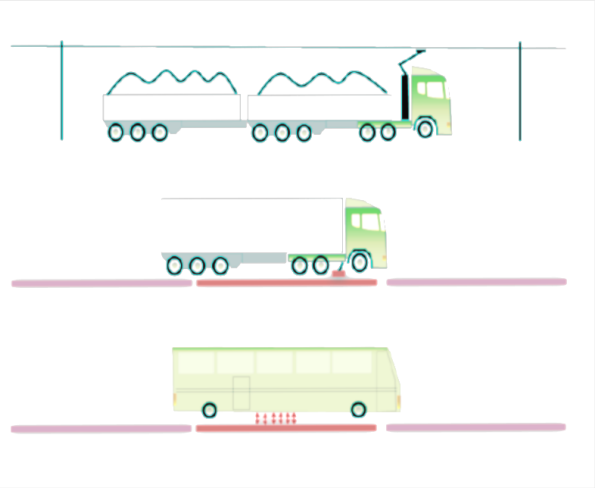




Swedish-German research collaboration
on Electric Road Systems



Standardisation of Electric Road Systems

REPORT FROM WORKSHOP AT FIRM19

28 MARCH 2019, BRUSSELS

Report by:

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Workshop host & organisers:



The research collaboration “CollERS”, Swedish-German research collaboration on Electric Road Systems, consists of the core members from the Swedish Research and Innovation Platform for Electric Roads and the two national German research projects Roadmap OH-Lkw and StratON:

- **German research partners**
 - Öko-Institut e.V.
 - ifeu – Institut für Energie- und Umweltforschung Heidelberg
 - Fraunhofer IEE – Fraunhofer Institute for Energy Economics and Energy System Technology
 - Heilbronn University of Applied Sciences
- **Swedish research partners**
 - RISE Research Institutes of Sweden
 - Chalmers University of Technology
 - KTH Royal Institute of Technology
 - Swedish National Road and Transport Research Institute (VTI)
 - Trafikverket – Swedish Transport Administration
- **Funding agencies**
 - German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
 - Trafikverket – Swedish Transport Administration

Additional information and resources can be found on the web:

www.electricroads.org

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Editor: Martin G. H. Gustavsson, RISE Research Institutes of Sweden

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Introduction

Electric Road System (ERS) is a technology concept that has the potential to dramatically reduce the fossil fuel dependency in the transport system. ERS is defined by electric power transfer from the road to the vehicle while the vehicle is in motion, and could be achieved through different power transfer technologies from the road to the vehicle, such as rail, overhead line, and wireless solutions. The basic technologies for power transfer from the road to vehicles in motion have been developed through various international research projects. In recent years, ERS has moved from conceptual idea to real-world application in countries such as Sweden (2016 and 2018), the United States of America (California 2017), and Germany (2019). In addition, projects are being planned in Italy and China [1].

National and international freight transports in Europe are usually determined by national and EU strategies and regulations. The success of ERS implementation, especially when it comes to a transnational roll-out, depends on using regulatory frameworks to identify areas where adaptation is needed [2].

The work in the CollERS project has included a consideration of ERS in national and EU transport strategies. The present report relates to identification of areas where standards are missing or have to be adapted, as well a stakeholder dialogue (Germany, Sweden, Denmark and EU), e.g. by means of expert interviews at national and EU-level (industry, science, politics, and road administrations).

The aim of this report is:

- To summarise, analyse and comment on the results from a collaborative workshop regarding standardisation of electric road systems that was organised by members of the CollERS project and hosted by [FEHRL](#) (the Forum of European National Highway Research Laboratories) at [FIRM19](#) (the FEHRL Infrastructure Research Meeting 2019) in Brussels 28 March 2019.

This report has been prepared for a dual purpose:

- For what may be called a discussion and **problem inventory** purpose, where the idea is to inject current problem inventories in the field of ERS standardisation with a snapshot of new and collaboratively generated ideas from a European perspective
- For **advancing discussions** about ERS standardisation by increasing stakeholder dialogue.

The Workshop: Standardisation of ERS from a European Perspective

The CollERS workshop at FIRM19 was organised for several reasons. Apart from contributing to the fulfilment of the above described report purposes, it was organised as a “meet and greet”-session between stakeholders sharing similar problems. Thus, it was the belief of the organisers that by bringing the discussion of ERS standardisation to a European level, the sharing of knowledge and stimulation of open exchange and dialogue between stakeholders could potentially provide valuable insights and perspectives beneficial for all participants.

