Hydrogen from an Infrastructure Manager's Perspective

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Objective

To give an infrastructure managers perspective on the potential application of hydrogen to the railway

Contents

- What is an Infrastructure Manager
- Challenges that Infrastructure faces
- Why hydrogen/fuel cells may be attractive
- Possible first applications
- Further research that is needed

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Infrastructure Managers

- Track, points, bridges, embankments, stations…
- Signalling and train control
- Electrification – small regional electricity company
- Telecoms network
- One of the largest project management and construction companies in the country
- Engineering equipment
- People

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Infrastructure Managers

- Characteristics of railway infrastructure

- Assets are long lived, 30 years plus
- Assets are geographically widely dispersed
  - Literally the length and breadth of the country
- Assets are often historic
  - Resistance to change
- Interface to a wide variety of environments
  - Urban, rural, mountainous, rivers, estuaries, seas, environmentally sensitive areas, areas of outstanding beauty
- Wide variety of technological environments
  - High voltage, high current, high KE, dangerous goods

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Challenges faced by IMs

- Within the context of energy there is increasing societal expectation that the railway will be:
  - Clean
  - Quiet
  - Cost effective
  - Reliable

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Current Energy Supply

- Diesel
- Electric
  - 25kv ac OLE
  - 1500 dc OLE
  - 750V dc third rail
- Others – biofuels, flywheel (on track or on board), hybrids, steam, supercaps (on track or on board) etc

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IM challenges

- Diesel
  - Emissions NOx, SOx, PM10
    - Especially in enclosed spaces
  - Noise
  - New emissions technology required for NRMM
    - Particle filters and SCR?
    - How to incorporate into a locomotive or railcar
  - But flexibility of operation, can go anywhere

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IM challenges

- Electric
  - Single point of failure, OLE fails then no train can run
  - Different traction systems cannot interoperate
    - Captive fleets
  - Live rails are a safety hazard
  - Clean at point of use
    - If electricity supply is nuclear or renewable then zero CO2
    - Quiet

Why Hydrogen/Fuel Cells may be Attractive

- Technology that is as clean and quiet as electric traction but also offers the flexibility of a go anywhere train is attractive

- Challenges are cost effectiveness, safety and reliability

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Possible First Applications

- Remote Power
- Auxiliary Power Units (APUs)
- Trains (depots)

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Remote Power

- Infrastructure managers require large, geographically dispersed power supply
- Often work is conducted in remote locations
  - Not feasible to connect to the electricity grid
  - Use diesel generators

Auxiliary power units

- Provide heat and light to rolling stock when main energy source unavailable
- Reduce idling in diesel engines
  - Train preparation at terminal stations
  - Unpleasant build up of fumes
- Freight up to 80% of the time spent idling
  - Major operator can save Euro 1 million a year through turning off engines
  - But issues of power to cabin for heat and light and engine start up from cold
  - Fuel cell APU provide clean quiet power to cover this
  - Again reduce noise and fume

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Business Case – APU and Remote Power

- If the price of fuel cells and hydrogen becomes comparable to diesel generators and diesel then both applications start to have positive business cases (NB NRMM forcing more expensive after treatments).

- Clear challenge to the manufacturers of fuel cells and hydrogen.

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Rolling Stock

- Infrastructure manager perspective
  - System interaction
  - Depots and refuelling
  - Life time and reliability
  - Safety

