



WORKSHOP A: Bus Operation

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Thank you!



Panelists:

- Kirt Conrad, SARTA
- Bob Devine, BAE Systems
- Salvador Llamas, AC Transit
- Marlene Rinner, STA
- Romuald Witkowski, Solaris
- David Yorke, Tower Transit Operations Ltd

1. Technical readiness level for widespread rollout

- Current TRL between 6 and 7. For next generation of buses, TRL 8 to be achieved for daily (2 shifts/d) line operation (from 2020 TRL 9).
- Focus of optimization on functionality of the entire system but specific components must also be optimized on continual basis.
- Not only technical optimization, but make spare parts available in a sufficient and fast way and from more than single supplier.
- Customers can not sufficiently recognize whether the promised technical performance and maturity are actually achieved and when.
- Intensive exchange should be considered which also includes the supply side.
- Clear statements regarding quality can be made in the purchase contracts (with penalties).
- Production of fc-buses still a niche, risk that quantities can not be delivered in time or quality suffers. Buyers need confirmation that numbers and timings can be met.

2. Status of reliability issues

- Availability of buses 90% in next phase. In the medium term 95% (as with diesel buses) needed.
- Refueling stations still weak in supply to bigger fleets. Availability 99% needed as only one station per depot available. Can be achieved when critical components (e.g., compressors) redundantly applied.
- Alternative solutions in the event of a failure of the stations (e.g. trailer delivery).
- Besides technical optimization of components support during operation needed. Includes fully functional after sales with fast and secure delivery (24h) of all spare parts as well as working diagnostic tools.
- Comprehensive training of the experts on-site (workshops etc.).
- Adequate availability could be supported by providing additional buses (such as in a pool for a region).
- After CHIC and even if regular professional exchange expires, benchmark should still be supported (specialized working groups, etc.)

3. What is the target efficiency?

- Depending on service, fuel cell buses (35 kg H₂ and 12 m bus) can reach approximately 400 kilometers. Usually sufficient but not always.
- Future buses should be made to customer requirements but still create economies of scale. (focus on components).
- Clear benchmark on efficiency of components and overall system in next phase of even higher importance (with different bus concepts as hybrid, REX
- OEMs to provide clear and meaningful information on efficiency, availability etc. on regular basis for planning of daily operation, size of refueling infrastructure etc.
- Data should also be included in the vehicle specifications in order to secure the future performance.
- More optimizations (reduction of weight due to lighter materials, new concepts for heating and air conditioning systems, etc.) to be integrated in next phase.

4. On road total bus efficiency vs. expected component level efficiencies



- ❑ Current availability of fuel cell buses about 70 to 80% compared to diesel buses. In mileage, values are often even lower.
- ❑ Also MDBF with 1.000 to 1.500 km/12m bus and 500 to 1.000 km/18m lower compared to diesel 2.000 km/12m and 1.400 km/18m. Appropriate target values must be contracted with manufacturers to reach operational fitness as diesel.
- ❑ Flexibility and productivity in operation like diesel buses as benefits of fuel cell buses. Take into account in overall economic assessment before purchase decision.
- ❑ Development of essential components for electric buses (fuel cells, batteries) is proceeding with different dynamics. Evaluate in preparation of future procurement decisions and general concepts.
- ❑ For investment decisions, operators need reliable statements re performance of vehicles with timelines when targets are safely(!) reached. Development partnerships with one or more manufacturers may help.

5. Where will cost improvements come from?

- Besides *hybrid fc-buses range extenders* gain importance (battery bus with fuel cells). Standards for fuel cells to be defined to achieve desired economies of scale.
- In funding, range extenders should be on equal terms with pure fuel cell buses.
- For economic evaluation, OEMs should provide further information on technical optimization to be achieved and impact on the costs on a regular basis.
- Expected that electric buses can be used for more than 10 - 12 years. The importance of this for TCO and when (and how often) relevant components have to be exchanged to be clarified.
- Joint procurement initiatives can help to reduce the investment costs for buses. However, in addition to the growing unit numbers regular and continuous procurement is needed.

6. Ways to improve maintenance

- ❑ Electric buses may require less maintenance than diesel buses in medium term. Mostly staff costs and cannot be ruled out that these cost reductions are eaten up by more frequent exchange of components.
- ❑ For economic evaluation of the workshop costs, clear statement about life of innovative components required. Has to be provided and communicated by the industry in due time.
- ❑ Maintenance by either own staff or external contracts. Based on experiences in CHIC and other ongoing projects, comparative calculations should be made.
- ❑ The education and training of technical staff should be standardized and follow the same (if possible international) guidelines.
- ❑ For the preparation, input of the industry (and a common task description) is necessary.

7. Next steps to bring volume up and price down



- Expand current activities for joint procurements of fc-buses in Europe (JIVE etc.) into international procurement network.
- Existing directives for timely conversion of bus fleets to emission-free (London, Oslo, Hamburg) communicated more intensively in international networks (C40 etc.).
- National as well as US and European funding programs for emission-free buses to be stabilized and harmonized on international level to safeguard commitments made at e.g. Paris Climate Conference.
- Focus of funding preferably on TCO instead pure investment funding.
- Number of OEMs offering fuel cell buses still small but might increase if more political pressure and commitment.
- Results of this ZEB Conference (including messages of Mayor of London and other cities) should be communicated strongly (especially in social media).

Summary of key aspects 1

Role of operators – business model

- Bus operators do not want to be engineers (but need sufficient insight)
- Full contract vs expertise by own staff
- White book of specification – buy American compliant

Optimisation

- Transparency on availability figures
- After sales, diagnostic; trouble shooting
- Intelligence diagnostics; but no over-sensoring
- Overall optimisation: weight, accessory loads
- Hunts for Watts
- Standard bus vs bus boutiques

Summary of key aspects 2

Market

- Specifications as stringent as necessary
- Joint procurement: predictable volume, continuity, spare parts
- Competition also in supply chain
- Performance standards, not technical standards (passenger capacity)

Knowledge sharing

- Sheltering knowledge - static price
- Tons of data; but little learnings
- Categorising non-availability reasons in detail
- Dialogue, benchmarks, transparency