The chosen format for the workshop was a World Café-style discussion.¹ A total number of 21 participants (15 stakeholders and 6 table hosts) were divided into three thematic groups: “Vehicle”, “Electric Power Supply”, and “Infrastructure”. The stakeholders were asked to answer four questions regarding identification of standards and which standardisation areas that they considered necessary for the successful development of ERS. The stakeholders were also asked to consider how they would prioritise these standards or standardisation areas in order of importance and timescales. As a round-off, all the tables got a chance to discuss more freely with a fourth question on whether there were any other issues related to standardisation of ERS that they found specifically important?

Results

The following section and sub-sections present the workshop discussion results per table theme and question. The main results section is then rounded off with some general comments on the themes and questions considered together.

The compilation of results started with, and was guided by, a basic text analysis of the written notes from the workshop participants using Voyant Tools [4]. This text analysis was supplemented by any additional notes from the table hosts, and the discussions as they were recalled by the hosts.²

It should be underlined that many of the answers from the table discussions were treated under various questions at the same time, since the questions were interlinked. For reasons of presentation however, the substance of the answers is discussed below in order of question and theme.

¹ This section will not delve into specific detail surrounding the actual execution of the workshop. More information can instead be found in Annex III.

² For more details about how [Voyant Tools](#) were used for analysing the raw data together with supplementary notes and the recollections of the table hosts, see Annex III.

The “Vehicle” Theme

Under the vehicle theme, one of the most frequently mentioned matter concerned questions of billing in ERS. In terms of substance, the discussions about billing gravitated around:

- What standardisation would be needed for billing?
- What kind of billing system will there be?
- What is going to be billed? Distance, time, speed or energy?
- How to solve questions of billing and energy use between countries? Could and should transponders be used?
- What about meter standards?

Commonly mentioned were also different aspects surrounding pantographs³ and catenary overhead lines. Here, the discussions revolved around:

- Standardisation of pantographs
- Whether standards for automation of the pantograph would be needed?
- Standard for pantograph and more specifically material, consistent type of wire, and pantograph.
- Standardisation of catenary overhead lines

Additionally, a variety of other matters were discussed under the ‘Vehicle’ theme:

- Electromagnetic currents (EMCs). For instance, is there a need for standards in this area to avoid negative interaction with electronics of vehicles, and what about electromagnetic currents from vehicles?
- Electrical safety in terms of short circuit from catenary overhead lines to the vehicle chassis.
- Is there a need for standards for a calibrated energy meter (kWh) in the vehicle or a calibrated back end?
- Mechanical force on electrical supply infrastructure.
- Should there be standards for power supply, and format standards for charging plug-in and voltage?
- Standards for communication like news, accidents and other types of communication, for example platooning.

³ I.e. the power receiver device.

Some more generally focussed opinions that emerged under the 'Vehicle' theme were that it is preferable to standardise the interfaces in ERS rather than the components of for example a vehicle. Another opinion was that standardisation will depend on the technical choice (for example AC or DC?), and that the success of ERS will depend on harmonised implementation, as a political decision. For the vehicle component in ERS, one opinion was that the latter will require standardisation of pick-up infrastructure, interfaces, and billing.

During the final and more freely orientated question, one of the most frequently mentioned matters concerned the EU, especially regulatory matters. Here, the discussions gravitated around:

- Any possible influence on standardisation from EU law?
- Whether ECE-standards for European Type Approval for the vehicles will be needed?
- Whether there are any CEE possibilities?
- That the EU is relatively open to create/change rules in this innovative area (i.e. ERS) and that the EU Commission is relatively open to promote European technology
- Whether the Weights and Dimensions Directive would allow ERS-Trucks to drive (in hybrid mode) across EU?
- Whether Weights and Dimensions exception (use of extra 50 cm) could be allowed for ERS vehicles?

Other matters discussed during the final question included:

- the dissemination of information from ERS-trials
- what are the main drivers to move from use case/demonstration to normal transport conditions in ERS, is it mainly cheap fuel or climate aspects? And finally,
- the question of source of power for ERS. Not all countries are on the same level of renewables.

