Report on the key findings from the Theme Development Workshop "Future Mobility - Value of Data & Trust in AI"

– January 2022 –

Executive Summary

The second Joint Theme Development Workshop (TDW) co-organised by CLAIRE, HumaneAI Net, TAILOR and VISION[1] on "Future Mobility - Value of Data & Trust in AI" took place on the 28th of October 2021 with the aim to develop and identify the most promising and emerging AI topics in the mobility and transportation sector. At this one-day workshop, experts from academia, industry and politics jointly developed initial input for the European Artificial Intelligence (AI) research and innovation roadmap. Inspired by introductory speeches and presentations from selected experts, the participants actively discussed a wide variety of topics during the breakout sessions and shared their main results in the subsequent plenary presentations. Furthermore, some initial ideas for follow-up activities and further collaborations have been identified.

This report contains a summary of the results from the Theme Development Workshop "Future Mobility - Value of Data & Trust in AI". To make the results available to a broader audience and the European AI community in particular, this report will be published via the organiser's websites.

[1] In alphabetical order.

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Introduction

In September 2020, four new AI networks were established by the European Commission via the call "Towards a vibrant European network of AI excellence centres" (ICT-48-2020). The aim of these networks is to foster the collaboration between the best research teams in Europe, and to address the major scientific and technological challenges in the field of AI. These four networks are coordinated and supported by the VISION project to foster activities that reach critical mass and enable the creation of a world-class AI ecosystem in Europe.

One of these activities are so-called Theme Development Workshops (TDWs), an innovative format bringing together key players from industry, academia and politics to jointly identify the key AI research topics and challenges in a certain area or for a specific industry sector. In December 2020, an agreement was made between the respective coordinators and leadership teams of TAILOR, VISION, HumanE-AI-Net and CLAIRE to plan and execute a series of Joint (co-organised) Theme Development Workshops, starting in 2021. This report is a result of the second Joint TDW organised and executed within the framework of this series of workshops.

Keynotes and introductory presentations

The TDW was opened by the Co-Chairs Philipp Slusallek (DFKI) and Jan Alpmann (German Entrepreneurship) on behalf of the Organising Committee (OC), which included further representatives from CLAIRE, DFKI, German Entrepreneurship, TNO, Volkswagen AG, LMU and ZF Group. The Co-Chairs outlined the objectives of the TDW as well as the agenda and programme, and introduced the invited keynote speakers to the participants.

The inspiring keynotes were provided by high-level experts from academia and industry. These introductory presentations served as a basis for the discussions about the value of data and the aspect of Trustworthiness in the mobility and transportation sector, and provided some interesting examples of application areas. Accordingly, these presentations stimulated the expert discussions in the following breakout sessions.

Introductory presentations by Dr.-Ing. Christian Müller, Dr. Manuel Götz and Dr.-Ing. Marc Hilbert

Dr.-Ing. Christian Müller, Head of Competence Center Autonomous Driving DFKI Saarbrücken, primarily focused on advancements in core AI and validation and verification in his keynote, but also featured examples from explainable AI and human-machine cooperation. Specifically, Dr. Müller focused his attention on a very promising set of methodologies, most commonly known as Hybrid AI – the combination of Machine Learning and Deep Learning with symbolic AI methods.He also focused on patterns for explainable learning systems through rational reconstructions. Furthermore, his presentation covered

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informed learning with prior knowledge, where a learning system is guided by information and learning can be constrained through symbolic constraints, enforcing safety conditions. Finally, he focused on patterns for learning an intermediate abstraction which have a high potential of overcoming the key limitation of learning purely statistical correlations. Dr. Müller also explained how these patterns are applied across his own research projects, specifically in the setting of trajectory planning of cars. The presentation was concluded by a brief introduction of the digital reality principle with examples on human behaviour generation.

