

Initial Testing Results

2024-2025 SAE Baja
Suspension, Steering and Brakes



Ryan Key
Ryan Latulippe
Oliver Husmann
Brennan Pongratz

Suspension

Taylor Hewitt
David Polkabila Jr.

Steering, Brakes

Customer Requirements (Suspension)

- Performance/Comfort
- Serviceability/Tunability
- Durability
- Affordable
- Ease of Fabrication
- Aesthetics
- Pass SAE Technical Inspection

Engineering Requirements (Suspension)

- Lightweight
- Suspension must pass tech
- Optimal ride height/ ground clearance
- Optimal Vehicle Width/Length
- Singular known replaceable failure point
- Efficiently designed knuckle
- Optimal camber/caster angles
- Optimize suspension travel

QFD (Suspension)

Suspension QFD										Baja 25' Suspension									
Team Members										Relationship		Date: 04/08/25							
Oliver Husmann										Strong	9	Legend							
Ryan Key										Moderate	3	A	2024 Comett #73						
Ryan Latulippe										Weak	1	B	2024 SDSU #43						
Brennan Pongratz										N/A	0	C	2024 NAU #44						
										Technical Requirements					Customer Opinion Survey				
Customer Weights		Customer Requirements		Light weight															
				B.8.7 - all steering or suspension links exposed in the cockpit shall be shielded with a sturdy, robust, metal cover.															
				Optimal ride height/ground clearance															
				B.L.6 - Limitations - Vehicle width															
				Vehicle length/approach angle															
				Singular known replaceable failure point (bolt)															
				Efficiently designed knuckle															
				Optimal camber angles															
				Optimal caster angle															
				Optimize maximum suspension travel															
				1 Poor															
				2 OK															
				3 Acceptable															
				4 Good															
				5 Excellent															
2	Performance/comfort	3	3	9	9	9	9	9	9	9		C				AB			
3	Serviceability/tunability	1	-1		3	9	9	9	9	3	3	9	C	B	A				
4	Durability	-3	3	3	3	9	9	9			3	C	B			A			
6	Affordable	3	-1				3	9				C		B	A				
5	Ease of Fabrication	1	1				3	9	1	1	1		C	AB					
7	Aesthetics		3	9	9	3	1	9	3	3	9				BC	A			
1	Pass Tech			9		9										ABC			
Technical Requirement Units		lbs	mm	In.	In.	In.	Psi.	lbs, in. hrs.	Degrees	Degrees	In.								
Technical Requirement Targets		<50	<6.35	12-16	64	58-62		-2 - 2	12-18	12-16									

Top Level Testing Summary (Suspension)

Experiment/Test	Relevant DRs	Testing Equipment Needed	Other Resources
Exp1- Travel Test	CR1: Performance/comfort CR2: Serviceability/ tunability CR3: Durability ER7: Efficiently designed knuckle ER10: Optimize maximum suspension travel	Tape measure Large T-square Painters tape	Testing space Stack Objects
Exp2- Ride Height Test	CR1: Performance/comfort CR2: Serviceability/ tunability CR3: Durability CR6: Aesthetics ER3: Optimal ride height/ground clearance ER4: Optimal Vehicle width ER8: Optimal camber angles ER9: Optimal caster angles	Tape measure Large T-square Painters tape Angle gauge	Testing Space
Exp3- Body Roll Test	CR1: Performance/comfort CR2: Serviceability/ tunability ER8: Optimal camber angles ER9: Optimal caster angles	Cones Helmet Stopwatch Means to make a video	Driver Testing Track Fuel

Detailed Testing Plans (Suspension)

- Experiment 2: Ride height test
 - Measure distance from ground to chassis for ride height (12 ± 2 ") , distance from outer edge of each tire for track width (64" F, 60" R).
 - Predefined ride height goals will define camber and caster angles, along with what adjustments need to be made.
 - Measure wheel alignment components mentioned with angle gauge
 - ~12" ride height (F and R)



Specification Sheet (Suspension)

Customer Requirements	CR met? (✓ or X)	Client Acceptable (✓ or X)
CR1: Performance/comfort	✓	✓
CR2: Serviceability/tunability	✓	✓
CR3: Durability	✓	✓
CR6: Aesthetics	✓	✓
CR7: Pass SAE Technical inspection	N/A	N/A

Specification Sheet (Suspension)

Engineering Requirement	Target	Tolerance	Measured/Calculated Value	ER met? (✓ or X)	Client Acceptable (✓ or X)
ER3: Optimal ride height/ground clearance	12in	±2in	12in	✓	✓
ER4: Optimal Vehicle width	62in	-4in	62	✓	✓
ER8: Optimal camber angles	0°	±2°	3.5°	X	X
ER9: Optimal caster angle	-5°	±3°	1°	X	X

Customer Requirements (Steering)

- Stay with the Budget
- Maximize Driver Comfort
- Simple to use
- Pass SAE Technical Inspection

Engineering Requirements (Steering)

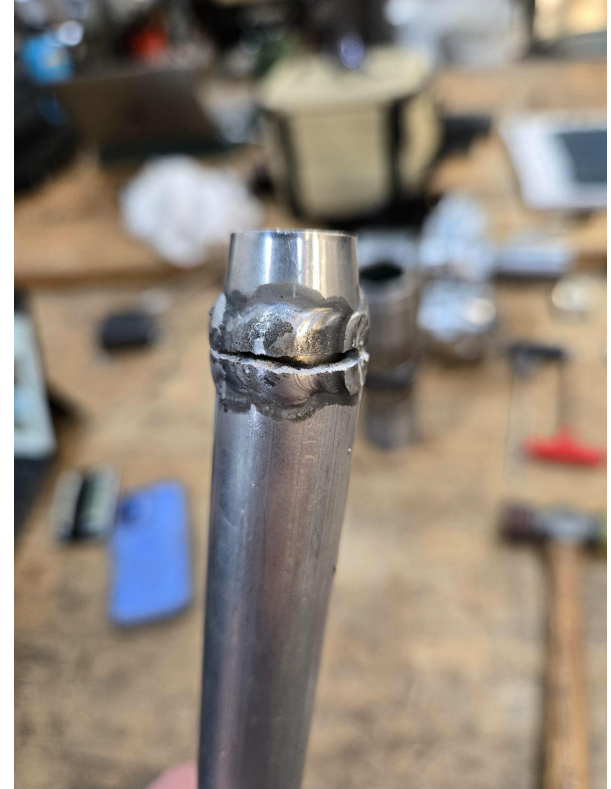
- Maximize Steering Angles
- Minimize Steering Slop
- Maximize Stability
- 7ft Steering Radius