The “Electric Power Supply” Theme

Under the “Electric Power Supply” theme, one of the most frequently mentioned topics regarded aspects of infrastructure. In terms of substance, the discussions about infrastructure concerned:

- Which part of regulation does ERS belong to? Road or energy/electric infrastructure? (marked as high priority in the short term), and does for example a pantograph belong to the energy grid?
- Height and depth of the infrastructure/height of catenary overhead line (marked as high priority), and questions of interoperability.
- Voltage level and position of infrastructure (marked priority: now)

Additionally, relating to infrastructure matters, the following was also added under the final more open question:

- Who will own the infrastructure and how will it be financed?
- The decision if ERS becomes part of road infrastructure and its regulation is important, and what will the implications be? (marked as high priority)

Other frequently mentioned matters concerned different aspects of power supply:

- How power supply will be adapted to the needs of vehicles.
- Authorisation of vehicles for power supply/access authorisation and control
- Voltage Level (marked as high priority), current of the traction current, electrical characteristics and electrical safety matters, and how much power can be supplied through a wire?
- The required power level (marked as high priority), definition of minimum power, and the source of energy?
- Different ERS in different countries ought to have at least the same voltage level.

Other matters surrounding railways were discussed. For instance, it was mentioned more than once that ERS is closer to light railway planning than heavy railway planning. Railways could also be used as an example where standardisation of interfaces is needed.

Additionally, a variety of other matters were discussed:

- Adaption of existing standards for components (for example from the application in the railway sector)
- That more expertise from the road sector is needed
- Calibrated electricity meters

- Prioritisation of standard needs and responsibilities of standardisation bodies, vehicle manufacturers and infrastructure owners and operators, and whether standardisation is needed?
- Whether energy consumption is charged or not (for example kilometre based approach), and its implications on standardisation?
- Identification of fields of interference, which impacts can come from the vehicle side? Risks for the grid, and whether the maximum disturbance from the vehicle to the grid ought to be standardised?
- Billing/the charge of energy and its complications
- That a system which fosters interoperability must be found (system needs standardisation)
- The border between already standardised spheres as a critical point
- Order/dilemma of prioritisation: 1. System design, 2. Standardisation, and 3. Technical Specification?

Finally, it was discussed whether there is an ambition to make vehicles capable of using different infrastructure systems (overhead as well as in the ground), and that inductive ERS solutions are a completely different story, both from a technology and standard point of view. A general comment was that it ought to be considered a high priority to reflect on the interfaces (for example road – vehicle, electric infrastructure – vehicle) between different kinds of ERS.

The “Infrastructure” Theme

Under the “Infrastructure” theme, one of the most frequently mentioned matters regarded field equipment. More specifically, the discussions about field equipment revolved around:

- Standardisation of field equipment installation (marked medium priority, within a timescale of 1-2 years⁴) and, dialogue with National Road Administrations and road operators regarding rights of where to position installations.
- Safety issues regarding the placement of field equipment and discussions of right of way/traffic rules, and standards for field mounted ERS infrastructure: cables, wires, poles, power supply, etc. (marked high priority within a timescale of 3-4 years).
- Position of track in road, standardisation of width and depth of the contact system in the ground, or cables/lines/overhead: height, exact position, same approach in different solution, and standardisation of bridges, tunnels and how the pantograph integrates with these constructions?

Other frequently discussed matters involved various aspects of power supply:

- The position of supply and its dimensions (marked as very high priority and within a timescale of 1-2 years).
- Possible limit for when to add/put on power supply, and whether to have a minimum speed limit (marked as very high priority and within a timescale of 3-4 years).
- Standardisation of voltage levels (marked as very high, within a timescale of 1-2 years).
- Power supply transfer.
- Standardisation of electric power supply and how to maintain electric supply according to a standard?
- Mechanic and electric interface of the energy supply and interfaces between the infrastructure and the power supply.

Other discussions that surfaced included a variety of topics like:

- Billing (marked as high priority within a timescale of 5-8 years), charging system along the road, communication and billing system (marked as medium to high priority).
- Safety issues regarding the placement of field equipment, and that safety standards were missing.
- Electrical safety, signs for electric roads/hazards.
- Maintenance schedules and standardisation of maintenance (both for road infrastructure and vehicles), where is the wear and tear going to be? Impacts on road and other impacts depend on type of ERS.

⁴ Timescales here and in the following are to be read as “between 1 and 2 years”, “between 3 and 4 years” etc.

