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X-TEAM D2D

EXTENDED ATM FOR DOOR2DOOR TRAVEL

This Project Management Plan is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 891061 under European Union's Horizon 2020 research and innovation programme.

Abstract

X-TEAM D2D project aims at defining, developing and initially validating a Concept of Operations (ConOps) for the seamless integration of ATM and Air Transport into an overall intermodal network, including other available transportation means (surface, water), to contribute to the ACARE SRIA FlightPath 2050 goal. X-TEAM D2D project aims contributing to this goal by providing and preliminarily validating a ConOps for seamless door-to-door mobility in urban and suburban (up to regional) environment, i.e. X-TEAM D2D target scenario addresses the connection of a big metropolis with the surrounding area (up to country-wide level).

The project is focused on the consideration of ConOps for ATM integration in intermodal transport network serving Urban and Extended Urban mobility, considering the transportation and passengers service scenarios envisaged for the next decades, according to baseline (2025), intermediate (2035) and final (2050) time horizons.

The target ConOps will encompass both the transportation platforms integration concepts and the innovative seamless mobility as a service including ATM concepts. The ConOps will be preliminarily evaluated against already existing and specifically defined applicable KPAs and KPIs, implementing both qualitative and quantitative performances assessment approach.

The X-TEAM D2D project will develop a simulation-based platform for validating the proposed concept, considering the most relevant elements of the transport in the future such as interfaces mode-mode, high-level network model, passenger-centric paradigm.

This deliverable is aiming at concept of operations for ATM service to passengers in intermodal transport system.

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The project has been funded under Grant Agreement No 891061.

1.1 Applicable Reference material

[1] SESAR JU (2019) Technical Specification of SESAR 2020 Exploratory Research Call H2020-SESAR-2019-2 (ER4). SESAR JU. Edition 4. 25 April 2019.

[2] Joint Planning and Development Office (2011) Concept of Operations for the Next Generation Air Transportation System. Joint Planning and Development Office I Version 3.2. Washington DC.

[3] Robin Lineberger. Aijaz Hussain. Matt Metcalfe. Vincent Rutgers (2019) Infrastructure barriers to the elevated future of mobility. Deloitte Insights found deloitte.com/insights. Deloitte Insights. April 2. 2019. Available: https://www2.deloitte.com/content/dam/insights/us/articles/5103_Infrastructure-barriers-to-elevated-FOM/DI_Infrastructure-barriers-to-elevated-FOM.pdf. Accessed 15-05-2021.

[4] Deloitte (2020). Economic Benefit Analysis of Drones in Australia Final Report (commissioned by the Australian Department of Infrastructure. Transport.Regional Development and Communications).

[5] NextGEN, FAA (2020) Urban Air Mobility. Concept of Operations v1.0. Available: https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf. Accessed 04.02.2021.

[6] Robin Lineberger, Aijaz Hussain (2019) Urban Air Mobility - What will it take to elevate consumer perception. October 2019. Available: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/urban-air-mobility.pdf. Accessed 15-05-2021.

[7] Chris Metts, Martin Bowman, Robin S. Lineberger, Aijaz Hussain (2018) Managing the evolving skies. Available: https://www2.deloitte.com/content/dam/Deloitte/global/Images/infographics/gx-eri-managing-the-evolving-skies.pdf. Accessed 06-06-2021.

[8] Embraer X. Airservices Australia (2020) Urban air traffic management. Concept of Operations Version 1.

[1] The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

[9] Christiane Edinger, Angela R Schmitt (2012) RAPID PROTOTYPING FOR ATM OPERATIONAL CONCEPT DEVELOPMENT. Institute of Flight Guidance. German Aerospace Center. DLR. Deutscher Luft- und Raumfahrtkongress 2012. DocumentID: 281379.

[10] Eurocontrol (2018) UAS ATM Integration Operational Concept. 27.11.2018.

[11] ICAO (2005) Global air traffic management operational concept (Doc 9854).

[12] ICAO (2009) Manual on global performance of the air navigation system (Doc 9883). p I-1-1.

[13] Karl-Heinz Keller, Florian Piekert, Yves Günther, Meilin Schaper, Sven Kaltenhäuser, Reiner Suikat et.al (2010) TAM. Total Airport Management. A holistic approach towards airport operations optimisation. ESUG Meeting @ SICTA. April 20.

[14] Yves Günther, Anthony Inard, Bernd Werther, Marc Bonnier, Gunnar Spies, Alan Marsden, Marco-Michael Temme, Dietmar Böhme, Roger Lane, Helmut Niederstraßer (2006). Total Airport Management. Operational Concept and Logical Architecture. Available: https://www.researchgate.net/publication/224997997_Total_Airport_Management_Operational_Concept_and_Logical_Architectur. Accessed 03-02-2021

[15] Allan M de Souza, Celso ARL Brennand, Roberto S Yokoyama, Erick A Donato, Edmundo RM Madeira, Leandro A Villas (2017) Traffic management systems. A classification. Review. Challenges and future perspectives. Available: DOI link: https://doi.org/10.1177/1550147716683612. Accessed 06-06-2021.

[16] S Djahel. R Doolan. G-M Muntean (2015) A communications-oriented perspective on traffic management systems for smart cities. challenges and innovative approaches. IEEE Commun Surv Tutor 2015; 17(1) 125–151.

[17] David Stephen (1994) Independent Generation of Electric Power. Butterworth-Heinemann. Pages 1-44. ISBN 9780750616911, https://doi.org/10.1016/B978-0-7506-1691-1.50005-8. Accessed 15-04-2021.

[18] SESAR Joint Undertaking (2018) European ATM Master Plan. Roadmap for the safe integration of drones into all classes of airspace. SESAR Joint Undertaking. 2018.

[19] Robin Lineberger. Aijaz Hussain. Vincent Rutgers (2019) Change is in the air. The elevated future of mobility. Deloitte Insights.

[20] Eurocontrol, European Commission, European Aviation Safety Agency. SESAR Joint Undertaking (2021) U Space Services. Implementation Monitoring Report. 2018. Available: https://www.eurocontrol.int/sites/default/files/publication/files/u-space-services-implementation-monitoringreport-ed-1.2.pdf. Accessed 22-01-2021.

[21] Z. Liu, C. Wang (2019) Design of Traffic Emergency Response System Based on Internet of Things and Data Mining in Emergencies. in IEEE Access. vol. 7. pp. 113950-113962. Available: DOI: 10.1109/ACCESS.2019.2934979. Accessed 22-05-2021.

[22] Eurocontrol (2017) Airport CDM Implementation. The Manual. EUROCONTROL Airport CDM Team. Version 5.0. 31. March 201.7 Available: airport-cdm-manual-2017.PDF (eurocontrol.int). Accessed 06-06-2021.

[23] ICAO (2021) A-CDM Manual. Airport collaborative decision-making (A-CDM). Available: EUROCONTROL, Accessed 06-06-2021.

[24] Eurocontrol (2003) Airport CDM Guide. July 2003. Available: Airport collaborative decision-making (A-CDM) | EUROCONTROL. Accessed 06-06-2021.

[25] TrafficQuest (2012) The future of traffic management. Center of Expertise in traffic management 10.13140/RG.2.1.1007.0568. Available: https://www.researchgate.net/publication/275329525_The_Future_of_Traffic_Management_-_State_of_the_Art_Current_Trends_and_Perspectives_for_the_Future. Accessed 06-06-2021.

[26] The Australian Government (2017) The whole journey - A guide for thinking beyond compliance to create accessible public transport journeys; Available: https://www.infrastructure.gov.au/transport/disabilities/whole-journey/files/whole_of_journey_guide.pdf. Accessed 06-06-2021.

[27] NextGen (2011) Joint Planning and Development Office Transportation System (2011) Concept of Operations for the Next Generation Air Transportation. System Version 3.2.

[28] Robin Lineberger, Aijaz Hussain, Vincent Rutgers (2019) Change is in the air. The elevated future of mobility. Deloitte Insights.

[29] Tobias Hesse, Jörn-Müller-Quade et al. (2021) Mit KI sicher reisen. Datenmanagement und Datensicherheit bei KI-basierten Reiseassistenten. Whitepaper aus der Plattform Lernende Systeme, München 2021.

[30] Li, B., Guo, T., Wang, Y., Chen, F. (2022) The Future of Transportation: How to Improve Railway Operation Performance via Advanced AI Techniques. In: Chen, F., Zhou, J. (eds) Humanity Driven AI. Springer, Cham. https://doi.org/10.1007/978-3-030-72188-6_5.

[31] Degas, Augustin, Islam, Mir, Hurter, Christophe, Barua, Shaibal & Rahman, Hamidur & Poudel, Minesh & Ruscio, Daniele & Ahmed, Mobyen, Begum, Shahina & Rahman, Md & Bonelli, Stefano & Cartocci, Giulia & Di Flumeri, Gianluca & Borghini, Gianluca & Babiloni, Fabio & Aricò, Pietro. (2022). A Survey on Artificial Intelligence (AI) and eXplainable AI in Air Traffic Management: Current Trends and Development with Future Research Trajectory. Applied Sciences. Computing and Artificial Intelligence. 10.3390/app12031295.

[32] Vilone G., Longo L. (2020) Explainable Artificial Intelligence: A Systematic Review. arXiv 2020, Volume 2006.00093.

[33] Xie Y, Pongsakornsathien N, Gardi A, Sabatini R. (2021) Explanation of Machine-Learning Solutions in Air-Traffic Management. Aerospace. 2021; 8(8):224. https://doi.org/10.3390/aerospace8080224.

[34] UITP - Union Internationale des Transports Publics (2020), AI in public transport, https://www.uitp.org.

[35] P Tulpule. V Marano. G Rizzoni (2011) Effect of Traffic. Road and Weather Information on PHEV Energy Management. SAE Technical Paper 2011-24-0162. Available: https://doi.org/10.4271/2011-24-0162. Accessed: 02-02-2021. Dhanasekharan Natarajan, ISO 9001 Quality Management Systems, Management and Industrial Engineering, Springer International Publishing, Cham 2017, https://doi.org/10.1007/978-3-319-54383-3.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

[36] Thomas Clauss. Sebastian Döppe (2016). Why do urban travelers select multimodal travel options. A repertory grid analysis. Transportation Research Part A. Policy and Practice. Elsevier. Vol 93(C). pages 93-116.

[37] Todd Litman (2021) Towards More Comprehensive and Multi Modal Transport Evaluation 18 March 2021. Victoria Transport Policy Institute.

[38] Ulrike Klugea. Jürgen Ringbeckb. Stefan Spinlerb (2020) Door-to-door travel in 2035 – A Delphi study. Technological Forecasting & Social Change. 157.

[39] D Esztergár-Kiss (2019) Framework of Aspects for the Evaluation of Multimodal Journey Planners. *Sustainability*. 11(18):4960. Available: https://doi.org/10.3390/su11184960. Accessed 06-06-2021.

[40] R F Abenoza. O. Cats. Y.O. Susilo (2019) How does travel satisfaction sum up. An exploratory analysis in decomposing the door-to-door experience for multimodal trips. *Transportation* 46**.** 1615–1642. Available: https://doi.org/10.1007/s11116-018-9860-0. Accessed 01-04-2021.

[41] J Hine. J Scott (2000) Seamless. accessible travel. users view of the public transport journey and interchange. Transport Policy. Volume 7. Issue 3. Pages 217-226. ISSN 0967-070X. Available: https://doi.org/10.1016/S0967-070X(00)00022-6. Accessed 01-04-2021

[42] Nesta Ideo (2017) Design for Public Services. Available: https://media.nesta.org.uk/documents/nesta_ideo_guide_jan2017.pdf. Accessed 01-04-2021.

[43] Marc Stickdorn, Jakob Schneider (2015) This is Service Design Thinking. Hoboken New Jersey. John Wiley and Sons.

[44] European Commission (2018) Cooperative. connected and automated mobility, Mobility and Transport, Available: https://ec.europa.eu/transport/themes/its/c-its_en. Accessed 06-06-2021.

[45] European Commission (2017) Multimodal Travel Information, Mobility and Transport, Available: https://ec.europa.eu/transport/themes/its/road/action_plan/multimodal-travel-information_en. Accessed 06-06-2021.

[46] IoT-EPI (2021) European Platforms Initiative. INTER-Iot. Available: https://iot-epi.eu/project/inter-iot/. Accessed 01-04-2021.

[47] IoT-EPI (2021) European Platforms Initiative. Big IoT. Available: https://iot-epi.eu/project/big-iot/. Accessed 01-04-2021.

[48] IoT-EPI (2021) European Platforms Initiative. VICINITY. Available: https://iot-epi.eu/project/vicinity/. Accessed 01-04-2021.

[49] LeMo (2021). Available: https://lemo-h2020.eu/objectives. Accessed 01-04-2021.

[50] SYN+AIR (2021) Synergies between transport modes and air transportation. Available: http://syn-air.eu/ Accessed 01-04-2021.

[51] International Transport Forum (2021) Use of Big Data inTransport Modelling - Discussion Paper. Luis Willumsen. Nommon Solutions and Technologies. London & Madrid. 2021. Available: https://www.itf-oecd.org/sites/default/files/docs/big-data-transport-modelling.pdf. Accessed 01-04-2021.

[52] IoT-EPI (2021) European Platforms Initiative. SymbIoTe. Available: https://iot-epi.eu/project/symbiote/. Accessed 01-04-2021.

[53] IoT-EPI (2021) European Platforms Initiative. MONICA. Available: https://european-iot-pilots.eu/project/monica/ Accessed 01-04-2021.

[54] 5GMOBIX (2021) Driving forward Connected & Automated Mobility) website. Available: https://www.5g-mobix.com/ Accessed 06-06-2021.

[55] SuM4All (2021) Sustainable Mobility for All. GRA IN ACTION SERIES Sustainable Mobility: Policy Making for Data Sharing. 2021. Available: https://www.sum4all.org/data/files/policymakingfordatasharing_pagebypage_030921.pdf. Accessed 01-04-2021.

[56] The CHARIOT (2021) Privacy. Security and Safety of IoT. Available: https://www.chariotproject.eu. Accessed 01-04-2021.

[57] The SERIoT (2021) Secure and Safe Internet of Things. Available: https://seriot-project.eu/. Accessed 06-06-2021.

[58] The SOFIE (2021) Secure Open Federation for Internet Everywhere. Available: https://www.sofie-iot.eu/. Accessed 01-04-2021.

[59] The SecureIoT (2021) Predictive Security for IoT Platforms and Networks of Smart Objects. Available: https://secureiot.eu/. Accessed 01-04-2021.

[60] Alcatel-Lucent Enterprise (2020) The Internet of Things in Transportation - Build a secure foundation to leverage IoT for improved passenger experiences. safety and efficiency. Available: https://www.al-enterprise.com/-/media/assets/internet/documents/iot-for-transportation-solutionbrief-en.pdf.

[61] CIVITAS (2021) Mobility measure - Developing integrated transport management systems. Available: https://civitas.eu/measure/developing-integrated-transport-management-systems. Accessed: 01-04-2021.

[62] IoT-EPI (2021) European Platforms Initiative. Agile. Available: https://iot-epi.eu/project/agile/. Accessed 06-06-2021.

[63] 5GZORRO (2021) The Zero-touch security and trust for ubiquitous computing and connectivity in 5G networks website. Available: https://www.5gzorro.eu/5gzorro/. Accessed 01-04-2021.

