FAQ: CYNGN DRIVEMOD TUGGER

DRIVEMOD TUGGER SPECIFICATIONS

Carts & Towing

What's the towing capacity of the DriveMod Tugger?
The DriveMod Tugger can tow up to 12,000 pounds.

*Refer to the **DriveMod Tugger Spec Sheet** for more information.*

How fast can the DriveMod Tugger travel?
~3 MPH Autonomously, 6 MPH in Manual Mode.

How many carts can Cyngn tow?
Remember, if a manually-operated tugger can operate in the environment, the DriveMod Tugger can operate in it autonomously. The number of carts that the DriveMod Tugger can tow is limited by:
- The towing capacity of the Tugger itself (12,000 lbs)
- The aisle widths of the environment. The DriveMod Tugger needs a minimum of 55" aisle width to operate, though this number may increase if the carts it's towing are wider than the Tugger itself.
- The steering profile of the carts the DriveMod Tugger would be towing. Quad-steer carts track behind the Tugger with much more fidelity than non-quad steer carts, for instance. Generally, this means the Tugger can tow more quad-steer carts in narrower aisles than non-quad steer carts that may require wider aisles to account for the lateral displacement of the later carts in the cart train.

What types of carts can the DriveMod Tugger tow?
The DriveMod Tugger can tow nearly any cart system. Quad-steer carts are preferred due to the high fidelity of their tracking profile, but any cart that is currently towed by a manually-operated tugger can be similarly towed by the DriveMod Tugger.

If a cart is not quad-steer, Cyngn's deployment team will test the tracking profile of the cart to verify the DriveMod Tugger is able to safely operate throughout the environment.

Does the auto-unhitch feature unhitch all carts at once?
Yes. The auto-unhitch feature will autonomously unhitch the first cart in the cart train which will unhitch the entirety of the cart train.

How does the DriveMod Tugger operate differently when towing multiple carts?
The DriveMod Tugger's safety settings are configurable to the steering profile and dimensions of the carts and load. During bring-up Cyngn will repeatedly simulate the customer's workflow, towing the maximum number of carts and heaviest load the customer would tow to validate safety and performance.

Battery Use & Charging

What type of battery does the DriveMod Tugger support?
The DriveMod Tugger supports 6.2, 9.3, and 12.4 kWh Lithium-ion batteries manufactured by Inventus.

*Refer to the **Battery Spec Sheet** for more information.*

How long does the battery last?
Estimated run times by battery configuration:
- 6.2 kWh: 6-8 hrs
- 9.3 kWh: 8-12 hrs
- 12.4 kWh: 10-14 hrs

Exact battery run time is dependent on the time spent actively driving and the total weight of load.

*Refer to the **Battery Spec Sheet** for more information.*

How long does it take for the battery to charge?
Charge time depends on the charger type:
- With a single charger, the battery will charge from 20% to 80% in ~3.5 hours.
- With a double charger (requires 240V) the battery will charge from 20% to 80% in ~2 hours.

*Refer to the **Battery Spec Sheet** for more information.*

Network Connectivity

Does the DriveMod Tugger need to be connected to the internet to function?
Connectivity is not required to operate autonomously. Missions can be saved locally on the Tugger. However, connectivity is required to access Cyngn Insight to remotely monitor their fleet and deploy missions. Additionally, connectivity is required to view real-time performance metrics on the analytics dashboard.

What kind of connectivity does the DriveMod Tugger need?
Either WiFi or cellular connectivity that offers minimum upload and download speeds of at least 1 mbps.

Outdoor Travel

Can the DriveMod Tugger operate outdoors?
Yes the DriveMod Tugger can operate outdoors under certain conditions. Please reach out to Cyngn Sales if a customer is considering the DriveMod Tugger for a use case that requires any level of outdoor navigation.

CYNGN ENTERPRISE AUTONOMY SUITE ("EAS") OVERVIEW

DriveMod

What is the difference between AGVs and AMRs?