Top Level Testing Summary (Steering)

Experiment/Test	Relevant DRs	Testing Equipment Needed	Other Resources
Exp1-Slalom Course	ER1: Reduce Steering Radius ER2: Minimize Steering Slop CR2: Maximize Driver Comfort ER3: Maximize Stability CR3: Simple to use	Cones Helmet Stopwatch Means to make a video	Driver Testing Area Fuel
Exp2-Driving Course	ER1: Reduce Steering Radius ER2: Minimize Steering Slop CR2: Maximize Driver Comfort ER3: Maximize Stability CR3: Simple to use	Cones Helmet Stopwatch Means to make a video	Driver Testing Track Fuel
Exp3-Radius Test	ER1: Reduce Steering Radius CR2: Maximize Driver Comfort ER3: Maximize Stability ER4: 7ft Steering Radius	Cones Tape measure Helmet Means to make a video	Driver Testing Area Fuel

Detailed Testing Plans (Steering)

- Experiment 1: Slalom Course
 - Driving the car around the parking lot while mimicking a slalom course
 - Tie rod weld broke during one of the slalom trials
 - Creating new tie rods made from steel with sizing changes to compensate.



Specification Sheet (Steering)

Engineering Requirement	Target	Tolerance	Measured/Calculated Value	ER met? (✓ or X)	Client Acceptable (✓ or X)
ER1: Reduce Steering Radius	8ft	±1ft			
ER2: Minimize Steering Slop	0°	±5°	3°	✓	✓
ER3: Maximize Stability	N/A	N/A	N/A	✓	✓

Customer Requirements	CR met? (✓ or X)	Client Acceptable (✓ or X)
CR2: Maximize Driver Comfort		
CR3: Simple to use	✓	✓

QFD (Steering)

[illegible]

Customer Requirements (Brakes)

- Safe to use
- Brakes are affordable
- Has no performance issues
- Easy to use
- Hydraulics within brake system function properly
- Brake rotors don't overheat when used excessively
- Brake pads work properly
- Brake system is easy to mount
- Brake system must pass tech inspection

Engineering Requirements (Brakes)

- Reduce braking distance
- Minimize pedal force
- Maximize safety
- Brakes must stop all four tires at once
- Maximize braking force
- Brake pedal made from aluminum or steel
- Vehicle must remain still while brakes are applied
- 2 independent reservoirs
- Maximize caliper clamping force

Top Level Testing Summary (Brakes)

Experiment/ Test	Relevant DRs	Testing Equipment Needed	Other Resources
Exp1 - Braking test	CR1: Safe to use CR3: No performance issues CR4: Easy to use CR5: Hydraulics function properly CR6: Brake rotors don't overheat CR7: Brake pads work properly ER1: Reduce braking distance ER2: Minimize pedal force ER3: Maximize safety ER4: Brakes stop all four tires at once ER5: Maximize Braking force ER10: Maximize clamping force	Cones, helmet, stopwatch, brake fluid, open reel tape measure, means to take a video	Testing area for driver, fuel
Exp2 – Brake Endurance test	CR1: Safe to use CR3: No performance issues CR4: Easy to use CR5: Hydraulics function properly CR6: Brake rotors don't overheat CR7: Brake pads work properly ER1: Reduce braking distance ER2: Minimize pedal force ER3: Maximize safety ER4: Brakes stop all four tires at once ER5: Maximize Braking force ER8: Brakes are designed for unobstructed travel ER10: Maximize clamping force	Cones, helmet, brake fluid, means to make a video	Testing area for driver, fuel

Top Level Testing Summary (Brakes)

Exp3 – Brake pressure test	CR1: Safe to use CR3: No performance issues CR4: Easy to use CR5: Hydraulics function properly CR7: Brake pads work properly ER2: Minimize pedal force ER3: Maximize safety ER4: Brakes stop all four tires at once ER5: Maximize Braking force ER10: Maximize clamping force	Brake fluid, brake line pressure gauge	Testing area, safety glasses
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Detailed Testing Plans (Brakes)

- Experiment 1: Braking test
 - Bring the car to about 10 mph, slam on the brakes at a specific spot, measure braking distance from that spot.
 - Car came to a stop quickly, will lock up brakes on dirt.



Specification Sheet (Brakes)

Customer Requirements	CR met? (✓ or X)	Client Acceptable (✓ or X)
CR1: Safe to use	✓	✓
CR2: Brakes are affordable	✓	✓
CR3: Has no performance issues	✓	✓
CR4: Easy to use	✓	✓
CR5: Hydraulics within brake system function properly	✓	✓
CR6: Brake rotors don't overheat when used excessively		
CR7: Brake pads work properly	✓	✓
CR8: Brake system is easy to mount	✓	✓
CR9: Brake system must pass tech inspection		

Specification Sheet (Brakes)

Engineering Requirement	Target	Tolerance	Measured/Calculated Value	ER met ? (✓ or X)	Client Acceptable (✓ or X)
ER1: Reduce braking distance	60 ft	±2 ft			
ER3: Maximize safety	N/A	N/A	N/A	✓	✓
ER4: Brakes must stop all four tires at once	N/A	N/A	N/A	✓	✓
ER5: Maximize Braking force	400 lbs	±25 lbs			
ER10: Maximize clamping force of brake calipers	90 psi	±1 psi			

QFD (Brakes)

[illegible]

Relationship		Baja 2025 Brakes		
Strong	9	Date: 9/12/2024		
		Legend		
Moderate	3	A	NAU 2024 #44	
Weak	1	B	Cal Poly 2024 #36	
N/A		C	Cornell Univ. #73	
Customer Opinion Survey				
1 Poor	2 OK	3 Acceptable	4 Good	5 Excellent
			A	BC
			A	ABC
			A	BC
			AB	C
			AB	C
			A	BC
			ABC	
				ABC
				ABC

Join NAU SAE Baja at:



April 17, 2025: 3-8 PM

Located at:

601 Piccadilly Dr

Flagstaff, AZ 86001

In Aspen Place at the Sawmill

Come meet this year's competing team and see the car while enjoying some drinks and learning about what NAU SAE Baja is aiming to accomplish this year.