[64] International Transport Forum (2021) Big Data for Travel Demand Modelling. Available: https://www.itf-oecd.org/big-data-travel-demand-modelling. Accessed 01-04-2021.

[65] Eurostat, UN and ITF (2019) Glossary for transport statistics — 5th edition, 2019.

[66] ELTIS - Urban Mobility Observatory (2019) Glossary of EU DG Mobility and Transport, https://www.eltis.org/glossary/intermodality.

[67] European Union (2011) WHITE PAPER - Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system /* COM/2011/0144 final */

EUROPEAN PARTNERSHIP

Co-funded by the European Union

[68] European Union (2016) CCAM - Connected Cooperative Automated Mobility– a R&I partnership to accelerate the implementation of innovative CCAM technologies and services in Europe, https://www.ccam.eu/library.

[69] Khattak, A.J., Targa, F., Yim, Y. (2004). Advanced Traveler Information Systems. In: Gillen, D., Levinson, D. (eds) Assessing the Benefits and Costs of ITS. Transportation Research, Economics and Policy, vol 10. Springer, Boston, MA. https://doi.org/10.1007/1-4020-7874-9_12.

[70] Willing, C., Brandt, T., Neumann, D. (2017) Electronic mobility market platforms – a review of the current state and applications of business analytics. Electron Markets 27, 267–282 (2017). https://doi.org/10.1007/s12525-017-0257-2.

[71] Beutel, M.C. et al. (2019). Information System Development for Seamless Mobility. In: Donnellan, B., Klein, C., Helfert, M., Gusikhin, O. (eds) Smart Cities, Green Technologies and Intelligent Transport Systems. SMARTGREENS VEHITS 2018 2018. Communications in Computer and Information Science, vol 992. Springer, Cham. https://doi.org/10.1007/978-3-030-26633-2_7.

[72] Krishnakumari, P.K., Kumar, H.D., Kulkarni, S., Sauter, E.M. (2021) Industry 4.0 and Circular Economy Digitization and Applied Data Analytics, in: An Introduction to Circular Economy, Liu, L., Ramakrishna, S. (eds), Springer Nature Singapore Pte Ltd., 2021.

[73] Kivimäki, M. (2014) MaaS-Finland on the leading edge. In Proceedings of the Mobility as a Service Seminar and Networking Event; Ministry of Transport and Communications: Ventaa, Finland, 2014.

[74] M. Hausenblas (2016), 5-star open data, http://5stardata.info/

[75] Iamamphai Phassarun, Noymannee Jeerama, San-Um Wimol, Pasupa Kitsuchart (2016). Investigations and comparisons of government open data websites through systematic functional analysis and efficient promotion approach. https://doi.org/10.1109/MITICON.2016.8025229.

[76] Toledo Tomer, Beinhaker Ross (2006) Evaluation of the Potential Benefits of Advanced Traveler Information Systems. Journal of Intelligent Transportation Systems - J INTELL TRANSPORT SYST. 10. 173-183, https://doi.org/10.1080/15472450600981033.

[77] Herweijer, C., Waughray, D., Warren, S. (2018). Building block(chain)s for a better planet, Fourth Industrial Revolution for the Earth Series, Geneva, World Economic Forum. http://www3.weforum.org/docs/WEF_Building-Blockchains.pdf.

[78] S. Amini, I. Gerostathopoulos, C. Prehofer, (2017) Big data analytics architecture for real-time traffic control, 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), 2017, pp. 710-715, doi: 10.1109/MTITS.2017.8005605.

[79] Vujic M., Dedic L., Furjan M.T., Pihir I. (2022) The Benefits of Open Data in Urban Traffic Network. In: Knapčíková L., Peraković D., Behúnová A., Periša M. (eds) 5th EAI International Conference on Management of Manufacturing Systems. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-67241-6_22.

[80] Jean-Paul Rodrigue (2020) The Geography of Transport Systems FIFTH EDITION New York, Routledge, ISBN 978-0-367-36463-2, doi.org/10.4324/9780429346323

[81] Morawski J. (2014) Reflexivity. In: Teo T. (eds) Encyclopedia of Critical Psychology. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-5583-7_263.

[82] Betz G. (2006) Expectations and reflexiveness. In: Prediction or Prophecy? DUV. https://doi.org/10.1007/978-3-8350-9053-8_7.

[83] Patomäki, H. O. (2020). Reflexivity of Anticipations in Economics and Political Economy. In R. Poli (Ed.), Handbook of Anticipation (pp. 1-26). Springer. https://doi.org/10.1007/978-3-319-31737-3_16-1 ("reflexivity is closely connected to fallibility", p. 558).

[84] Yves Crozet, Jean Coldefy, Report Mobility as a Service (MaaS): A digital roadmap for public transport authorities, CERRE Centre in Regulation in Europe, 2021

[85] European Union (2016) EU Regulation 2016/679 of the European Parliament and of the Council of 27 April 2016.

[86] European Commission (2021) DECISION of 3.12.2021 on setting up the Multimodal Passenger Mobility Forum; https://transport.ec.europa.eu/news/call-applications-selection-members-multimodal-passenger-mobility-forum-2021-12-09_de

[87] European Commission (2020) Sustainable and Smart Mobility Strategy – putting European transport on track for the future Action Plan, 9.12.2020, https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en.

[88] European Commission (2020) A European strategy for data, COM(2020)66 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593073685620&uri =CELEX%3A52020DC0066

[89] European Commission (2022) Regulation of The European Parliament And Of The Council on harmonised rules on fair access to and use of data (Data Act) 2022/0047 (COD) https://digital-strategy.ec.europa.eu/en/policies/data-act;

[90] European Committee (2020) Proposal for a Regulation of the European Parliament and of the Council on European data governance (Data Governance Act)' (COM(2020) 767 final) EESC 2020/05545.

[91] European Committee (2020) Proposal for a Regulation of the European Parliament and of the Council on European data governance (Data Governance Act)' (COM(2020) 767 final) EESC 2020/05545, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020AE5545.

[92] European Commission (2017) Delegated Regulation 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide multimodal travel information services (OJ L 272, 21.10.2017), https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX%3A02017R1926-20171021.

[93] European Commission (2004) Regulation (EC) 261/2004.

[94] Elena Riva (2010) The future of the seamless traveller journey is now, Inline Policy, 2020 https://www.inlinepolicy.com/blog/future-of-the-seamless-traveller-journey

[95] https://www.lexology.com/library/detail.aspx?g=59c87ffe-cd46-44a6-9325-79ce21d38ca7

[96] Timothy Morey, Theodore Forbath, Allison Schoop (2013) Customer Data: Designing for Transparency and Trust, Harvard Business Review, May 2015Litman, T., Towards (2013) More Comprehensive Multi-modal Transport Evaluation, in: Journeys (September 2013), https://www.vtpi.org/JOURNEYS_2013.pdf

1.2 Acronyms

A-CDM	Airport Collaborative Decision Making
ADS–B	Automatic Dependent Surveillance–Broadcast
ALRS	Alerting Service
APOC	Airport Operations Centre
ASM	Air Space Management
ATC	Air Traffic Control
ATFM	Air Traffic flow management
ATM	Air Traffic Management
ATS	Air Traffic Services
CCAM	Connected Cooperative Automated Mobility
CIRA	Centro Italiano Ricerche Aerospaziali
CNS	Communication, Navigation and Surveillance
ConOps	Concept of Operations
DLR	German Aerospace Center
eVTOL	Electric Vertical Take-off and Landing
FIS	Flight Information Service
KPA	Key Performance Area
KPI	Key Performance Indicator
IATA	International Air Transport Association
IAQ	Internal Air Quality
ICT	Information and Communication Technology
ID	Identification
IoT-EPI	European Platforms Initiative
MaaS	Mobility as a Service
MONICA	Management of Networked IoT Wearables
NMS	New Mobility Services
ODM	On-Demand Mobility

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PATS	Personal Air Transport System
SAT	Small Air Transport
SecureIoT	Predictive Security for IoT Platforms and Networks of Smart Objects
SERIoT	Secure and Safe Internet of Things.
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
SMS	Safety Management System
SOFIE	Secure Open Federation for Internet Everywhere.
SRM	Safety Risk Management
SSA	Social Security number
SuM4All	Sustainable Mobility for All
TAM	Total Airport Management
TIS	Traffic Information System
TOLA	Take-off and Landing Area
TSA	Security Screening Process at Airports
TTM	Total Traffic Management
UAS	Unmanned Aircraft System
UATM	Urban Air Traffic Management
UAM	Urban Air Mobility
X-TEAM D2D	eXTEnded AtM for Door2Door travel

1.3 Definitions

Airport: A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft.

Aircraft: Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface. An aircraft can include a fixed-wing structure, rotorcraft, lighter-than-air vehicle, or a vehicle capable of leaving the atmosphere for space flight.

Air Space Management (ASM): The planning and division of available airspace with the aim of making the best possible use of this airspace. To achieve this, permanent separation must be avoided and a dynamic division of airspace between the different airspace user categories (civil commercial aviation, civil non-commercial aviation, military aviation) must be achieved.

Air Traffic Flow Management (ATFM): Planning and controlling the volume of air traffic with the aim of ensuring a safe, orderly and high traffic flow. To this end, (1) the maximum utilization of existing capacities must be ensured and (2) congestion situations in individual traffic areas must be avoided by regulating traffic.

Air Traffic Management (ATM): The dynamic, integrated management of air traffic and airspace—safely, economically, and efficiently—through the provision of facilities and seamless services in collaboration with all parties). ATM is used to ensure the safe and efficient movement of aircraft during all phases of their operation. It subsumes all functions and services of Air Space Management (ASM), Air Traffic Flow Management (ATFM) and Air Traffic Services (ATS).

Air Traffic Services (ATS): Combination of the operational services Air Traffic Control (ATC), Flight Information Service (FIS), Alerting Service (ALRS) for the operational management of air traffic. Air Traffic Services are part of the air navigation services provided by air traffic control.

Automatic Dependent Surveillance–Broadcast (ADS–B) is a surveillance technology in which an aircraft determines its position via satellite navigation or other sensors and periodically broadcasts it, enabling it to be tracked.

Blockchain is a decentralized, distributed, and oftentimes public, digital ledger consisting of records called blocks that are used to record transactions across many computers so that any involved block cannot be altered retroactively, without the alteration of all subsequent blocks.

Communication, Navigation and Surveillance ATM (CNS/ATM): Communications, navigation, and surveillance systems, employing digital technologies, including satellite systems together with various levels of automation, applied in support of a seamless global air traffic management system.

Intermodality in freight transport: Multimodal transport of goods, in one and the same intermodal transport unit by successive modes of transport without handling of the goods themselves when changing modes

Intermodality in passenger transport (not to be confused with multimodality): Relates to improving the efficiency and attractiveness of a single trip made with more than one transport mode (e.g. walking, train and bus), with the aim of offering travellers a seamless journey. This requires the creation of integrated transport systems through the harmonisation of different transport services and the creation of organised connections between different transport modes, for instance as in park and ride.

Mobility as a service (MaaS) is a type of service that, through a joint digital channel enables users to plan, book, and pay for multiple types of mobility services.

Multimodality in freight transport: Transport of goods by at least two different modes of transport.

Multimodality in passenger transport (not to be confused with intermodality) refers to the selection of alternative transport modes for different trips over a certain period of time (e.g. a day or week). For instance, a person may cycle to work, walk to the shops and use public transport to visit friends. Multimodality (and also intermodality) requires integration of infrastructure and transport services across modes in both passenger and freight transport.

Reflexivity: Circular relationships between cause and effect, especially as embedded in human belief structures

Safety Management System (SMS): The process that provides a systematic method for managing safety. The four components of an SMS are policy, architecture, assurance, and safety promotion.

Safety Risk Management (SRM): The set of processes and practices to identify hazards and control the risks they pose.

Smart Contracts: A SYN+AIR project term, they are agreements among TSPs that define data sharing criteria (scope, parties' obligations, contract's time span and fulfilment criteria). TSPs can use the agreements for structuring a collaboration scheme with another TSP either strategically or tactically. Data generated by Travel companion apps will also be analysed in the context of enriching the Smart Contracts Framework. This will allow TSPs to improve their activities and execute informed decisions.

Unmanned Aircraft System (UAS): In its most basic sense, a UAS is any aircraft that can be flown without a human on board. UAS is a preferred term by RTCA, FAA, and DOD. UAS includes: All classes of aircraft (airplanes, helicopters, airships, and translational lift aircraft), Aircraft Control Station, Command & Control Links, and autonomous, semi-autonomous, or remotely operated vehicles. Other commonly used terms include Unmanned Aerial Vehicle (UAV), RPA, Remotely Piloted Vehicles (RPV), and Drone/Model/RC Aircraft.

Urban Air Traffic Management (UATM) is the collection of systems and services (including organisations, airspace structures and procedures, environment and technologies) that support the integrated operation of UAM (Urban Air Mobility) vehicles in low level airspace. The objective of UATM is to support UAM operations and maximise the performance of UAM and low-level airspace

2 Project Objectives

High level aim of the X-TEAM D2D project is to define, develop and initially validate a Concept of Operations (ConOps) supporting the seamless integration of ATM and Air Transport into an overall intermodal network, including other available transportation means (surface, water), to contribute enabling the door-to-door connectivity, in up to 4 hours, between any location in Europe, in compliance with the target assigned by the ACARE SRIA FlightPath 2050 goals.

More in particular, the X-TEAM D2D project is focused on the detailed consideration of ConOps for ATM integration in intermodal transport network serving Urban and Extended Urban (up to Regional) mobility, considering the transportation and passengers service scenarios envisaged for the next decades, according to baseline (2025), intermediate (2035) and final (2050) time horizons.

The target ConOps provided and initially validated by the X-TEAM D2D project will encompass both the transportation platforms integration concepts and the innovative seamless mobility as a service including ATM concepts. The developed ConOps, then, will be also preliminarily evaluated against already existing and specifically defined applicable Key Performance Areas (KPA) and Key Performance Indicators (KPI), implementing both qualitative and, where possible, also quantitative performances assessment approach.

In the project activities, the integration of ATM and air transport into overall intermodal transport system will be considered not only with respect to currently available transportation alternatives on the surface and water but also with respect to emerging new mobility forms that are envisaged for the next decades. In particular, emerging innovative mobility paradigms will be considered, including: extended urban and regional air transport (Small Air Transport (SAT), Personal Air Transport System (PATS), vertical urban mobility - Urban Air Mobility (UAM), road autonomous mobility (autonomous cars and buses), high-speed rail mobility (including Hyper-Loop related concepts), water autonomous mobility (autonomous vessels). In addition, emerging disruptive concepts aimed to implement seamless mobility of passengers by using passengers' pods (e.g. "*Link and Fly*" concept proposed by AKKA Technologies and "*Clip-Air*" concept proposed by Switzerland's Federal Polytechnic Institute) will be considered from the perspective of ATM integration into intermodal transport. The X-TEAM D2D project, therefore, will analyse and review both the status quo of different transport modes presents in Europe and the new emerging ones that new technology is developing, all of them immerse in the on-demand and shared economy which in combination with passenger-centric view will revolutionize the future transport modes.