- Other impacts: business models – someone will have to pay, and if national road administrations do not want to pay, can there be an investment model? What about business models with licenses to electric companies to supply power?
- Business model: depends on fleet owners. Can there be a business model for investment that helps interoperability? Possibly digitalised? Interoperability between countries – fleet owners need to pay for rebuilding vehicles?
- Road/traffic signs: will there be a need for instance for signs like ‘Please lower your pantograph?’
- Materials used in different ERS and installation: how is it done, in what, and what materials are used?
- Driver’s license, additional qualifications, and any mutual recognition between countries?

Finally, various questions regarding interfaces were discussed. For example, the standardisation of interfaces between the infrastructure and the vehicle, the (road) infrastructure and the electric supply, and that “interface” is the physical interface, between the infrastructure and the solution – which also includes communication and billing. Another general comment was that the interfaces are the most important area to standardise.

Connecting the Dots – An Overview of the Table Themes Considered Together

As a final part of the results section, it is appropriate to consider the table theme discussions together to form a possible overview. The table themes belong to an envisioned common system architecture [5], where the respective themes are interlinked and naturally cross-cutting, for example regarding issues of road infrastructure and infrastructure for electric power supply.

Comparing the three table themes, it can be concluded that the major topics⁵ discussed were:

Major topics discussed according to table theme		
“Vehicle”	“Electric Power Supply”	“Infrastructure”
<p>Billing</p> <ul style="list-style-type: none"> - What standardisation is needed for billing? - What is going to be billed? Distance, time, speed, or energy? - How to solve billing and energy use between countries? 	<p>Infrastructure (physical/technical matters & system component association)</p> <ul style="list-style-type: none"> - Height and depth of infrastructure? - Ownership and financing of infrastructure? 	<p>Field equipment</p> <ul style="list-style-type: none"> - Standardisation of field equipment installation - Position of track in road, width and depth of the contact system in the ground, cables/lines/overhead: height, exact position, standardisation of bridges
<p>Pantographs (and catenary overhead lines)</p> <ul style="list-style-type: none"> - Standard for pantograph and material, consistent type of wire, and pantograph - Standardisation of catenary overhead lines 	<p>Power supply</p> <ul style="list-style-type: none"> - Adaptation of power supply to the needs of vehicles? - Required power level, definition of minimum power, and source of energy? 	<p>Power supply</p> <ul style="list-style-type: none"> - Position of supply and dimensions - Standardisation of voltage levels
<p>European Union matters (varied)</p> <ul style="list-style-type: none"> - Influence on standardisation of EU law? - ECE-standards for type approval of vehicles needed? - ERS-trucks driving across the EU vs weights and dimensions directive? 		

It should also be added that an outstanding general topic, that all tables seemed to consider as high priority, was **the importance of standardising interfaces**. The interfaces that were discussed varied. These included, for example, both the vehicle/road infrastructure interfaces and road/electric power supply interfaces.

From a priority of importance and timescale perspective, it is not possible to get a clear and uniform picture that would suggest a possible ranking of the different topics or matters discussed at the tables. The range of ranked importance varied from “very high priority - medium priority” and the timescales varied between “now - 5-8 years”. Moreover, different tables ranked the same topics differently.

⁵ The table only shows the major themes including some examples under each theme. For a closer look at the details and nuances of the discussions, see sections above for respective table theme results.

Arguably, this suggests that there was no clear and common understanding regarding the priority of the topics discussed at the different tables.

When comparing the topics across the table themes, it is perhaps no surprise that recurring substance in the discussions surrounding various topics can be found, although these can be discussed under different labels. For instance, similar substantive infrastructural aspects were discussed under “Electric Power Supply”, under the topic “Infrastructure” (e.g. height and depth of ERS infrastructure, and voltage level and position of infrastructure), and the “Vehicle” and “Infrastructure” themes. However, under the latter themes, the discussions hovered over similar substance, for example catenary overhead lines and pantographs, and cables/lines/overhead, in connection to terms like “pantographs (and catenary)”, and “field equipment”. Thus, taking a “substance over form”-perspective on the table discussions, it can be concluded that similar discussions were held at the tables, although under different labels. Apart from infrastructural aspects, this also included questions about billing in all groups, as well as aspects of power supply. Nevertheless, concluding that many of the table discussions were more or less the same would not be a fair representation of the details and variety of substance discussed within the various topics. This would be to resort to some kind of reductionism according to well-defined and clearly formulated topics. Such neatly packaged topics were simply not present during the discussions!