Dr. Manuel Götz, Head of AI & Cyber Security Technology Center at ZF Group, started his keynote with an introduction to Autonomous Driving – highlighting the huge step-up in complexity for highly automated driving. First, he discussed full sensory set and augmented use of AI versus camera only and strong E2E use of AI. Secondly, Dr. Götz focused on current typical deep learning tasks for automated driving such as detection and classification of objects and compared these to the advanced deep learning tasks for Autonomous Driving (such as multi-agent scene and trajectory prediction). Thirdly, he moved on to the important topic of safety and security in the automotive industry, focusing on existing and upcoming regulations and standards. He then moved on to the main part of his presentation, explaining what trustworthy AI means in the context of automotive products, and which issues the industry is facing. In the context of data availability and quality, he highlighted the need for robust metrics and automated checking for data and label quality. Regarding reliability and safety, he focused on the importance of good generalisation and robustness to unforeseen changes in the operational design domain as well as interaction of upcoming AI standards. Furthermore he discussed robustness and resilience against physical adversarial attacks and data poisoning. Another topic covered was verification and validation, where realistic simulation models and improved statistical methods are particularly relevant. The next issue was identified as human-in-the-loop and explainability, where improvement of the explainability and transparency of large and complex deep learning models are necessary. His next topic dealt with ethics, privacy, and liability, where it is important to have methods that ensure privacy in the development of AI through learning on anonymised or encrypted data and federated learning. Last but not least, Dr. Götz mentioned AI governance and monitoring, addressing in particular the necessity of appropriate documentation, traceability and quality control of data, labels and AI models in product software. He concluded that trustworthy AI encompasses many aspects and phases in the development of AI products and that automotive industry standards will address safety and security of AI based products, however addressing robust behaviour to unseen situations will be also essential.

Dr.-Ing. Marc Hilbert, Team Lead VW Data: Lab Munich at Volkswagen AG, started his keynote with a quick overview of Data:Lab Munich and how it has utilised Machine Learning to develop data driven products for Volkswagen (VW). Overall, he argued that bridging the gap between research and industry is an incredibly important challenge to bring value created by academias to companies. The first major topic of the keynote was focused on the difference between innovation and invention and that innovation is key for companies. If an invention cannot be commercialised, innovation is impossiblea point that according to Dr.

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Hilbert is sometimes forgotten by academia. Oftentimes, it is not the best method that can be commercialised, but the most robust, explainable, and trustworthy one. He also highlighted that Autonomous Driving is only one of many innovation areas, with process innovation being an equally important application area for high-level Machine Learning. Another application area is business model innovation where discussions around the use of data are particularly relevant. The second major topic that Dr. Hilbert focused on was the current state and development of how to achieve AI innovation. Specifically, he argued that it is necessary to move away from a model based approach towards a data driven approach. He concluded that the data infrastructure for models needs to be improved to avoid bias. The last major topic of the presentation was focused on explainability and trust. Dr. Hilbert defined explainability as support for someone to understand how something works, whilst trust refers to the ability to trust in something without understanding it. Explainability is thus necessary to understand models, which allows for cooperation with supranational organisations such as the EU for certification. Whereas trust is necessary for customers, as the customer should not have to understand AI systems, and society must be able to simply trust them.

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Key results from the Breakout Sessions

Trustworthy AI for Future Mobility - Group A

The Breakout Session 'Trustworthy AI for Future Mobility ' was very popular among the participants, so the discussion was split into two groups. Group A was well balanced with participants with a background in Autonomous Driving and other domains in Mobility. During the session, commonalities were identified, for example that many aspects are applicable outside of Autonomous Driving in terms of trustworthy AI for Mobility. To tackle trustworthiness, a fusion of the domains would not necessarily help to reach this objective due to known problems like compatibility with SOTIF standards in Autonomous Driving. However, some of the Key Trustworthiness Indicators (KTIs) like fairness, non-bias or robustness are also needed in public transportation. One of the key takeaways of this session was to correctly classify domains and to neither neglect their commonalities nor their differences. One of the ideas to expose data to the community was to use large-scale publicly governed data to establish trust as a long-term goal. As for challenges and roadmapping, one idea was to use concise data bases that are easier to obtain. Another idea was to generate a roadmap showing how to approach Trustworthy AI in a holistic way.