While pursuing the above aim, the project will consider the outcomes of other EU funded projects aimed to support the intermodal transport (e.g. BigData4ATM, DORA) and addressing not only air transport but also other transport means on ground and water (e.g. applicable projects addressing the impact of a new airport to the ground transportation in a certain area) and will also consider available studies in literature.

Under the above outlined overall objectives of X-TEAM D2D, one specific aim will be to develop a simulation-based platform for validating the concept proposed in the project. This platform will consider the most relevant elements of the transport in the future such as interfaces mode-mode, high-level network model, passenger-centric paradigm. The X-TEAM D2D proposed ConOps, therefore, will be validated with the simulation platform and a description of the semantic values of future KPIs and a diagnosis of the inefficiencies of the ConOps will be provided.

In order to better specify the scope of the X-TEAM D2D project in the wider framework of the FlightPath 2050 global target, it has been clarified in the X-TEAM D2D Kick-off Meeting, and it is here reported for the sake of clarity, that X-TEAM D2D does not address the complete FlightPath target of door-to-door

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travel between any location in Europe in up to 4 hours but X-TEAM D2D project aims *contributing* to this goal by providing and preliminarily validating a ConOps for seamless door-to-door mobility in urban and suburban (up to regional) environment: X-TEAM D2D target scenario addresses the connection of a big metropolis with the surrounding area (up to country-wide level).

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3 Background framework and assumptions

3.1 Assumptions and definitions

In this section the main assumptions and definitions both on the level of project as well as considered areas will be provided.

Three-time horizons: The Concept of Operation will be defined for 2050-time horizon understood as time perspective in which the set of externally and internally to the project defined processes is going to be finalised[2]. 2025 and 2035 horizons described in D2.1 Future Scenarios and barriers are seen as an intermediate step towards the goal of 2050 perspective.

Passenger transport, passenger centredness: The developed ConOps covers exclusively passenger transport on urban, suburban up to regional level including connections to/from the both regional and hub airports.

The integrated urban/suburban transport network is determined and specified by set of drivers, trends and factors of various nature identified within the scope of WP2 and described in form of scenarios in D2.1 Future Scenarios and Barriers.

Final scenario description with regard to virtual dimension of transport integration process:

Global perspective/Economy:

- Over 80% of European citizens lived in urban areas. The number of economically active people to the number of children and the elderly will decrease due to ageing of the population. A mass rise of the middle class which together with the upper class should exceed 82% of population.
- Digitalisation and mobile communications will grant universal access to various services. The fourth industrial revolution will lead to decline in living costs, value-driven consumption and demographic shift to regional cities or metropoles.

European policy/mobility:

- net-zero emissions in transport, the Comprehensive TEN-T Network completed, walkable cities, domination of soft modes, mass transit, NMS (new mobility services), CCAM (connected cooperative automated mobility), UAM.
- Digitalisation in transport together with algorithmic governance will enable domination of automated/autonomous mobility in almost all modes of transport enabling significant progress in operational efficiency.

European Policy/Regulatory:

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[2] It concerns both the process of transport integration as well as the goal of climate neutrality for which the integration of transport is considered as a determinant.

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- The delivery of the Digital European Sky should be completed enabling efficient optimisation and management including unexpected disruptions.

European Policy/ICT:

- Access to data. The question access, sharing and processing of data both related and indirectly related to the transport will be regulated assuring equal, secure and privacy and stakeholders' interest protecting rules.
- Algorithmic governance. The increasing complexity of future system will require application of new approach with regard to management of such systems. The algorithmic governance readable for computer and enabling orchestrating from the level of regulations will be implemented for crucial component of digitally integrated urban and suburban transport system.
- Policy strongly supporting development of ICT especially IoT, 6G and beyond, Big Data as well as the smart city concept allows to expect that that all regulatory barriers inhibiting projected applications of ICT potential/solutions will be overcome in 2050-time horizon.

Internet and Communication Technologies:

- Digitalisation of transport. Application of Internet of Things technologies will enable introduction of autonomous/automated operations and less human resource dependency, more accurate, real-time data shared among all interested parties will be generated leading to the significant increase of transport efficiency and digital integration.
- Big Data processing, access to various private data and identification of data being a transport need precursor will allow for near real time demand forecasting – in few hours advance.
- Communication Technologies – 5G and beyond communication technologies will be available over urban areas enabling data transfer performance meeting the current needs of digitally integrated multimodal transport system.
- Digital integration of transport. All the mentioned technologies together with availability of data and possibility to share it in regulated but unconstrained way and supported by development of hardware and software technologies dedicated to complex multimodal transport system management will allow for shifting the management level to the level of multimodal network and introduction of dynamic timetable and routing based on demand short term forecasting.

Use cases/passenger perspective:

- Ticketless change/transfer. Access to the modes enabled by face recognition or identification based on portable device signal. Portable devices exchanging data between passenger and system are the main tool integrating passenger with the transport system.
- Passenger needs oriented system. Dynamic timetables and routing of mass transport means enabled by: autonomation, digitalisation and ability to near-real time demand forecasting driven by access to privately generated data.

Disruption management:

- Digitalisation in transport will result with decrease the frequency of technical failures – due to proactive approach implementation as well as multilevel reliability management.

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- Access to real time, accurate transport data will enable quick identification of disruption of various reason and take appropriate mitigation actions.
- Mitigation actions based on dynamic management of supply deficiencies resulted from disruption or unexpected demand increase. Supply deficiencies in disrupted mode will be compensated by additional resources activated in other mode.

Barriers: Implementation of all assumptions and turning defined use cases into real situations in future require overcoming of numerous barriers of various nature. The crucial ICT barriers were identified and addressed in further part of the document.

3.2 Overall approach

In general, each ConOps should be structured by carefully considering eventual risks, performance estimates, temporal developments and validation processes. Below, the approaches that this ConOps follows as guidelines:

- **Risk based**

  The ConOps, in line with the **EASA regulation**, follows a risk-based approach. Broadly, this means that the level of "effort" devoted to maintaining safety is proportional to the risk associated with not doing so.

- **Performance based**

  The ConOps adopts a performance-based approach, being evaluated against already existing and specifically defined applicable Key Performance Areas (**KPAs**) and Key Performance Indicators (**KPIs**), implementing both qualitative and, where possible, also quantitative performances assessment approach.

- **Stepwise approach**

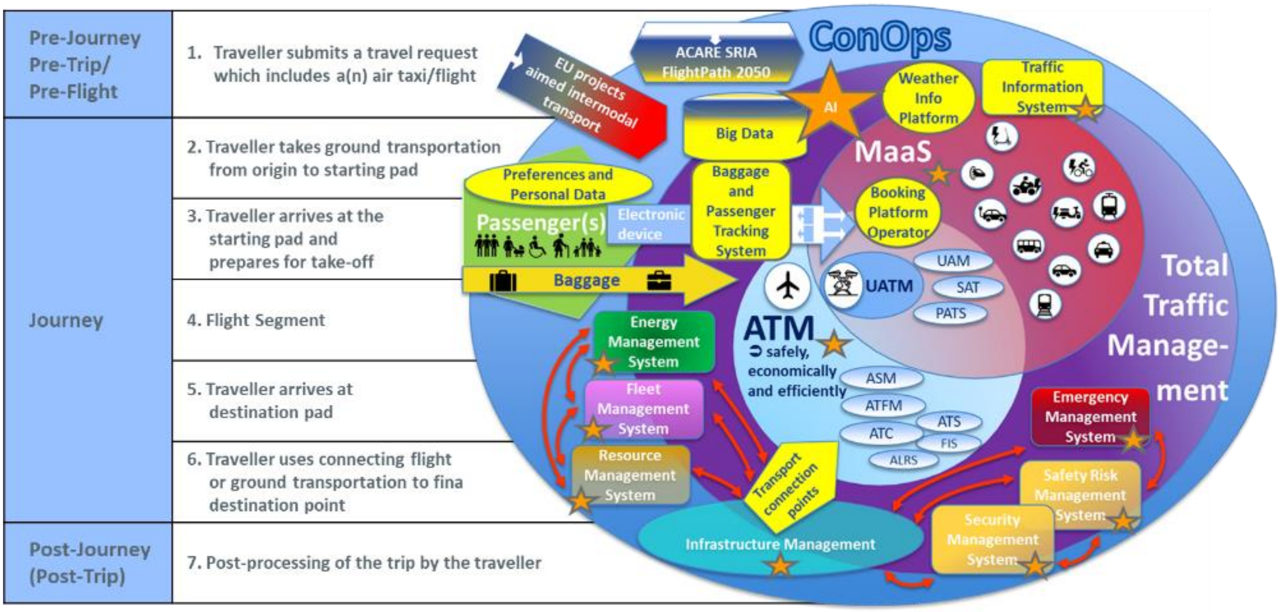
  The ConOps follows a stepwise approach, considering the transportation and passengers service scenarios envisaged for the next decades, according to baseline (**2025**), intermediate (**2035**) and final (**2050**) time horizons.

- **Validation based**

  Since X-TEAM D2D is an exploratory research project, the various concept elements should be validated before deployment. Therefore, the ConOps will be validated with a specific **simulation platform**. In addition, a description of the semantic values of future KPIs and a diagnosis of the inefficiencies will be provided.

3.3 Study logic

The approach of this concept of operations (ConOps) with the core of a conventional ATM is covered by operational steps defining a door-to-door journey with a flight segment for a passenger, which shall be improved by the multiple management systems and applications. It aims to show how travel conditions can change positively in their favour (e.g. time saving, more pleasant, safer, more efficient, more economical, more ecological) through planning and execution of the journey - over time.



AI	Artificial intelligence	FIS	Flight Information Service
ALRS	Alerting Service	MaaS	Mobility as a Service
ASM	Air Space Management	PATS	Personal Air Transport System
ATFM	Air Traffic flow management	SAT	Small Air Transport Research
ATC	Air Traffic Control	SMS	Safety Management System
ATS	Air Traffic Services	SRM	Safety Risk Management
ATM	Air Traffic Management	UAM	Urban Air Mobility
ConOps	Concept of Operations	UATM	Urban Air Traffic Management

Figure 1 – Basic Concept of Operations for ATM service to passengers in intermodal transport system with travel steps of the passenger

Focusing on passenger services through an enhanced ATM operational concept, the following management systems, tools and applications, should be built, managed and harmonised to be integrated into an overall (smart) transport management system 2050 covering all transport modes (road, rail, water and air):

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- Air Traffic Management,
- Urban Traffic Management,
- Mobility as a Service,
- Fleet Management System,
- Infrastructure Management System,
- Safety (Risk) Management System/Security Management System,
- Emergency Management/Response System,
- Energy Management Systems
- Resource Management System,
- Traffic Information System,
- Baggage and Passenger tracking System,
- Booking Platform Operator,
- Authoritative Weather Info Platform.

The ACARE SRIA FlightPath 2050 and other EU projects on intermodal transport feed into the design. Coherence with the ConOps of SESAR-ER4-13-2019 "Innovation in Airport Operation" is ensured as there was not only a close exchange but also collaboration from other multimodal projects such as IMOTHEP and TRANSIT.

4 Operational service context description

Modern societies need reliable traffic management systems to minimise negative impacts on their travel behaviour. Traffic management systems consist of a set of application and management tools to improve the overall traffic efficiency and safety of transport systems. To achieve this, the traffic management system, among other things, collects information from heterogeneous sources, uses this information to identify hazards that could affect traffic efficiency, and then provides services to control them. Against the background of this question, the following is an attempt to set up a ConOps for a holistic and comprehensive traffic management, the core of which is the well-known Air Traffic Management (ATM). This is intended to open up future perspectives for the implementation of a comprehensive traffic management system.

This approach is based on a model concept of operations for Urban Air Mobility (UAM) and Urban Air Traffic Management (UATM), which is used by passengers with preferences and optional baggage for a door-to-door journey. This ATM service for passengers in an intermodal transport system is intended to exemplify how traffic management for initial UAM operations can be safely provided within existing air traffic management capacity and could be scaled over time as new traffic management services are developed. This can only become possible if UAM is considered as part of a fully integrated urban and suburban transport system. Deep and multi-layered integration is the only way UAM can contribute to or even enable the 4hrd2d goal defined in FlightPath 2050.

Transport integration is an organisational process through which the planning and delivery of transport system elements are brought together across modes, sectors, operators and institutions with the aim of increasing net environmental and societal benefits. The process of integration should encompass three dimensions:

- Physical interface between the modes covering the convenient, time and effort efficient change/transfer nodes related to mainly to infrastructure planning.
- Operational integration between modes, understood as coordination between modes to be achieved through management and digital integration, starting with data exchange and shared fleet, resource, emergency, safety, risk and infrastructure management and ending with a city-wide traffic management system.
- Service integration from passenger perspective, i.e. common fare, common and paperless ticketing system, etc.

Both the physical and service integration dimensions have been addressed as part of Concept of Operation of 2050 urban and suburban integrated transport system in D3.1. The Operational integration will be part of operational ConOps in this document.

The operational concept in this study is a "living document" that will be updated as needed. It describes the "what" and as such must be seen as a visionary perspective. The "how" needs to be validated. This, together with the experience gained during introduction and implementation, will lead to improvements in the maturity of the operational concept.

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4.1 Introduction to Air Traffic Management and current Enhancements

As already mentioned, Air Traffic Management (ATM) forms the core of these ConOps. In addition, current extension approaches - such as Airport Collaborative Decision Making (A-CDM) and Total Airport Management - (TAM) gain further aspects for a comprehensive Total Traffic Management, in which the passengers, but also the other stakeholders, are the focus in order to generate a benefit for the overall system.

4.1.1 Introduction to Airport Collaborative Decision Making (A-CDM)

For example, Airport Collaborative Decision Making (A-CDM) is a joint project of ACI EUROPE, EUROCONTROL, the International Air Transport Association (IATA) and the Civil Air Navigation Services Organisation (CANSO) that enables airport operators, aircraft operators, air traffic controllers, ground handling agents, pilots and traffic flow managers to share operational information and work together to efficiently manage operations at airports and, where appropriate, en-route operations and planning. Although each A-CDM process is different and should always be adapted to the local needs, requirements and constraints of the airport, information sharing and transparency are key requirements in any situation. Reduced taxiing times, reduced controller workload, improved stability of operations under adverse conditions and increased airport throughput are just a few examples of the operational and financial benefits for air traffic control. While the European A-CDM process is very much focused on the handling process of flights at airports, the US Surface CDM is very much focused on the management of traffic flows at the airport surface and the queues for runway departures. The A-CDM process depends on the quality of the information provided, which is entered by each of the partners. The information must be reliable in order to produce a reliable and useful result for both individual flights and overall operations. A-CDM requires a number of significant changes in the way stakeholders work at the airport. It is imperative that all stakeholders work together to overcome the potential difficulties caused by the implementation of the concept.

Information sharing and transparency are key enablers for A-CDM. All stakeholders will still make their own decisions, but the flight information will be shared in order to create a common situational awareness. This could be done in varies ways, e.g. an A-CDM dialog system or an A-CDM Information Sharing Platform, depending on the technical possibilities of the airport and its stakeholders (Fig. 2)[3].

[3] EUROCONTROL (2017) Airport CDM Implementation - The Manual.

