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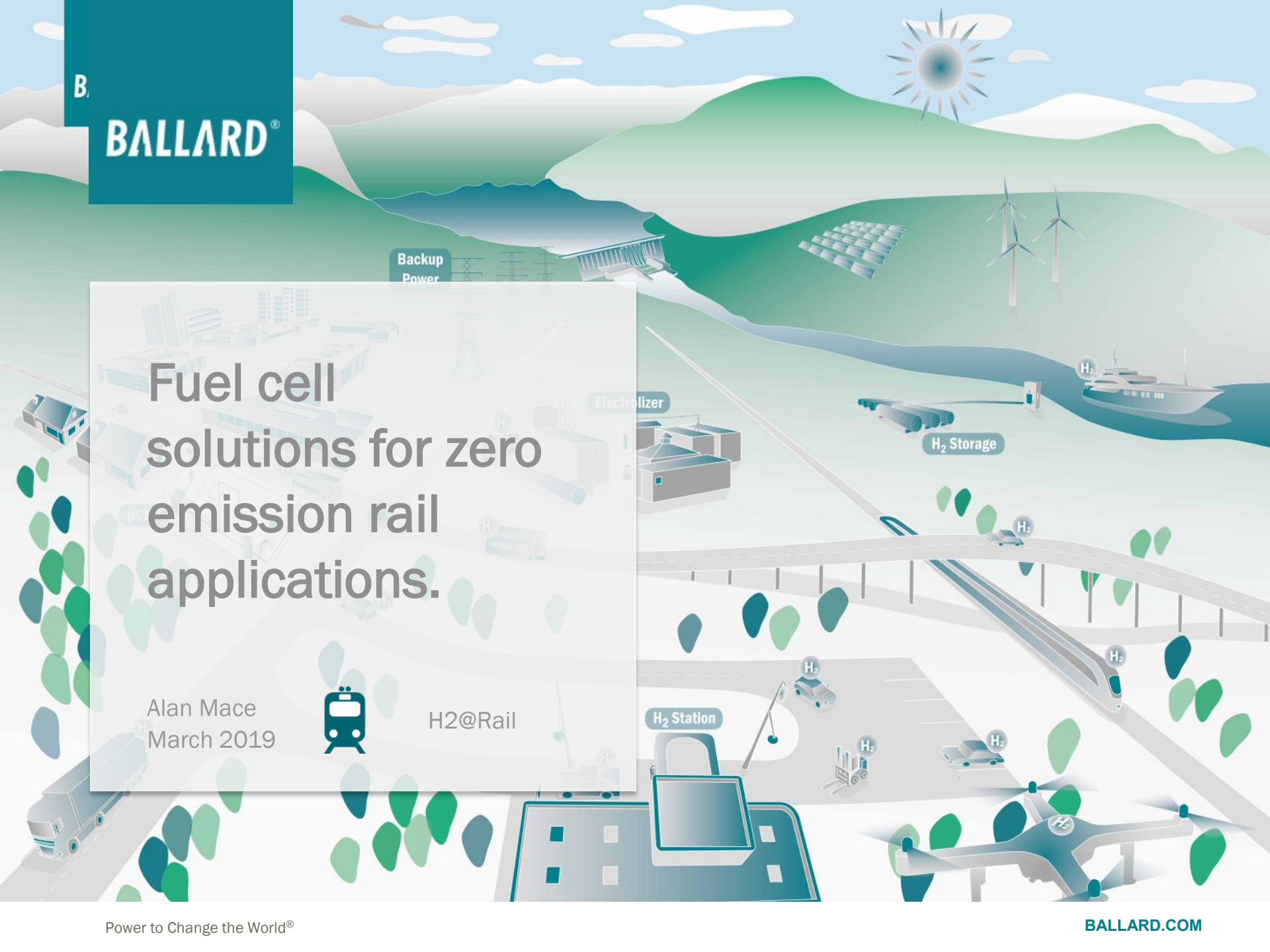
BALLARD®

Fuel cell solutions for zero emission rail applications.

Alan Mace
March 2019



H2@Rail




Content

- Fuel cell Technology for Rail
- Rail Applications
- Ballard Experience and Solutions
- Hydrogen as a fuel for trains

The Ballard logo is a teal square with the word "BALLARD" in white, bold, sans-serif capital letters. A registered trademark symbol (®) is located to the upper right of the text.

BALLARD®

A high-speed train is shown on a set of tracks that curve through a green, grassy landscape. In the background, a city skyline with several tall buildings is visible under a cloudy sky. The train is white with blue accents and is moving away from the viewer.