Would you like to support the Team?

All tax-deductible donations can be made through the QR code.

Please, when donating, write in the gift comments "Baja"

If you have any further questions, please reach out to drc385@nau.edu.



Thank You

SAE Baja

Chassis Team
2024-2025



Engineering Requirements

Requirement	Description		points A & B (within 2in)
ER1	Increase Strength	ER19	B.3.2.8 RHO & RRH dimension and placement <u>guidelines</u>
ER2	Light Weight	ER20	B.3.2.10 SIMs run 8in-14in above lowest point of the seat
ER3	Low Cost	ER21	B.3.2.11 UST connect to LFS members securely below the seat
ER4	Driver Egress	ER22	B.3.3.1 Roll cage clearance for the largest driver (6in helmet) (3in torso & limbs)
ER5	B.3.2.17 Roll Cage Spec sheet filled out	ER23	B.4.2 Min. 5 point harness with 3in webbing with single metal buckle
ER6	B.3.2.16 Primary members steel OD, ID requirements	ER24	B.4.2.4.2 Shoulder webbing laterally placed 6in-9in
ER7	B.3.2.16 Alternate Material requirements	ER25	B.12.2 Lap and anti-sub mounting tabs (double shear) ≥ 0.09 in thick & ≥ 1.3125 in of weld length
ER8	B.3.2.3 Secondary members OD, ID requirements	ER26	B.4.5 Must have a conventional seat (<u>65-90deg</u> back angle) with back & bottom plane
ER9	B.3.2.15 Welding samples requirements	ER27	B.4.5.3.2 Seat has 4 mounting points on the bottom and 2 on the back plane
ER10	B.3.2.1 Straight (40in) and bent members (33in unsupported, <u><30deg</u> length	ER28	B.12.2 Seat tabs ≥ 0.125 in thick, fastener of 0.25in dia. spacers ≤ 0.5 in thick
ER11	B.3.2.5 Lateral cross member and CLC ≤ 8 in requirements	ER29	B.4.2.6.2 Anti-Sub belt angle <u>0-20deg</u> aft of the chest line
ER12	B.3.2.6 RRH Continuous vertical members & +/- 20 degree verticality	ER30	B.4.2.4.1 Mount shoulder belts at or below driver's shoulders ≤ 4 in
ER13	B.3.2.7 LDB max 5in from top & bottom of roll cage	ER31	B.10.3.3.1 Cockpit kill switch is within easy reach of a restrained driver
ER14	B.3.2.12 FBM max 45 deg. from vertical, FBMup & <u>FBMlow</u> joints		
ER15	B.3.2.9 LFS must extend from RRH to past driver's heels		
ER16	B.3.2.12.1 Gussets required if RHO and FBMup are not continuous		
ER17	B.4.2.4.3 Safety harness tubes are in RRH plane from one side to the other		
ER18	B.3.2.13.2 Rear bracing structural triangle connecting		

Customer Requirement

CR1	Performance
CR2	Safety
CR3	Durability
CR4	Affordable
CR5	Comfort
CR6	Ease of Fabrication
CR7	Aesthetics
CR8	Pass Techs
CR9	Balanced Weight

Top Level Testing Summary

Test	Relevant DRs	Testing Equipment	Other Resources
Exp 1 - Drive the Car	CR1,2,3,5,9 ER1 - ER3	Fuel Fully Functioning Drivetrain Fully Function Suspension	Location to drive the Car.
Exp 2 - Mock Tech Inspection	ER5 - ER31	Tech Sheet from SAE Tape Measures Angle Gauges Different Sized Rods	2025 SAE Baja Rulebook Someone to Proctor Mock Tech Inspection
Exp 3 - Driver Egress	ER4	The Car Stopwatch	Driver or Someone that is the Same Size

Detail Testing Plan

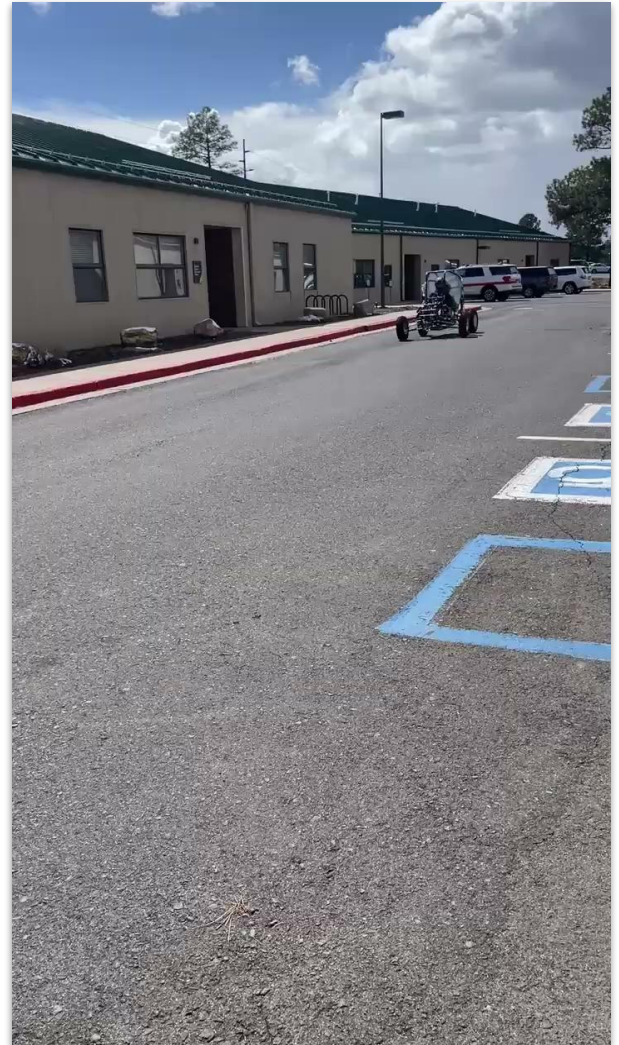
Experiment 1: Driving the Car

- Questions:
 - Gauging overall performance
 - Visually monitoring vibrations
 - Feedback on driver position
 - Visually inspect frame for deflections or interference