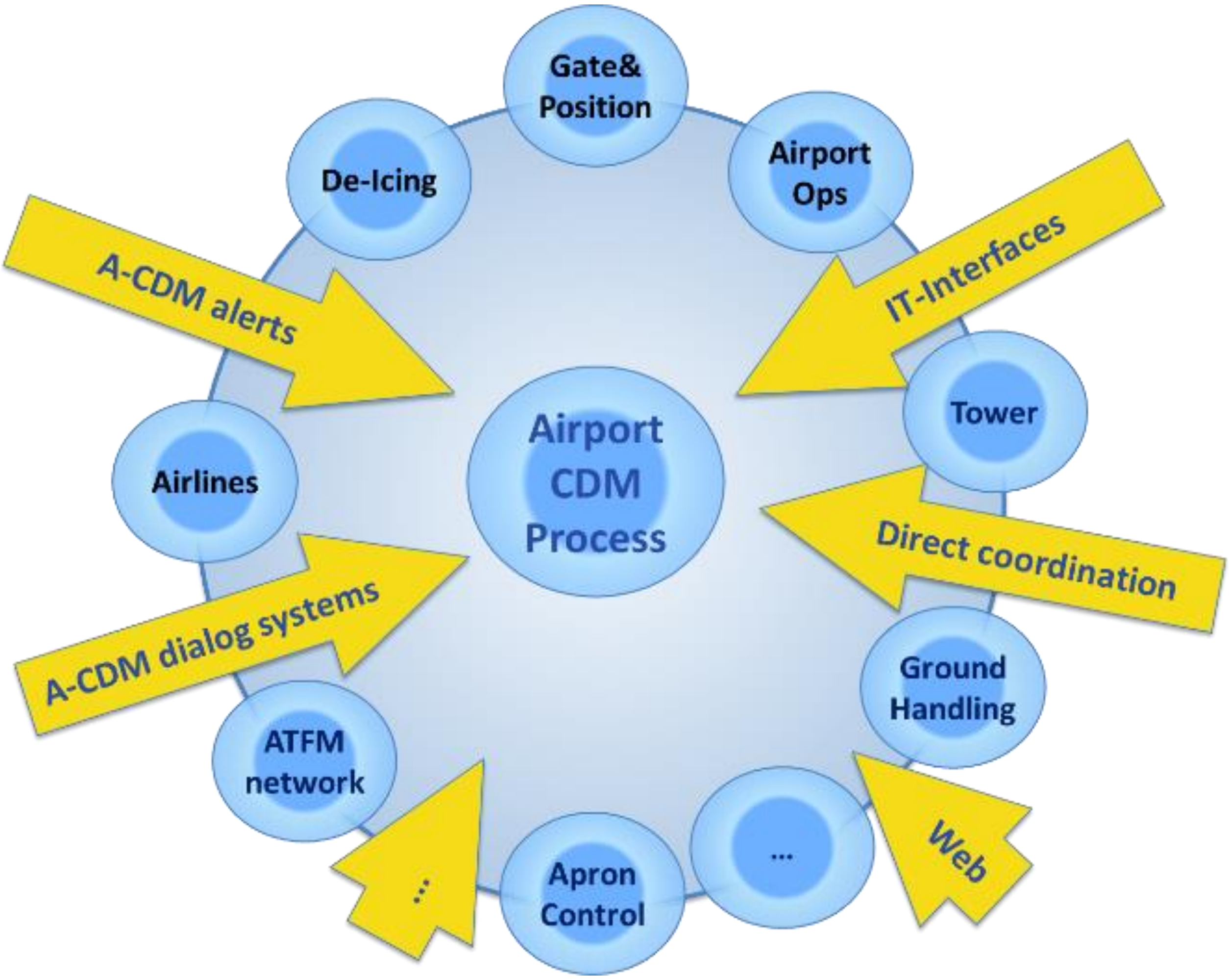
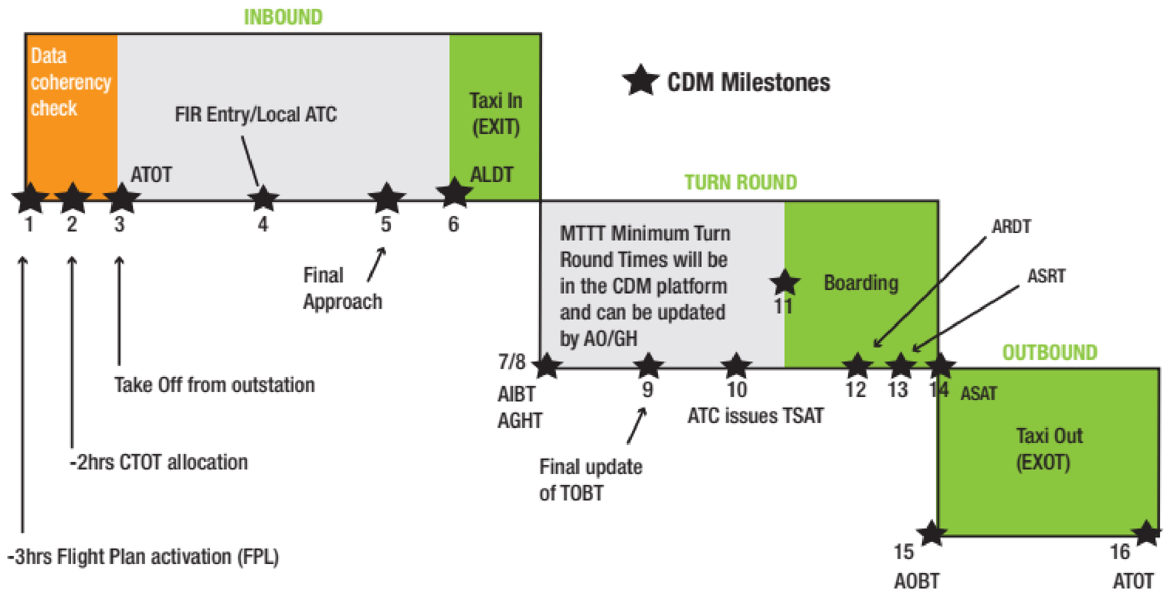


Figure 2 – Airport CDM Process

Airport Collaborative Decision Making (A-CDM) is nowadays embedded in the ATM operational concept as an important enabler that will improve operational efficiency, predictability and punctuality to the ATM network. The A-CDM Implementation Manual is designed to facilitate the harmonised implementation of Airport Collaborative Decision Making (Airport CDM) at European airports. The Implementation Manual guides the user through all the steps required for successful implementation and operation. Guidance is given from the time a management decision has been taken to organise an A-CDM project through to implementation. The measurement of success and planning for operational use are included as a basis for analysis and evaluation after implementation. Where Airport CDM Information Sharing has been implemented, significant further improvements can be achieved by implementing the Milestone Approach for the turn-round process. The Milestones Approach (Turn- Round Process) aims to achieve common situational awareness by tracking the progress of a flight from the initial planning to the take-off (Fig 3).[4]

[4] EUROCONTROL (2017) Airport CDM Implementation - The Manual



Number	Milestones	Time Reference	Mandatory / Optional for Airport CDM Implementation
1	ATC Flight Plan activation	3 hours before EOBT	Highly Recommended
2	EOBT – 2 hr	2 hours before EOBT	Highly Recommended
3	Take off from outstation	ATOT from outstation	Highly Recommended
4	Local radar update	Varies according to airport	Highly Recommended
5	Final approach	Varies according to airport	Highly Recommended
6	Landing	ALDT	Highly Recommended
7	In-block	AIBT	Highly Recommended
8	Ground handling starts	ACGT	Recommended
9	TOBT update prior to TSAT	Varies according to airport	Recommended
10	TSAT issue	TOBT -30 mins to -40 mins	Highly Recommended
11	Boarding starts	Varies according to airport	Recommended
12	Aircraft ready	ARDT	Recommended
13	Start up request	ASRT	Recommended
14	Start up approved	ASAT	Recommended
15	Off-block	AOBT	Highly Recommended
16	Take off	ATOT	Highly Recommended

Figure 3 – Process A-CDM – Approach Airport Collaborative Decision Making

Although every A-CDM process is different, and should always be adjusted to the local needs, requirements and constraints of the airport, information sharing and transparency are key enablers in every situation. Decreased taxi time, decreased controller workload, improved stability of operations under adverse situations and increased airport throughputs are a few examples of the operational and financial benefits for ATC. While the European A-CDM process is very much focussed on the turnaround process of flights at airports, the US Surface CDM focuses very much on the management of airport surface

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traffic flows and runway departure queues. The A-CDM process depends on the quality of the delivered information input by every single one of the partners. Information needs to be reliable to achieve a reliable and useful result for both single flights and overall operations. A-CDM requires a number of significant changes in the way parties at the airport operate. It is imperative that all stakeholders work together to overcome the possible difficulties that implementation of the concept causes.

4.1.2 Introduction to Total Airport Management (TAM)

Total Airport Management (TAM) is planned as a successor of A-CDM, for pre-tactical planning and execution of AOP. It is a holistic approach (landside and airside) towards airport operations optimisation and leads to commonly agreed performance targets and global airport optimisation.

The Figure 4 shows the overall concept of decision making on a pre-tactical level in an Airport Operations Centre (APOC), regardless of whether it is realized in a distributed form or as a single control room. The diagram depicts how APOC decisions provide orientation for the existing tactical operation centres without infringing on their local decision-making authority.

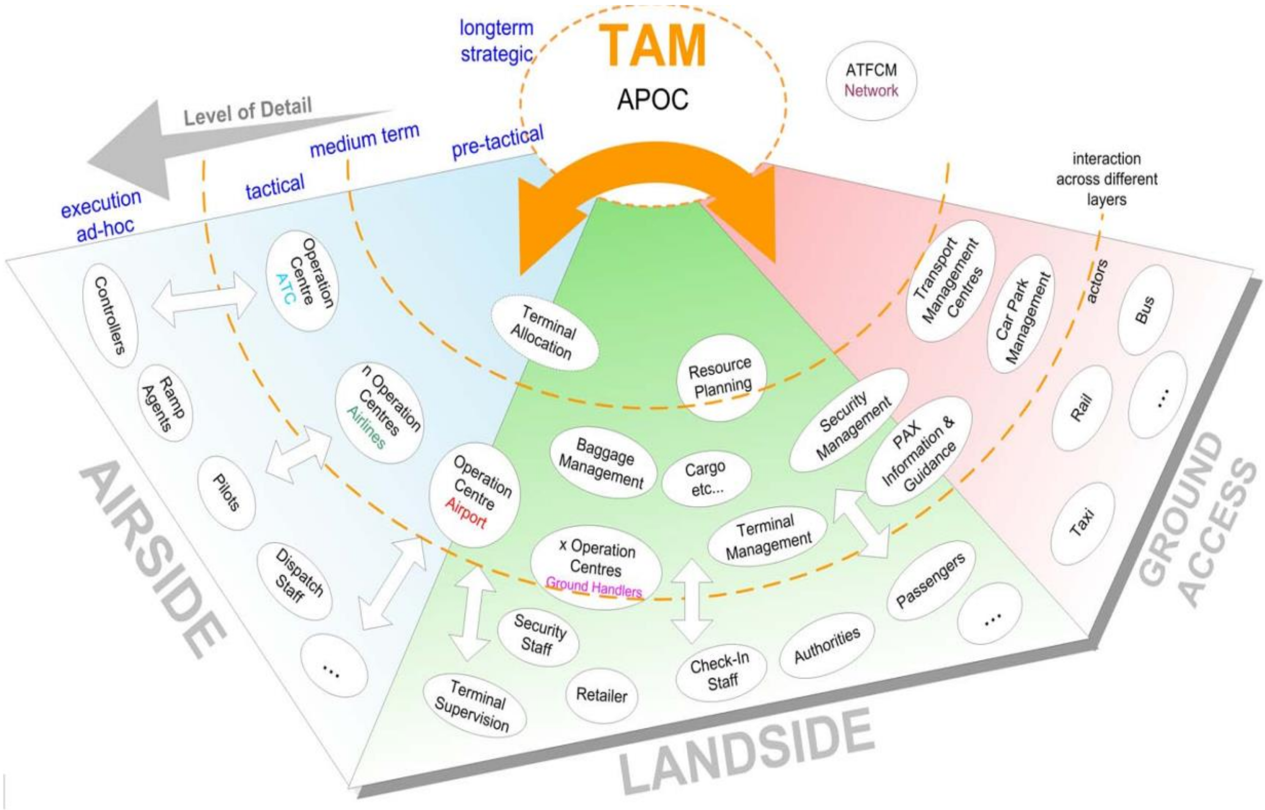

Figure 4 – Process TAM – Approach Total Airport Management[5]

The integration of Air (processes of the aircraft) and Landside (processes of the passenger) from the studies of Total Airport Management in Figure 5 shows the close link between the stakeholder groups such as the operators (e.g. airport/airline) and the passengers/travellers. It is in these processes that common goals or preferences (e.g. saving time on travel) become apparent.

[5] Karl-Heinz Keller. Florian Piekert et.al (2010) TAM. Total Airport Management. A holistic approach towards airport operations optimisation.

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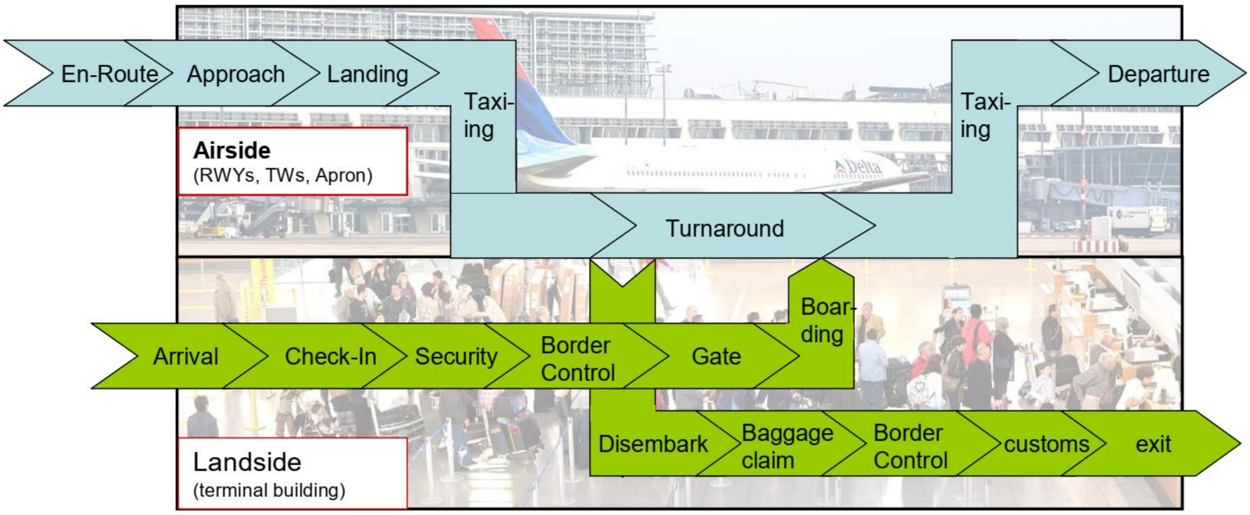

Figure 5 – TAM – Total Airport Management - Integration of Airside and landside[6]

4.1.3 Proceedings of the Air Traffic Management Extensions

At first glance, the following insights can be gained from ATM and the A-CDM and TAM extensions under consideration: ATM and the add-ons are more about basic cooperation and exchange of data and this, of course, only within the air transport sector. There are no overarching management systems installed across all stakeholders in the aviation business that address common issues and areas of impact. However, the individual processes are presented in a very detailed way for the stakeholder groups at the airport or for the handling and the flight, so that a simple transfer of these steps to a UAM flight can be considered. The process steps, which describe the passenger from check-in to deboarding (Figure 5), were therefore adopted almost identically and are shown in Table 1. Only points 1 and 7 were added, neither of which belong to Part 2: "Journey", but to Part 1 "Pre-Flight" and Part 3 "Post-Journey Processing" respectively. These seven process steps are crucial for an intermodal journey of a passenger in this ConOps and are therefore the focus of the scenario under consideration.

