Maven Cargo E-bike Near-Shoring Industrialization

Integral Electrics LLC

Funding Provided by:
Appalachian Regional Commission

Western Carolina University

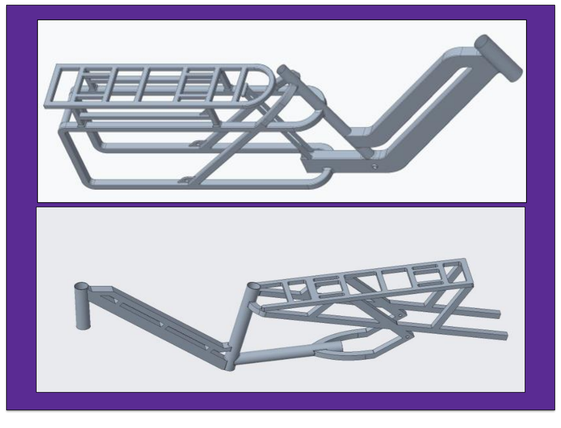
PROBLEM STATEMENT

Integral Electrics LLC designs family-friendly, cargo-style e-bikes with a “female-first” approach—prioritizing comfort and safety for smaller riders while remaining adjustable for a wide range of users. Their bikes meet the latest U.S. and EU safety standards and are built to carry children, pets, groceries, and more. To support near-shoring production of their Maven Cargo e-bike to Mexico, Team 18 has been tasked with redesigning the bike for steel frame manufacturing, as aluminum frame facilities are not available in Mexico. This requires new CAD models for the frame, components, and assembly. The redesign must maintain Integral Electrics' design philosophy while ensuring the final product is durable, versatile, and aesthetically appealing.

REQUIREMENTS

#	Description
1	Frame wights less than 85 lbs.
2	Rear rack height is less than 23 in.
3	Maximum payload is between 350-400 lbs.
4	Batteries must be placed on the low backside between rider and cargo
5	Seat post must be lowered by 2 in. compared to the current frame
6	Meet Industry Standards: ASTM F2273-03, F2274-03, F2711-19, F2802-19, and EN 17860.
7	Bike repairs must be done under 30 min
8	Maintain a low center of gravity

CONCEPTS



FINAL DESIGN, APPROACH, PLAN

The final bike frame design was developed in alignment with the sponsor's specifications and current aluminum design. In response to a request from the sponsor, Team 18 revised the design by replacing the original rectangular aluminum tubing with round steel tubing to facilitate ease of manufacturing. Due to project time constraints, a physical prototype was not constructed. Instead, all structural analyses and performance evaluations were conducted using Finite Element Analysis (FEA) and simulations within PTC Creo.

Final Frame Design – Model (CREO PARAMETRIC)

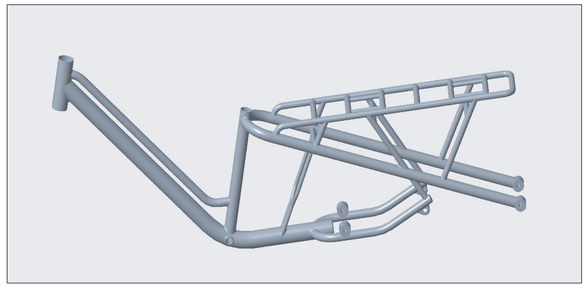


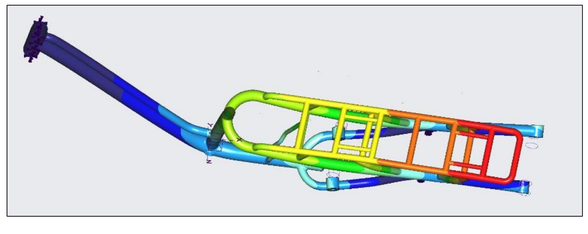
Photo Caption: Final Bike Frame Design

RESULTS

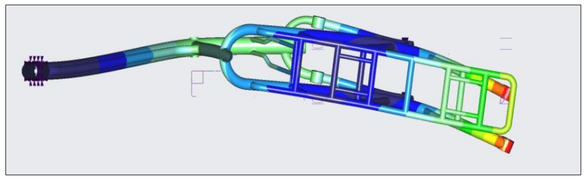
FEA tests on the version 2.1 Maven Cargo E-bike frame confirm it meets all required performance standards. Static analysis shows a maximum displacement of 0.007 inches and a safety factor of about 2.69, depending on the grade of low-carbon steel used (36,000–45,000 psi). Stress is highest when 400 pounds are applied to the seat post. Stress is lower but similar when 300 pounds are applied to the seat post and 120 pounds are evenly distributed on the cargo rack. Modal analysis, used to assess the frame’s response to vibrations, indicates the frame remains stable up to frequencies around 63.835 Hz—above the expected range for typical urban use—ensuring structural integrity and minimizing the risk of resonance or fatigue.

