HOUSTON
RADAR

ARMADILLO TRACKER

TRAFFIC SENSOR AND COLLECTOR

TECHNICAL SPECIFICATION

Rev February 1, 2022

Contents

Background on Houston Radar

Houston Radar LLC is a private company based in the United States of America established in 2004 with the intent of providing innovative radar-based solutions to the traffic and industrial markets around the world.
Starting from the industry leading DR600 OEM Doppler radar that set the standard for ultra-low power speed measurement to the world's lowest power 0.18W FMCW distance measurement and presence detection radar for lane-by-lane volume and stop bar presence detection we have established ourselves as an innovative, unique, and reliable supplier of radars all around the world. The crowning achievement for our company has been the Traffic Management category award given to our SpeedLane true dual beam side-fire radar at Intertraffic 2016.
We have supplied over 50,000 radars of all types to over 60 countries. Houston Radar is represented by reputable companies in different parts of the world.

Houston Radar's Armadillo Tracker for Traffic Data Collection

Features and Benefits

- World's smallest radar-based stats collection box with target tracking, multi-lane and bi-directional capabilities
- Ultra-low power consumption allows up to **2 weeks of run time** on built-in batteries and full autonomy with a small 5W solar panel (most locations, 10W or larger may be required for higher latitudes)
- Collects **individual time stamped** vehicle counts, speeds and class (up to 3) per direction in up to 2+2 lanes making it a perfect fit for traffic monitoring and speed study applications
- Simple "point and go" installation. No measurements, no trigonometric computations, no computer required on the road
- Weatherproof security switch for turning unit on and off
- Beeper and mobile app to indicate passing vehicles during setup facilitates high-confidence deployment
- Best-in-class 0.4% speed accuracy and up to 97% count accuracy depending on traffic conditions
- Vehicle classification in up to 3 factory set size classes
- On-board memory to store **315,000** individual vehicles
- High performance LiFePO4 rechargeable battery pack operates in wide temperature range and allows over 2000 recharge cycles
- High speed AC charger for a 3.5hr charge cycle or a standard USB charger for convenient 12VDC car plug or computer charging
- USB, long range Bluetooth, and GSM or LTE modem interfaces
- **GPS** for geo-tagging of collected data
- Optional high performance integrated **solar charger** with maximum power point (MPPT) technology
- Certified for license free worldwide operation
- Windows-based StatsAnalyzer program to generate reports and graphs of vehicle counts, averages and 85th percentile speeds
- Tetryon Cloud Server integration to send data with online modem connection or off-line file downloaded via Bluetooth
- Designed and manufactured in the USA at an ISO9001 certified facility

Quick Primer on Operation of Armadillo Tracker

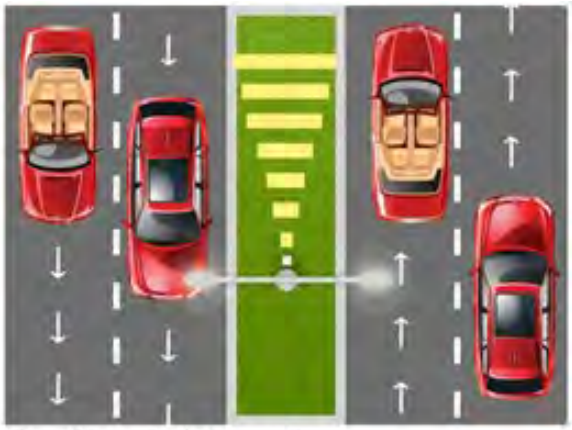
The heart of the Armadillo Tracker is our DC310, an ultra-low power high sampling rate bi-directional target tracking Doppler radar. When mounted in the three possible setup's on the road shown below, the Doppler radar continiously tracks incoming and outgoing vehicles present in it's radar beam. A beam angle of 20°x60° allows wide horizontal coverage of upto two adjacent roads on either side of the mounted box.

