BUSINESS CASE

ZTR™

KickStart™

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The reliability of a locomotive is essential to railway operations. Locomotive batteries are expensive to replace and the cost of a failed start can affect operational costs. The importance of improving locomotive reliability and availability cannot be understated. KickStart improves starting reliability and battery health for a direct impact to the bottom line and a strong return on investment.

About **KickStart**

KickStart uses supercapacitor technology to supplement the locomotive batteries' power (amperage) during the engine start to reduce the strain on the batteries. The results for batteries are less power drain, longer life, less time to recharge, and reduced voltage drop during the starting cycle, for an overall improvement in locomotive reliability and availability.

Benefits:

- Extended locomotive battery life
- Increased locomotive availability
- Reliable cold weather performance
- Minimized battery voltage drop
- Easy installation and zero maintenance
- Reduced battery charge time

Challenges:

When it comes to locomotive operation and maintenance, time is critical and reliability is measurable in operational dollars. Batteries are an important part of the starting system for a locomotive, but aren't the best option when it comes to the power required for starting the locomotive. In the past, few options were considered safe additions to the locomotive that had measurable ROI. Today, KickStart is a safe supercapacitor solution that augments the starting power to increase locomotive starting reliability and enhance the locomotive's starting systems.

KickStart Assists Locomotive Batteries for Greater Starting **RELIABILITY**

While there are many types of energy sources, only a few provide the power density required for locomotive starting. The supercapacitors in KickStart help augment the batteries in locomotive starting and have been able to help start the locomotive when the batteries are drained and unable to start the locomotive on their own.

When considering a supercapacitor solution to assist batteries in locomotive starting, it is important to know how batteries and supercapacitors differ. Supercapacitors and batteries both provide energy, but are designed to release that energy differently.

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The battery is designed to provide steady power for long-term loads, whereas the supercapacitor is designed for rapid high power releases.

Lead acid batteries have excellent energy density but limited power density. They need hours to fully charge, and if they don't get a full charge, their lifespan is drastically reduced. They also have limited charge/discharge cycles because they rely on electrochemical energy storage. Supercapacitors have less energy density than batteries but they can charge and discharge very quickly and will operate tens of thousands more cycles than lead acid batteries.

LOCOMOTIVE (LEAD ACID) BATTERIES:	SUPERCAPACITORS:
• Slow to recharge and slow to disperse energy	• Quickly releases a high amount of power
• Multiple recharges can affect overall life	• Capable of hundreds of thousands of cycles
• Require maintenance	• Zero maintenance
• Last 2-5 years (often with a rebuild)	• Lifespan of 20+ years
• Reduced ability in cold weather	• All weather ability

KickStart Enhances Locomotive Starting Systems for Superior Locomotive **AVAILABILITY**

Since a locomotive doesn't always have new batteries, there can be a significant voltage drop during the locomotive starting cycle. KickStart aids the locomotive batteries during the locomotive engine's starting phase by providing a surge of additional electric current at the beginning of the cranking sequence. This supplement of power from KickStart reduces the voltage drop during starting to keep onboard electronics powered, provide a consistent flow of power to starting systems and reduce the stress on the batteries.

Beneficial Effects of KickStart on the Locomotive

- **Batteries –** The surge of power required for the locomotive starting cycle is supplemented by KickStart, so the strain on the batteries is reduced and they are likely to perform better for longer.
- **Supercapacitors -** KickStart has protection circuits in place to prevent supercapacitors from exposure to overvoltage, which extends the life of the supercapacitors in KickStart and ensures that charge voltages are maintained at expected levels.
- **Starting Equipment –** With KickStart, the locomotive requires fewer cranks to start, so starting equipment has less stress during this process and can perform better for the long run.
- **Onboard Systems –** The drop in battery voltage during start is reduced with KickStart, allowing critical cab electronics to remain operational during the cranking sequence.

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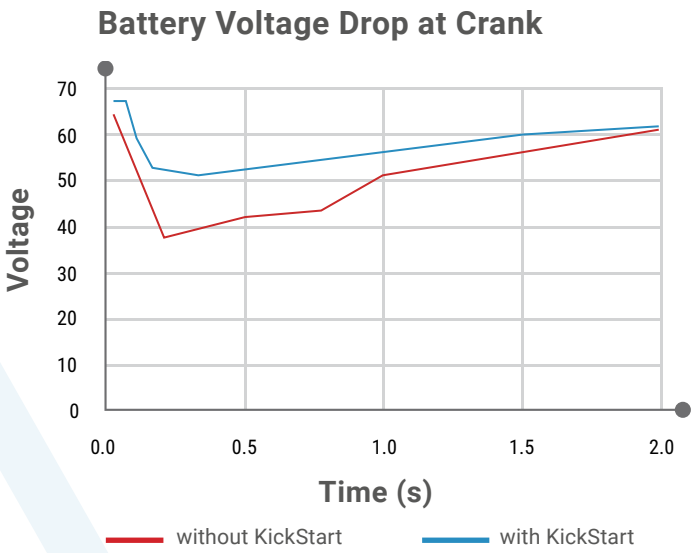

