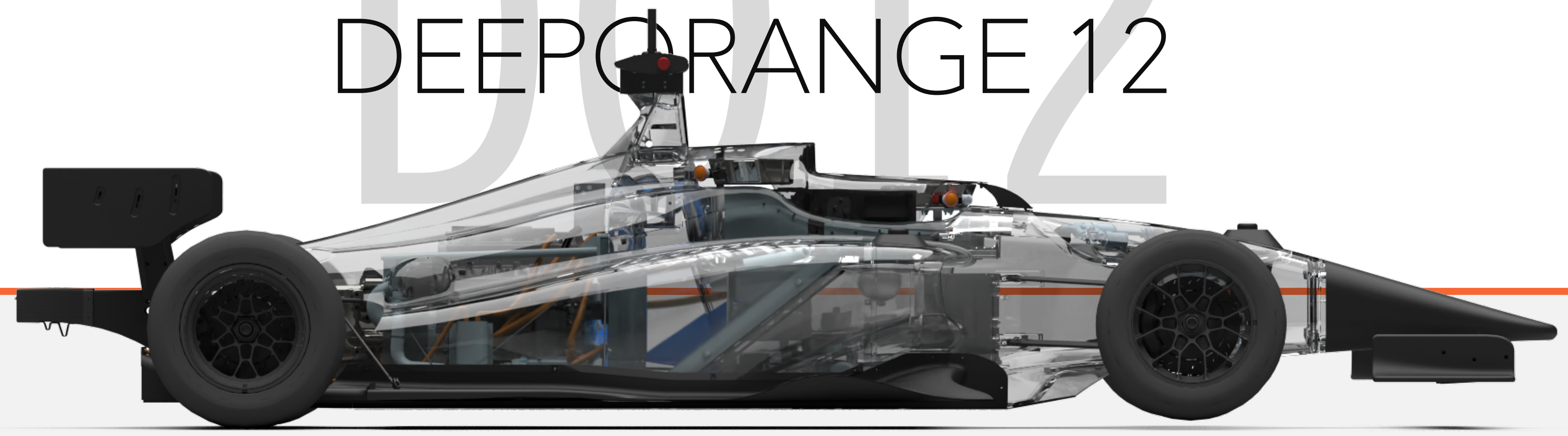
HIGH-SPEED DRIVERLESS RACECAR

DEEPORANGE 12



ENGINEERED BY: POWERED BY: DESIGNED BY:

The Deep Orange 12 vehicle was engineered around five primary goals: Engineer an autonomous racecar, within an IL-15 package, to reach up to 180mph, to be easily and cost-effectively manufacturable, that prioritizes safety.

The 38-student team achieved these goals by means of eight key technology innovations, or unique selling propositions.

Learn more at **CuicarDeepOrange.com.**

Advanced Perception Systems

Clemson's 180 mph autonomous racecar covers the length of a football field in 1.2 seconds. Without a driver, the car requires advanced perception systems that allow it to digitally observe its environment sufficiently fast and reliably to control the car safely at racing speeds. The Clemson team integrated a robust suite of cameras, radars, long-distance LiDARs, and centimeter-accuracy GPS sensors that are synchronized through ultra-precise timing protocols and capture the full surroundings of the vehicle over a high-speed network, at data rates that fill up a 1TB hard drive in 20 minutes. This sensor configuration is the first of its kind, unique to Clemson's autonomous vehicle.

Precision High-speed Drive-by-wire Control

In traditional vehicles, the human can steer and brake even if all power is lost. In a drive-by-wire vehicle, losing power means losing control. Working closely with industry partners, Clemson engineered electrically powered steering, braking, throttle and shifting controls with backup systems and triply-redundant safety checks. In addition to a backup battery, hierarchical controllers make sure all actuators are not only intact, but in the desired position, drawing the nominal amount of power, communicating as expected, and continually receiving end-to-end heart-beat signals.

Low-Latency, High-Throughput, Ultra-Reliable V2X Communication

While the autonomous racecar will not be allowed to receive any information from the pit crew during the race, it is crucial from a safety perspective the racing teams be able to monitor the status of the vehicle hardware and software at all times. The Clemson team integrated a wireless communication system that can send telemetry data such as vehicle speed, engine RPM, or tire temperatures, as well as autonomy data such as video, and localization information in real-time without any data loss as the vehicle moves around the 2.5-mile track at the Indianapolis Motor Speedway.

Purpose-Built Structural Racing Engine

Unlike street vehicles, the compact packaging and lightweight nature of Indy racecars required Clemson to design a complex engine packaging system to withstand the stresses of high-speed driving while meeting the needs of autonomous racing. Because competition teams need to validate their algorithms starting at low speeds, Clemson also engineered the internal combustion engine to run as slow as possible in first gear while still allowing speeds up to 180mph. This allows teams to perform a "track walk" to collect mapping data from the radars, LiDARs, cameras and GPS/GNS systems. To further ease the burden on the autonomous driving systems, the engine is also fitted with a special anti-stall clutch system that allows for significantly simplified launches from the pit lane. Finally, an advanced electronic control system coordinates engine throttle and gear shifting.