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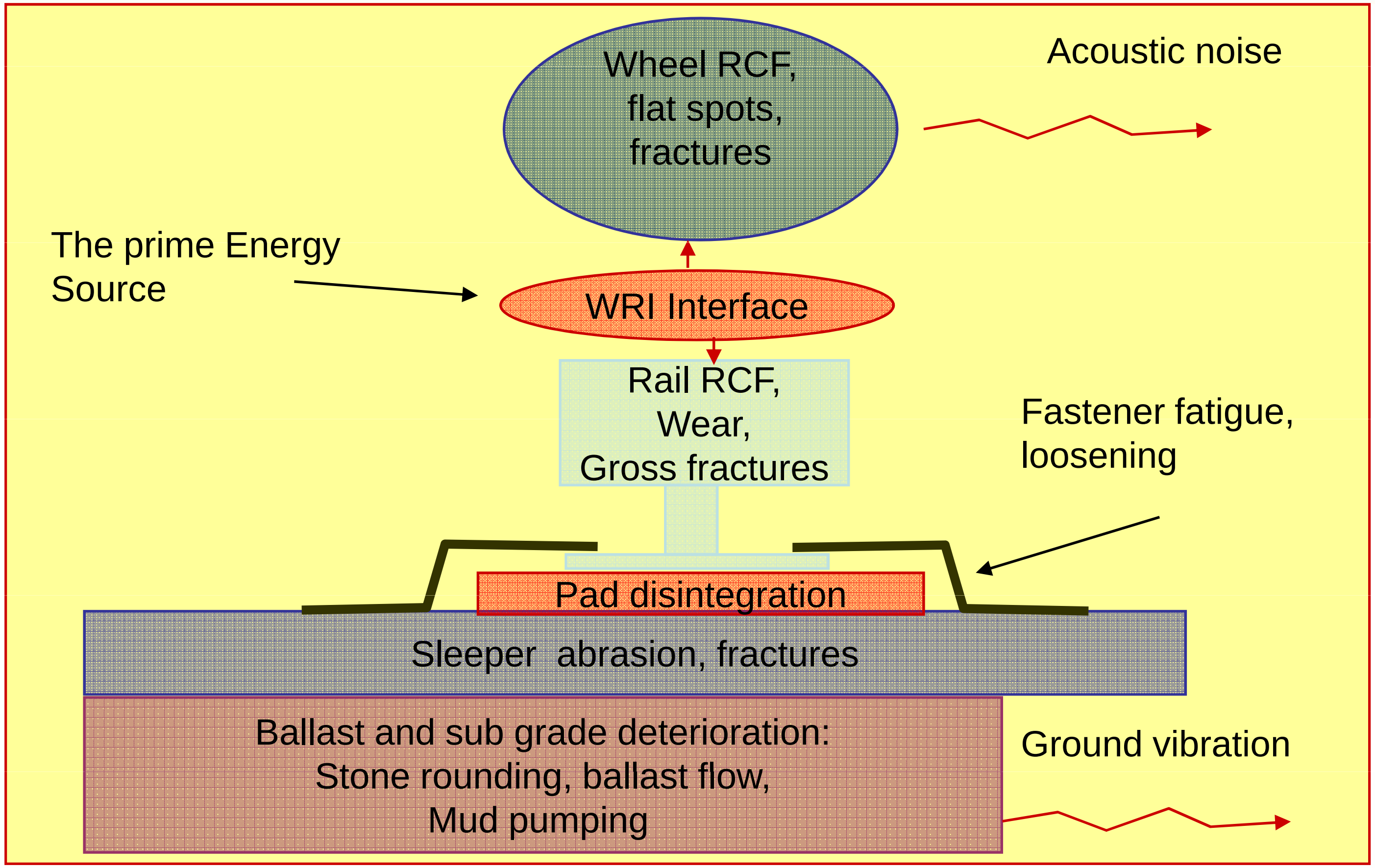
Rolling Stock – System Interaction



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Rolling Stock – System Interactions

- One of the classic ways to reduce vehicle mass is to place the traction equipment on the trackside - electrification
- Mass of fuel cell and hydrogen storage should not increase vehicle mass – ideally lower mass
- Lower the mass the lower the maintenance cost to the infrastructure manager

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Rolling Stock – System Interactions

- Power output of the fuel cell.
- Vehicle should be able to accelerate and attain a velocity equivalent to the average of the existing rolling stock (including when climbing gradients)
- Otherwise reduce capacity on the network

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Rolling Stock – Depots and Refuelling

- For the purposes of a trial a tanker of hydrogen can be used as a refuelling point
- Requires road access to the trackside
- Appropriate safety arrangements