Installation:

The radar may be mounted to any convenient pole on the side of the roadway or on a median. The only requirement is that is be no more than 12' (4m) off to the side of the closest lane to be measured and no more than 2 adjacent lanes be measured. The unit will pickup a 3rd lane as well, but counting accuracy will be sacrificed.
The following three schematics show the possible mounting locations.

Armadillo on the side with 1 lane each direction

Armadillo on the side with 2 lanes incoming. No outgoing lanes can be detected

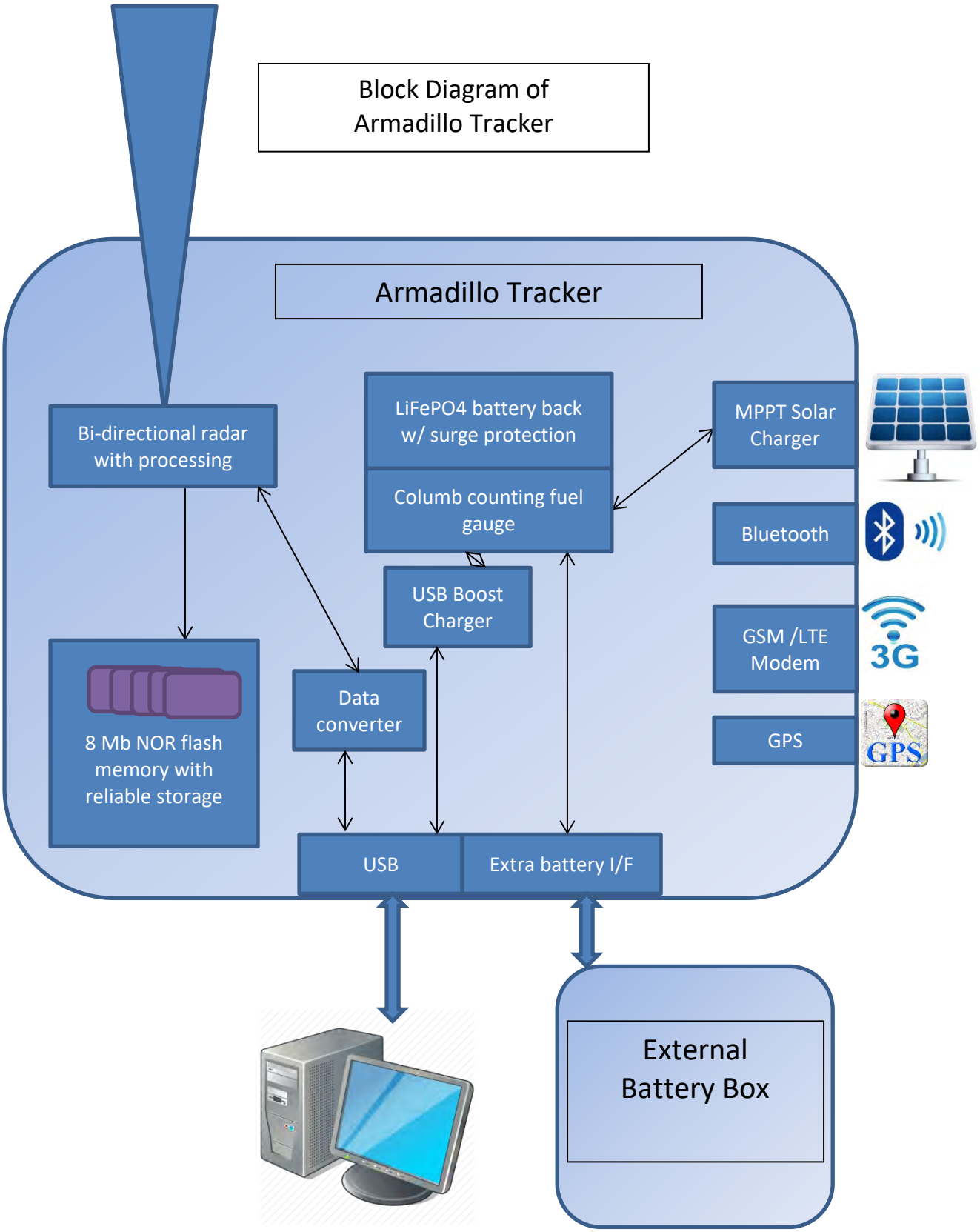


Armadillo on single lane median with up to 2 lanes on each side

Please refer to the Armadillo Tracker Quick Start Guide document for details on installing the radar to achieve performance within specifications.