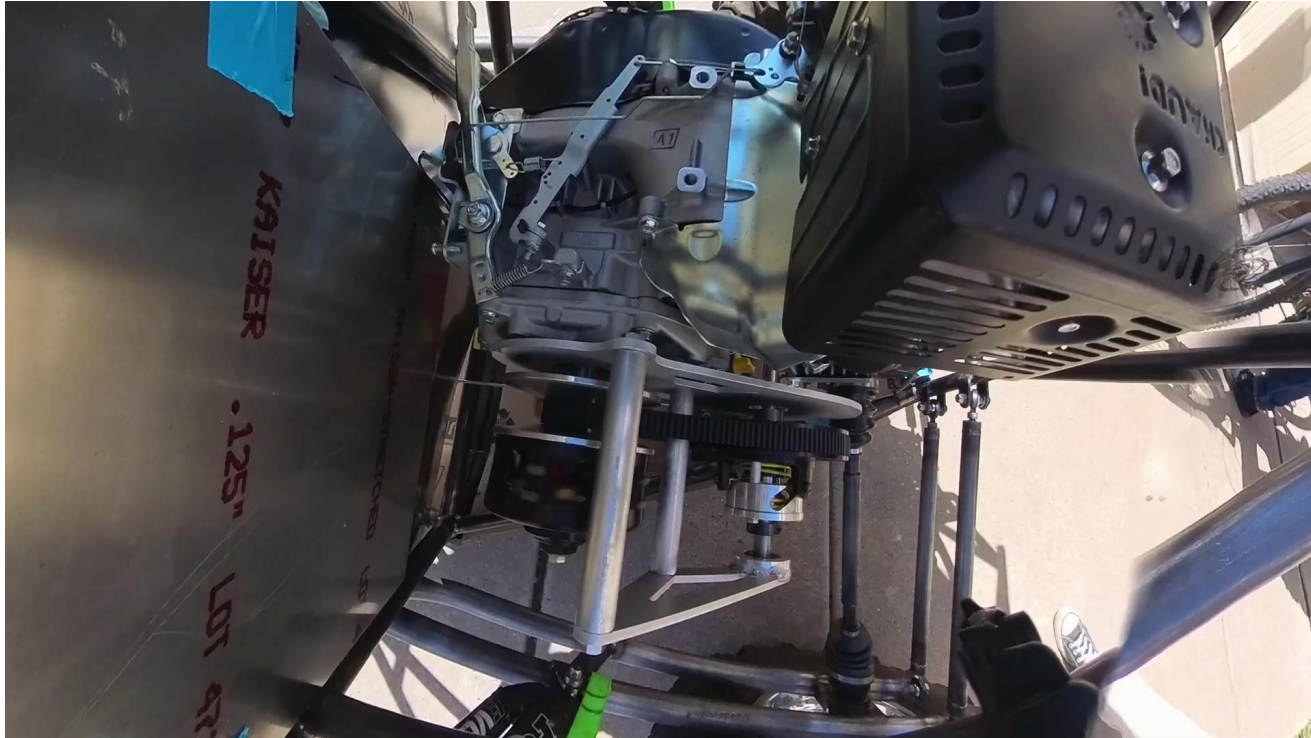
Detailed Testing Plan

- Findings:
 - Frame is balanced (no front lifting)
 - Need more bracing around engine to increase rigidity.
 - Seat is slightly off center

Charles



Detail Testing Plan



Detail Testing Plan

Experiment 2: Mock Tech Inspection

- Questions:
 - Will the chassis pass technical inspection
- Procedure:
 - Print out a tech inspection sheet to run through
 - Have Willy or third party present for unbiased opinion
 - Address any potential issues

Detail Testing Plan

Experiment 3: Driver Egress

- Questions:
 - Can the passenger exit the car in 5 seconds
- Procedure:
 - Have the drivers of the car present
 - Buckle the driver into the frame with the seat and wheel
 - Time the driver exiting the car



Pass



Not Passed

Tech inspection sheet

B.3.2.17	Newly completed roll cage specification sheet must be present and filled out.		FR
B.3.7.1	Calculations, purchase invoices, and material certifications of the materials used in the roll cage and bracing shall be required at technical inspection. Must be within 5 years of Jan 1 of the competition year.		FR
B.3.2.16	Primary roll cage members must be constructed of steel tubing with a minimum carbon content of 0.18%, OD of 25 mm (1.0 in), wall thickness of 3.0 mm (0.120 in).		FR
B.3.2.16	Roll cage documentaiton package was accepted online. If status is not accepted, documentation package must be verified on site.		FR
B.3.2.3	Secondary members may be circular or rectangular in shape and have a minimum OD (or width) of 25.4mm (1.0 in) and a minimum wall thickness of 0.89mm (0.035 in).		FR
B.3.2.16	Check thickness of Primary and Secondary Roll Cage Materials in a minimum of two places each. (1.57 mm (0.062 in) and 0.89 mm (0.035 in) minimum)		FR
B.3.2.15	One destructive testing (sample #1) and one destructive inspection (sample #2) weld sample for each process performed by each roll cage welder is required at technical inspection. Weld samples shall be permanently marked with welder name, welder school, and weld date. A completely separated destructive test specimen (sample 1) will not be accepted.		FR
B.3.2.15	Weld samples are constructed of the same Primary Material and with the same process(es) as the inspected vehicle.		FR
B.3.2.15	Weld samples exhibit superior weld strength with respect to the base material.		FR
B.3.2.15	Weld samples exhibit sufficient and substantially uniform weld penetration.		FR
B.3.2.1	Straight members may not extend longer than 1016 mm (40 in.) between Named Points and bent roll cage members may not be longer than 838 mm (33 in) unsupported. Bent members shall not contain an individual bend greater than 30 deg. or comply with B.3.2.4		FR
B.3.2.5	Front two points (C) shall be joined by a lateral cross member (CLC); Located on the top plane of the roll cage. Lateral cross members not less than 8 in. long.		FR
B.3.2.6	RRH must have continuous vertical members and driver seat cannot protrude aft of the RRH plane.		FR
B.3.2.6	Rear Roll Hoop (RRH) must be substantially vertical (+/- 20° from vertical).		FR
B.3.2.7	LDB max 127 mm (5 in) from top and 127 mm (5 in) from bottom of roll cage. Min angle of RRH and LDB ≥ 20°. A single, straight LDB exempt from length requirement.		FR
B.3.2.12	Front Bracing (FBM) max 45 deg. between vertical and FBMUP w/o Front FAB. No angle requirement if front braced.		FR
B.3.2.12	FBM _{UP} joins points C to D. FBM _{LOW} joins points D to F.		FR
B.3.2.9	LFS members must extend from RRH to points forward of driver's heels which are connected by the FLC (and ELC for nose cars).		FR