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Rolling Stock - Depots

- Diesel is currently supplied to depots by a variety of means
  - Piped direct from refinery
  - By rail
  - By road
- All of these are possible for hydrogen (either as gas or liquid)
- Reforming on site

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Rolling Stock - Depots

- Hydrogen storage can be problematic and there is an infrastructure to consider
- A national distribution network for natural gas already exists
- One can reform on site at the depot to supply hydrogen on demand
- This is the strategy that bus companies have adopted in regard to hydrogen

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Rolling Stock - Depots

- Diesel train will typically refuel once every two days
- Issues with the storage of gaseous hydrogen necessitate daily or even twice daily refuelling
- Places an operational limitation on the fuel cell powered vehicle unless a clever solution to on board hydrogen storage can be found.
- Also, means that the vehicle is taken out of service reducing its commercial potential
- Means that the depot must be designed to accommodate a greater number of trains

- All this drives cost and limits usefulness

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Life Time and Reliability

- Currently the life expectancy of a diesel engine in a DMU is perhaps 3 million km
- Interval between major overhauls is 0.8 million km
- Overhaul every 80,000 km
- Fuel cell is 30,000-40,000 hours
  - 1 million km?

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Life Time and Reliability

- At present fuel cell lifetime (for PEM) is limited by the build up of impurities on the catalyst
- Necessitate the change of the fuel cell at regular intervals
- Need to link this to regular maintenance intervals
- Diesel train do not take train out of service to change engine
  - Take the engine out of service and put another on the train

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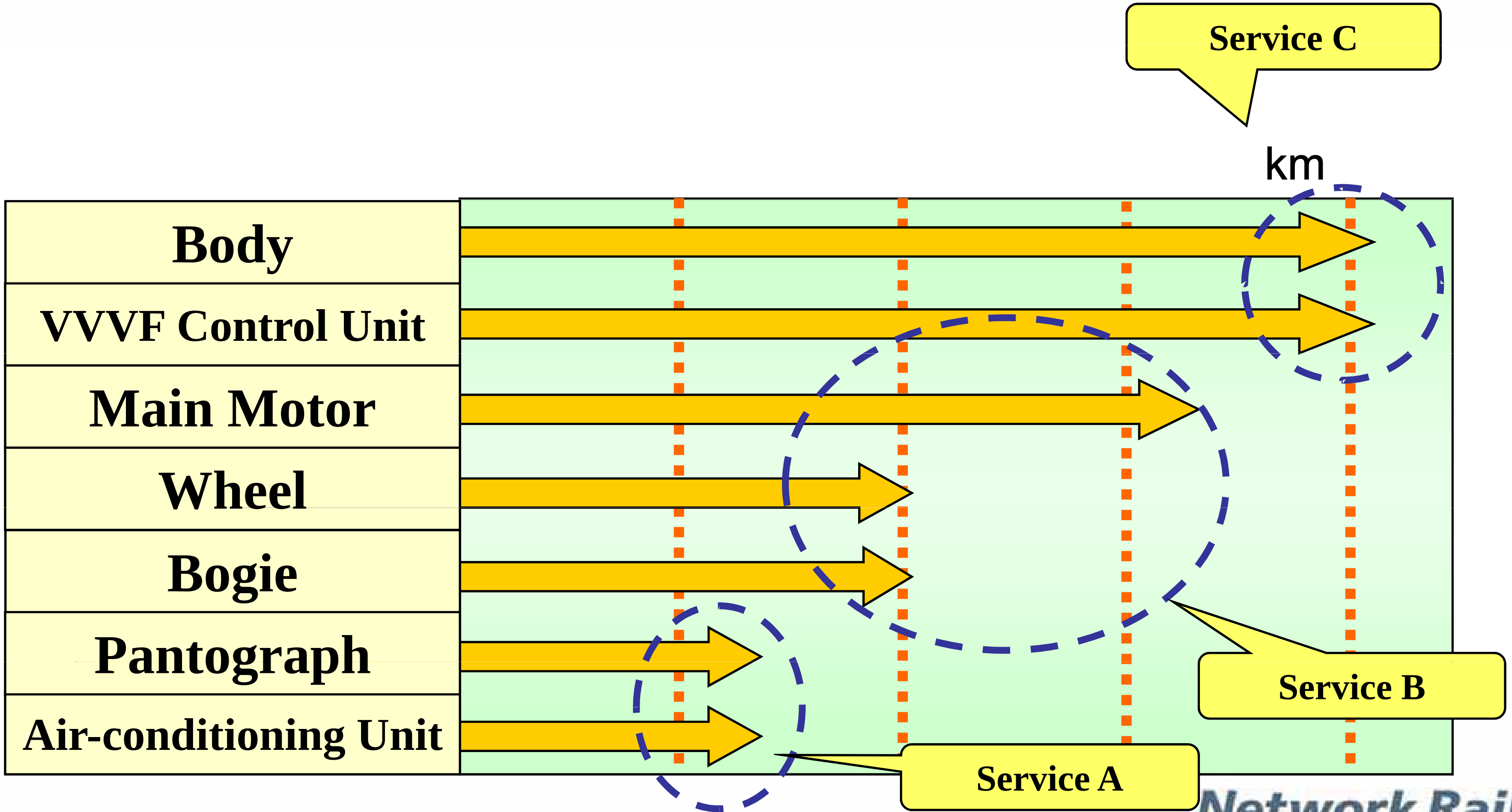
Life Time and Reliability