Lightning-fast On-Board Computing and Software

High-speed racing requires high-speed decision-making and controls. The Clemson-designed racecar includes a high-end, ruggedized computer specifically configured for autonomy. It includes a 3 TB high-speed solid-state drive, a state-of-the-art GPU with 4,608 parallel-processing cores, and a 40 Gbps network communication card. Together with industry partners and the Autoware Foundation, the Clemson team built the base software for the vehicle in the ROS2 robotic operating system. This provides a well-structure software interface through which the teams participating in the IAC competition can access all the advanced sensing, communication and drive-by-wire capabilities of the racecar.

CUICAR
CLEMSON UNIVERSITY INTERNATIONAL CENTER FOR AUTOMOTIVE RESEARCH

DO12

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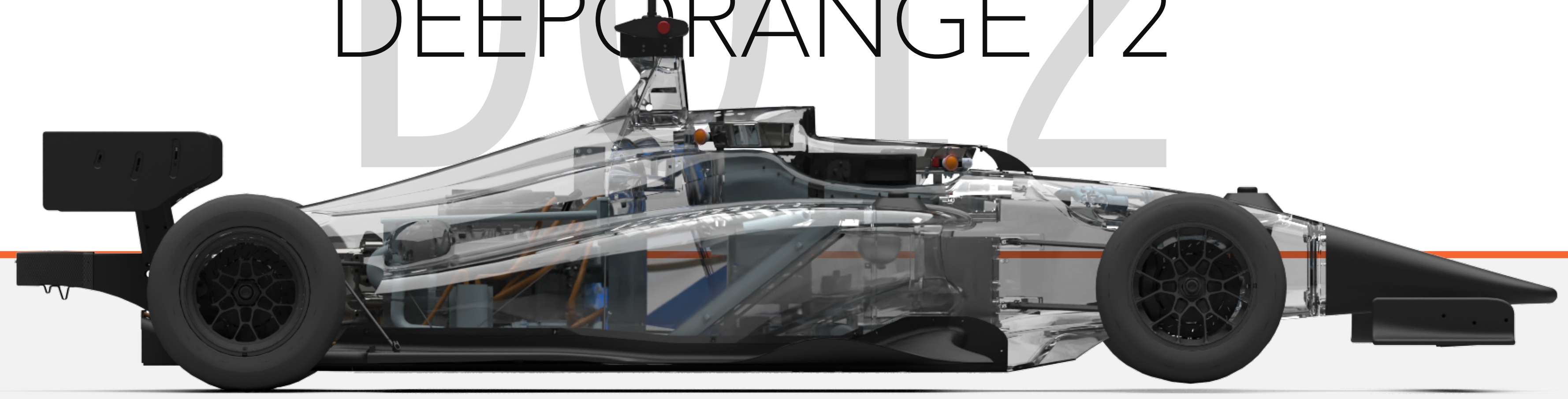

ENGINEERED BY: Department of AUTOMOTIVE ENGINEERING Clemson University

POWERED BY: EY Building a better working world

DESIGNED BY: dallara

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Designed for Series Production

Clemson's autonomous racecar represents the University's first-ever vehicle to go into production. Unlike previous Deep Orange prototypes, this vehicle is not a one-off build. In the spirit of the competition, all vehicles must be mechanically and electrictronically identical, so Clemson orchestrated full manufacturing plans to reflect that. This drove students to balance performance and functionality with reproducibility, intentionally seeking lower-cost components with existing aftermarket support and low operating and maintenance costs. The team produced a detailed bill of materials, developed detailed manufacturing specifications, selected vendors, , and coordinated vehicle builds at outside facilities, all unique to the needs and requirements of their grand challenge.

Rules and Procedures for Head-to-Head Autonomous Racing

For human drivers, following race rules and procedures requires training but is relatively intuitive. Clemson was tasked not only with programming the vehicle for those rules and procedures, but also with inventing the rules themselves. To enable multi-vehicle, head-to-head autonomous racing in the spirit of both traditional racing and this competition, the Clemson team wrote the rule book that involves a series of flag states, safety measures, and limits on how vehicles must behave when on the race track.

Ultra-Compact Aerodynamic Component Packaging

At 180mph, aerodynamics matter. The team had to fit all of their complex autonomous racing systems into the space normally occupied by the driver, all while preserving the aerodynamic efficiency and integrity of the ultra-lightweight chassis. The Clemson team chose the Dallara IL-15 as a base structure for its world-class quality and streamlined design, while paying homage to the heritage and strong fanbase of Indy racing.

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Unparalleled Systems Integration Education

Over 18 months, during a pandemic, the Clemson students honed both their hard and soft skills by collaborating with more than 38 global partners to deliver a first-of-its-kind autonomous racecar capable of high-speed racing. Students put their knowledge of advanced engineering concepts into practice, performing simulations across hundreds of design iterations and ultimately validating their creation on the track. While the Clemson student team will not be competing in the head-to-head race in October, their experience will help launch their careers this summer as they join more than 800 automotive engineering alumni working in all levels of the global mobility industry. Regardless of the race outcome, each vehicle - including the winner - will bear a tiger paw to commemorate Clemson's accomplishments. Because all vehicles on the track in October will be designed by the Deep Orange team, the Clemson students are guaranteed to win the race, and more importantly, guaranteed to win the opportunity for a successful career that builds on the strong systems integration skills acquired during this Deep Orange project.