One explanation for recurring substance in the different table discussions could be the interlinked and system dependent nature of the table themes: the topics belong to a connected system and therefore have relevance across table themes. Another more practical and methodological explanation could be that the same persons repeat and voice similar arguments as they travel to different tables, although under varied table themes.

As a final observation, it can be added that a text analysis, using Voyant Tools, of all the table discussion notes combined, as opposed to analysis of notes table per table, gave a rather high occurrence of the term “Q4”. Q4, which was marked on the answers for the more openly formulated question four,⁶ occurred to varying degrees in the different table discussions. By way of example, especially under the “Vehicle” theme, several EU-related questions surfaced when discussing question four. The high occurrence of “Q4” may suggest that there were, and still are many other relevant cross-European issues to discuss in relation to ERS than merely standardisation.

Discussion

As stated in the introduction, the purpose of preparing this report was dual:

- it had a discussion and problem-inventory purpose, where the idea was to inject current problem inventories in the field of ERS standardisation with a snapshot of new and collaboratively generated ideas from a European perspective, and
- it had the purpose of advancing discussions about standardisation of ERS, especially by increasing stakeholder dialogue, where this report could be a starting point for further dialogue, as well as for any future collaboration platforms dealing with standardisation of ERS.

Judging from the results above, it may well be argued that this report gives a snapshot from a discussion and problem inventory purpose of the field of ERS standardisation from a European perspective. Whether the report will also help advance discussions and stakeholder dialogue in future discussion forums and collaboration platforms is yet too early to say.

⁶ I.e. “Are there any other issues related to standardisation of ERS that you find specifically important?”.

As a matter of relevance, the limitations of the results in this report ought to be discussed. One aspect of relevance of the results in this report could be discussed from a methodological perspective. It was for instance observed that some table participants were more active and voiced their opinion with more emphasis than others, which could have skewed the noted main topics of the discussions. This is a known weakness of data gathering in group discussions. On the other hand, the fact that discussions are in fact held in groups, as opposed to one-on-one interviews, can also have an enabling effect on otherwise silent participants, since they may feel supported by others also present in a group discussion.

Another limitation of this report's results is that the relevance and the possibility to draw any general and representative conclusions from discussions between 15 stakeholders can be questioned. The open nature of the questions posed at the World Café-discussion served to generate qualitative data that could be used for probing basic attitudes about the standardisation of ERS among a limited population of experts. Thus, based on the data gathered and analysed for this report, there is no possibility to draw any general conclusions about attitudes and priorities beyond this population of experts without also confirming with complementary and larger quantitative data sets.

All the same, in this early stage of scoping the field of standardisation of ERS, the gathering of basic attitudes, even in a small population of ERS experts, can be of high relevance for assembling knowledge that can help formulate useful hypotheses about stakeholder opinions in the field. Furthermore, due to lack of other available results covering similar discussions, and possibly also that the workshop on ERS standardisation at FIRM19 between stakeholders may have broken entirely new ground, this report is arguably nevertheless a good starting point. It can therefore at least give an indication of some key topics among stakeholders surrounding the standardisation of ERS that ought to be further taken into consideration.

Additionally, when some of Europe's foremost experts on varying topics linked to ERS meet and discuss problems and solutions regarding standardisation, even when they are only 15 persons, it is hard to claim that the discussions would lack relevance because there are too few contributors. Thus, the results in this report can still be a valuable starting point for future and broader cross-country and cross-stakeholder dialogues.

Post-script – Some Notes Following the 3rd Electric Road Systems Conference, May 7-8, 2019, Frankfurt am Main

As noted under the "Discussion" section above, one of the purposes of this report was to increase stakeholder dialogue, for example by serving as a starting point for discussions at conferences promoting topics relating to the standardisation of ERS. At the 3rd Electric Road Systems Conference, May 7-8, 2019, Frankfurt am Main, there was a dedicated roundtable discussion about standardisation. The author of this report was present and participated during the mentioned roundtable. The text below aims to summarise the main takeaways from this roundtable discussion, and to offer some additional reflections for the current report, based on the roundtable discussion outcomes.