The key difference between AGVs and AMRs is technological sophistication. Generally speaking, AGVs follow fixed routes, such as laser-guided or magnetic tape pathways, which can make them more limited in what they can do. AMRs on the other hand, use advanced sensors and software to safely and dynamically navigate and interact with their environment without the need for installation of any special infrastructure like magnetic tape, QR codes, fiduciaries, or April Tags.

Additionally AMRs are more dynamic than AGVs and can seamlessly adapt to changes in their environments through simple reprogramming.

Lastly, because of their reliance on special infrastructure installation, implementation for AGVs is much more cumbersome than for AMRs. Where completion of an AGV deployment may take months, completion of an AMR deployment can take mere days.

Cyngn transforms legacy industrial vehicle platforms into Autonomous Mobile Robots (AMRs).

How does Cyngn's autonomous system work?

DriveMod, Cyngn's autonomous navigation system, utilizes a 3D LiDAR to create a "localization map", or digital blueprint of its environment, and a "semantic map" that is overlaid on top of the localization map. The semantic map stores information on the localization map such as permissible driving zones, waypoints, stop signs that ensures customer rules of the road are adhered to by DriveMod.

Cyngn's DriveMod Vehicles then utilize the 3D LiDAR to perceive its environment, localize based on existing features in the localization map, and navigate. Because Cyngn's localization map is three dimensional, unlike many competitors, it is robust to dynamic environments and enables advanced perception techniques such as pedestrian detection and tracking.

What happens if someone drives the DriveMod Tugger outside of the mapped area?

If the DriveMod Tugger is driven outside of the drivable route defined by the semantic map, the user will have to return the Tugger to the driveable route manually for it to operate in autonomous mode. The Tugger will tell the user if it is not on the semantic map. Additionally, while the Tugger is in autonomous mode, the Tugger will never deviate from the semantic map.

Can customers make changes to their maps?

Currently no. Customers must reach out to Cyngn Customer Support to make changes to their existing maps. Depending on the nature and severity of the change request, Cyngn is likely to be able to assist with this remotely. On rare occasions, Cyngn may need to return to the customer site to facilitate the map change.

*Refer to **Cyngn's EAS Support Services Rates** for more information on post-deployment services pricing.*

Does the DriveMod Tugger require a designated lane to operate?
No. Cyngn's autonomous vehicles can operate alongside pedestrians and manually-operated vehicles. There is no need to designate a lane solely for autonomous vehicles unless desired. With that said, adding signage and physical markings on the floor may inform staff of the autonomous vehicle's routes. If the customer can operate in their current environment with manually-operated tuggers then Cyngn can operate in it autonomously.

Cyngn Insight

How does Cyngn Insight work?
Cyngn Insight is Cyngn's web-based fleet management system. Through Insight, users are able to create, edit, and deploy missions to DriveMod Vehicles and monitor the fleet's performance and location in real-time.

How does mission execution work?
Users have the ability to assign missions to either the entire fleet or to specific Vehicles. If the former, Insight will arbitrate selecting a Vehicle to carry out the work. When there are multiple missions to execute Insight will build a mission queue and the fleet will execute missions in the order they were deployed chronologically.

Missions can also be saved locally on the Vehicle to enable deployment from the Vehicle's HMI (touchscreen). These missions can only be deployed to the Vehicle they are saved on. However, the same mission can be saved on multiple Vehicles.

Does Cyngn Insight share data externally?
No, Cyngn does not share customer information with any third parties.

Is ERP/WMS system integration possible?
Yes. Cyngn maintains APIs that enable customers to control their Vehicles through triggers in their execution systems. Please contact Cyngn Sales if a customer requires ERP/WMS integration to move forward with a DriveMod Tugger sale.

How are software updates managed?
EAS software updates are installed and managed remotely. When a new update is available, Cyngn will contact the customer to set aside a time when their Vehicles are down to perform the update. A support representative will confirm with the customer that their Vehicles are powered on and connected to a network when the update is conducted. Typically this is done remotely, at times an in person Cygnn representative may need to come to the site.