B.3.2.12.1	If the RHO and FBM _{UP} are not made of a continuous tube, a gusset is required at point C.		FR
B.4.2.4.3	Tubes anchoring safety harness shoulder straps shall be mounted to the primary welded structure of the vehicle and within the plane of the RRH. Shoulder belt harness tube must extend from one side of the RRH to the other.		FR
B.3.2	Roll cage members and tubes shall be joined by welding the entire circumference and shall not exhibit any injurious defects such as cracking, burn-through, cold lapping, or insufficient penetration.		FR
B.3.6	Members which are drilled through both walls for the purpose of mounting fasteners or routing accessories shall be reinforced with a weld-in sleeve no larger than 50% of the member diameter.		FR
B.3.2.13	Projected to side view, roll hoop bracing triangulation angles must be at least 20°.		FR
B.3.2.13.1	If front roll hoop bracing is used, it must connect FBMUP, LFS, and SIM <5 in from Point C. Point P must be vertically supported to Point Q. Points P and Q only exist with a complete front FAB system.		FR
B.3.2.13.2	If rear bracing is used, there must be a structural triangle connecting point B (within 2 in) to either point A or S (within 2 in). The aft vertex of the structural triangle must also be connected to whichever point A or S (within 2 in) is not part of the structural triangle (this member is exempt from the maximum 30° bend rule). The aft vertices must be joined the lateral cross member RLC. Members connecting to A must have a 45 degree angle with ALC.		FR
B.3.2.8	RHO must be >1041 mm (41 in) above driver seat; LC at point C must be >305 mm (12 in) forward of seat back; and RRH must be >737 mm (29 in) wide at 686 mm (27 in) above seat. All dimensions are with respect to the template in B.3.2.8		FR
B.3.2.10	The side impact members shall run between 203 mm (8 in) and 356 mm (14 in) above the lowest point of the seat in contact with the driver.		FR
B.3.2.11	The UST shall connect the LFS members and pass below the seat.		FR
B.3.2.14	All butt joints are reinforced with an internal sleeve and exhibit at least 102 mm (4 in) linear distance of weld bead.		FR
B.3.5	Bolted roll cage meets specifications.		FR
B.3.3.1	The roll cage is large enough for the largest driver. The driver's helmet will be at least 152 mm (6 in) away from a straight-edge applied to any two places outside of the structure.		FR
B.3.3.1	The driver's torso, knees, shoulders, elbows, hands, and arms must have 76 mm (3 in) of clearance to the outside structure of the cockpit, less the roll cage padding.		FR
B.3.2.10	The structure provides 25 mm (1.0 in) of clearance between a straight edge applied to any two points on the roll cage and any part of the driver's foot while actuating all pedals through the full range of motion.		FR
B.3.1	The roll cage protects the driver as intended. No tubes showing any cracks or deformation. Final judgment will rest with National Technical Inspectors.		FR



Pass



Not Passed

Tech inspection sheet

B.4.4	SFI 45.2 rated head restraint must be mechanically fastened (No Velcro or adhesive) to the vehicle. Head restraints may also be mechanically fastened or integral to the driver's seat.		1
B.4.2	Minimum 5-point harness with 3-inch webbing and a single metal-to-metal quick release lever buckle. No cam lock systems.		1
B.4.2.1	All driver restraint systems must meet either SFI Specification 16.5/16.1, or FIA specification 885/98. Not older than 3 years as of Jan 1st of competition year. New style tags only.		1
B.4.2.4.2	The shoulder webbing shall be laterally spaced between a minimum of 152 mm (6.0 in.) and 229 mm (9.0 in.) center to center and be directly routed towards the driver's shoulders.		1
B.4.2.4.6	Restraint webbing may pass through the firewall as long as the firewall construction is extended to protect the harness webbing.		2
B.4.2.4.3	Shoulder belts shall be looped around a straight frame tube meeting secondary member requirements and have provisions to limit lateral webbing movement.		2
B.4.2.4.3	The shoulder harness must be securely mounted to the primary welded structure of the vehicle and within the plane of the RRH. Check for proper adjuster routing.		2
B.12.2	Lap and anti-sub belt mounting tabs shall be no less than 0.090 in. thick, have at least 1.3125 (1-5/16") in of weld length per tab, have no holes other than those required for bolts, and not display significant deformation when pulled on. Fastener and tab hole diameters must be the same.		2
B.4.2.5.2	Lap belt tabs must be in double shear, free to pivot and align with the direction of the load. Tabs must be welded to the primary structure. Webbing may not be routed against the seat as to impede the function of the restraint system.		2
B.4.2.6	Anti-submarine belts may be bolted by tabs, wrapped around a tube, or wrapped around a bolt in double shear. Webbing redirections over 30° are unacceptable. Webbing must not significantly twist between mounting point and latches.		2
B.12 B.4.2.5.2 B.4.2.6.3	All fasteners in the driver's harness system shall meet requirements of B.12. Lap belt and/or anti-submarine belt bolts must be at least 12 mm or 7/16 in.		2
B.4.5	Vehicle must have a conventional seat with the driver's back angle between 90 and 65 degrees from horizontal. Suspension seats are prohibited.		2
B.4.5.3.2	The seat has a distinct back plane (not the firewall), with at least two mounting points no closer than 6 inches apart, at or near the RRH to tubes meeting at least secondary frame member requirements.		2
B.4.5.3.2	The seat has a distinct bottom plane (not the skid plate), with at least four mounting points no closer than 6 inches to tubes meeting at least secondary frame member requirements.		2
B.4.5.3.3	Unmodified FIA or SFI rated seats are permitted if factory mounting procedures are followed.		2
B.4.5.3.3	Any tubes mounting the seat shall be terminated at both ends		2
B.12.2	All tabs used to mount seats shall be at least 0.125 in thick accommodating a fastener of 0.25 in. diameter. Seat tab dimensions shall meet requirements of B12.2. Spacers shall not be greater than 0.5 in thick. Radially drilled tubes must be sleeved.		2
B.4.2.6.2	Driver anti-submarine belt angle is between 0 and 20 degrees aft of the chest line.		2
B.4.2.4.5	Belts shall be adjustable for different drivers. Minimum excess webbing is 4 inches.		2

