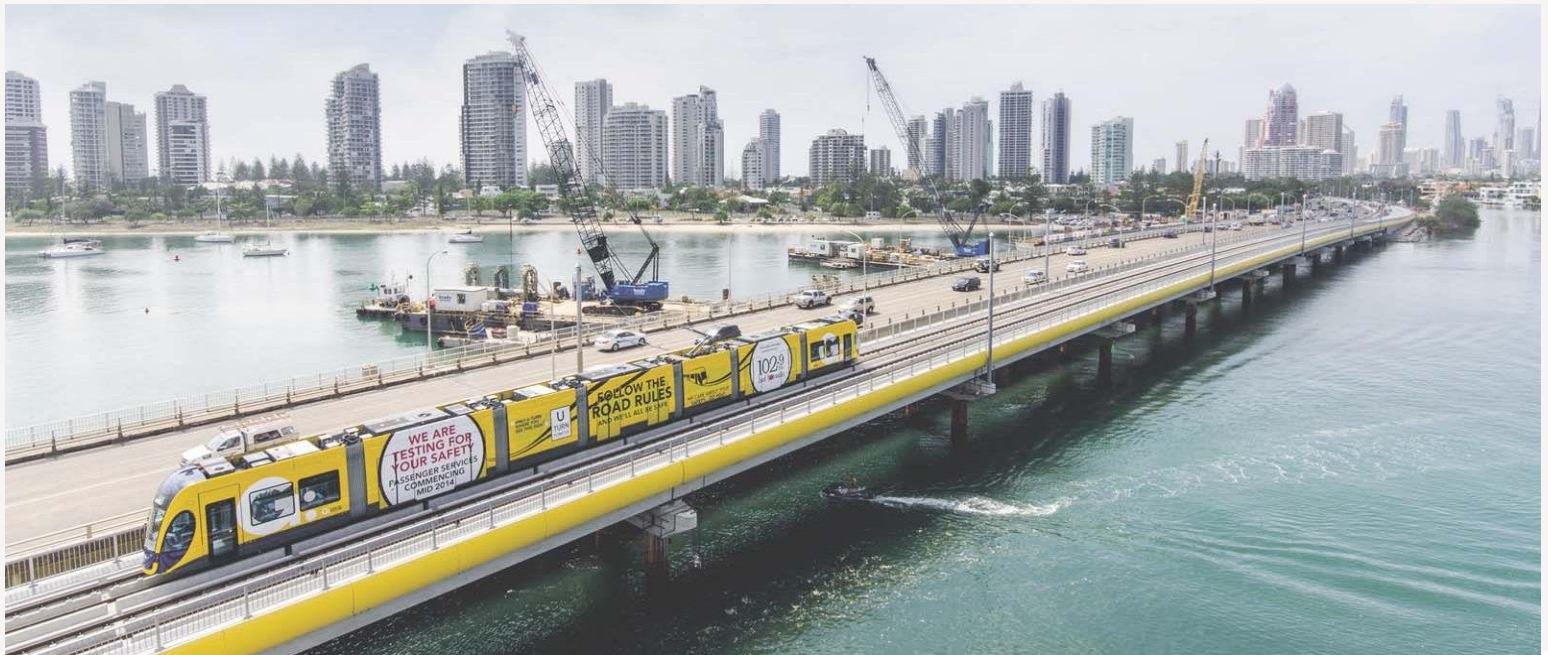


Progress in Light Rail / Streetcar Vehicle Off-Wire Technology

John D. Swanson, Principal Consultant

APTA Rail Conference 2018

› June 11, 2018

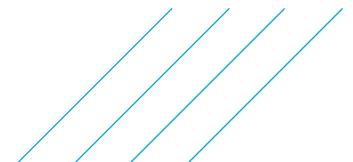


Traditional Overhead Contact Systems (OCS)

- ▶ The preferred power distribution system since 1887!



Richmond



Off-Wire Technology Background

- ▶ **Complex subject best approached from a *systems* viewpoint**
- ▶ **Three basic types:**
 - ▶ **Ground Level Power Supply (GLPS)**
 - ▶ **Onboard Energy Storage System (OESS)**
 - ▶ **Onboard Power Generation System (OPGS)**
- ▶ **Plus hybridized combinations!**

Dubai



Nice,
France



Off-Wire Advantages / Disadvantages

Advantages

- ▶ Improved aesthetics
- ▶ Reduction in conflicts with other users of the street space
- ▶ Potential for infrastructure simplification

Disadvantages

- ▶ Vehicle becomes more complicated
- ▶ Weight, space and performance trade-offs
- ▶ Onboard Energy Storage- unknown life expectancy of energy storage elements
- ▶ Ground Level Power- high cost / proprietary
- ▶ Onboard Power Generation- hydrogen technology expensive, requires fueling