The roundtable on standardisation was hosted by a representative from the Swedish Transport Administration, and a representative from Fachhochschule Erfurt – University of Applied Sciences. At most, there were over 20 participants present during the discussions, including the two hosts.⁷ After

⁷ Unfortunately, no list of participants from the roundtable specifically was released by the conference. Nevertheless, based on official pictures released after the ERS conference, the roundtable was visited by over 20 persons from among other countries Sweden, Germany, China, France, Japan, and Israel. Most participants had a State or industry background. There were also participants with university, research institute, and independent

a short round of introduction of the roundtable participants, the hosts proposed some discussion topics including: joint ERS system definitions, brief updates on ongoing standardisation issues, topics for standardisation and regulation, peoples – countries – projects, and possible further progress in the form of a meeting/workshop.⁸

In the discussions that followed, some of the topics concerned the choice of voltage levels for ERS, whether to use AC or DC in ERS, and the establishment of ‘electric road systems/ERS’ as an international common term for on-road vehicle systems employing dynamic charging (irrespective of technology).⁹

Regarding standardisation, one ERS technology manufacturer expressed some concern that certain technological solutions would be standardised and thus become favoured unfairly. A standardisation expert present at the round table however explained that the normal procedure in international standardisation does not allow a certain technology ‘to be crowned and become the standard’. Rather, standardisation organisations work actively to create standards allowing openness for current and future technologies to fulfil a standard if the technologies achieve the basic requirements of solving a certain problem at hand. Finally, the crucial aspect of standardisation of interfaces in ERS was stressed.

Viewing the FIRM19 workshop results and the ERS conference roundtable discussion together, the discussion at the ERS conference roundtable to a large extent echoed several of the concerns discussed more thoroughly at the FIRM19 ERS workshop. For example, questions such as choice of voltage level and preferred technology for ERS were discussed at both instances.

The roundtable discussion as such was not a result of the previous version of this report being available before the ERS conference, but it was another independent confirmation that there are yet many unsolved matters to discuss among stakeholders surrounding ERS and standardisation. Once again, an overarching and perhaps the strongest point brought forth by stakeholders at both the workshop and the roundtable was that interface standardisation is crucial for ERS.

organisation backgrounds. A common denominator for all participants was a shared interest in or expertise on electric road systems.

⁸ This list of proposed discussion topics was based on the slides shown by the roundtable hosts.

⁹ As understood by the author of this report, the establishment of ‘electric road systems/ERS’ as an international common term was proposed by one of the roundtable participants to speed up international collaboration for expedited ERS introduction. Since ‘electric road systems/ERS’ is arguably already the most established term, it would make sense to stick to this term and refrain from introducing further terms for the same phenomenon. The latter could slow down international dialogue because of unnecessary confusion, instead of enabling it.

Conclusions and Possible Further Research

All in all, this report has summarised, analysed and commented on the results from the collaborative workshop regarding standardisation of electric road systems that was held at FIRM19 in Brussels 28 March 2019. It did so with the dual purpose of providing a discussion and problem-inventory in the field of ERS standardisation from a European perspective, and for the purpose of advancing discussions about standardisation of ERS, especially by increasing stakeholder dialogue.

To conclude this report, it could be observed that the stakeholder discussions at the FIRM19 ERS standardisation workshop chiefly surrounded the following major topics under the three themes of “Vehicle”, “Electric Power Supply”, and “Infrastructure”:

- Billing
- Pantographs and catenary overhead lines
- European Union matters (varied)
- Infrastructure (physical/technical matters & system component association)
- Power supply, and
- Field equipment

Also, an outstanding general topic that was considered as high priority at all discussion tables was the **importance of standardising interfaces**. Additionally, at the 3rd Electric Road Systems Conference in Frankfurt, the question of interface standardisation was once again brought forth by stakeholders as crucial for ERS. The interfaces that were discussed at both instances varied, and it could be worth further consideration what ‘standardisation of interfaces’ really implies to different stakeholders.

On this note, the definition of interface standardisation ultimately depends on focus. For instance, taking a system level perspective, which relates to viewing ERS as a system of systems [6], the most common way of understanding interface standardisation (among the stakeholders at the FIRM19 workshop and the ERS conference roundtable) was that it entailed solving interface conflicts *within a country*, that also potentially uses several ERS solutions. The interface conflicts mentioned specifically related to the vehicle/road infrastructure interface and the road/electric power supply interface. Could standardisation then solve interface conflicts within a country so that a vehicle can switch from, say a conductive dynamic charging system to another, or even from a conductive to an inductive electric road system?