B.4.5	Seat works in concert with the safety harness to secure driver.		2
B.8.3	This firewall must be metal, and at least 0.508 mm (0.020 in) thick. Large cutouts, including those for CVT and engine air intakes are explicitly prohibited. Drivetrain clearances are permitted per B.9.1 and have no gaps larger than 6.35mm (0.25in)		1
B.8.7	Open universal joints in steering system near drivers feet shall be covered to prevent entanglement. Steering linkages shall be properly shielded and covered with a sturdy, full width cover.		1
B.8.6	Skid plate material must be metal, fiberglass, plastic, or similar material. Skid plates shall extend the length of the cockpit and prevent debris and foreign object intrusion into the cockpit.		1
B.8.8	Fire extinguisher mounted on the right side, easily accessible, with the top below the driver's eye, and the top half above the SIM. Mounting bolts must meet B12 and match hole geometry. The pull knob shall be free and clear of any access obstructions. <u>Radial clearance to the pull knob shall be 2.5 in.</u>		1
B.12.2	The fire extinguisher may be mounted with traditional 0.125 in thick tabs per B.12.2, or by fuel tank style tabs per B.6.5.1.		1
B.8.8.4	Mount must resist shaking loose, but the extinguisher must be easily removable.		1
B.8.8	Two extinguishers with a Minimum UL rating of 5 B C; must be equipped with a manufacturer installed dial gauge ; gauge must be readable and properly charged . Must have OEM pin retainer. No zip ties or tape.		1
B.8.8.3	Fire extinguisher mount is the approved Drake or DV8 quick-release mount. No other mounts are acceptable.		1
B.8.8.1	All extinguishers must be labeled with school name and car number.		1
B.7.2	Only foot operated, cable throttle controls are allowed. Wide open throttle stop is required (at the pedal).		1
B.7.2	Throttle cable cannot be bare from the forward mounting point to the firewall.		1
B.8.3	The firewall shall separate the cockpit and engine area, covering the entire plane of the RRH. Pass throughs for 4WD equipment are permitted if sealed.		1
B.8.5	Body panels must cover the area between LFS member and SIM. The material must be plastic, fiberglass, metal or similar material. No gaps can exist that are larger than 6.35 mm (0.25 in). Must use quick-disconnect methods.		1
B.10.4.1	BSAE approved, unmodified brake lights shall be mounted minimum 1000 mm (39.4 in) from ground, and clearly visible in daylight when illuminated. Light shall be completely extinguished when brakes are not actuated.		1
B.10.4.1	Brake and reverse lights must be entirely visible when viewed at a 45 degree angle from center. The total viewing angle shall be no less than 90 deg.		1
B.10.4.1	Each independent brake circuit must be equipped with a hydraulic pressure switch. Actuation of any one circuit or combination of any circuits shall turn the brake light on.		1
B.10.4.2	Cars with reverse must have reverse light (SAE "R") of LED design and alarm mounted at min 700 mm (27.6 in) from the ground and aft of the RRH/firewall.		1
B.10.3.2	Vehicle must have two kill switches of type: Ski-Doo 01-171, 27-0154, 27-0152, or Polaris 4015321 and must only be used for engine kill switch functions and shall not de-energize the brake light.		1
B.10.3.3	One switch must be located on the driver's right side of the vehicle, aft of the RRH, on a <u>panel perpendicular (±15°) to the firewall</u> , no more than 178 mm (7 in) from the top of the roll cage. Threaded kill switch fasteners shall meet rule B.12.		1



Pass



Not Passed

Tech inspection sheet

B.10.3.3	The second kill switch must be located on the driver's left side, along the SIM, and be easily actuated by the driver. No other push button switches are permitted on the left SIM. Any type of guard/cover to prevent accidental contact is explicitly prohibited.			1
B.10.2	Kill switch wiring must be sealed, protected or securely attached to the frame to prevent the wires from being entangled with the driver or obstacles.			1
B.10.4.1	Reverse and brake lights shall remain effective at all times. No cut-out or disabling switches are permitted for any braking or reverse system.			1
B.10.1	Max system voltage 60 VDC or 50 VAC RMS. All circuits shall have appropriate means of circuit protection.			1
B.10.1.1.3	Min battery voltage for safety appliances is 11 VDC (nominal).			1
B.10.1.1 B.10.1.1.5	The batteries must be effectively sealed and secured and not leak in the event of a roll over. Terminals shall be insulated. Check battery chemistry.			1
B.11.2	Front hitch is tubular, Max OD 1.25 in, Min OD 1.00 in. Vertical location between LFS and SIM. Must be able to pass hitch inspection gauge.			1
B.11.3	Rear hitch may be fixed or swivel style, 0.125 to 0.375 in thick, Hole diameter is 1.0 in to 1.25 in. 1.0 in max edge distance. Fixed style attachment width is 3.0 in minimum. Swivel hitches require a graded fastener and tabs 0.125 in thick with a total attachment weld length of at least 3.0 inches.			1