Bordeaux,
France



Current Off-Wire Status Worldwide

Thirteen years ago (2005) there was only one “off wire” system in commercial service (Bordeaux, using GLPS)

Today there are:

- ▶ **10 systems using Ground Level power + 2 more under construction**
- ▶ **25 systems using Onboard Energy Storage for off-wire + 7 more under construction**
- ▶ **6 systems using Onboard Power Gen.**
- ▶ **A few systems using onboard energy storage to achieve energy savings / emergency battery drive**
- ▶ **27 development prototypes**



Orleans, France



Dallas

Evolution

- ▶ Automotive sector driving development of energy storage devices
- ▶ Onboard Battery, Super Capacitor, Flywheel, Fuel Cell technology has continued to advance
- ▶ Light rail / streetcar / tramway vehicles ideal candidate for application of OESS
- ▶ Market factors slowing initial progress:
 - ▶ Low production quantities
 - ▶ Inherent conservatism of railcar market, where 30 year vehicle life is norm
- ▶ OESS has multiple uses- energy savings, and off-wire



San Antonio Concept

Evolution – Ground Level Power Supply (GLPS)

- ▶ Initial approach was to provide a continuous power supply over part or all of system with limited onboard energy storage
 - ▶ Advantageous where HVAC requirements are high, steep uphill gradients, etc.
 - ▶ Downside is that complex ground level infrastructure is high cost / proprietary
- ▶ Adding more onboard energy storage allows reduction of GLPS infrastructure (e.g. install only at stops and uphill segments) reducing cost,
- ▶ Proprietary technology now being licensed



Bordeaux, France



Sydney, Australia

GLPS Early Days - Conduit Current Collection



Washington, D.C.



London



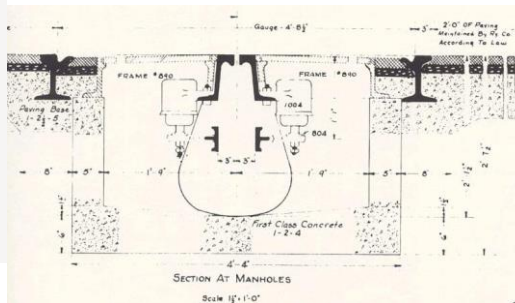
Paris



NYC Broadway
(1897)



Bordeaux



Today's Ground Level Continuous Power Supply



Rheims



Orleans



Tours



Dubai



Anger



Bordeaux – 2002



Rio de Janeiro

Evolution – Onboard Energy Storage System (OESS)

- ▶ OESS is a non-continuous power source (requires recharging enroute)
- ▶ Charging method depends on system design-
 - ▶ Charging while under OCS (works with short off-wire segments)
 - ▶ “Charging station” at stops (alternative for longer distances)
- ▶ Length and number of “off-wire” segments increasing on new systems
- ▶ Battery supercapacitor hybrid (BSH) devices now available.
- ▶ Completely wire-free systems now in service
- ▶ This is now the most popular approach



Detroit



Kaohsiung, Taiwan

Early OESS - Battery Powered Cars Came First

Electric-powered streetcars, which ran on batteries, first began operating in New York City in 1874, replacing horse-drawn cars that had been introduced in 1832.



New York City 1913



Concord Street Railway, N.C. 1910

Today's On-Board Energy Storage Systems



First Hill Streetcar Line



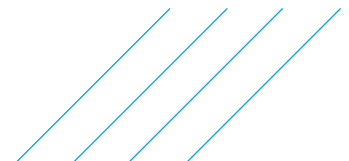
Dallas Oak Cliff Streetcar Line



Detroit Q Line



Milwaukee Streetcar Line



Evolution – Onboard Power Generation System (OPGS)

- ▶ **Slowest to develop due to cost, space impacts and other trade-offs**
- ▶ **Limited early diesel hybrid tram-train applications**
- ▶ **Recent hydrogen fuel cell vehicles now in service.**
- ▶ **Requires OESS and fuel storage.**
- ▶ **All major suppliers developing fuel cell vehicles**



Qingdao, China



Foshan, China

Conclusions

- ▶ **Alternative power supply approach now becoming service proven**
- ▶ **Must be designed using systems approach**
- ▶ **Energy storage devices still evolving rapidly, driven by automotive, heavy equipment, marine, utility and military sectors**
- ▶ **Application remains very project-specific**
- ▶ **Commercial issues are significant**
 - ▶ **Little unbiased hard data regarding initial, operating and life-cycle costs available**
- ▶ **Onboard energy storage has multiple uses (and can also be applied at wayside)**



Zaragoza, Spain

Building what matters

   snclavalin.com