KickStart reduces the drop in voltage by up to 38%.
This figure shows typical results obtained during testing.

KickStart is Safe for Locomotives and Improves Locomotive **MAINTAINABILTY**

Kickstart is maintenance free. This increases safety, as operators don't need to do any additional work once the supercapacitors are installed. Similar to batteries, special care is required for handling of supercapacitors, but when treated right they are just as safe to handle as batteries.

Supercapacitors, similar to those used in KickStart, are found in many other industries like transportation (rail, trucking, automobiles, aerospace) for starting and power applications, industrial equipment (construction, wind turbines and other heavy equipment) for a high burst of energy to move heavy components, and other industries for power generation, capture and storage.

KickStart Increases Operational **SAVINGS**

The best starting systems employ both supercapacitors and batteries to provide a power source that matches the starter and locomotive power requirements – a quick burst of current to start, and low current output to provide power to peripherals when the engine is off. Adding KickStart to a locomotive will provide this winning combination, which results in greater locomotive reliability and availability, and significant operational savings.

The following are examples of potential annual savings per KickStart equipped locomotive.

Extended Battery Life - Savings of $600

KickStart improves battery life by 50%. On a 5-year battery, that's a 2.5 year extension, or potential savings of $3000 or more over the life of the battery.

Consultations with battery manufacturers about the load on the batteries during start sequences, with and without the KickStart, yielded a 50% life-extension estimate for locomotive batteries when they are on a KickStart-equipped locomotive. Assuming a new battery costs $8,000 and the battery life is extended by 2.5 years, the total cost is spread out and results in annual savings of up to $600 per locomotive per year.

Additional AESS Fuel – Savings of $500

KickStart improves fuel savings from AESS systems by reducing the amount of time the locomotive needs to idle in order to fully charge the battery.

KickStart supplements some of the power required for starting to reduce strain on the batteries and help keep them in better shape, allowing them to charge better, hold a charge longer and drain down less than

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damaged batteries. SmartStart® IIe (the AESS system) reports indicate that one of the top reasons for restart of a locomotive is to recharge the batteries. When a locomotive restarts with an AESS system and KickStart on board, it may not have to idle as long to recharge the batteries as they haven't been drained down as much and can recharge faster. This results in more fuel savings over time.

Reduced Failed Starts – Savings of $1000

Re-assigning locomotives (if one is available) is costly and time consuming. Using KickStart means no one has to worry about losing a unit due to a failed start, which can cost more than $10,000 per incident.

Railway customers provided the estimated costs of a failed start with a 10% incidence estimate per year, per Class I locomotive fleet (including the costs of the loss of locomotive availability and the re-assignment of another unit to that service). KickStart allows for starting with low or dead batteries, reducing the likelihood of locomotive inoperability due to a failure to start and could significantly reduce these costs.

Reduced Battery Maintenance – Savings of $500

Regular battery maintenance and troubleshooting is costly. Batteries cost roughly $1000 per year to maintain.

If the strain on the batteries is reduced, there are likely to be fewer battery issues and less time needed to diagnose unforeseen issues. The costs of regular battery maintenance and maintenance for unexpected issues (as estimated by Class 1 Railways) will go down if Kickstart is part of the starting circuit.

Using industry estimates, KickStart has a substantial ROI that could quickly affect the bottom line and **SAVE** valuable operational dollars.

Expenses	Industry Estimated Savings (USD)
• Extended battery Life	**$600**
• Additional AESS Fuel Savings	**$500**
• Reduced Failed Start	**$1000**
• Reduced Battery Maintenance	**$600**

Total Annual Potential Savings: **$2,600 or MORE!**

Whether reliable starting, locomotive availability or operational savings are driving factors, KickStart supercapacitor battery assist system from ZTR is a safe, effective and maintenance free solution. It can complement a locomotive's current battery systems to reduce operational costs and increase starting reliability.

Reduce starting issues, improve starting reliability and increase locomotive availability today with KickStart.