Trustworthy AI for Future Mobility - Group B

The second group discussing 'Trustworthy AI for Future Mobility' consisted mainly of participants from academia, startups and SMEs, allowing for a view on this topic from different perspectives. During the session, the group agreed that Europe is currently handling data in the right way, and that this creates trust among the public. One of the main topics of the discussion was the question how black boxes can be transformed into a more transparent "glass box" to create more trust in the model. The key takeaways of this session were to explain how data is being used to increase trust, to have more experts and resources in Europe and also to invest in projects to educate people how to build good models and to remove biases as well as collecting data in the right way. The participants also identified wishes towards a EU research roadmap, namely the wish for more standards for data-driven programming, to improve the media coverage on the topic and to also have more investments on the hardware side to have secure supply chains for a fully trustworthy system.

Explainable AI for time series & verification approaches

The breakout session 'Explainable AI for time series & verification approaches' dealt with the question which possibilities exist to verify methods and how their suitability to certain problems could be measured. The group considered the topic as very complex, also in terms of a clear distinction of trustworthiness and explainability, namely asking which use cases require explainability or trustworthiness. One idea to follow-up on this was to organise a dedicated workshop, gathering stakeholders from various backgrounds to discuss these distinctions between trustworthiness and explainability in more detail, especially as many open questions of explainable methods exist in general. Therefore, a generalisation was

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considered difficult. A question that came up in this regard was how generalisation could be established not only from a local but also from a global approach. It was also agreed that it is important to consider multiple methods in close cooperation with experts to ensure that the algorithms work properly and give reasonable results. The overall goal would be to create a xAI rulebook. To get there it could be helpful to first categorize AI application areas. As an outlook, the participants regarded it as necessary to generate ideas and find suitable partners for cooperation as the topic is relatively new. They shared the idea to use a big data pool for everyone to work and train on common datasets for an easier understanding and to identify potential errors.

Estimating the value of data

In the breakout session 'Estimating the value of data' the participants addressed the complex question of how the value of a given dataset could be estimated. During the discussion, a lot of ideas were exchanged, i.e. the question how to put numbers (or Euros) behind data to establish trust in customers who share their data. The key takeaways of this session for estimating data and generating a roadmap were that data has value to different customers, so estimating the value of data is considered as an important step concerning writing down the actual value of the data. Also, the group identified different types of values to the customers, i.e. on an individual, business or social level. An important element would be to generate the value on the customer and the vendor side to allow for a comfortable feeling when contributing data to certain applications. The group also agreed that data always has a certain bias which needs to be taken into account when formalising and generating a roadmap for estimating value of data. Finally, the discussion concluded with the insight that there is no linear relationship between value and data and that data has to have a good quality to be rightly estimated in its value.

Towards standardisation & certification of AI

The breakout session "Towards standardisation & certification of AI" aimed to discuss the challenges of developing standardisation and validation processes for machine learning components in the context of camera sensor-based algorithms, i.e. in Autonomous Driving. After a quick warm-up session, the participants dived into the discussion about the aims of certification. One of the main aims identified is to bring AI into the market while safety, security and privacy (e.g., video recording by an autonomous car) as well as explainability, robustness and steadiness are further important aspects and aims of AI solutions. In addition, another goal of the certification of AI systems is the controllability by humans, so that humans have control over the AI system at any time and can intervene if necessary, for example when the driver still has the opportunity to disagree with the Advanced Driver Assistance Systems (ADAS). In this context, a new way of controllability might be the process of keeping the human in the whole system through the human-in-the-loop mechanism. The second topic discussed by the participants was the aspect and meaning of self-awareness of the systems, meaning that the system can assist itself in case it is unfamiliar with the situation. This aspect could also address the safety argument of certification. Some possible solutions were highlighted by the participants, like Bayesian

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Inference Technique for handing over the control to humans or how to quantify the uncertainty or methods for quantification of uncertainty. Another item discussed in this breakout session was the idea of "Breaking the Rule" in Autonomous Driving, which means that Autonomous Driving systems should be allowed to break traffic rules in case of an emergency. However, this would make it more difficult to get a certification of the AI system, which has led to solutions for special cases like this by redefining the rules for Autonomous Driving where necessary.