Typical Counting, Average Speed and 85th Percentile Measurement Accuracy				
Radar Installation Location	Number of Incoming Lanes	Number of Outgoing Lanes	Typical Direction Count Accuracy	Average Speed and 85th Percentile Accuracy
On Side of incoming lane	1	1	97+%	+/- 0.6 mph +/- 1 km/h
On Side of incoming lane	2	X	93+%	+/- 0.6 mph +/- 1 km/h
Median between two directions	1	1	97+%	+/- 0.6 mph +/- 1 km/h
Median between two directions	2	2	93+%	+/- 0.6 mph +/- 1 km/h

Notes:
1. Accuracy numbers are listed for typical free flowing traffic. Stop and go traffic will have worse accuracy that will depend on actual traffic conditions
2. Armadillo radar may be mounted with 0 to 12 feet offset to the side of the road or in middle of median that is no more than 12 feet wide
3. Armadillo radar is installed per suggested instructions in the installation manual


Block Diagram of
Armadillo Tracker
Armadillo Tracker
Bi-directional radar with processing
LiFePO4 battery back w/ surge protection
Columb counting fuel gauge
MPPT Solar Charger
Bluetooth
USB Boost Charger
GSM /LTE Modem
3G
8 Mb NOR flash memory with reliable storage
Data converter
GPS
GPS
USB
Extra battery I/F
External Battery Box

Operation Principle of Armadillo Tracker Radar

The Doppler radar in the Armadillo Tracker transmits a fixed frequency in the 24GHz worldwide ISM band. Any moving target within the beam pattern (and range) of the radar, reflects a signal back to the radar that is shifted either up or down in frequency based on the well-known Doppler effect. This return signal is mixed with the transmitted signal and an IF frequency generated that is a mixture of all received Doppler signals (from all targets moving at different speeds). Sophisticated digital FFT processing extracts the different frequency components in the IF signal with a frequency resolution corresponding to approximately 0.37 MPH (0.6km/h). A total of 12 individual target frequencies are extracted.

These frequencies are then input into a sophisticated target tracking algorithm that rejects spurious noise and prevents dropouts due to frequency nulls on the road due to multipath reflections. The target tracking algorithm is well able to distinguish between closely following vehicles that may be following each other closely at the same speed. Vehicles must be tracked at least 80' (25m) or longer to be successfully logged as a vehicle. They may be tracked for as far as 320' (100m) (for trucks) provided enough straight-line road is available. This extra tracking is not mistaken for a second or third vehicle. However, this extra tracking allows for reliable pickup of vehicles that may get partially occluded by traffic moving in the closer lane, thus allowing for the device to be mounted relatively low on a pole and still provide excellent counting accuracy.

Speed accuracy is always excellent due to the direct measurement of the vehicle speed by the Doppler effect which is extracted via the digital FFT and stabilized via high accuracy crystal oscillators.

Storage Method of Measured Data

All measured data is stored on board 8Mb NOR flash memory chip. A lightweight yet effective "object storage" software layer manages the NOR storage. This layer ensures correct date/time stamping of the stored object, reliable storage via CRC of each object and guaranteed integrity of the entire system via CRC of the stored pages and unique and monotonically increasing page serial numbers.

Newer data logically wraps around the end of the NOR flash and overwrites the oldest data as required.

Reading is done via uploading the entire flash page(s) and parsing on the host where sufficient processing power is available.

