



Industrial Vehicle Impact Management

Intelligent Impact Management Technology in
PowerFleet Enterprise Vehicle Management Systems (VMS)

WHITE PAPER

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When it comes to impact sensing for industrial vehicles, one must use careful consideration evaluating technologies. Depending on the volume of trucks and drivers in your facility, and the complexity of the jobs performed there are different types of impact management that may meet your needs. The main things to consider when assessing the various impact technologies are the likelihood of false alarms, the risk of missing events you wanted to know about, and the types of actions you want to take when the impact occurs.

Even today, impact sensing for industrial vehicles is a “gray science”. Pick the wrong technology and you could be plagued by false alarms, excessive vehicle shut downs, and needless disruption of productivity, often resulting in systems falling into disuse.

To help reduce the risk of investing in the wrong system, PowerFleet offers a variety of solutions from traditional static G-force threshold systems to more advanced dynamic calibration solutions that use algorithms and combine factors such as initial force and sustained force over some time.

Static G-Force threshold systems like PowerFleet Essence and Expert require more time to properly configure and provide benefits in improved driving from operators knowing they’re being monitored, as well as capturing harsh events. Dynamic algorithms like PowerFleet Enterprise, self-configure in a short period, capture more events without disrupting operations and provide total flexibility in taking different actions for different levels of impact.

This paper details the inner workings of the PowerFleet Enterprise impact management system algorithms and how you can use them to generate value. Typically, customer profiles who pursue this technology have ample fleet size or diversity in fleet mix, terrain type, and driver aptitude.

PowerFleet Enterprise has taken technology to a whole new level.

PowerFleet Innovations

PowerFleet’s impact management solution capitalizes on the intelligence of its on-vehicle computer – the Vehicle Asset Communicator, or VAC, to deliver a sustainable return on investment in more complex environments . Previous generations of the system have included simple Wizard-based configuration, remote wireless adjustments, automatic categorization of impact events across multiple severity levels, and uniquely flexible choices on how the system responds to impacts of different severities.

PowerFleet’s Enterprise solution has taken the science of impact management to a new level, by optimizing algorithms that automatically detect, analyze, and “normalize” G-forces exerted—and how long they resonate,—on vehicles in varying conditions over time. This approach has elevated the effectiveness of impact sensing and made event data more meaningful and fairer to vehicle operators.

The patented technology learns a specific vehicle’s operational behaviors and establishes a “normal” range of forces on the vehicle.

Intelligent Impact Management

PowerFleet’s patented impact solution is called “Intelligent Impact Management.” In this system, the VAC uses proprietary processing logic to analyze “force-over-time” impulses in a vehicle’s changing environment, rather than just peak G-forces, to draw conclusions about impact-inducing behavior.

The technology automatically configures and continuously re-configures event parameters to reflect actual vehicle activity as it changes over time (as the vehicle operates in different areas in the facility, and performs various tasks by different operators). The system establishes and continually reevaluates what “normal” impact behavior for each vehicle is. It flags events that are outside of that normal range, rather than above a particular fixed threshold.

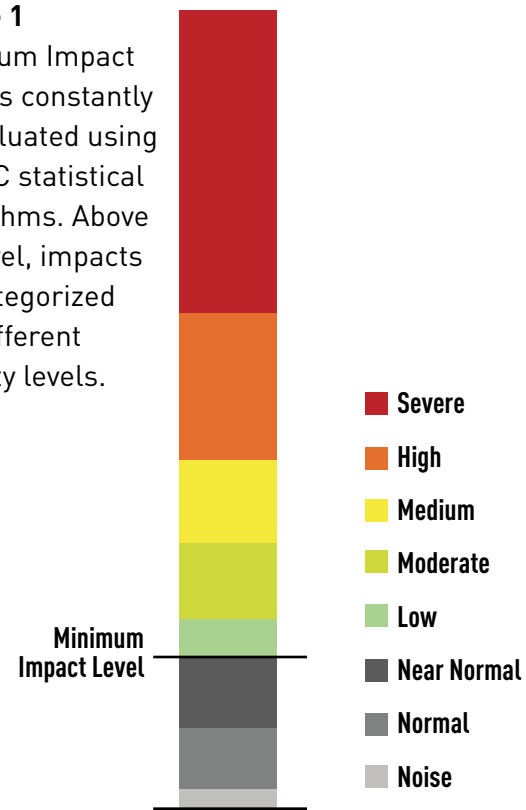
This revolutionary “fit and forget” capability eliminates the problems associated with the setting, validation testing, and fine-tuning of an absolute, fixed impact threshold. It also overcomes the challenges of input variability: changing environments, vehicle types, and varying sensor mounting locations.