Fuel cells offer the environmental benefits of electrification without significant infrastructure investment and with the flexibility of diesel

Fuel cells offer the benefits of electrification without significant infrastructure investment

- No requirement for overhead catenary infrastructure and power substations
- No impact on existing bridges, over-path and level crossings

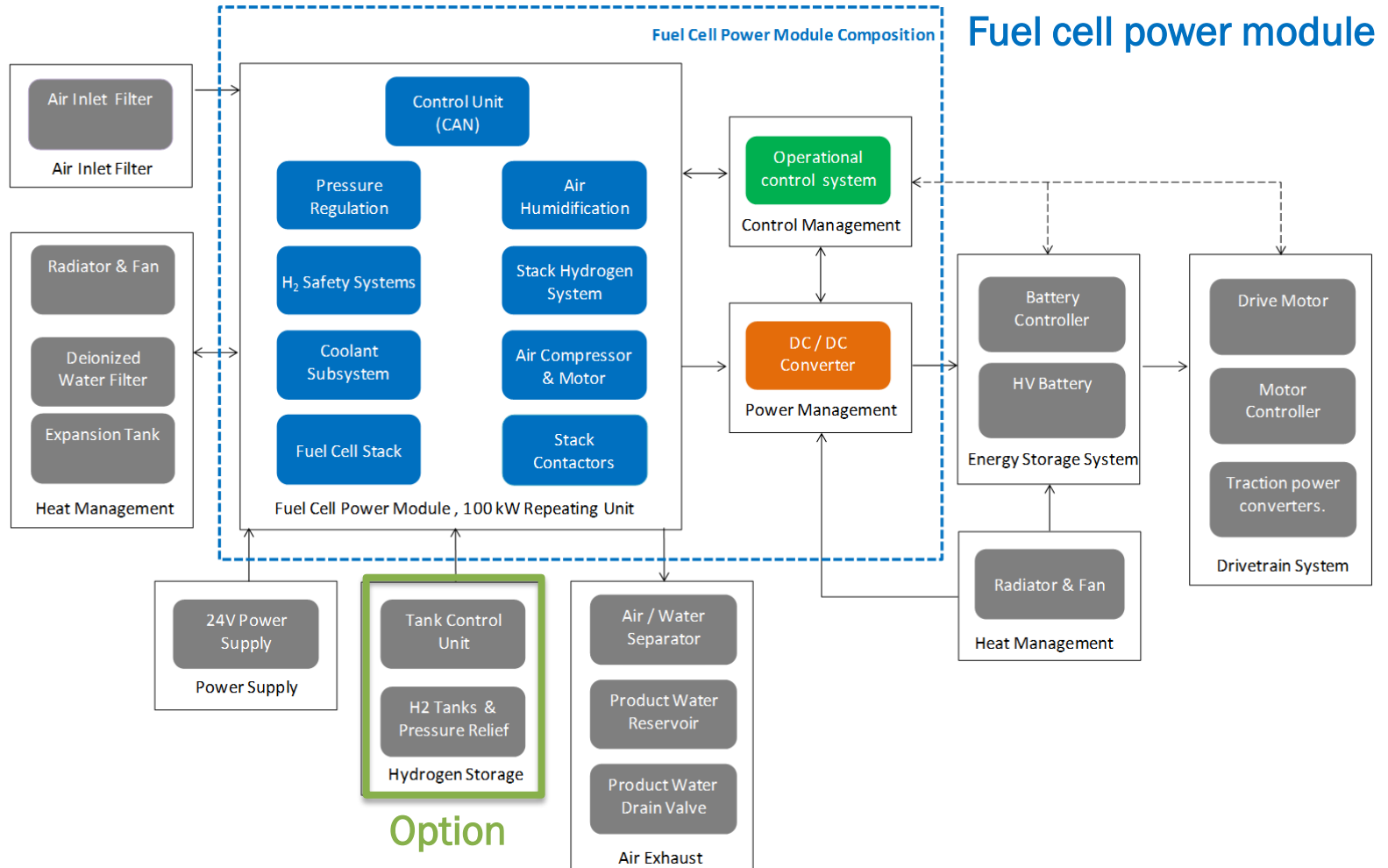
Fuel cell technology addresses several rail applications.