[6] Yves Günther. Anthony Inard. Bernd Werther et.al (2006) Total Airport Management. Operational Concept and Logical Architecture.

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Table 1 shows the seven steps of a passenger on a door-to-door journey with a flight segment and thus forms the approach of this ConOps.

Table 1 - Requirements Steps of a door-to-door journey with a flight segment from the passenger's perspective within an overall intermodal network

Steps of a door-to-door journey with a flight segment from the passenger's perspective within an overall intermodal network	
PART	**STEP**
Pre-Journey (Pre-Trip/ Pre-Flight)	**1.** Traveller submits a travel request which includes a(n) (air taxi) flight
Journey	**2.** Traveller takes ground transportation from origin to starting pad
	3. Traveller arrives at the starting pad and prepares for take-off
	4. Flight Segment
	5. Traveller arrives at destination pad
	6. Traveller uses connecting flight or ground transportation to final destination point
Post-Journey (Post-Trip)	**7.** Post-processing of the trip by the traveller

The further task is now to adopt air traffic management and its extensions as the core for the ConOps to be created and additionally to find common management systems and applications that have impact areas for all modes of transport. Passengers in particular should benefit from positive results, but ultimately all other stakeholders should benefit as well. Regarding the possible applications, the "Process TAM" in Figure 4 gives some hints in the area of tactical and pre-tactical application areas (e.g. Resource Planning, Security Management, Baggage Management), which will be examined in more detail in the following. Ultimately, a ConOps is to be created that will significantly further develop the entire traffic management by 2050. The task would be to expand these extensions of air traffic management to all modes of transport and to further develop them into total traffic management.

4.2 Integration of Urban Air Mobility into the ConOps

On Demand Mobility for Aviation proposes to develop a network of small aircraft that could operate at low altitudes and high speeds in close proximity to many of the world's most congested cities. However, despite the vision and efforts of numerous companies and individuals over the past decades, urban air mobility networks have not been realised on a large scale. The non-existence of these services is evidence that there are significant barriers or constraints that have so far discouraged or prevented sustainable inner-city air transport enterprises (Figure 6).[7]

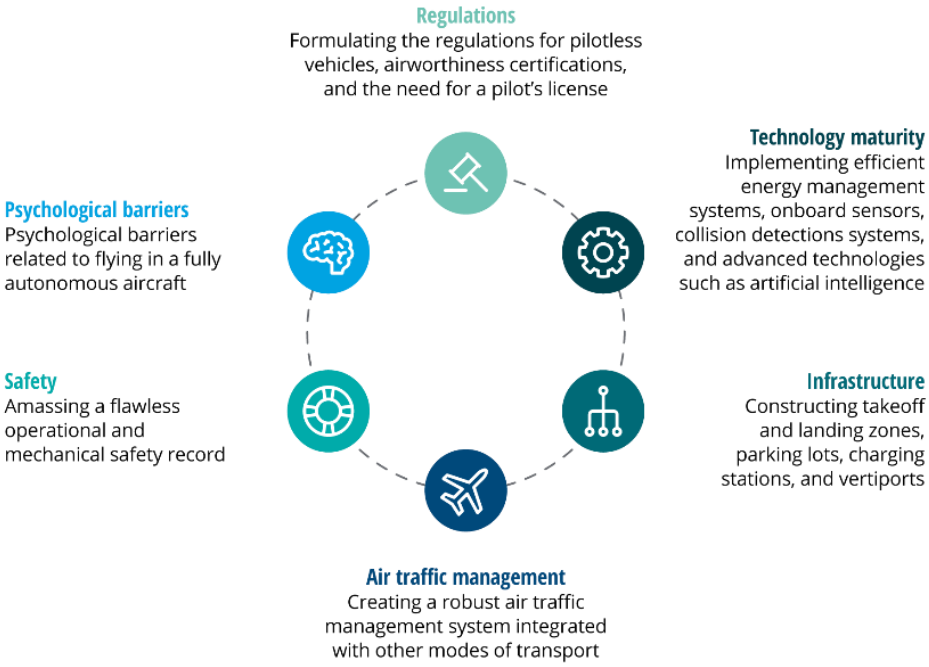

Figure 6 – Elevated future of mobility challenges

This chapter presents a subset of the ODM Aviation missions of ConOps, which includes passenger and flight activities of UAM. A comprehensive assessment and design are required for ground infrastructure that is consistent with the conditions of a particular city. Companies will need to meet the requirements of an integrated UAM ConOps and comply with regulations in the planning, design and operational phases. "TOLA" stands for "Take-off and Landing Area" and refers to any location from which an ODM aircraft can take off or at which it can land. Depending on the V/STOL capabilities of future aircraft, the generic term TOLA can stand for a variety of infrastructures ranging from an airport to a helipad to an open field or perhaps even a car park or empty road.

As mentioned earlier, a model Concept of Operations (ConOps) is presented here that focuses on the passenger side of traffic management systems (including technical and management elements), which should facilitate the process flow in the long-term implementation of a new total traffic management system. It describes the phases of a door-to-door passenger journey, including UAM operations from initial deployment (with piloted, voice-based flights) to mature, high-density autonomous operations, albeit with varying levels of detail at different time horizons. This approach to integrating UAM operations is important because both urban air mobility (UAM) operations and urban air traffic management (UATM) operations need to be considered to minimise subsequent rework and costs due to initial design decisions.

[7] Robin Lineberger. Aijaz Hussain. Vincent Rutgers (2019) Change is in the air.

Changes in ATM are on their way. The future traffic is forecasted in EUROCONTROL's Long-Term Forecast or FAA's Aerospace Forecast, concepts like SESAR (Single European Sky ATM Research), for European airspace, and NextGen (Next Generation Air Transportation System).

An important point is that the concept of operations is largely technology-independent, i.e. it considers that within a planning horizon of more than 25 years, much of the technology that exists or is being developed today may change or be phased out and replaced by new, as yet unknown technologies. A ConOps is a statement of what is planned. It asks and answers the question of what requirements need to be met for optimised door-to-door passenger travel including UAS integration in an improved ATM system of the future. It is a statement of a vision. It is not a technical manual or blueprint; nor does it specify how things should be enabled; that is in lower documents in the hierarchy, which may include operational or usage concepts, technical standards and strategic plans.

For example, the safe and efficient integration of unmanned aerial systems (UAS) into air traffic management (ATM) is one of the biggest challenges in aviation in the first half of the 21st century. UAS - including remotely piloted aircraft systems (RPAS) and automated aerial vehicles, including driverless personal air vehicles (DPAVs). As the scope of operations expands, these will need to co-exist with manned aviation. This results in the need for an extension of ATM to a Total Traffic Management (TTM), which not only describes the operation of aircraft and UAS in European airspace, but is also capable of integrating ground-based traffic and fulfilling specified requirements. For the extended ATM, this includes operations below 500ft and above FL600. ICAO has identified four main requirements for UAS-ATM integration alone:

- The integration of UAS shall not imply a significant impact on current users of the airspace;
- UAS shall comply with the existing and future regulations and procedures laid out for manned aviation;
- UAS integration shall not compromise existing aviation safety levels nor increase risk more than an equivalent increase in manned aviation would.
- UAS operations shall be conducted in the same way as those of manned aircraft and shall be seen as equivalent by ATC and other airspace users.

Figure 7 illustrates the different environments and modes of operation in each environment.[8] UAM corridors are shown along with airfields that support UAM operations. The following describes operations inside and outside UAM corridors for UAM aircraft, fixed wing aircraft, helicopters and UATM aircraft. Inside the UAM corridors:

- All aircraft operate under UAM specific rules, procedures and performance requirements
- Fixed-wing and UTM aircraft traverse UAM corridors
- Helicopters and UAM aircraft operate within or cross UAM corridors
- Operations do not vary with airspace class x
- Outside UAM corridors, operations adhere to relevant ATM and UATM rules based on mode of operation, airspace class and altitude
- Conformance monitoring is of fundamental importance to ATC operations and future surveillance environments may enable more sophisticated procedures to be developed for this task

[8] NextGEN. FAA (2020) Urban Air Mobility. Concept of Operations v1.0.

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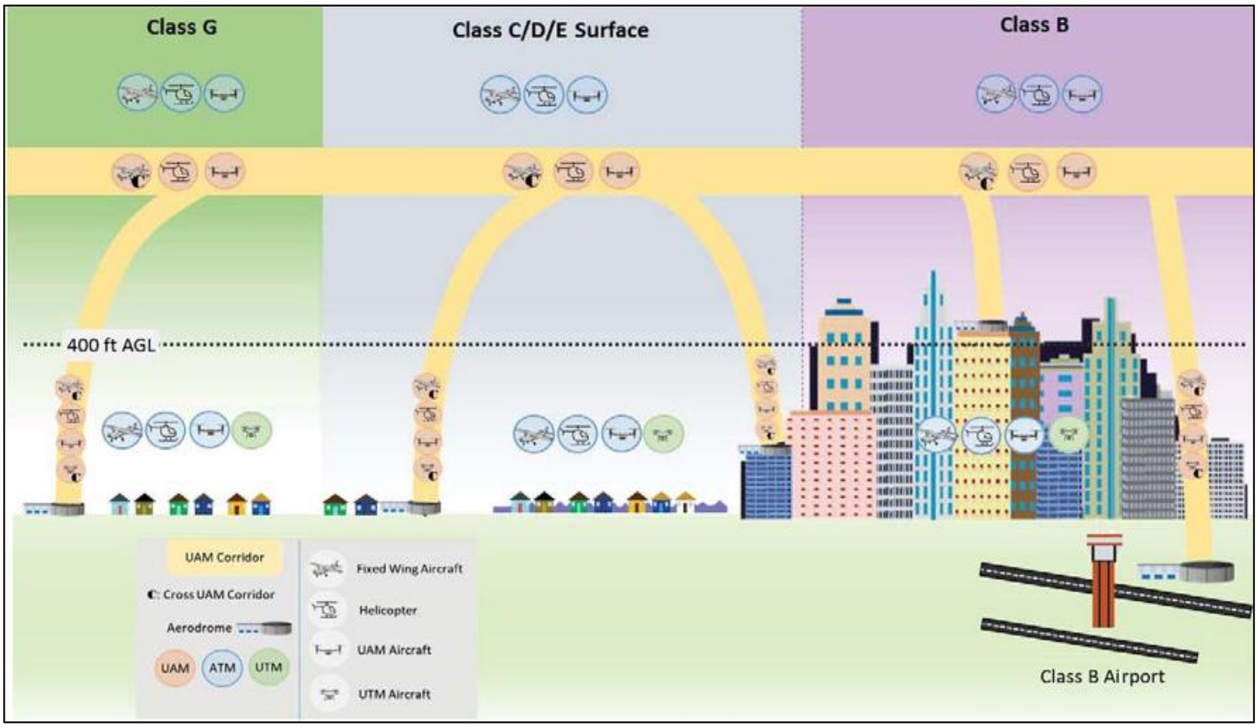

Figure 7 – UAM, UATM, and ATM Operating Environments[9]

Traffic management systems for UAM, UAS and conventional aircraft must interact or be integrated to support deconfliction, shared situational awareness and cooperative decision making. The UATM concept was developed to meet the specific requirements of UAM traffic management. With low traffic density, initial UAM operations are expected to be based on current ATM services. However, as complexity increases, digitised and automated services will be required for some, if not all, elements of the UATM services. The provision of these digitised services will be achieved through UTM services, bespoke UATM services or a combination of both. As traffic density continues to increase and higher levels of aircraft autonomy are introduced, this is likely to bring the need for highly integrated and unified airspace management across all traffic management systems, leading to Total Traffic Management (TTM).

Figure 8 shows a fictitious UAM ConOps for an ODM aviation mission. For all these sequences to work and for the passenger to get a performance that is (more than) satisfactory to him, a lot of tuning and cooperation within the system is required.[11]

[9] NextGEN. FAA (2020).

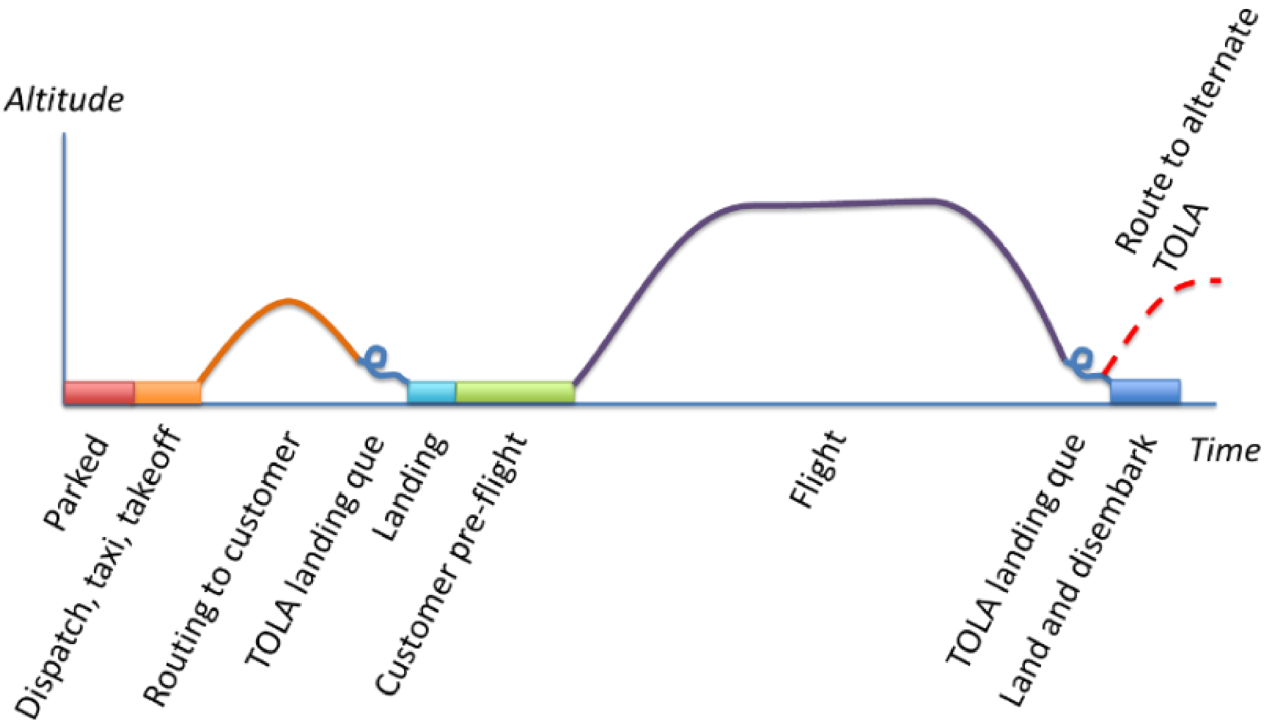

Figure 8 – Notional aircraft ConOps for an ODM Aviation mission

Taking a closer look at the passenger area for a door-to-door journey with flight segment (here focusing on UAM-flight) in Table 2, it becomes clear that there are many factors, applications and interfaces that need to be managed across all stakeholders (and also modes). Coordination in routing and timetables is only a very small part of this network.