AI expertise in Future Mobility - Group A

Also this topic was very popular among the participants, so the discussion was split into two groups. In group A, participants from industry and academia discussed the challenges in accessing expertise and attracting talents to AI research departments in academia and industry. While many unsolved problems and undefined needs in developing AI expertise remain, industry and academia in particular should work together to identify the kind of expertise that is needed in a specific field, and also to define a basic level of AI related knowledge needed for leadership as well as for the general public. In this context, the participants also discussed the question of what the specific needs for AI training and upskilling programmes are, and how these needs can be aligned with academic activities and doctoral programmes. They came to the conclusion that knowledge management, especially sharing AI knowledge in the AI communities and initiatives, is a key factor besides bridging the gap between the needs in industry and the training in academia through small courses and activities in universities (out of degree). It was also considered worth mentioning, that it is becoming increasingly difficult to attract interdisciplinary AI researchers to industry and research across Europe's borders or to prevent them from leaving. One reason identified by the group was that visa applications and entry requirements are becoming more complex. They also added that AI researchers in academia often cannot gain enough practical experience, while many individuals move to industry too early and therefore do not deepen their basic research and application-driven research.

AI expertise in Future Mobility - Group B

The second group focusing on "AI expertise in Future Mobility" also discussed specific needs for AI training and upskilling programmes and how these needs can be aligned with academic activities and doctoral programmes. To structure the discussion within the group, the participants divided the topic into three pillars: (1) AI technology for AI experts who build AI systems; (2) Other users who use AI systems to build other non-AI-systems; (3) People who simply use AI systems. The discussion has shown that within the first pillar, scientists from various disciplines with problem solving skills, for example physicists and engineers, start to work with AI, but they might need more training in AI. This is why AI or Data Science in general should be taught more in the various scientific courses in academic studies. This issue also became relevant in the second pillar where people need more skills on statistical knowledge and data handling, i.e. comparable to the level in algebra. Therefore, Data Science and Statistics should play an important role in all curricula in a way that it complements but not replaces disciplines like algebra or such. To ease the use of AI for

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non-AI researchers, the solution could be to build (modular) frameworks in order to reduce the complexity of AI models. On the other hand, a guarantee for these modules would be required. It seems that a variety of frameworks exist that are widely used but may be too complex for other disciplines (e.g., biology) and too tailored to Computer Science. Therefore, visual and/or graphical user interface tools and “AI as a Service with a web interface” are needed. During the discussion, it also became clear that technology needs to move towards the average user (pillar 3), but users still need to “understand” the general behavior of an AI system, including the capabilities and limitations of those systems. Otherwise it might cause the risk of a so-called “Uncanny Valley” in the Mobility & Transportation sector, leading to mistrust and fear of using AI. Accordingly, it is necessary to allow people to have a realistic impression of the technology through public engagement and communication for example, and to build trust in the wider community.

Reliable Confidence Measure

Currently used deep learning methods do not produce sensible confidence. Therefore, the reliability of deep learning methods in safety critical use cases cannot be assessed and trusted. In this breakout session the participants discussed reliable confidence measures to handle these challenges. The participants jointly elaborated the term "Confidence Measure" as a basis for further discussion. They came to the conclusion that measurable metrics for this term could be safety, robustness, “out of distribution data”, “adversarial attack” as well as certain quantifiable measures from 3rd party validation, which seems to be more trustable to the user. Based on their common understanding, the participants also identified the challenges of Reliable Confidence Measure in the Mobility & Transportation sector, where solutions need to be developed. According to the group, the Deep Neural Network (DNN) models are nowadays over-confident, whilst, with respect to the Reliable Confidence Measure, it might be better if a model is under-confident, enabling the user to take better action, e.g., in case of an emergency break. The Mobility sector faces another challenge, namely that in the research community people from industry as well as academia are often more interested in “high accuracy” in Machine Learning when it might be better to have another type of matrix to keep track of reliable confidence for cases like Expected Calibration Errors (ECE). These challenges led the group to to formulate some ideas for possible Hackathons in the Mobility and Transportation sector like “DNN Models Benchmarking keeping Reliable confidence measure in focus” to identify additional performance metrics like ECE or adversarial attacks to assess their suitability and reliability as performance measures and regularisation elements. In this context, the group also discussed potential assessment strategies, resulting in the finding that large test datasets are needed in a series of runs to make overfitting difficult.