- Shunter / yard locomotives
- Regional and commuter trains
- Trams and Light rail
- Underground mining

Fuel cell system design considerations for rail

- Component choice to reduce noise level and system weight
- Flexible system layout to meet space requirements (roof-top or custom configuration)
- Protection against dust ingress (safety hazard)
- System frame design to meet shock and vibration requirements

Ballard scope of supply



Rail Standards and product testing experience

- Experienced with automotive and rail standards (~20 international rail standards)
- Extensive testing capability: vibe & shock, EMC, noise, dust ingress



Ingress Protection



Ingress Protection



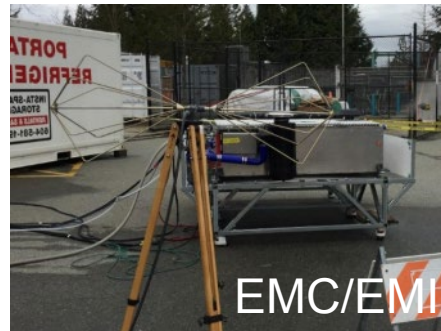
Shock & Vibration



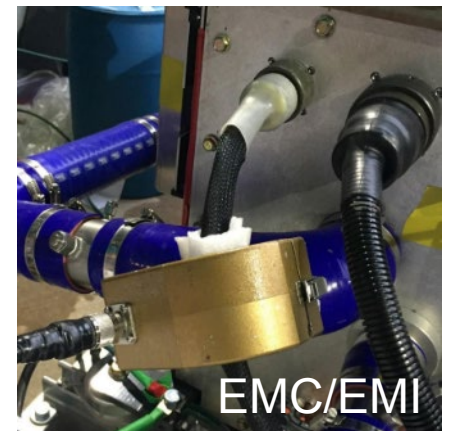
IP testing



Fire Suppression



EMC/EMI



EMC/EMI

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BALLARD®

From bus to rail

- 15 years of experience in designing heavy duty fuel cell engines.
- Integration experience with multiple vehicle platform (bus, truck, train..)
- Proven technology with millions of operating hours in revenue service



The Ballard logo is a teal square with the word "BALLARD" in white, uppercase, sans-serif font. The background of the slide is a photograph of a train at a station. The train is silver with blue and red accents. It has a "JR" logo on the front and a "スマート電池くん" (Smart Battery-kun) logo on the side. The train is stopped at a platform with overhead power lines and a utility pole. The train is decorated with red and green streamers. The train is a JR East commuter rail train. The train is a light rail project with CRRC in China. The train is a BNSF Railway shunt locomotive in the US. The train is a Mireo commuter train development program with Siemens.

BALLARD®

We have the experience in rail applications

- JR East commuter rail in Japan
- Light rail projects with CRRC in China
- BNSF Railway shunt locomotive in the US
- Mireo commuter train development program with Siemens



BALLARD®

Fuel cell tram demonstration project in Tangshan.



- World's first Hydrogen-powered tram in pilot test phase
- 5 stations - 14 km lines
- 40 km range up to 70km/hr.
- Hydrogen refilling in 15 min
- 3 cars, 66 seats and 336 passenger capacity
- Power by 2 x FCveloCity® 150kW modules



BALLARD®

Fuel cell tram line in Foshan

- Project with CRRC Qingdao Sifang Co, Ltd
- Expected to enter in service in 2019 in Goaming district of Foshan
- Speed up to 70km/h with 100km autonomy
- 200kW fuel cell module for rail applications



**中国中车
CRRC**



A large, dark grey, rectangular fuel cell power module is shown from a three-quarter perspective. The top surface is covered in a grid of small, square cooling fins. The front panel features a circular port on the left, a rectangular access panel in the center, and a yellow emergency stop button on the right. Labels for "TO RADIATOR 2" and "HYDROGEN" are visible on the front. The module is mounted on a reinforced frame with red accents. The Ballard logo is overlaid in the top left corner.

BALLARD®

Fuel cell tram line in Foshan

FCveloCity®-XD200:

- Integrated 200kW fuel cell power module
- Robust design: reinforced frame with rigid plumbing
- Built-in fire suppression systems
- Easy service access
- Weight and noise optimized

Fuel cell tram line in Foshan

Ballard scope of work:


- Develop 200kW fuel cell system for rooftop light rail applications
- Meet rail-specific design standards
- Deliver 1 fuel cell system for engineering testing at Qingdao, China
- Deliver 9 fuel cell systems for revenue service in Foshan, China





HYDRO
FLEX

HYDRO
FLEX

porterbrook 
in partnership with



UNIVERSITY OF
BIRMINGHAM

Zero emissions for a greener railway

Hydroflex project

- Conversion of a classic 'Class 319' electric unit to be supplied by Porterbrook into hydrogen powered train “HydroFlex”
- Development work has commenced and HydroFlex will undertake testing and demonstration runs in summer 2019
- Ballard supplies 100kW FCveloCity®-HD fuel cell power module to be integrated to existing electric drive as “range extender”
- The HydroFlex will retain the ability to operate across existing electric routes (on either 3rd rail or 25kV overhead power) and with the addition of a hydrogen fuel-cell it will also be capable of operating in self-powered mode, without the need for diesel engines
- This demonstrator version focuses on delivering an electric/hydrogen bi-mode to UK gauge and the need to make more effective use of existing electrification with additional emission-free running beyond the wires.