Table 2 - Basic Architecture for a Passenger ConOps.

<table>
<tr><td colspan="4">Pre-Journey / Pre-Flight</td></tr>
<tr><td colspan="4">1. Traveller submits a travel request which includes a(n) (air taxi) flight</td></tr>
<tr><td colspan="4">Contact of a Booking Platform Operator or MaaS (Mobility as a Service) operator: The booking platform will provide the interface for trip requests from customers and will connect the request with the fleet operator.

The booking platform operator will consider different routings and vertiports for operating the flight or the journey. Options under consideration will include preferences of the customer, arrival and/or departure from different locations, airports or vertiports and connection with other transport mechanisms.

MaaS (Mobility as a Service): various forms of transport services into a single mobility service accessible on demand. Any necessary bookings (e.g. calling a taxi, reserving a seat on a long-distance train) would be performed as a unit.</td></tr>
<tr><td>Booking Order in Advance / Pre-order ≥24h</td><td rowspan="2">Required information and preferences from the passenger/ customer

➢ Day of departure
➢ Time, Time frame
➢ Starting point/Origin and Destination
➢ Routing
➢ How many passengers /A group
➢ Weight: The average weight for regular flights is 88 kg per person with 10 kg hand luggage
➢ Check in Luggage (up to 20 kg)
➢ Hand luggage (one bag and 10 kg)
➢ Method of payment
➢ Identification, ID card
➢ TSA's Secure Flight Program
➢ Special needs (people with reduced mobility)</td><td>Via electronic device: phone, smartphone/ tablet/PC;

Call, APP, E-Mail,</td><td>Pre-booking
The further in advance, the better/ more likely for a reduced rate/ more likely for realization.
=> FAST LANE</td></tr>
<tr><td>Short-term order /shortly before departure (>1h)

Normal/Express</td><td>Direct at the check-in;
Via phone, Smartphone/

tablet/PC electronic devices

App, E-Mail, PC/Internet</td><td>Short-term order (>1h)

➢ Waiting list
➢ Express surcharge => FAST LANE
➢ Booking on site at check-in</td></tr>
<tr><td colspan="4">Journey</td></tr>
<tr><td colspan="4">2. Traveller takes ground transportation from origin to starting pad</td></tr>
<tr><td>Approach to origin TOLA</td><td>➢ Walking, micro transport, public transport, individual traffic, car sharing, taxi, plane, (connecting flight) air taxi.
➢ With the expected emergence of autonomous vehicles, new opportunities will arise to complement scheduled and scheduled mass transport with so-called on-demand shuttles.
➢ Enter destination into the device, request route, compare means of transport by duration and price or select by weather and occasion</td><td>Booking at check-in</td><td>Parking, Connectivity, (combi-)ticket,</td></tr>
</table>

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3. Traveller arrives at the starting pad and prepares for take-off			
Arrival at origin TOLA	➢ Check-in for flight ➢ Waiting line, Fast lane/Express ➢ Weight Check of Passenger and luggage ➢ Hand over any luggage that would need to go into the aircraft hold (if travelling with luggage) ➢ Pass through security gates to the departures area ➢ Security briefing ➢ Find boarding pad		Vertiport operators will be responsible for overseeing ground safety, security and boarding procedures (and charging or refueling), although this responsibility could sit with fleet operators or other third parties. The vertiport operator will provide information regarding the operating status of their vertiport, including the availability of FATOs, stands (where applicable), personnel and fuel (e.g. electricity).
4. Flight Segment			
After boarding air taxi, the flight segment begins	➢ Board the air taxi ➢ Stowing of hand luggage ➢ Seating ➢ Fasten seat belt ➢ Security briefing per Video/APP (e.g. behavior during the flight: Staying seated, non-smoking, eating drinks). ➢ Passenger entertainment, WLAN, ➢ Short flight time 10-25 minutes	Checked-in luggage: Loaded (manually or automatically) or only hand luggage allowed?	
5. Traveller arrives at destination pad			
Landing at the destination TOLA	➢ Getting off the Air taxi (e.g. checking personal items), ➢ Unloading of luggage (baggage claim/ picking up of luggage ➢ Leaving the security area ➢ Leaving the landing area	Checked-in luggage: Unloaded (manually or automatically)	
6. Traveller uses connecting flight or ground transportation to final destination point			
Departure from destination TOLA to final destination	➢ Walking, micro transport, public transport, individual traffic, car sharing, taxi, plane, (connecting flight) air taxi.		
Post-Journey			
7. Post-processing of the trip by the traveller			
	➢ Rate the trip, complaints, travel accounting, exchange of experiences, evaluation (e.g. social media)		

The growth of the UAM industry will introduce new types of aircraft and infrastructure (TOLA, vertiports) into the low-level airspace and urban environment. UAM aircraft will exhibit unique operational characteristics that are currently not catered for in the existing ATM environment. Initially, UAM operations are expected to operate within the requirements of the current ATM operating environment in accordance with existing procedures and/or concessions that can easily be accommodated. However, the expected increase in traffic density when compared to existing air traffic and the need for UAM vehicles to operate in IMC in low-level airspace will present unique operational challenges. The proximity and frequency of operations to the urban community will also create important considerations. As the UAM industry matures, variations in the level of aircraft automation (including piloted, partially autonomous and fully autonomous operations) are expected to be in operation within the same airspace. Finally, the expected diversity in new technologies and aircraft types in the low-level airspace (e.g. UAS, UAM, low altitude GA) presents traffic management challenges that cannot be solved by the current ATM system.

The existing ATM system has been the core which is around the needs of existing airspace users. UAM operations necessitate different solutions to address issues, including

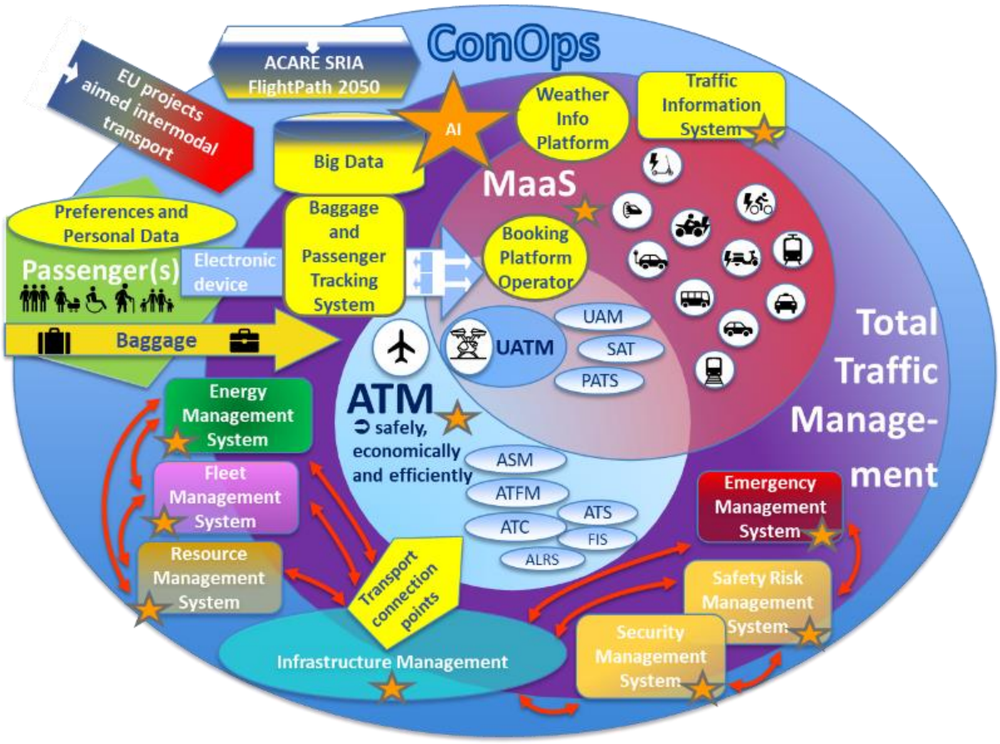
- urban canyoning (A concept wherein communications, navigation, and surveillance technologies currently in place can be severely degraded by urban interference such as terrain, buildings/obstacles, or terrestrial radio frequency interference.);
- diversity in aircraft performance, automation and pilot capability;
- limitations of current Communication, Navigation and Surveillance (CNS) systems to accommodate a higher density of urban operations in VMC or IMC; and
  noise abatement.

In an effort to increase the efficiency and safety of transport in urban areas and at the same time to cope with the growing demand for air transport, the development of an ATM that comprehensively includes all modes of transport will be necessary. The existing ATM will be the core of this total traffic management. Within ATM, the previous concept of free flight allows any aircraft to plan four-dimensional trajectories in real time, replacing the rigid and inefficient discrete airspace structure. These changes are made possible by GPS and various other technological innovations.

4.3 Ingredients for a Concept of Operations for ATM service to passengers in intermodal transport

Seamless inter-aircraft communication demands effective integration of the existing airspace management systems with unmanned aircraft system traffic management, allowing operators to interact with multiple vehicles flying simultaneously. According to the study Managing the evolving skies, while air navigation service providers have long been the primary source of oversight for safe and secure airplane travel, achieving a scaled commercial deployment of VTOLs requires a traffic management system to oversee airspace design, dynamic geofencing, guidance for severe weather and wind avoidance, congestion management, route planning and re-routing, sequencing and spacing, and contingency management. Furthermore, advanced communication technologies such as 5G connectivity that target high data rate, higher system capacity, and massive device connectivity would be essential for seamless communication between multiple eVTOLs flying in the air.

The following diagram (Figure 9) is intended to give an overview of which components might be necessary for the operational concept for the ATM service for passengers in intermodal transport in order to realise it in the future in such a way that passengers benefit from it in their sense.



AI★	Artificial intelligence	FIS	Flight Information Service
ALRS	Alerting Service	MaaS	Mobility as a Service
ASM	Air Space Management	PATS	Personal Air Transport System
ATFM	Air Traffic flow management	SAT	Small Air Transport Research
ATC	Air Traffic Control	SMS	Safety Management System
ATS	Air Traffic Services	SRM	Safety Risk Management
ATM	Air Traffic Management	UAM	Urban Air Mobility
ConOps	Concept of Operations	UATM	Urban Air Traffic Management

Figure 9 – Concept of Operations supporting the seamless integration of ATM and Air Transport into an overall intermodal network

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The improvement of products and services as a prerequisite for business success in the market means an increased need for efficient management systems, which in turn results in an intensive development of standardisation. It is in the interest of one's own market position to observe the change in the development of standards and the resulting changes. Quality, safety and management systems represent a modern form of work organisation and company management, so that the management of any organisation, including transport companies, faces a problem which is posed here as a task. The management components of the ConOps presented here are explained below and defined in context.

The aim of this ConOps is to show how the door-to-door passenger journey can be improved among the stakeholders. The global ATM community is invited to read and comment on this document to learn how a cross-modal Total Traffic Management (TTM) system could be developed and implemented to achieve one of the overarching goals of the aviation industry: Customer and passenger satisfaction in a network optimised for all. As a boundary condition for this approach, it should be noted that passenger traffic activities must be defined considering the level of equipment of the systems addressed and the tools and infrastructure required to achieve the expected benefits. It should also be noted that this takes place in a mixed environment, with different levels of equipment and accessibility, different levels of performance of systems and technologies, and different levels of ground support and infrastructure. This system could be balanced very precisely if optimized with artificial intelligence (AI). AI can make an important contribution here, on the one hand by being able to relieve infrastructure, the environment and resources in a sustainable and efficient way, and on the other by guiding travellers to their destinations in a time-saving and flexible manner.

4.3.1 Customer Focus, Human Capabilities and automation Possibilities

With the focus on passengers, these ConOps could be more flexible and effective in its response time to user needs. A growth in satisfied and loyal customers means a flourishing overall system and thus added value for the other stakeholders in the system. Capacities can then be expanded by investing in new infrastructure and managing resources as needed. Efficient management and cooperation in the different areas enables optimisation and harmonisation of the overall system. For example, by implementing fleet management and increasing passenger throughput at transport hubs at peak times according to demand. Shared data pools would help minimise impacts and constraints (e.g. due to weather) on the ability to plan journeys. The system should be flexible to effectively adapt to different needs and allow more creative sharing of transport space for all users while meeting their safety needs. A selection of passenger preferences with a focus on urban transport is shown in Figure 10.

- ⇨ Assistence in travel planning
- ⇨ Assistence in travel performance
- ⇨ Big data and Information (e.g. weather, delays)
- ⇨ Time saving in travel duration
- ⇨ Good connections
- ⇨ Flexibility and more choices
- ⇨ Punctuality
- ⇨ Safety and security during the journey
- ⇨ Comfort
- ⇨ Efficiency
- ⇨ Accessibility
- ⇨ Barrier-free access
- ⇨ Compliance with ecological aspects

Figure 10 – Passengers preferences and focus on an urban travel

Urban ATM (UATM) services will integrate UAS operations into the lower airspace. These services will ensure that the key performance attributes of the UAM environment are ensured and maximised as defined by the Key Performance Areas (KPAs) applicable to ATM. The ConOps described in this document is guided by these International Civil Aviation Organisation (ICAO) KPAs to ensure, among other things, the improvement of customer satisfaction. These are also reflected in the Passengers preferences in Figure 11.

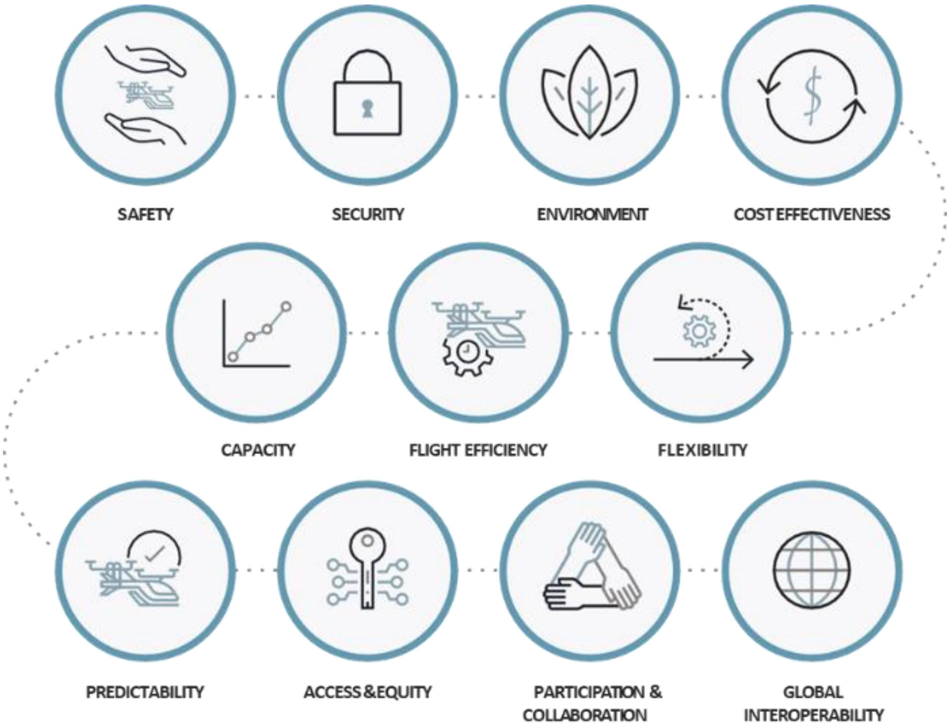

Figure 11 – ICAO Key Performance Areas[10]

In addition to the above, the existing human-centric approach to ATM will be very quickly overwhelmed, even by early UAM traffic growth. In traditional aviation, a centralised system of traffic management is clearly defined. ATM services are provided by an Air Navigation Service Provider (ANSP), which enables safe and efficient aircraft operations. Building on many of the foundational principles of ATM, a new approach to traffic management is necessary to safely, efficiently, reliably, securely and equitably manage UAM traffic.