QFD

Frame QFD												Baja 25' Frame				
Team Members												Date: 9/9/24				
Ryan Carley												Legend				
Charles Anderson												Strong	9	A	NAU 2024 #44	
Wyatt Walker												Moderate	3	B	Cornell 2024 #73	
												Weak	1	C	ETS 2024 #27	
		Technical Requirements										Customer Opinion Survey				
Customer Weights		Customer Requirements														
Increase Strength		9	9	-3	9		9	9	9	9	9	9	9	9	9	9
Light Weight		9	-3	-3	-3	9	9	9	9	9	9	9	9	9	9	9
Low Cost		9	-3	-1	1		9	9	9	9	9	9	9	9	9	9
Driver Egress																
B.3.2.17 Roll Cage Specs sheet filled out																
B.3.2.16 Primary members steel OD, ID requirements																
B.3.2.16 Alternate Material requirements																
B.3.2.3 Secondary members OD, ID requirements																
B.3.2.15 Welding samples requirements																
B.3.2.1 Straight (40in) and bent members (33in unsupported, <30deg length																
B.3.2.5 Lateral cross member and CLC <8in requirements																
B.3.2.6 RRH Continuous vertical members & +/- 20 degree verticality																
B.3.2.7 LDB max 5in from top & bottom of roll cage																
B.3.2.12 FBM max 45 deg. from vertical, FBMup & FBMlow joints																
B.3.2.9 LFS must extend from RRH to past driver's heels																
B.3.2.12.1 Gussets required if RHO and FBMup are not continuous																
B.4.2.4.3 Safety harness tubes are in RRH plane from one side to the other																
B.3.2.13.2 Rear bracing structural triangle connecting points A & B (within 2in)																
B.3.2.8 RHO & RRH dimension and placement guidelines																
B.3.2.10 SIMs run 8in-14in above lowest point of the seat																
B.3.2.11 UST connect to LFS members securely below the seat																
B.3.3.1 Roll cage clearance for the largest driver (6in helmet) (3in torso & limbs)																
B.4.2 Min. 5 point harness with 3in webbing with single metal buckle																
B.4.2.4.2 Shoulder webbing laterally placed 6in-9in																
B.12.2 Lap and anti-sub mounting tube (double shear) >=0.09in thick & >=1.3125in of weld length																
B.4.5 Must have a conventional seat (65-90deg back angle) with back & bottom plane																
B.4.5.3.2 Seat has 4 mounting points on the bottom and 2 on the back plane																
B.12.2 Seat tube >=0.125in thick, fastener of 0.25in dia. spacers <=0.5in thick																
B.4.2.6.2 Anti-Sub belt angle 0-20deg aft of the chest line																
B.4.2.4.1 Mount shoulder belts at or below driver's shoulders <=4in																
B.10.3.3.1 Cockpit kill switch is within easy reach of a restrained driver																
1 Poor																
2 OK																
3 Acceptable																
4 Good																
5 Excellent																
Technical Requirement Units		psi	lbs	\$	Seconds	N/A	Inches	N/A	lbs/in	N/A	Inches	Inches	Inches	Inches	Inches	Inches
Technical Requirement Targets		100	2500	5	1, 0.065, 0.118	1, 0.035	40, 33	8	5	1, 1	1	1	1	1	1	1

Thank You

Join NAU SAE Baja at:



April 17, 2025: 3-8 PM

Located at:

601 Piccadilly Dr

Flagstaff, AZ 86001

In Aspen Place at the Sawmill

Come meet this year's competing team and see the car while enjoying some drinks and learning about what NAU SAE Baja is aiming to accomplish this year.



Would you like to support the Team?

All tax-deductible donations can be made through the QR code.

Please, when donating, write in the gift comments "Baja"

If you have any further questions, please reach out to drc385@nau.edu.



SAE Baja

2024-2025



Design Requirements Summary

Engineering Requirements

- ER1 - Rear Ratio – 6.98:1
- ER2 - Front Ratio – 3.62:1
- ER3 - 4WD – Yes
- ER4 - Moving powertrain parts must be guarded on all sides – Yes
- ER5 - Gearbox vent system 100 mm away from exhaust – 100 mm
- ER6 - 4WD driveshaft surrounded and separate from cockpit – Yes
- ER7 - Minimum life cycle of gears – 10^9 cycles
- ER8 - Torque output – 226 ft*lbs
- ER9 - CV Length - <16 inches
- ER10 - CV Angle – 40 degrees
- ER11 - CV Joints – Yes
- ER12 - Thickness of CV axle – 1.2 inches
- ER13 - Weight – 75 grams
- ER14 - Max diameter – 70mm
- ER15 - Max Thickness – 40mm

Customer Requirements

- CR1 - Efficiency
- CR2 - Safety
- CR3 - Durability
- CR4 - Affordable
- CR5 - Ease of Manufacturing
- CR6 - Aesthetics
- CR7 - Pass Techs
- CR8 - Acceleration
- CR9 – Lightweight

Top Level Testing Summary

Experiment/Test	Relevant DRs	Testing Equipment Needed	Other Resources
EXP1 – Top Speed Test, Gear Efficiency Test	ER 1, 2, 4, 8 CR 1, 3, 7, 8, 9	Long Straightaway for reaching top speed	Performed at the Shop
EXP2 - Drive Car with 2WD	ER 1, 2, 4, 5, 8-15	Fuel Functioning Drivetrain Functioning Suspension Functioning 4WD system	Performed at the Shop
EXP3 – Terrain Test	ER 1, 2, 4, 5, 8-15	Rocky Terrain	Strenuous location to drive the car
EXP4 – Drive Car with 4WD	ER 1-6, 8-15	Fuel Fully Functioning Drivetrain Fully Functioning Suspension Fully Functioning 4WD system	Strenuous location to drive the car

Detailed Testing Plans

EXP1- Top Speed Test, Gear Efficiency Test

Test/Experiment Summary: The vehicle's top speed and acceleration are key performance metrics. The acceleration event at competition evaluates how quickly the car can cover 100 to 150 feet from a standstill. Top speed influences performance in other dynamic events. Testing these parameters will help assess the sub team's success in designing a drivetrain that effectively transfers power from the engine to the wheels.