Software updates to Cyngn Insight occur automatically in the web application. If there are any major updates that may impact the customer's operation, the customer will receive notice prior to the update.Safety & Certifications

Which certifications does the DriveMod Tugger adhere to?
We are designed to the following certifications RIA 15.08 and ANSI B56.5 but are not certified under any of them. If this is of concern please contact the Cyngn team regarding certification requirements for a customer.

What are some of the safety features of the DriveMod Tugger?

360 LiDAR. The DriveMod Tugger's primary sensor is the 3D LiDAR mounted on top of the steering column. The LiDAR completes a full 360 degree scan of its environment 9 times every second and enables robust obstacle detection and pedestrian identification and tracking. If an obstacle either comes close to or obstructs the Tugger's path the LiDAR will detect it and slow down or stop the Tugger appropriately.

Virtual Bumper. There is also a redundant safety sensor located on the front of the Tugger called the Virtual Bumper (VB). VB has an independent linkage to the Tugger's throttle, steering, and brake controls and will stop the Tugger if it detects anything in front of it regardless of what the LiDAR sees or does not see.

LED Lights. Underneath the LiDAR, LED lights inform passersby of the Tugger's state and intent of the Tugger. Different light colors indicate if the Tugger is in manual or autonomous mode, when it's safe to interact with the Tugger and its carts, and when it detects an obstacle in its path.

Emergency Stop Button (E-Stop). The DriveMod Tugger is equipped with two E-Stop buttons that will immediately stop the Tugger and disable autonomous driving functionality to halt any erratic or undesired driving behavior.

Audio Cues. The DriveMod Tugger is also equipped with configurable audio cues that provide additional awareness to staff on the floor. These cues can be programmed to sound with varying frequency or at specified locations.

*Refer to **Product Overview Docs** for more information.*

Does Cyngn have any safety incidents?
Cyngn is proud of its perfect safety record. EAS has caused zero collisions.

DEPLOYMENT & DEMOS

Is it possible to set up a demo at a customer site?
Yes! *Refer to the **Demo Overview** for more information.*

How long does it take to implement a Cyngn DriveMod Tugger?
Just under 2 weeks from the Tugger's arrival on site to training and Go Live.

*Refer to the **Deployment Timeline** for more information.*

Does installation require any infrastructure changes?
No. There is no need for fiducials, stickers, tape, or any other sort of special infrastructure in order to enable localization or navigation.

How long does training take?
Training is broken up into classroom and on-vehicle sessions. Typically, training takes about 2-3 hours.

SUPPORT, MAINTENANCE, & TROUBLESHOOTING

How does support work?

Dealers are customers' first line of support. All dealer-sourced customers can reach out to the dealer that sold them their DriveMod Tugger(s) when they have an issue or question.

Generally, dealers will own resolution for any issue with an underlying Motrec MT-160 component (e.g., tire, axle). For any autonomy-related issue involving EAS or the DriveMod Kit, dealers can first *refer to the **Dealer Troubleshooting Guide** to assist customers.*

If Dealers require escalation to Cyngn for resolution, they can utilize the Contact Cyngn Customer Support link in the **Dealer Portal** to escalate any customer support inquiries to Cyngn.

What happens if a customer encounters any issue with a component of the underlying Motrec-160?

The customer would contact the dealer they bought the DriveMod Tugger from for any and all vehicle hardware-related issues.

What happens if a customer encounters any issue with the DriveMod Kit or EAS?

The customer would contact the dealer they bought the DriveMod Tugger from to attempt to resolve the issue. If the dealer is unable to resolve the issue, they will escalate the issue to Cyngn Customer Support via the Contact Cyngn Customer Support link on the **Dealer Portal**.

What is the best way to contact Customer Support?