How It Works

Intelligent Impact Management technology continuously collects vehicle impulse activity and runs the data through onboard statistical analyses. Event activity is instantaneously categorized by severity (below-normal, normal, near-normal, and abnormal) and fed back into the system’s algorithms to re-adjust the “normal” level. Events must exceed the normal level by a consistent, statistically calculated amount to be considered abnormal; otherwise, they are merely near-normal.

These statistics account for variations in installation location and orientation, vehicle types and sizes, and facility conditions to determine the “Minimum Impact Level” in the fairest and most uniform way possible. Normal event-generating behavior, such as driving over rough terrain and lifting heavy pallets, is factored into a Minimum Impact Level. However, the system does not use abnormal events (data points above the Minimum Impact Level) in recalculating normal activity.

Figure 1
Minimum Impact Level is constantly re-evaluated using on-VAC statistical algorithms. Above the level, impacts are categorized into different severity levels.



Continuous on-vehicle feedback has many advantages:

- Works out-of-the-box (“fit and forget”); algorithms generate accurate data within hours of installation, without calibration, user training, or fine-tuning.
- Provides relative, not absolute, data correlation, resulting in different inputs generating similar event severities (e.g., a high-force/short-duration impact is likely to cause the same extent of damage as lower-force/longer-duration impact, and flags the impact at a similar event level).
- It generates results without any wireless data communication/bandwidth consumption due to intelligent, decentralized, on-vehicle processing.
- Adjustments to variable operator behavior and vehicle use occur in real-time. Thus, if a “careful” operator drives a vehicle at the start of the day and a “rough” operator takes over later, the system automatically adjusts to avoid over-reporting the severity for the secondary operator.
- Event metrics are normalized and unbiased for any fleet and any mix of vehicles.

Additional Advantages of Intelligent Impact Management

In addition to continuous on-vehicle feedback, PowerFleet’s Intelligent Impact Management System has several other useful features:

- 360-degree force analysis. Forces on industrial vehicles are rarely registered directly front-to-back or side-to-side, and the orientation of the sensor is never exactly perpendicular to the vehicle axis. For those reasons, the PowerFleet Enterprise impact algorithms look at the forces from all angles when assessing a single event and bundles those forces together for a holistic assessment of the event’s severity to the vehicle. As a result of this comprehensive analysis, each impulse is effectively assessed for the overall effect on the vehicle.

For example, the impulse generated by a vehicle inserting its forks under a 5,000-pound pallet may be within the normal range of behavior because it is along the vehicle’s front-to-back axis. Still, if the vehicle experienced

the identical impulse from the side, it could indicate a severe impact, most likely due to a collision. The ability to make this distinction enables the system to identify true collisions vs. non-collisions more accurately.

- Relative severity levels. The system categorizes each impulse anomaly based on its severity relative to a “trigger” level. The ratio of impulse severity to trigger level represents the relative Impact Level. By comparing impact levels from one vehicle to another or one driver to another, the system normalizes the data for comparative reporting among the entire fleet.

For example, a Moderate impact on a small pallet jack will have the same ratio as a Moderate impact on a large forklift, even though the absolute impulse and trigger values may be different on each vehicle. This relativity based on ratio makes the results comparable and fair to the vehicle operators, regardless of the vehicle type, the task being performed, the operational environment, and other factors.