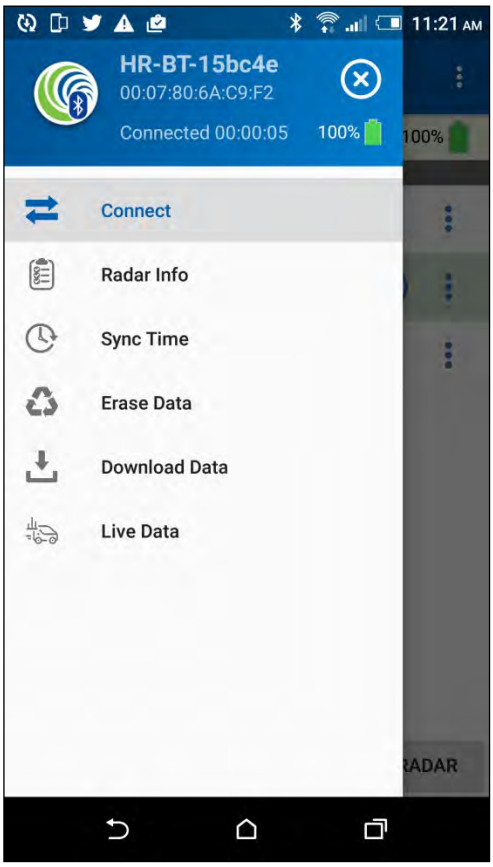
Since the storage software layer is completely agnostic of the data objects it's storing, it's easy to add new object types. In fact, we have expanded the system numerous times during the life of the product as we added new features like GPS location, on/off timestamps etc. without ever breaking backward compatibility. The object mechanism is self-describing, thus allowing older hosts to skip over objects they do not recognize yet continue to read the objects they do recognize. The "object storage" layer version is also stored.

Transfer of Data from Radar to Backend Tetryon Cloud Server

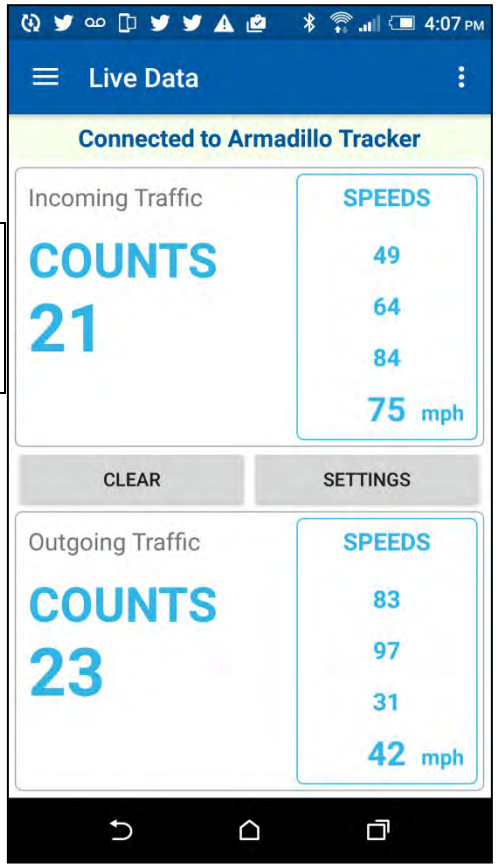
Radar with the optional built-in GSM or LTE modem periodically powers on the modem and makes a connection to the configured server IP address. Once connected, the server queries the radar for its unique “silicon ID”, a unique 48-bit ID soldered on the radar PCB.
Once the server identifies the radar, it logs a registration for first time calls and then uploads the radar configuration including firmware version number.
For subsequent connections from the same radar, server looks up data page # already uploaded and uploads new pages till blank data page is encountered. Unique serial numbers for stored objects identify data already uploaded in the past. CRC protection on both objects and data pages guarantee the integrity of the uploaded data.
The protocol between the radar and the server is the “Houston Radar Binary protocol” which is available for examination. This is a two-layer software protocol with a “data link” layer that guarantees reliable “at least once” delivery of payload packets and an “application layer” that defined the payload. On the request packet, it defined the request command and on the response payload, it defined the command response or error code.
Retries for corrupt or missing packets are handled by the data link layer transparently by the protocol.
Our smartphone/tablet app can download stored data as a “data flash memory image” file. It is envisioned that we will add functionality for this app to email or otherwise upload this file to the Tetryon Cloud Server. This will act like an alternate mechanism to transfer data from radar to server in units that may not have a built-in GSM/LTE modem or where modem does not have cellular network coverage.