Utilize the Contact Cyngn Customer Support link on the **Dealer Portal** to contact customer support via their email address: customersupport@cyngn.com. *Refer to the **Dealer Support Guide** for more information.*

How often is preventative maintenance required on the DriveMod Tugger?

The DriveMod Tugger requires minimal preventative maintenance. Sensors should be wiped down with a microfiber cloth before each use and there is a fan filter inside the DriveMod Kit that needs to be replaced every month or so.

*Refer to the **DriveMod Tugger Maintenance Manual** for more information.*

How much does the DriveMod Tugger cost to maintain?

Cost to maintain the DriveMod Tugger will be minimal for the hardware and software for the first 5 years. Purchases include a 3 year warranty on the underlying Motrec MT-160 components and a 2-year warranty on the DriveMod Kit.

Typically, the only part replacement that will be necessary after 5 years is the batteries which cost ~$2500 per 3.2 kWH unit.

*Refer to the **Dealer Troubleshooting Guide** for more information.*

GLOSSARY OF TERMS

AGV: Automated Guided Vehicle. Standard abbreviation for automated vehicles which typically follow an installed track with minimal safety sensors

AMR: Autonomous Mobile Robot. Standard abbreviation for autonomous industrial vehicles that include artificial intelligence and robust perception and navigation capabilities.

April Tags: A visual fiducial system that is used for a wide variety of applications including augmented reality, robotics, and camera calibration. Not required for DriveMod Tugger installation.

Autonomous Mode: The state of a DriveMod Vehicle when it is driving autonomously.

Cyngn Enterprise Autonomy Suite (EAS): Cyngn's suite of products that includes DriveMod, Cyngn's proprietary full-stack autonomous navigation system and Cyngn Insight, Cyngn's Fleet Management System.

Cyngn Insight: Cyngn's Fleet Management System (FMS) that enables users to manage, monitor, and control fleets of DriveMod Vehicles.

DriveMod: Cyngn's proprietary full-stack autonomous navigation software stack.

DriveMod Kit: The collection of hardware integrated onto industrial vehicle platforms that enables autonomous driving capabilities (e.g., sensors, wiring, compute, harnesses, etc.).

DriveMod Tugger: The Autonomous Motrec MT-160 powered by Cyngn's Enterprise Autonomy Suite (EAS).

ERP: Enterprise Resource Planning. A software system enables users to manage and/or automate core business processes.

Fiducials: A visual marker that enables some automated systems to properly localize and navigate. Not required for DriveMod Tugger installation.

kWH: KiloWattHour is a standard unit of measure for battery capacity. The larger the number, the higher the battery capacity.

LiDAR: Light Detection and Ranging. A sensing method that utilizes light in the form of a pulsed laser to measure variable distance and position. LiDAR has broad applicability in a variety of industries such as mapping, autonomous navigation, and precision measurement.

Localization: The process by which an autonomous vehicle understands its position within its environment.

Localization Map: The map the DriveMod Tugger generates with its 3D LiDAR and utilizes to localize in order to properly navigate.

Manual Mode: The state of a DriveMod Vehicle when it can be operated by a human driver.

Mission: A series of stop points that the DriveMod Tugger will navigate to. Missions can be deployed via the Tugger's HMI (touchscreen) or through Cyngn Insight.

Quad-steer: A type of steering profile for industrial cart systems whereby all four wheels of the cart are able to freely turn. This allows for a small turn radius, greater flexibility in navigating through tight spaces, and excellent tracking capability behind a tugger or tow tractor..

Semantic Map: The map layer that is overlaid on top of the Localization Map that stores information such as routes, waypoints, stop signs, speed limits, and other rules of the road.

Virtual Bumper (VB): The redundant safety sensor located on the front of the DriveMod Tugger that maintains an independent linkage to the Tugger's throttle, steering, and brake controls.

Waypoint: A marker on a semantic map that designates specific locations as stop points.

WMS: Warehouse Management System. Software that enables users to manage and control daily warehouse operations.