- “Black Box” function. Depending on which PowerFleet Enterprise features are enabled, the VAC can record detailed vehicle data (motion, speed, fork load) during the 5 seconds before and after each Severe impact event. This data can give users more in-depth insight into post-accident analyses (revealing, for example, which vehicle was moving or stationary at the time of impact).

Initializing the System

The installation of the Intelligent Impact Management system is remarkably straightforward. The impact sensor itself must be affixed on a flat, stable location, close to the vehicle’s center of gravity, and parallel to both the ground and the vehicle’s front-to-back axis. After that, the VAC’s installation wizard takes over. It automatically runs diagnostics to validate the sensor’s readings. If issues are found, the wizard guides the installer to resolve the problem via on-screen prompts.

Immediately after the installation process is finished, the system begins the auto-configuration process. It sequences a series of impulse thresholds until it adapts to the vehicle’s individual “background noise” level and registers enough impulse data points to set a vehicle-specific “Minimum Impact Level” starting point. Algorithms then commence the constant attuning process to fine-tune the initial Minimum Impact Level.

To set a Minimum Impact Level, the system “listens” to several initializing events (along the X and Y axes and everywhere in between) without acting on them. When the initialization sequence is complete, the system turns on the automatic on-vehicle and system-wide responses that have been defined by management. This Minimum Impact Level initialization process can be re-

started any time (e.g., if a sensor is remounted).

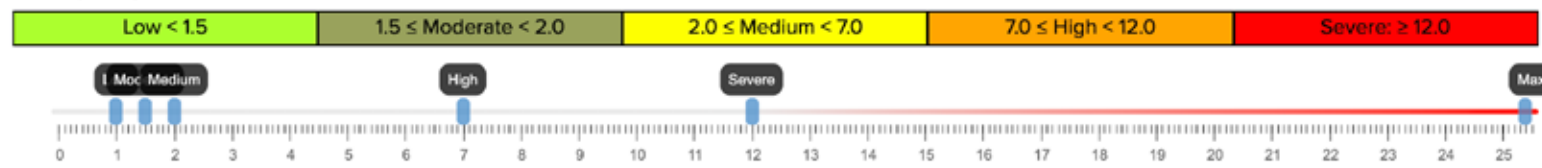
Adjusting Severity Levels

Five Severity Levels (Low, Moderate, Medium, High, Severe) are defined in the Vehicle Settings tab in the System Settings software module (figure 2). Each level is assigned a range of numeric values. The numbers represent a ratio, based on each vehicle's Minimum Impact Level, which equalizes the relative severity of impacts across a diverse fleet of individual vehicles. The numbers are not an absolute measure of impacts.

Severity is calculated as:

$$\text{Severity Level} = (\text{Impact Level}) / (\text{Minimum Impact Level})$$







- A "Low" impact is reported when an event on any given vehicle registers at 1x to 1.4x of that vehicle's individual Minimum Impact Level.
- A "Medium" impact is a reading between 2x and 6.9x of a vehicle's individual Minimum Impact Level.
- A "Severe" impact is flagged for any value greater than or equal to 12x a