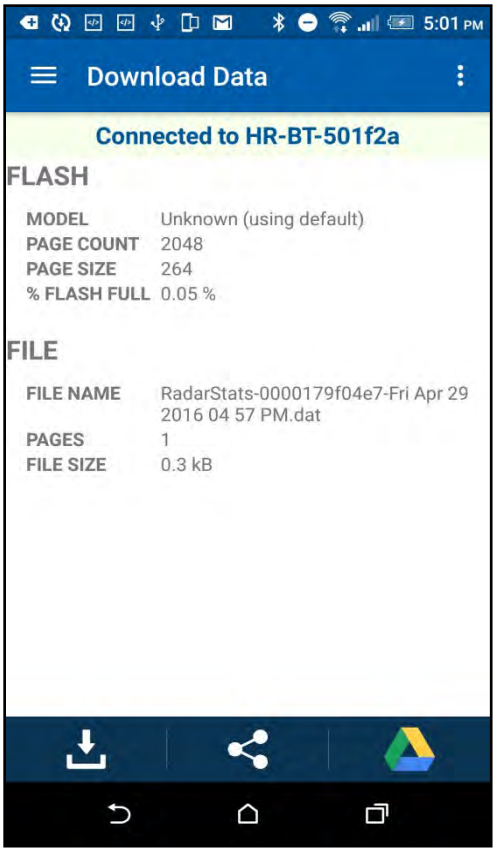
Provided Smartphone App with Validation Tool

To facilitate setup on the road, Houston Radar provides a smartphone app for Android tablets and smart phones as standard, and optionally for Apple iOS devices, to connect via the built-in Bluetooth wireless connection to setup the radar. Complete functionality is available to connect to the radar, confirm live target detections, including real time speed and direction.
Users can also download stored data from the radar into a *.dat file that may then be shared via email or “Dropbox” or “Google Drive” or any other file sharing mechanism available on the smartphone/tablet.
See example screen shots showing these features. A complete App user guide is available.
A feature to configure the app to share the download file (along with information of unique radar it was downloaded from) with the Houston Radar Tetryon Cloud Server for exporting via API is envisioned and shall be implemented as required.

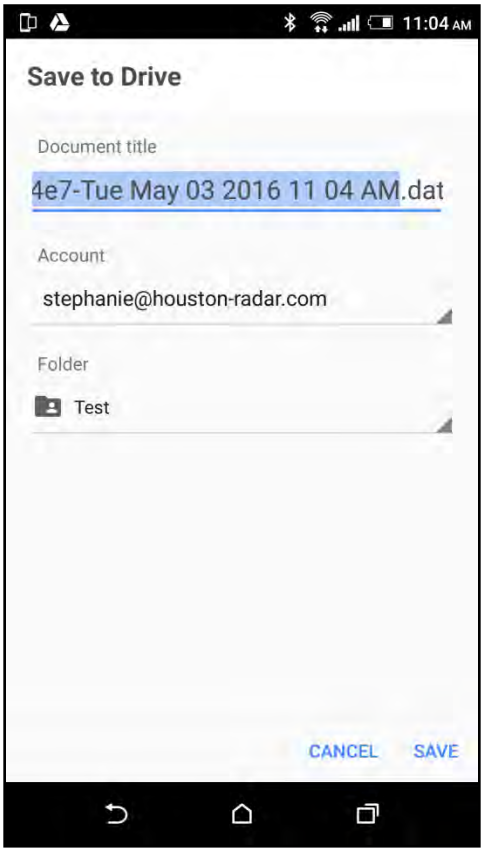


App screen shots showing connected Armadillo Tracker and live data





Android App screen shots showing data download and file sharing



Length Measurement

The Armadillo Tracker features a factory pre-set “small”, “medium” and “large” vehicle classification system. These roughly correspond to vehicle length as follows:

Armadillo Tracker Vehicle Class Size	Approximate Length	Example Vehicle Types	FHWA Class
Small	<14 feet (<4m)	Motorcycles, “Smart” car	1
Medium	~14 feet to ~20 feet (4m to 6m)	All sedans, minivans, pickup trucks etc.	2 & 3
Large	> ~20 feet (>6m)	Delivery vans, busses, dump trucks and 18-wheelers	4 through 12

Gap Measurement

The Armadillo Tracker timestamps vehicles when they are detected. Gap measurement calculations are done based off these timestamps in the host once data has been uploaded from the radar.

GPS Based Geo-location Stamping of the Data

The Armadillo Tracker can be optioned with a very low power GPS. The GPS is powered on when unit is first turned on, attempts to acquire a 3D location local and when successful, saves the location coordinated in the data memory as a “location record”. The GPS is then powered off to save battery life.
Thus, it is important that the unit be powered cycled at a new location to re-acquire the location coordinates for the new location. The average power usage of the GPS is negligible and has no material effect on the battery run time of the unit.

Built-In Modem

The Armadillo Tracker can be optioned with a built-in low power GSM or LTE modem (availability depends on installation location). The modem may be configured by operator to automatically turn on periodically during operation of the device to connect to Tetryon Cloud Server and upload data. Having the modem powered off when not connected to the server results in a reduced power usage. Configuring the modem to power on once/hour results in an average power usage of the modem that is less than 1 to 2% resulting in negligible reducing in operating time of the unit.
The GPS functionality is included with the cellular modem.

Battery Charging/External Battery Boost

The Armadillo Tracker's internal battery runs approximately 12 to 14 days on a full charge. A long-life Lithium Iron Phosphate (LiFePO4) battery is used in the unit. This battery has the characteristics of long life (>4 to 5 years), high number of recharge cycles (>2000), and ability to be 100% discharged without sacrificing life of the battery.
The internal battery is charged via 3 methods.

1. External provided high speed AC charger. A fully depleted battery is charged in under 3.5 hours.
2. Solar panel option. A 5 Watt (or larger depending on modem option and location latitude) solar panel can charge the battery via the built-in temperature compensated Maximum Power Point Technology (MPPT) solar charger.
3. USB power. When the unit is connected a computer, USB charger or powered USB hub, a built in USB boost converter/charger also charges the battery.

Additionally, there is an optional battery Armadillo Booster Pack whereby the run time may be extended by a further 12 to 14 days (24 to 28 days total run time with fully charged batteries).

Fuel Gauge for Accurate Battery Capacity

Since LiFePO4 batteries have an extremely flat discharge curve, and battery voltage is dependent on ambient temperature, it is not feasible to measure remaining charge simply by measuring the battery voltage. Thus, the device has an internal true "Columb counting" electronic fuel gauge that measures actual Columbs of charge flowing into and out of the battery for a very accurate readout of percentage battery capacity remaining. This readout is available on the Windows-based StatsAnalyzer application, smartphone app, and Tetryon Cloud Server.

Environmental Operating Conditions

The Armadillo Tracker has a NEMA 4x/IP56 weather-proof enclosure. This allows operation in ambient temperatures from -4° to +140° F (-20° to +60° C), with up to 95% non-condensing relative humidity. The Armadillo Tracker can be stored in temperatures from -40° to +140° F (-40° to +60° C).