Progress in Light Rail / Streetcar Vehicle Off-Wire Technology

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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!
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
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
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
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

- London
- Paris
- Bordeaux
- NYC Broadway (1897)
- Washington, D.C.
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
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.
Today’s On-Board Energy Storage Systems

- First Hill Streetcar Line
- Dallas Oak Cliff Streetcar Line
- Detroit Q Line
- Milwaukie 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

Quingdao, 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

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