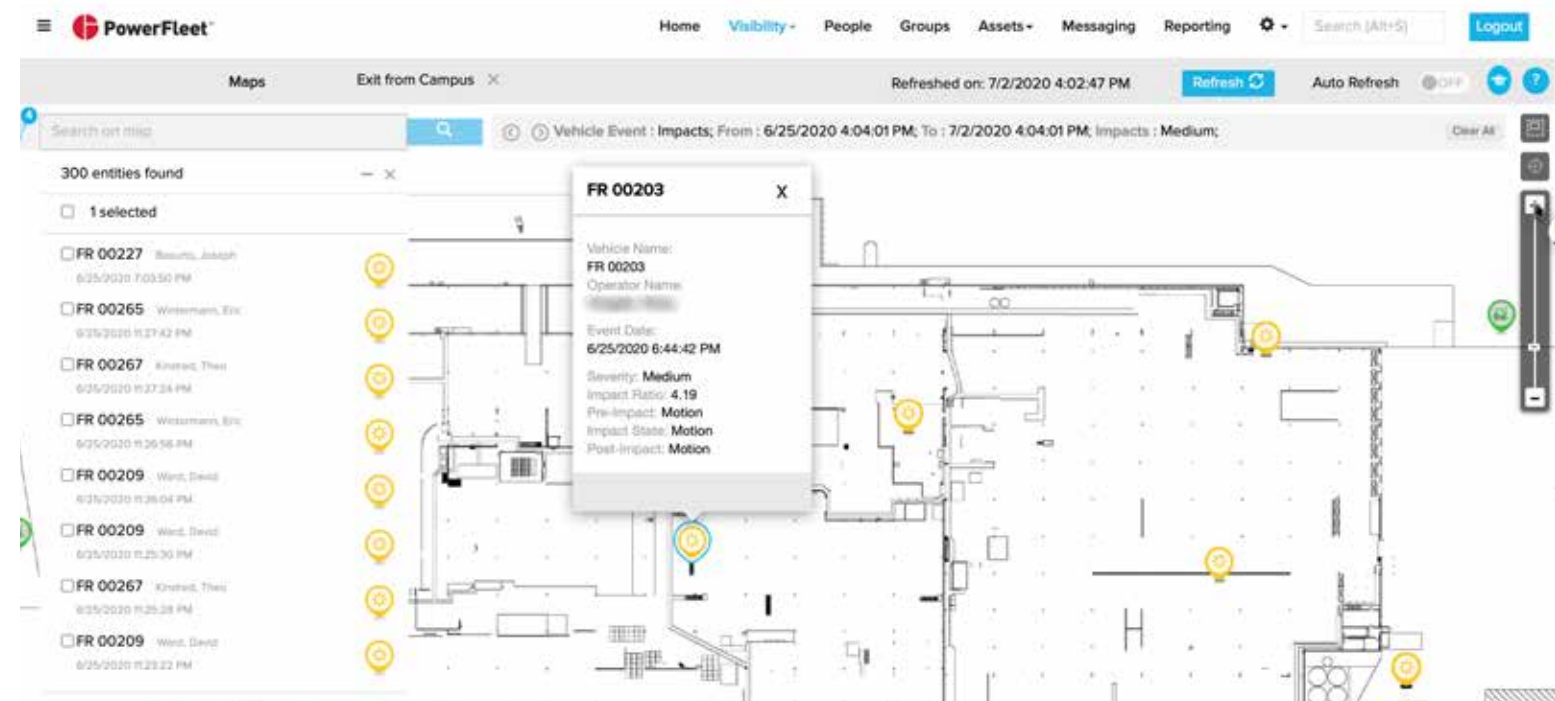
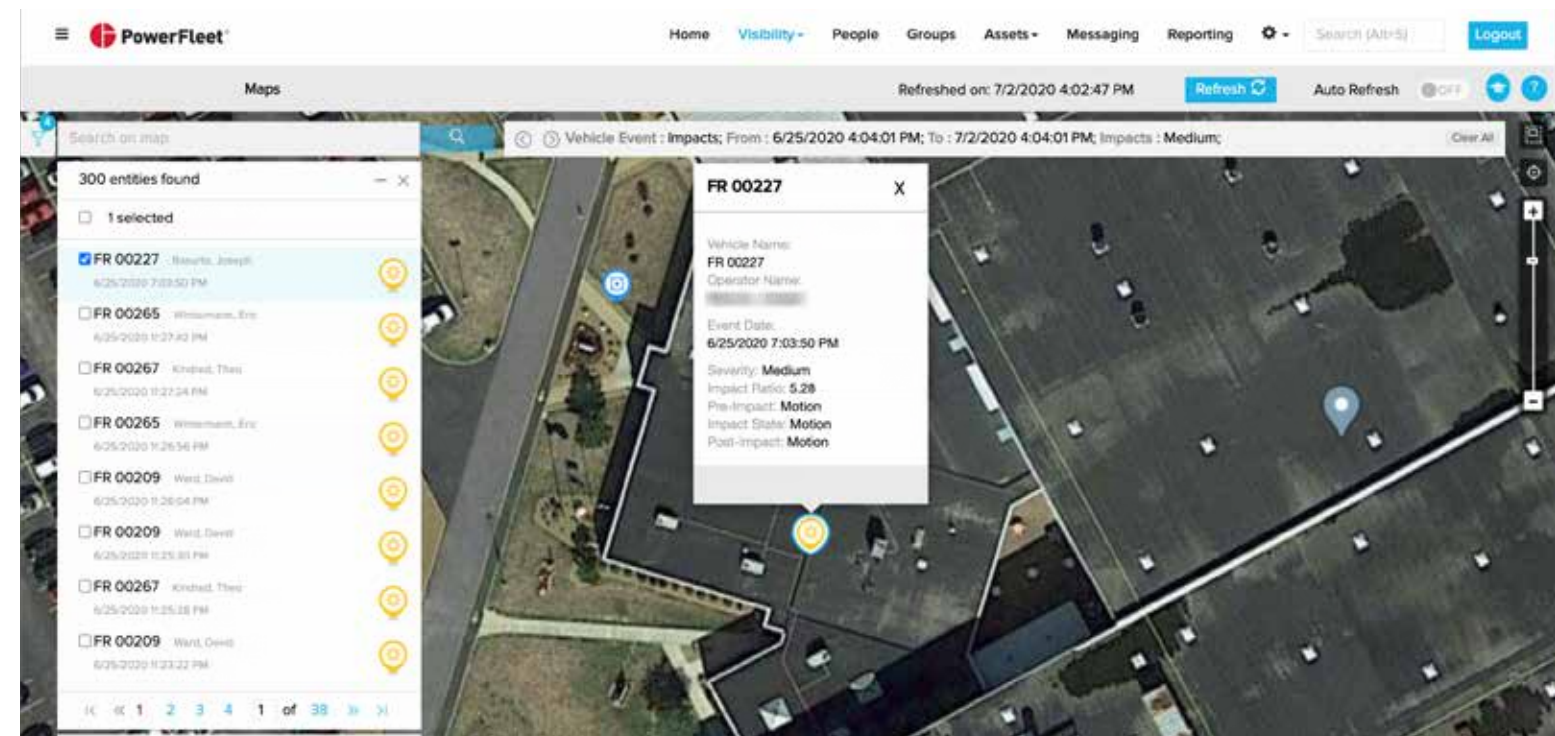