Machine Learning in the context of personal data and GDPR

The driving question of the discussion in this breakout session washow data from individuals can be used for Machine Learning to create GDPR compliant human-centred AI applications . This also includes the issue of how ‘private’ data can be related to the certain exclusivity between privacy and data utility. The more private a data set gets, the less utilisable it is for

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building up Machine Learning models. Under the umbrella of GDPR, the most important aspect for developing Machine Learning algorithms in research institutions is to have a trusted middleman that governs over the data together with an ethics committee (that only grants access to people for research purposes falling under Article 89 of the GDPR). This could also partly apply to industry applications. In industry, other options need to be considered, so that the personal data can still be used without any infliction on people's privacy. One way that was discussed in this group could be Edge Computing for extracting data without touching individuals' sensitive data, i.e. by using blurred images. The arising challenges for such a solution however are computational limitations for example. Another option using personal data would be to use federated learning with morphic description. An obvious problem is that these data sets are often biased, which raises the question of whether conclusions can be drawn about the individual based on these biases.

AI sensitivity analysis for time series

In this breakout session, the application of AI in safety-critical situations and the importance of knowing the influence of input signals on an output due to safety reasons was widely discussed among the participants. It was also discussed whether pre-processed features can improve safety. The drawback of using pre-processed features is that the AI might miss some important input signals. Another item discussed in this group was the question whether there is some kind of benchmark for safety in AI. It was further elaborated whether safety categories with recommendations can further improve the safety development of AI algorithms. Nowadays, there are still some unsolved problems regarding the safety of AI. An example of this are the so-called 'black swan events' (tail of distribution). To handle such events, AI systems should be robust and resilient to these sorts of events. The participants agreed that it would be beneficial for the AI system to be able to tell the user that it does not know how to handle a specific situation and delivers a kind of certainty value. All participants agreed that much more research on that field is necessary to overcome the lack of knowledge.

AI for energy autonomous assets

In the transport and logistics sector, there are many moving goods without power supply. More and more of these assets are connected via (battery-powered) IoT devices to collect their positions and data. However, data transmission is a major challenge here. Accordingly, this breakout session discussed the opportunities and challenges for the use of AI under such conditions. From an energy consumption point of view, it is certainly necessary to plan the device's computing and communication operations carefully to optimize energy consumption. AI algorithms (constraint planning) have shown in the past, also before IoT, that they are able to successfully manage devices in a high constraint environment, e.g., satellites and rovers for space exploration. So, it is necessary to reflect on whether the AI application should run on the device itself or on a cloud server. Decentralised, multi-agent oriented AI algorithms can offer solutions in multi-IoT systems where centralised solutions are difficult with regard to data transmission limitations. The centralised versus decentralised AI dilemma is discussed within the classical computing paradigm/hardware. The group also

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touched on some future issues in this context, for example that quantum computing with its potential application to AI would make the dilemma even more interesting/harder, since quantum machines nowadays are all cloud-based and too size-overwhelming to be IoT devices.

Input for the roadmap

Based on the results summarised in the previous section, the Organising Committee identified several topics which could be a valuable input to a European AI research and innovation roadmap. These topics will be presented to and further discussed with experts from TAILOR, HumaneAI Net, VISION and CLAIRE in order to enrich the respective roadmap activities.

The below topics are the ones that stood out most prominently and will thus provide the 'core' of the input. However, when the roadmaps will be constructed, all inputs from the Theme Development Workshop will be considered.

