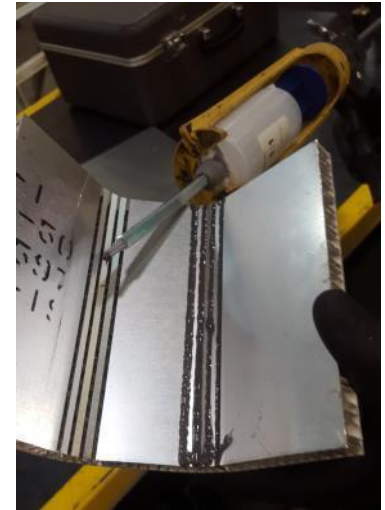
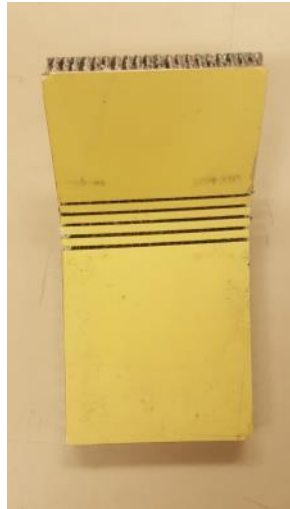
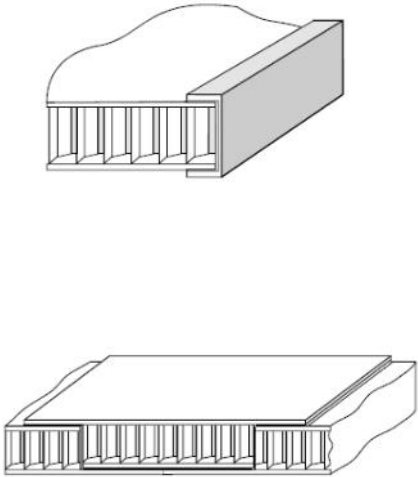
Battery Pack: Melasta 10AH 10C

10 modules of 20 cells each, 7.4 kWh

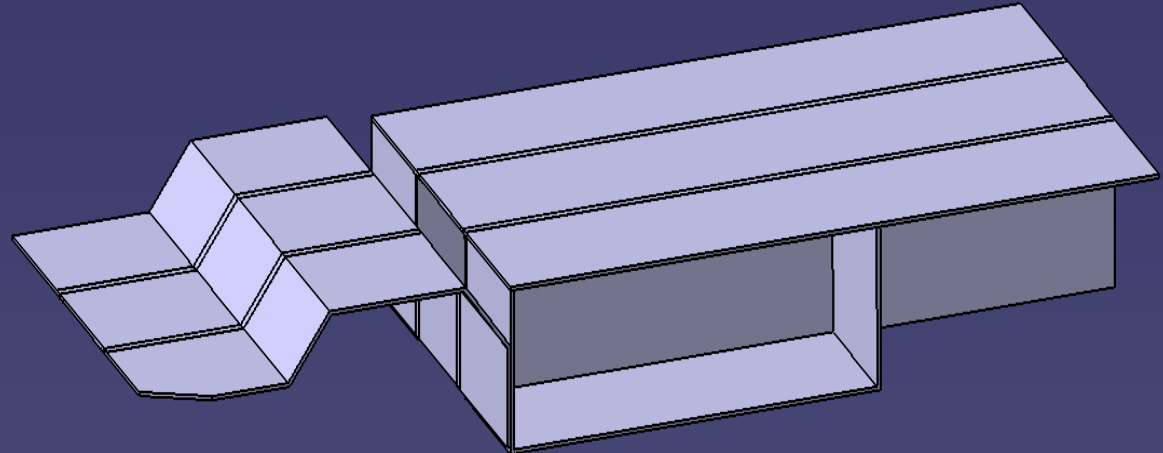
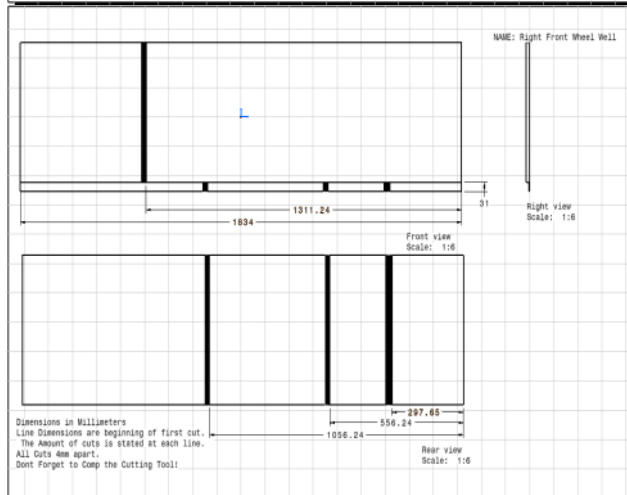
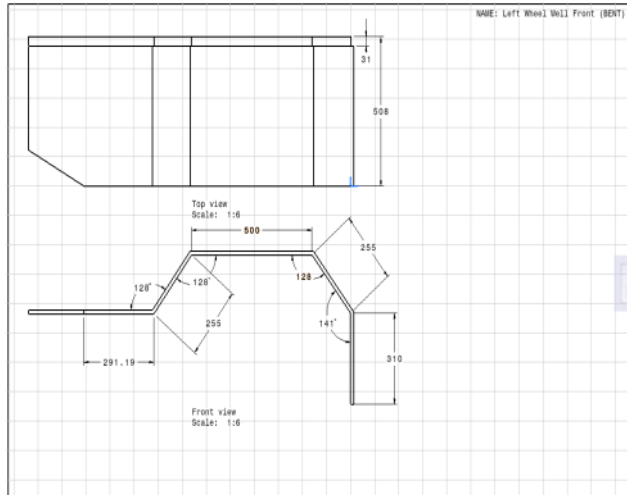
[illegible]

Modules - 10					Dimensions:			
Cells per Module:	20	cells	Width:	2	cells	Module Width:	139 mm	5.47 in
Voltage per Module:	37	V	Length:	5	cells	Module Length:	74 mm	2.91 in
Module Cell Mass:	6100	g						
Module Energy:	740	Wh				Built Estimate:		
						Overall Width:	164 mm	~165
						Overall Length:	99 mm	~100

Fabrication and Manufacturing



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