vehicle's individual Minimum Impact Level.

Impact-Triggered Actions

Flexible on-vehicle and system-wide reactions to events, according to severity, can be set via the PowerFleet Enterprise software. In Figure 3, high/severe impacts are set to lock-out the vehicle automatically, trigger the on-vehicle alarm, and require a supervisor to unlock the vehicle. Medium impacts trigger a self-administered driver checklist that asks about damage and injury (reinforcing driver accountability without hindering productivity or requiring a supervisor to get involved). Low and Moderate impacts are recorded and reported for statistical analysis, but otherwise have no effect on the vehicle, driver, or supervisor. Events can trigger other system reactions as well, including vehicle creeper mode, capturing a video clip of the incident, an email or text alert, and an alert displayed on the home screen of the software and a map of the facility.

05	Impact High - Severe	  	 MASTER/MAINTENANCE OPERATORS
06	Impact Medium - Medium		 STANDARD OPERATORS



The facility map also displays the vehicle's location, status, and impact event details



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PowerFleet is a leading provider of M2M solutions for securing, controlling, tracking, and managing high-value enterprise assets, including vehicles, powered equipment, trailers, containers, and cargo. The company's patented technologies address the needs of organizations to monitor and analyze their assets to improve safety, security, efficiency, and productivity.

PowerFleet is listed on the NASDAQ stock exchange under the symbol PWFL.

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