Mobility and transportation sector specific

- **Grasp Trustworthy AI holistically**
  Trustworthy AI is a difficult to grasp topic that should be perceived and approached holistically, including the areas of "Robustness & Security", "Human-in-the Loop & Explainability", "Ethics, Privacy & Liability", "AI Governance & Monitoring", "Verification & Validation", "Data Availability/Quality", "Reliability & Safety". Accordingly, these topics should be addressed in a European AI research and innovation roadmap. On a political level, it would be beneficial to consider using the same terms in ongoing and future initiatives, especially in the area of AI Ethics (digital Ethics)

- **Data**
  Data enables new AI technologies to be developed, tested, and implemented. This is particularly true in the automotive industry which relies heavily on data to, among other things, develop autonomous driving solutions. There are, however, significant issues related to the availability and usage of data that are holding back the industry. These challenges could in part be addressed by:
  1. Creating and using easy to obtain data bases.
  2. Creating better standards for data-driven programming and increasing investments on the hardware side to have secure supply chains for a fully trustworthy system.
  3. Creating a big data pool for everyone in the automotive industry to work with and train on common datasets for easier understanding and error identification.
  4. Redefining some rules regarding the certification of AI systems and specifically Autonomous Driving technologies, e.g., if an AI system does not know how to react/handle a situation, it should inform the user.
  5. Ensuring that users are able to understand the general behaviour of AI systems, including their capabilities and limitations which requires increased

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data transparency. – Otherwise there is a large risk of mistrust and fear of using AI.

- **Communication**
  The wider public must be able to trust new AI technologies that the automotive industry develops; otherwise such technologies will fail. One of the best ways to increase such trust is by communicating information about new AI technology to the wider community and creating positive public engagement

More general topics not limited to the Mobility and Transportation sector

- **Trustworthy AI & Explainable AI**
  Trustworthy & explainable AI are very important for the success of AI in Europe. This TDW has uncovered some important insights in relation to these two important topics:
  - Improving media coverage on the topic of trustworthy AI should greatly improve trust in AI.
  - Differences between explainable and trustworthy AI must be addressed and clarified to avoid spreading confusion.
  - Knowledge management regarding AI and especially sharing knowledge in the AI community is very important to spread awareness of trustworthy & explainable AI.
- **Data**
  Some important conclusions regarding data from this TDW are:
  1. Data has different value to different customers – estimating the value of data is very important.
  2. Data is always biased to a degree, which should be considered accordingly. Also there is no linear relationship between value and data.
- **Academia / Education**
  - Discussions in this TDW revealed important issues regarding education and AI across Europe. Specifically, it has become clear that too little AI training is offered at universities and that research roadmaps are often lacking this important topic. Additional AI training through small courses is essential (outside of degree or secondary school) in academia/school.
  - It is becoming increasingly difficult to attract interdisciplinary AI researchers to Europe (visa process/entry requirements are some of many limiting factors). This issue should be addressed.
  - AI researchers in academia often cannot gain enough practical experience, but some also move to industry too early and fail to deepen their basic research skills. From the perspective of the industry, however, future talents gain practical experience too late. Industry needs both people that have a deep research background, but on the other side people who are willing to

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start a career in industry early with focus on applying AI knowledge. In addition, because of the lack of talent, the industry has to overcome this problem in upskilling people quickly. The resulting gaps in training and experience should be closed.

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Summary and Conclusion

The high international interest that was expressed in response to the announcement of the AI for Future Mobility Theme Development Workshop translated into excellent attendance of the event. Fifty-six participants joined the TDW, ranging from a diverse set of backgrounds. Fourteen (predominantly EU) countries were represented, with thirty participants indicating that they are affiliated with industry, whilst twenty-one participants indicated that they are affiliated with academia (five participants indicated "other"). The participation of major industry representatives, with companies like ZF Group and the Volkswagen Data Lab, is particularly noteworthy and testifies to great interest on the part of industry. Equally important being the participation of those affiliated with the European Commission. The TDW, therefore, caught the attention of some of the most important actors in the field of Future Mobility and brought together representatives from key companies, supra-national institutions, and academia. The workshop thus successfully provided a platform for discussions between representatives from academia, industry and politics: Discussions that are key in unlocking the full potential of AI in Europe.

The Organising Committee would like to express its deep gratitude to all experts for their valuable input and contributions to this Theme Development Workshop! Their active participation in the workshop and engagement in the breakout session discussions paved the way for the excellent results presented in this report.

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