Modal Analysis

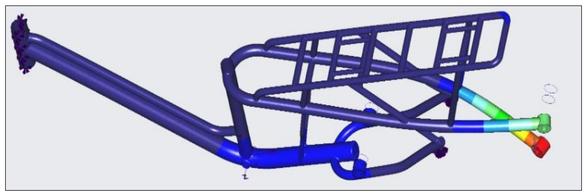
Modal 1(63.8354 Hz)



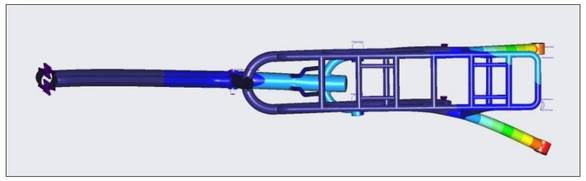
Modal 2 (77.401 Hz)



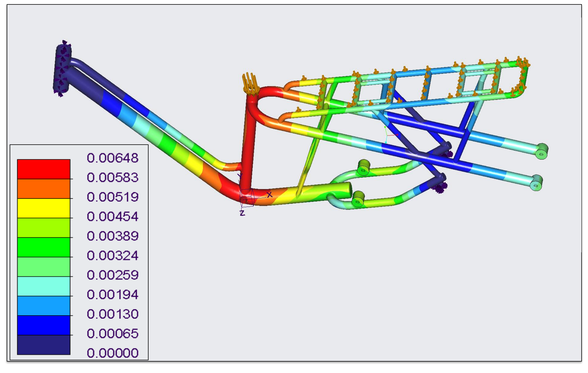
Modal 3 (99.012 Hz)



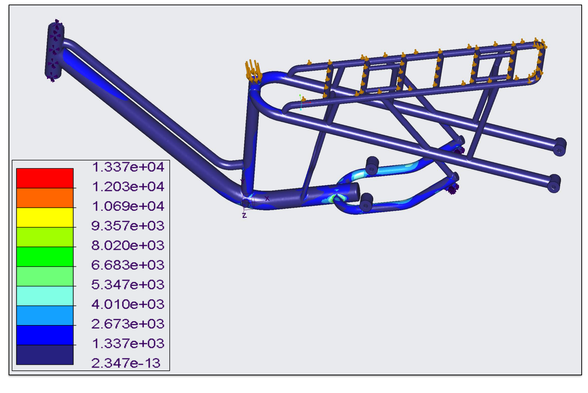
Modal 4 (100.685 Hz)



FEA Analysis: *Displacement (Inches)*



FEA Analysis: *Von Mises Stress (psi)*



SUMMARY AND CONCLUSIONS

Team 18 was tasked with redesigning the Maven Cargo E-bike frame. Initially planned with mixed tubing, the frame was redesigned using round steel tube stock to simplify manufacturing. Due to time constraints, validation was completed through CAD modeling and finite element analysis (FEA) in PTC Creo instead of physical prototyping and testing.

Despite changes and time constraints, Team 18 delivered a manufacturable and performance-ready bike frame design. The team met all requirements through simulation-based testing, providing detailed CAD files and analysis results. The final design is ready for review and supports the transition to near-shore production in Mexico.

FUTURE WORK

The next phase of the project involves developing a full-scale physical prototype of the redesigned Maven Cargo e-bike frame. The prototype will be used to validate the results obtained through CAD modeling and simulation in Creo, ensuring that structural integrity, ride quality, and overall performance meet the intended design goals. Additionally, the steel frame prototype will allow for comprehensive testing of accessories and component fitment, verifying compatibility and ease of assembly. Further refinements based on testing outcomes will help optimize the design for manufacturability and user experience.

TEAM & ACKNOWLEDGEMENTS

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- Enrique Zuniga Rios, B.S.M.E.
- David Borders, B.S.E.T.
- Laura Belmar, Sponsor (Not Pictured)

Integral

References

1. Watson, J. (2023, August 22). Steel vs aluminum bike frames: In-detail comparison with pros and cons. Bike The Sites. https://www.bikethesites.com/steel-vs-aluminum-bike/.
2. Integral Electrics. Maven Cargo E-bike. https://integralelectrics.com/products/the-maven-cargo-e-bike