According to this author, there are also at least three additional ways to view ERS interface conflicts in relation to standardisation. One is to consider upward interoperability, and try and resolve ERS interface conflicts on a higher system level, that is inter-State ERS interface conflicts. Thus, can standardisation aid a smooth shift-over for prospective large volumes of international transports between future different ERS systems in different countries?

A second ERS interface conflict that could be imagined is related to downward interoperability, and standardisation on a minor system scale. Here, a question is whether standardisation can solve ERS interface conflicts within a certain system component area, and within a specific ERS technology? Accordingly, can standards guarantee for example that all vehicles can connect to various conductive technical solutions within the same country, and furthermore, within the framework of a certain technology, say for rail-in road charging?

A third forward-looking interface discussion is the question associated with horizontal interoperability between systems created for instance for light vehicles and buses, and ERS. Taking the example of charging infrastructure, it is already now critical to pose the question whether standardisation can aid

interface conflicts between dynamic and static charging infrastructures. There are already standards for static charging of vehicles, but are these requirements compatible with future requirements for ERS and dynamic charging? Thus, is there a future where certain ERS technology could be used both for dynamic and static charging of various vehicle types?

As some general conclusions from a panoramic view, it can be added that the discussions about ERS standardisation mostly revolved around rather practical questions during the workshop. For example, the physical characteristics of a certain ERS technology or a billing system. For the most part, the discussions did not venture into details about any specific standards. Another general conclusion is that the standardisation discussions at the different tables mostly took the perspective of technology manufacturers and state authorities like national road administrations, but not the perspective of possible end-users of ERS, for example medium to small freight operators and shippers.

Moreover, based on the discussions and the feedback from the workshop participants during and after the workshop, there seems to be a lot of room for more talks about standardisation of ERS and other aspects on European and national (and international) levels. For ERS to take off successfully in international settings, co-operation and open dialogue will therefore be key for a successful development of standardisation and other issues related to ERS.

Based on the above, some suggestions for possible further research in the area of standardisation of ERS could be:

- interface standardisation: examination of various issues of interoperability at different levels
- integration of further stakeholder perspectives, for instance end-user perspectives on ERS
- any of the major topic themes listed in this section

References

- [1] “Electric Road Systems Conference 2019, May 7-8, 2019, Frankfurt, Paving the way to large-scale implementation”. <<https://www.electricroads.org/>>. Last visited 26 August 2019.
- [2] Hacker, F., *et al.* (2020), “National and EU freight transport strategies – Status quo and perspectives and implications for the introduction of electric road systems (ERS)”, Swedish-German research collaboration on Electric Road Systems, May 2020.
- [3] The World Café Community Foundation (2015), “A Quick Reference Guide for Hosting World Café”
- [4] “Voyant Tools”. <<https://voyant-tools.org/>>. Last visited 26 August 2019.
- [5] Gustavsson, M., *et al.* (Eds) (2019), “Overview of ERS concepts and complementary technologies”, Swedish-German research collaboration on Electric Road Systems, 2 April 2019
- [6] Tongur, S., Sundelin, H. (2016), “The electric road system: transition from a system to a system-of-systems” in “Energy, Power and Transportation Electrification (ACEPT)”, Asian Conference on (pp. 1-8), IEEE

Annex I - List of FIRM19 ERS Standardisation Workshop Participants

Name		Affiliation
Philip	Almestrand Linné	VTI
Marco	Aimo Boot	Iveco S.p.A.
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Ewa	Zofka	ERICA
Christer	Thorén	SCANIA CV AB
Patrik	Åkerman	SIEMENS
Julius	Rücker	Institute for Energy and Environmental Research
Matthias	Hartwig	IKEM
Lina	Nordin	VTI
Jose Luis	Peña Ruiz	Spain Road Technology Platform
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Florian	Hacker	Öko-Institute
Michael	Lehmann	SIEMENS Mobility GmbH
Jean-Claude	Roffé	ROUTES DE FRANCE
Thierry	Goger	FEHRL
Mohammed	Hoseini	VTI
Helena	Andersson	Swedish Transport Administration
Orestis	Giamarelos	BASt
Melanie	Zorn	BASt

Annex III - Method for Conducting the FIRM19 ERS Standardisation Workshop

This annex recapitulates to commenting on the method used for conducting the workshop on ERS standardisation at FIRM19. It also elaborates on some details that were intentionally left out in the introduction of this report.