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Life Time and Reliability

- Research Challenge for Fuel Cell manufacturers

- Increase life time of a fuel cell substantially
- Or fuel cell as a cheap disposable item that is changed regularly

- So, longer life or reduced cost
  - But not both

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Safety

- Hydrogen is believed to be a safe energy vector
- There is a need to demonstrate this
- One of the critical areas of railway infrastructure is tunnels especially long ones such as alpine tunnels
- Need to ensure that an accident in a tunnel does not lead to explosion or asphyxiation
- Design the rolling stock to the same design requirements as for a diesel train e.g. fuel tank integrity and design
- Interface to the SRT TSI

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Business Case – Rolling Stock

- Diesel – cost of fuel cells and hydrogen has to be comparable to ICE and diesel
- Electric traction – cost of fuel cells and hydrogen has to be comparable to cost electricity, cost of electric motors and cost of maintaining the electrification on the line
- From Baumgartner these are substantial ongoing costs

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Implementation

- One of the big advantages of fuel cells is that it is not a disruptive technology
- Trial or operate fuel cell vehicles with little or no modifications to the infrastructure
- Gives the possibility to implement gradually as technology and business case develops

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Key Future Challenges

- Cost fuel cell and hydrogen has to come down
- But there is already a global research effort of over 1 billion Euro addressing this
- And a steady downward trajectory in price
- Challenge for railways is to be ready and informed for when this research pays off

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Railway Research Needed

- Prove the safety of fuel cell and hydrogen operation on a railway – SRT TSI
- Depot designs for reforming natural gas
- Hydrogen storage on trains – capacity and crash worthiness
- Performance of the fuel cell powered vehicle – vehicle mass, acceleration
- System integration of the fuel cell traction package into the railway environment
- Reliability of the fuel cell vehicle in service
- Customer reaction to hydrogen traction

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Railway Research Needed

- These are best addressed by an EU wide demonstration project
- Output of this would be the railway requirements (including business case) to be fed back to the fuel cell and hydrogen suppliers
  - Size, mass, life time, reliability, cost ……..
- Define what success for fuel cells means in railway terms

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Conclusions

- Fuel cells have attractive properties for infrastructure managers
  - In a variety of applications
- We can see how a business case can be constructed for the introduction of the technology
- Still more work for the fuel cell industry
  - In particular cost must come down
  - But there is a huge global research effort in this field
- Challenge for railways is to inform this research and to be ready should it succeed
- EU wide trial is proposed to deliver this.

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