This ConOps system aims to ensure that passenger preferences help to increase capacity, improve safety and increase operational efficiency. This is achieved by building processes and systems to help passengers realise their preferences. In addition, information is collected, collated, monitored, evaluated and shared through the management systems. Research and analysis will determine the appropriate division of tasks between systems. This will include determining when decision support is needed to assist humans and when functions need to be fully automated.

[10] ICAO/NextGEN.

ATM will become more complex in the coming decades due to the growth and increasing complexity of aviation and will need to be improved to maintain flight safety. It is agreed that without significant improvements in this area, the safety goals set by international organizations cannot be achieved and the risk of further incidents/accidents is to be expected.

4.3.2 Artificial Intelligence

The component Artificial Intelligence might be necessary for the operational concept for the ATM service for passengers in intermodal transport. A multitude of possible applications can make mobility safer, more ecological, more efficient, more comfortable, more intelligent and more resource-saving. And this does not only mean the development of autonomous means of transport, but also the implementation and control of inter- and multi-modular linked management systems.

Through the targeted analysis of traffic, energy, fleet and resource management systems can be optimized and risks can be minimized. Forecasts of possible incidents (delays, weather, etc.) increase the agility of the systems and increase the efficiency of passenger transport. However, the regulation of traffic not only requires the minimization, if necessary the abolition, of individual traffic driven by raw materials, but is also based on the possibility of innovative and combinable transport options. New traffic modes and the links to existing systems, as well as the expansion of the networks define the traffic of tomorrow.

In addition to urban apps that offer us various sharing options or create the perfect route for us through the city: Attractive footpaths and cycle paths, equal access to individual public transport and uniform booking systems make it easier to switch to digitized means of transport. However, AI in transport will also change jobs and create new ones.

Nowadays, computer science plays an important role in data management and the decisions made in ATM. Despite this, artificial intelligence (AI), one of the most researched topics in computer science, has not quite reached end-users in the field of traffic management. There are several challenges that exist throughout the transportation industry. Among them are safety, reliability and efficiency, to name a few examples here, which have an important aspect of transport and require attention.

Speaking of BIG DATA: Through the use of artificial intelligence technologies, it is hoped that the ability to process and predict data and outcomes in much larger volumes than is possible for humans, travel and transportation companies, and eventually the public itself will give the public plan and private transport services significantly improved. Technology has made increasing the level of security much easier over the years, with the advent of AI technologies increasingly being adopted by companies in the transportation space, the level of security could be increased.

Another important aspect in the travel or transportation sector is the reliability of the services or vehicles and vehicle fleet planning. The use of artificial intelligence in public transport to improve the reliability of the service is one of the most important factors for its adoption in the industry.

Energy efficiency is a more important aspect of travel and transportation as travel and commuting become more integrated with technology. This undoubtedly has its advantages, but it also means that new technologies have to manage their power supply much more efficiently. Artificial intelligence technologies can undoubtedly improve the efficiency of the systems in which they are integrated.

The current trends and developments of artificial intelligence (AI) and explainable artificial intelligence (XAI) were analyzed at the state of the art in the fields of transport, aviation and ATM. It includes research work of the last decade of AI in air traffic management, the extraction of relevant trends and characteristics, and the extraction of representative dimensions. It has been shown how general and ATM XAI works, where and why XAI is needed, how and with limitations it is currently provided. The assessment concludes that AI systems within ATM need further research to be accepted by end users. The development of appropriate XAI methodologies, including validation by competent authorities and end users, are key issues that need to be addressed.

Different influences will change and optimize mobility in the coming years. The transport offer is expanding and the prioritization of the means of transport is adapted to the demand for individual mobility needs. The multimodal linking of the traffic routes enables the residents to move around comfortably. Access to mobility tools is becoming more flexible thanks to communication technologies such as urban apps.

Advances in trusted autonomy of ATM systems are currently being pursued to cope with the projected growth in air traffic density in all airspace classes. Highly automated "ATMs" relying on AI algorithms for anomaly detection, pattern recognition, precise reasoning, and optimal conflict resolution are technically feasible and demonstrably capable of taking over a variety of tasks currently performed by humans. However, the opacity and inexplicability of most intelligent algorithms limit the usability of such technologies. Consequently, AI-based ATM decision support systems (DSS) are expected to integrate eXplainable AI (XAI) in order to increase the interpretability and transparency of the system justification and consequently build the trust of human operators in these systems. The presented approach is not only limited to traditional applications, but is also suitable for UAS traffic management (UTM) and other emerging applications.

Figure 12 – Applications of current use of AI in public transport (2020)[11]

[11] UITP - Union Internationale des Transports Publics (2020), AI in public transport, https://www.uitp.org.

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4.3.3 Resource Management Systems

Resource management focus on Quality of Service requirements, among others. To obtain the most useful and complete traffic information, including location coverage, an efficient resource management mechanism for vehicular multimedia applications is essential. For example, the resources can be used according to the level of importance of the different traffic data. The goal is to improve the diversity, completeness and overall value of traffic data.

More people will move through the landside areas of airports, including passenger terminal buildings and ground access points, to get to and from an airport. Accordingly, effective resource management systems can improve passenger flow management and connectivity to intermodal ground transport. The same applies to vertiports, train stations, bus terminals or passenger terminals at ports, once they are integrated into the ongoing operation of Urban Total Transport Systems.

Using network-centric infrastructure and services, resource management systems help operators synthesise real-time information and proactively manage resources in anticipation of short-term events for the benefit of passengers, typically on an hourly or daily timeframe. Landside functions also benefit, including passenger flow in the terminals and the parking situation or necessary security checks or check-in procedures.

Resource management clearly shows links to the following systems, which are described in the upcoming chapters. Therefore, a bundling and thus a control function of diverse service across all modes of transport could take place here. The modes of transport and thus the passengers meet at the transport interconnection points: Efficient passenger flows are important to ensure that congestion, queues and baggage do not impede passenger movements. Passenger flows are influenced by display systems for traffic information, business models and marketing. In addition, changes in security protocols can create bottlenecks, which affects a passenger terminal's ability to meet its requirements and objectives. To ensure smooth passenger flow, coordinated information is communicated to users, including current status and forecast for security checkpoint wait times, Customs and Border Protection processing and travel status. Although these systems exist today in some traffic sections, they are not sufficiently synchronised to facilitate passenger flow.

SESAR provides open information standards for a centralised wireless system to disseminate passenger flow information at major airports to include ground transportation connectivity, weather, delays, parking availability and check-in times within a single network.

4.3.4 Traffic Information System

An intelligent traffic information system must be integrated within Con Ops. The information must be made available to the entire traffic system. The exchange of information between transport vehicles of all types, including aircraft, and the infrastructure is generally considered to be an enabling technology to reduce accidents, congestion and peaks in the long term and to improve traffic efficiency. This ad hoc communication and dedicated message set as well as for management and safety operations should be increasingly used. To this end, this system should integrate a range of applications and management tools, such as communication, detection and processing technologies. In summary, the traffic information system collects traffic-related data from heterogeneous sources such as vehicles, signal points, intersections, interchange points, road networks and sensors. By aggregating and analysing (through artificial intelligence) such traffic-related data in a cooperative manner (e.g. between vehicles or aircraft) or in a traffic management centre concentrated in a cloud or data centre, various problems can be identified and consequently actively managed. The overall efficiency of traffic would be improved and a smoother traffic flow ensured.

In this context, conformance monitoring will also be of particular importance in the future. Conformance monitoring in air traffic control is an approach used to monitor and detect deviations of an aircraft's flight path from the assigned flight plan that could jeopardise safety or efficiency. Conformance monitoring will be important for resolving conflicts between manned and autonomous operations. Currently, the task of conformance monitoring is performed by controllers based on comparisons between observed aircraft positions from radar surveillance and expected aircraft positions based on clearances or flight plans. If the differences between the observed and expected positions exceed some permissible deviations, a finding of non-conformity may be made. Due to the limited resources available to controllers, this method does not provide good performance. The task of conformance monitoring would become even more difficult in future air traffic control operations. The same problems will be faced by ground-based traffic in future.

Under SESAR, it is expected that a larger number of aircraft will operate with reduced separation thresholds between aircraft within a given airspace. The new concept of operations also allows aircraft the flexibility to change flight routes (or flight plans) in response to changing conditions. In addition, different aircraft would have very different navigation capabilities due to different levels of equipment. With such complex scenarios in future ATC operations, it would be important to have a compliance monitoring tool to monitor aircraft movements.

4.3.5 Mobility as a Service

Mobility as a Service (MaaS) is an approach to replace transport with own vehicles with a range of different mobility services tailored to customer needs. The mobility services can be provided by different providers and are to be offered and billed as a combined, multimodal service. This requires both joint route planning of the individual mobility services and their joint billing.

For UAM to gain widespread acceptance, operators must go beyond how commuters might save time. Most users will expect a comparatively seamless mobility experience both on the ground and in the water as well as in the air. To deliver this experience, providers and agencies will need to offer and implement an efficient MaaS that can integrate all available modes of transportation - from e-scooters, cars, and subways to trains, sidewalks, bicycles, and eVTOLs. Initially, mobility providers can start by building on existing public-facing and proprietary applications that are capable of connecting multiple urban and suburban modes of transportation for a connected and complete end-to-end journey. Offering a UAM option should illustrate to customers how using an eVTOL will - for example - shorten some trips and thus increase demand for the service. Features that estimate fees and arrival times, help travellers navigate in and around vertiports, and relay incoming information to vertiport operations-for example, notifying a vertiport of a passenger's impending arrival and preparing to use facial recognition to get users through security-would enhance the experience. The eVTOL infrastructure must not only provide passengers with an integrated transportation experience, but also provide seamless cargo delivery services.

A MaaS should incorporate these delivery service requirements. As with any transportation, the boarding experience is important, meaning that operators should provide visual/directional cues and signage to make using eVTOLs an enjoyable part of a passenger’s overall journey. Given that many vertiports and vertistations will likely be on building rooftops, which might have multiple landing platforms, guiding commuters to the right take-off locations and vehicles may prove a challenge.

Figure 13 – Keeping customers at the centre of urban aerial mobility is the key[12]

To meet the goals and objectives, the ConOps involves a transformed air transportation system that allows all communities to participate in the global marketplace.

4.3.6 Energy management systems

To achieve efficient energy consumption of electric vehicle technology on the ground and in the air, energy management will play a key role. The state of charge of a battery during the entire travel distance determines the electrical energy consumption. Knowing the energy demand is necessary to achieve the best results with regard to the entire transport system. The performance of the energy management algorithm is closely related to the amount of information available in the form of road gradient, speed profiles, driving distance, weather characteristics and other exogenous factors. As mentioned earlier, Intelligent Information Systems in vehicles enable them to communicate with each other and with the infrastructure to collect data about the environment and predict expected events, such as traffic conditions, road gradients, weather/wind conditions and weather forecasts. The ability to effectively interpret this traffic and weather data to estimate energy demand is important for energy management and plays a critical role in battery usage across the transport system.[13] Another issue is the charging infrastructure and power plants needed to support the electrical infrastructure. For this, all possible energy sources must be included, planned and managed. Only with a comprehensive supply will passengers have a choice and a predictable security in the choice of their mode of transport and their travel route.

[12] Deloitte Insights (2021) Infrastructure barriers to the elevated future of mobility..

[13] P Tulpule. V Marano. G Rizzoni (2011) Effect of Traffic. Road and Weather Information on PHEV Energy Management. SAE Technical Paper 2011-24-0162. Available: https://doi.org/10.4271/2011-24-0162. Accessed: 02-02-2021.

4.3.7 Fleet Management System

The fleet management of these ConOps must ensure that all vehicles within the system and the integrated providers are used economically and that sufficient transport capacity is available for all processes. Fleet management should include a variety of tasks, which will be briefly explained here.

The fleet management within ConOps must ensure that the right vehicles are available in sufficient numbers at the required time at the place of operation so that the processes run smoothly. Otherwise, there will be high downtime costs and other impairments in the system, which will ultimately affect the passengers. At the same time, the ConOps fleet must be used economically; if possible, costs must be saved or services increased without compromising safety. Finally, it is important to follow and pick up on new trends and take special measures if necessary. Examples are emission and climate protection, the promotion of alternative drive systems for vehicles, customer requests, etc. In order to see whether the ConOps' fleet management meets the requirements, an overarching fleet controlling system must be used. It should be the basis for all planning and controlling. Overview of fleet management tasks: Fleet management encompasses a wealth of different tasks - depending on the depth and stage of development of the ConOps over decades:

- Establish strategy and framework for fleet management in the ConOps
- Central procurement of vehicles/vehicles
- Central management and optimisation of the vehicle fleet in terms of number of vehicles, type, brand, equipment, age, optical condition
- Central planning of the technical availability of vehicles/aircrafts
- Central review and reduction of costs
- Central control and optimisation of the tours and routes driven and flown
- Central planning of repair, maintenance, TÜV acceptance of vehicles
- Central control of driver and pilot licenses or software for autonomous systems
- Control and optimisation of vehicle deployment within ConOps
- Control and planning of personnel requirements within the ConOps
- Optimisation of driving personnel within the ConOps

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4.3.8 Emergency Management/Response System

The ConOps system must be resilient and robust to respond to failures and/or interruptions. This includes contingency measures to ensure continuity of operations in the event of major outages, natural disasters, security threats or other unusual circumstances. Following SESAR, a balance of reliability, redundancy and procedural backups should ensure security in the event of a failure of individual systems or components. Ultimately, SESAR provides a system that has high availability and requires minimal time to restore functionality.

Urban emergencies are hard to avoid. Traffic emergency response after an incident plays an important role in reducing losses and is a key link in urban emergency management. The introduction of Internet of Things and data mining technology to establish a traffic emergency response system under urban emergencies can significantly improve the level of urban emergency response and realize efficient intensive management. The system mainly includes sub-systems, such as personnel evacuation data collection system, vehicle operation data collection system, rescue material distribution data collection system, personnel settlement place data collection system, traffic bayonet intelligent identification system, etc. It also devises the working programs for command management, personnel evacuation and disaster disposal in case of emergency, and improves the urban emergency support management system. The traffic emergency response system can timely and accurately control the flowing information of personnel and vehicles, quickly and conveniently resettle personnel and vehicles, effectively carry out follow-up rescue work, effectively improve rescue efficiency and improve the level of urban management.