British Class 319 dual-voltage electric multiple unit



SIEMENS

Mireo

Development of a new generation of hydrogen powered EMU

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[siemens.com/mireo](https://www.siemens.com/mireo)



Nationales Innovationsprogramm
Wasserstoff- und Brennstoffzellentechnologie
nip

Gefördert durch:

Bundesministerium
für Verkehr und
digitale Infrastruktur

Koordiniert durch:

NOW
Nationale Organisation Wasserstoff-
und Erneuerbare Energietechnologie



Mireo Plus – Value added for our customers

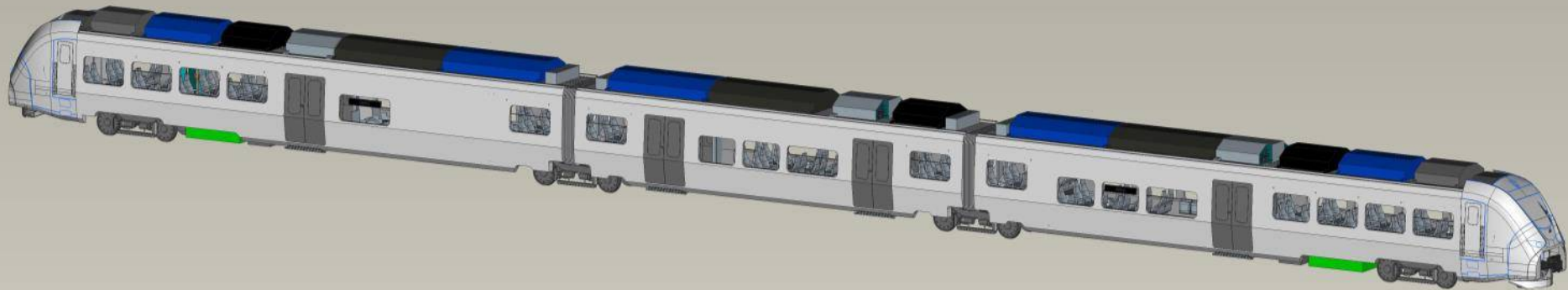


The focus of our innovation roadmap is the improvement of Life Cycle Cost

SIEMENS



Mireo Plus The future becomes hybrid



Mireo Plus H (Hydrogen train by Siemens Mobility)

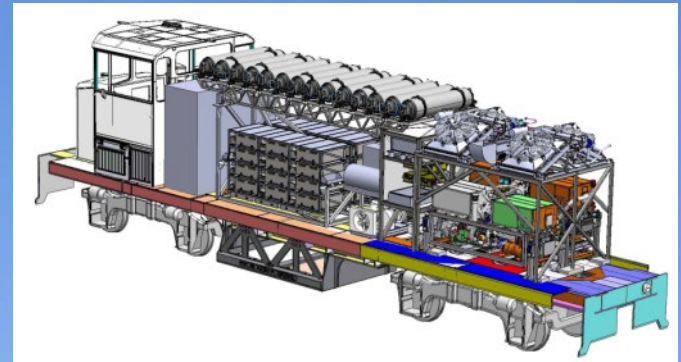
Powered by **BALLARD**[®]

BALLARD®

HYDROGEN HYBRID

Prototype fuel cell powered shunt locomotive.

- Moves railroad cars over short distances in yard
- 300-500kW gross power with 60kg H₂
- Refueled at hydrogen station within railyard
- Public-private project partnership with Vehicle Projects, BNSF Railway, US Army Corps of Engineers & Ballard



Fuel cell and hydrogen provide and attractive solution for zero-emission rail.





BALLARD®



Power to change the World®

- Committed to sustainable mobility and clean air for everyone
- Developed technology over 30+ years
- We have leading talent with >600 people passionate about our mission
- HQ in Vancouver (Canada) with offices in China, Denmark and USA.

The Ballard logo is displayed in white, uppercase letters on a teal rectangular background. The background of the entire slide is a photograph of a modern city skyline with several skyscrapers and a blue and white high-speed train moving on an elevated track in the foreground.

BALLARD®

Power to Change the Word®

Alan Mace
541 678 8086
alan.mace@ballard.com
WWW.BALLARD.COM