As already stated above,¹⁰ the chosen format for the standardisation workshop was a World Café-style[3] discussion among stakeholders. This method was mainly chosen for the workshop as a way of fostering collaborative dialogue in an informal and friendly setting. In this way, it was believed that stakeholders sharing similar problems would start talking to each other in a European context, and that they would hopefully also start sharing knowledge that could in turn further stimulate open exchange in the future.

There are several definitions of the World Café-method, but one reference guide describes it as:

“A method for creating a living network of collaborative dialogue around questions that matter in service to real work” [3]

Essentially, the method rests on the principles of *collaboration* and *informality* in dialogue, to aid the generation of new ideas in a relaxed and friendly setting. Given the purposes described above and considering that many of the participants met for the first time at FIRM19, this method was deemed suitable for the workshop.

After four short presentations regarding ongoing research projects about ERS and standardisation of ERS, the workshop participants were randomly divided into three thematic groups with a dedicated table and table hosts. In total, there were 21 participants (15 stakeholders and 6 table hosts) divided into three thematic groups: “Vehicle”, “Electric Power Supply”, and “Infrastructure”. These three group themes were considered representative enough as basic points of departures representing stakeholder interests in a possible ERS system architecture.

The table hosts distributed four questions and these were discussed for around 20 minutes in total at each table, before the group participants were mixed according to new patterns to ‘cross-pollinate’ the discussions. At the start of the discussions, the participants were served coffee and other refreshments to create a friendly and relaxed discussion environment at the thematic group tables.

The following questions were distributed in all groups:

- *Which standards/standardisation area(s) do you identify as necessary for the successful development of Electric Road Systems?*
- *How would you prioritise these standards/standardisation area(s) in order of importance for ERS?*

Scale: VERY HIGH – HIGH – MEDIUM – LOW – VERY LOW

- *In what order would you prioritise the development of these standards/standardisation area(s) timewise?*

Scale: Within 1-2 yrs, 3-4 yrs, 5-8 yrs

¹⁰ See section ‘The Workshop: Standardisation of ERS from a European perspective’ above.

- *Are there any other issues related to standardisation of ERS that you find specifically important?*

The discussion participants were asked to write down their answers to these questions on large post-its in different colours (one colour per thematic group/table). The post-its were collected by the table hosts at the end of each 20-minute session. After the three 20-minute sessions, the table hosts gathered all the workshop participants for a ‘town meeting’ with a wrap-up of the discussions at all tables. All large post-its were put on display on different walls in the same room and were then commented on by the table hosts according to respective table theme. The workshop participants could also intervene, add to, and clarify the points discussed during the final summary.

For the compilation and analysis of data from the FIRM19 ERS standardisation workshop, all post-it notes were transcribed into a wordfile according to table theme. The text from each table theme was run through the web-based Voyant Tools[4] to yield a basic text analysis. With some filtering of for instance non-substantial prepositions, Voyant Tools listed the number of instances that substantial original terms occurred for each table theme. To get an overall sense of the proportion of substantial terms across tables, the gathered texts from all table themes was also run through Voyant Tools an extra time as a unity in the end. For increased comprehension and clarity, the text analysis was also supplemented by any additional personal notes from the table hosts, and the discussions as they were recalled by the hosts.

Based on the lists of occurring substantial terms, the main topics could be identified and organised under each table theme. A further task that was also performed for the analysis was that similar terms could be connected via shared context. As expressed above,¹¹ taking a “substance over form”-perspective, recurring substance in the discussions surrounding various topics could be found, although discussed under different labels. By way of example, comparable substantive infrastructural aspects were discussed under different labels under “Electric Power Supply” and under the topic “Infrastructure” (e.g. height and depth of ERS infrastructure, and voltage level and position of infrastructure). For this part however, Voyant Tools could not be used to make the compilation of substantial terms and their relation. Similar context had instead to be traced by the author of this report guided by knowledge of related discussion topics.

Finally, yet another way to present the result of raw data compilation can be found in “Annex II – Cirrus Cloud Presentation of FIRM19 ERS Standardisation Workshop Discussions”, also generated by Voyant Tools. This word cloud gives a supplementary overview and sense of proportion of substantial terms across the table themes, based on the entire gathered text mass from the discussions at all tables.

¹¹ See section “Connecting the Dots – An Overview of the Table Themes Considered Together” above.