Procedure:

1. Identify locations that have long, flat straightaways for reaching top speed
2. Measure 100 to 150 feet away from the start line
3. Time the vehicle to see how long it takes to cross the 100-to-150-foot threshold
4. Continue driving the vehicle until it stops accelerating and calculate the maximum speed of the vehicle

Results: The data collected from this experiment will show the effectiveness of all drivetrain components based off the magnitude of the speed calculated.

Conclusion: Assessing the top speed of the car will demonstrate how the vehicle will perform in the acceleration event in the competition and will allow any modifications or adjustments to be made to further enhance the vehicle's speed.

Detailed Testing Plans

EXP2- Drive Car with 2WD

Test/Experiment Summary: The 2WD functionality test is an important experiment to conduct to ensure the vehicle operates correctly and appropriately in 2WD. The team will assess the vehicle as it makes laps near the machine shop to better understand the effectiveness of the drivetrain system.

Procedure:

1. Start the vehicle
2. Slowly drive the vehicle around the machine shop
3. Assess the vehicle as it is in motion to determine if any adjustments need to be made

Results: The results of this experiment will indicate if there are any major flaws or failures in the drivetrain system, which will help the team provide a functional vehicle for competition.

Conclusion: This test is an important first step in the testing of the Baja vehicle and will ensure the 2WD system is functioning correctly.

Detailed Testing Plans

EXP3- Terrain Test

Test/Experiment Summary: The terrain test will include the vehicle traversing obstacles that may be found at the competition, such as large boulders, loose dirt/gravel, and other rocky terrain features. This test will help the team assess the vehicle's capabilities in rough terrain and will give a sense of how the vehicle will perform in the terrain at competition.

Procedure:

1. Identify locations with rocky terrain that are easily accessible.
2. Drive the car over small obstacles to start off with and increase the size of the obstacle to test the vehicle's limits.

Results: The results of this test will demonstrate how the vehicle traverses larger obstacles and will prepare the team for the obstacles seen in the competition.

Conclusion: This test will show the team how the vehicle functions over rough terrain, like terrain that will be seen at competition, to better understand the weaknesses and strengths of the vehicle.

Detailed Testing Plans

EXP4- Drive Car with 4WD

Test/Experiment Summary: The 4WD functionality test will demonstrate the vehicles' ability to both shift into 4WD and shift backing in 2WD. The test will include a stationary test of the vehicle shifting into 4WD and a possible moving and shifting test, depending on the vehicle's capabilities at the time. This test will show the team if the 4WD system works efficiently and if there are any improvements or adjustments that need to be made to the vehicle.

Procedure:

1. For the stationary test, the vehicle's rear will be jacked off the ground and held up by blocks to ensure the rear tires are off the ground
2. The vehicle will then be shifted into 4WD and will slowly accelerate to see if the 4WD system has actuated
3. The possible moving test will be done later in the testing phase

Results: This test will show the team the functionality of the 4WD system in the vehicle and will highlight any area of improvement, like adjusting the chain or tensioners to make the chain drive more efficient. These changes will help the team perform better in competition.

Conclusion: This test will be an important milestone in the testing of the Baja vehicle and will be a large indicator of whether or not the vehicle will perform well in the hill climb event in competition.

Specification Sheet Preparation

Customer Requirements	CR met? (Y/N)	Client Acceptable (Y/N)
CR1 - Efficiency	Y	Y
CR2 - Safety	Y	Y
CR3 - Durability	Y	Y
CR4 - Affordable	N	Y
CR5 - Ease of Manufacturing	Y	Y
CR6 - Aesthetics	Y	Y
CR7 - Pass Techs	Y	Y
CR8 - Acceleration	Y	Y
CR9 - Lightweight	N	Y

Specification Sheet Preparation

Engineering Requirements	Target	Tolerance	Measured/Calculated Value	ER Met? (Y/N)	Client Acceptable (Y/N)
ER1 - Rear Ratio – 6.98:1	6.98:1	+/- 0.25	6.98	Y	Y
ER2 - Front Ratio – 2.95:1	3.62:1	+/- 0.25	2.95	Y	Y
ER3 - 4WD – Yes	Yes	N/A	N/A	N	N
ER4 - Moving powertrain parts must be guarded on all sides – Yes	Yes	N/A	N/A	N	N
ER5 - Gearbox vent system 100mm away from exhaust – 100mm	100mm	+/- 10mm	110mm	Y	Y
ER6 - 4WD driveshaft surrounded and separate from cockpit – Yes	Yes	N/A	N/A	N	N
ER7 - Minimum life cycle of gears – 10^9 cycles	10^9 cycles	+/- 10^8 cycles	200*10^3	Y	Y
ER8 - Torque output – 226 ft*lbs	226 ft*lbs	+/- 10 ft*lbs	226ft-lbs	Y	Y
ER9 – CV Length - <16 inches	16 in	+/- 2 in	8" Front, 16" Rear	Y	Y
ER10 – CV Angle – 40 degrees	40 degrees	+/- 5 degrees	40 degrees max	Y	Y
ER11 - CV Joints – Yes	Yes	N/A	Chosen	Y	Y
ER12 - Thickness of CV axle – 1.2 inches	1.2 in	+/- 0.25 in	1"	Y	Y
ER13 – Hub Weight – 75 grams	75 grams	+/- 25 grams	87.6 grams	Y	Y
ER14 – Hub Max diameter – 70mm	70 mm	+/- 10 mm	79.4 mm	Y	Y
ER15 – Hub Max Thickness – 40mm	40 mm	+/- 7.5 mm	44.4 mm	Y	Y

Nolan

Nolan

Videos



Driving Test over curbs



~100 ft test drive



CV Axles plunge test

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Thank You Any Questions?