4.3.9 Safety Management System

Safety is promoted through use of an integrated Safety Management System (SMS) approach for identifying and managing potential hazards. This includes equipment, organizational, operational or systems problems. Specifically, SESAR uses a formal, top-down, business-like approach to manage safety risk, which includes systematic procedures, practices, and policies for safety management. Components of SMS include the following items:

- Safety Policy: Defines how the organization will manage safety as an integral part of its operations, and establishes SMS requirements, responsibilities, and accountabilities.
- Safety Risk Management: The formal process within the SMS that consists of describing the system; identifying the hazards; and assessing, analysing, and mitigating the risk. The SRM process is embedded in the processes used to provide the product or service—it is not a separate process.
- Safety Assurance: SMS process management functions that systematically ensure that organizational products or services meet or exceed safety requirements. This includes the processes used to ensure safety, including audits, evaluations, and inspections and encompasses data tracking and analysis.
- Safety Promotion: Training, communication, and dissemination of safety information to strengthen the safety culture and support integration of the SMS into operations.

In this context, "safety" is seen as anything that deals with the methods and techniques used to prevent accidents. "Security" is concerned with the protection of people and the system from criminal acts.

4.3.10 Security Management System

Secure airports and TOLAs must have an integrated facility security system that can be adapted to different capacities, accesses and risk situations. It includes both technological and procedural measures to protect against the dynamically developing threat including cyber security. This flexible security system uses advanced network-centric capabilities to minimize ID and access controls while ensuring SSA in the event of a security incident or ID control problem. The airport's network centring, or TOLA, seamlessly connects sensors and data sources from access and control points for passengers, visitors, employees and vehicles, perimeters and critical building infrastructure. Airport security technologies and customizable procedures are nominally transparent to passengers and difficult to see through for those who want to cause harm. In addition, the airports have local response and recovery programs made possible by local and regional agreements and supported by the federal government. The systems are also located in the following areas within the facilities mentioned above, as required:

- Land side: Public and commercial streets and parking lots of the terminal, entrances and exits of the terminal, international arrivals / customs, security control centre, response and recovery measures.
- Air side: Terminal environment, terminal airspace (security)

In this context, "security" is concerned with the protection of people and the system from criminal acts.

4.3.11 Infrastructure Management System

Intermodal ground access to all transport connection points are essential for intermodal networks. Functioning and passenger-appealing transitions in the form of transport interconnection points are needed to link transport networks within a regional system and enable more efficient traffic flow.

Design guidelines for passenger terminal buildings or stations are being implemented to facilitate the flexible integration of new technologies and procedures (e.g. advanced passenger and baggage handling, remote check-in and security) and to assist in the development of new terminal layouts and signage that promote smooth passenger flow during peak periods. With flexible terminal designs, changes in check-in technologies and security screening requirements can be accommodated within a terminal shell that allows for rapid reconfiguration of the building to meet current demands. The existing infrastructure would support shared facilities such as gates, ticket counters, kiosks and information systems. Note that shared infrastructure is not intended to be a government mandate; each airport and its users will determine gate allocation based on their specific needs and factors related to efficiency, cost and availability. New terminal designs will increasingly incorporate provisions to support energy and resource conservation, including environmentally friendly design and technologies.

At airports with significant scheduled air traffic, the physical and functional layout of passenger terminals is likely to evolve in response to changes in passenger handling, aircraft size and geometry, remote data access and collection, information sharing and high occupancy intermodal transport links. The trend towards passenger check-in at off-airport locations, such as at home, by mobile phone and in hotels, will continue and expand as remote terminals support off-airport passenger and baggage handling. The infrastructure required to support security screening should decrease as these processes are integrated and refined. These developments also apply to the other transport connection points, of course.

A joint management of the infrastructure would bring about a clear quality control and set the standards in the system.

4.3.12 Authoritative Weather Info Platform

Users no longer see weather information as separate data, but integrated into automation and human decision-making processes. Improved communication and information sharing give all stakeholders access to a single authoritative weather source. Weather data is translated into information presented to users and service providers, e.g. the likelihood of flight deviations and mode impairment due to potential severity and likelihood of weather hazards. Decision support systems incorporate weather data directly and bypass the need for human interpretation. This allows decision-makers to determine the best response to the potential operational impact of weather (both tactical and strategic) and minimise the extent of traffic restrictions. This integration of weather information platform, combined with the use of probabilistic forecasts to account for weather uncertainty and improved forecast accuracy, minimises the impact of weather on traffic.

4.3.13 Baggage and Passenger Tracking System

Depending on their specific needs, airports can integrate off-airport terminals with different services into their operations. The passenger and baggage tracking system decentralise passenger handling and allows baggage handling to be carried out in a remote area of the airport if required. This increases capacity, reduces check-in time, reduces staffing requirements and also enables tracking for passengers. Baggage is treated as information that is monitored remotely by the passenger (e.g. via a mobile device). The demands on the aircraft operator's check-in staff are reduced, as is the space in the terminal for handling. Passenger baggage is routed via an industrial sorting centre either to the terminal or to the passenger's final destination. A baggage and passenger tracking system could support continuous tracking and availability of the current location of passengers and their baggage (e.g. door-to-door baggage transfer). Remote terminal security screening systems increase the value of implementing full passenger and baggage screening.

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4.3.14 Interactions and relations between the management systems

The management systems must interact or the actors or systems must interact with one another. This interaction is closely linked to the concepts of communicating, acting, planning and working with each other and – last but not least – informing one another.

For example, the infrastructure management system must work closely with the energy, fleet and resource management systems, since there are many relations, similarities and intersections that complement and overlap or influence each other. These interactions also apply to the emergency, security and safety management systems. This mutual interaction should be aimed for and used for all management systems in this overall system.

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5 Analysis of D2D mobility demand in the urban and extended urban and regional scenarios Passenger-centred

5.1 D2D mobility demand under passenger perspective

5.1.1 Relevant factors for passenger's multimodal choice and satisfaction

The analysis of the determinants of the door-to-door passenger transport demand, i.e., which combination of travel options and modes is actually preferred by customers, is a complex task due to the presence of several components, as for example the purpose of the trip, the social composition of travellers and the duration, whose interrelationships influence the final choices.

Recent analyses on multimodal door to door transport journeys, also including the air travel leg in the multimodal chain, have confirmed the presence of traditional and well-known factors, as costs (prices) and time efficiency, associated with flexibility and quality of the service provided, among the key drivers of travel mode choice. The analyses are based on in-depth interviews with urban travellers, Delphi surveys and meta-analysis of scientific literature[14].

The importance of such traditional determinants of multimodal door-to-door demand is also confirmed by the criteria with which policy makers and planners have evaluated in general the transport system performances. As shown in Litman[15], the review of factors and impacts that are primarily considered in the transport systems evaluation points out basically at the prominent role of prices (for the governments and policymakers), travel speed and quality of services, overlooking the impacts and indicators addressing users' comfort, affordability, public fitness and health.

[14] Thomas Clauss. Sebastian Döppe (2016) Why do urban travelers select multimodal travel options. A repertory grid analysis. Transportation Research Part A. Policy and Practice, Elsevier, vol. 93(C), pages 93-116 and Ulrike Klugea. Jürgen Ringbeckb. Stefan Spinlerb (2020) Door-to-door travel in 2035. A Delphi study, Technological Forecasting and Social Change. 157.

[15] Todd Litman (2021) Towards More Comprehensive and Multi Modal Transport Evaluation 18 March 2021. Victoria Transport Policy Institute.

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		← Accessibility Factors →				
		Automobile	Transit	Active Modes	Road Connectivity	Land Use Accessibility
↑ Impacts ↓	Government costs	Yes	Yes	Yes	Yes	Yes
	Travel speeds, delays	Yes	Yes	No	Sometimes	Sometimes
	Safety and security	Yes	Yes	Sometimes	No	No
	User costs & affordability	Oper. costs	Oper. costs	No	No	No
	Mobility for non-drivers	No	Yes	Sometimes	No	No
	User comfort	No	No	No	Not Applicable	Not Applicable
	Parking costs	No	No	No	No	No
	Energy consumption	Sometimes	Sometimes	Sometimes	No	No
	Pollution emissions	Sometimes	Sometimes	Sometimes	No	No
	Land use objectives	No	Sometimes	No	No	No
	Public fitness and health	No	No	Sometimes	No	No

Figure 14 – Towards More Comprehensive and Multi-modal Transport Evaluation[16],

However, the review stresses that to a certain degree a paradigm shift is undergoing in transport planning and evaluation criteria. Indeed, in the old paradigm, transportation activities were conceived as simply instruments to make mobility as smoothly as possible, e.g., going from the origin to destinations without substantial interruptions and delays. On the other hand, a new paradigm may emerge, in which the goal of transport activities is accessibility and service provision (i.e., the people's ability to reach services and activities). This is particularly true in the light of the future transport services, conceivably serving in the coming years a growing and diversified share of travellers, not before used to travel, e.g., the elderly, disabled people, and young generations.

This rising manifestation of a new paradigm, which implies a different specification of the determinants of multimodal transport demand as well, may be captured through the analysis of how the traditional drivers of multimodal transport demand are changing and are deemed to change further in the coming years.

Price

As stated in Ulrike Klugea, et al. (2020)[17], in a multimodal travel journey paradigm characterised by accessibility and new service provision, the price sensitivity maybe be higher than before. In the next years, transport providers (e.g., airline industry, transport operators) along the multimodal chain, will be required to offer an overall better travel experience to differentiate their products in order to compete effectively with other operators.

Price sensitive passengers already exist today, e.g., travellers ranging from cheap (standardized trips as those provided for example by low-cost carriers) to expensive (individualized) products and services, but it is likely to be expected that the price component will be more important in the near future.

What is it to be expected is that the incoming multimodal door-to-door passenger transport should be able to offer a flexible price structure, which is able to accommodate the needs of a heterogenic customers' composition.

[16] Todd Litman (2021). p. 8.

[17] Ulrike Klugea. Jürgen Ringbeckb. Stefan Spinlerb (2020).

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From low-cost transport targeting price sensitive customers interested in access and egress transport providers like public transport, railways, long-distance bus services and taxis that can offer basic and affordable prices, to premium, highly customized mobility options for higher income travellers, with on-board amenities to enhance the travel experience or to enable work during travel; all that should be reflected in the price structure.

In general, the price component of the incoming multimodal journeys will be of the outmost importance, to the extent that it will be able to go along with the personalization and heterogeneity of passengers' needs.

Time

As already pointed out, the time component has been already identified as one of the main determinants of multimodal passenger transport demand, mostly focussing on the time saved along the overall chain, including changes among transport modes (interchanges at nodes).

More specifically, all the analyses, experts' interviews and Delphi analysis have confirmed how among the most important passengers' requirements stands the need to spend actual travel time in a value-adding activity, such as for working or entertainment.

It can be said that as time is going to be a valuable resource, nowadays as well as in the near future, travel time can be used much more efficiently thanks to the increased usage and development of new technologies, as the Information and Communication Technologies (ICT), which may offer a valid support to travellers, also considering that there is a wide range of customers' preferences that must be met.

For example, ICT can satisfy the attitude of younger travellers to be connected and in constant digital exchange with private life, friends and family. The same can be said for travellers aiming at performing working tasks, due to the fact that ICT and devices are able to perform and conduct work-related tasks.

Besides, the likely availability of autonomous cars in the long-term period, can lead, on the one hand, to an increase in the willingness to pay for in-vehicle services (augmenting the price-sensitivity of multimodal prices, as discussed above) and, on the other, can determine a growing role of the time component value.

Indeed, with the advent of autonomous vehicles, the customers' appreciation (and demand) of travel will be not just the mere transport from A to B, but an issue of how this time is being used. It is likely that future passengers will increasingly demand to use travel time along their door-to-door journey as value-adding time, such as for working, networking, education, and other activities. In terms of new services, as discussed below, it can be said that digitalization will be more advanced and seamless internet access throughout a journey will be a crucial requirement.

Range and quality of services

In such a context, which type of services will be considered as standard requirements in the door-to-door multimodal transport?

First of all, the likely growth of different types of passenger profiles approaching multimodal transport should be carefully considered. Technological developments, digitalisation and new type of vehicles can disclose new possibilities previously denied to disabled people and elderly. If passengers are going to become increasingly diverse, new services will have to adapt, and, according to these differentiated profiles, travel preferences might differ as well.

The new generation of mobility services serving the next transport demand of door-to-door journeys should be customisable according to individual travel types, needs, requirements and travel preferences, while still providing access to real time travel information of the own journey, i.e., providing passengers with the necessary (real time) travel information.

Conclusions and introduction to the scenarios

Despite the identification of the drivers of mobility demand in door-to-door intermodal transport leads to the straightforward conclusions that costs (journey price), time spent, and quality of services will be among the most important components, it is important to stress that there is high uncertainty around future developments.

On the one hand, the uncertain pace of technological development, e.g., a slow penetration rates of autonomous vehicles, or the imperfect multi-modal integration, hampered by legal or technological failures, may hamper the development and take-up of multimodal door-to-door journeys.

On the other hand, the interaction of social and economic factors may lead to undesired outcomes, e.g. a not fully recovering from the COVID-19 outbreak, which may undermine safety and affordability of multimodal journeys.

In the next sections, the interplay of the key determinants of multimodal passenger transport is discuss in three scenarios: 2025, 2035, and 2050, briefly outlining the underlying key social and technological assumptions. In each scenario, the future demand is specified by type of journey (business and non-business).

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5.1.3 Scenario 2025

In 2025 the problem of the pandemic COVD-19 will be solved, allowing the air transport to be deployed again as usual, in particular for touristic routes.

Travel demand detects the continuous decrease of motorized private modes (limited traffic zones, congestion charges, diesel ban, speed limits, etc.) and the increase of collective modes of transport and development of NMS (new mobility services), e.g., car-sharing, ride-hailing, bike-sharing, e-scooters.

This is partly due to increasing constraints for private modes, especially in urban areas, but also to major awareness on climate change challenges and impacts affecting behaviours and choices, despite not yet predominant.

In particular for transport having an airport at its core, different modes (trains, bus connections, taxi, etc.) connect a hub airport to the city, while in case of a regional airport, beyond some PT services (train, bus), it is easier than in hub airport to rent a car or use NMS services, including e-bikes or e-scooters (depending on location of airport).

The interaction among modes is still limited: privately generated data are not available for public use modes, while there are mobile applications collecting traffic information from various operators and providing users with optimal routes.

Travel time reduction is an important component of multimodal journey travel demand and foreseen a common access to services enabling reduction of time spent on change nodes (ability to buy ticket online in advance, proceed check-in at least the day before flight, remote ticket validation systems).

Travel time mainly occur to waiting for connection from the airport to the city (usually several minutes). For example, assuming that passenger has to be on gate at least 30 minutes before take-of, time needed for reaching gate after leaving train or taxi in hub airport is about 25 minutes and 15 in case of regional airport.

The following implications in terms of demand requirements may be derived.

Business

- Personalised-on-demand services are required, in particular allowing persons to work during the travel time. The latter is still, all along the overall D2D chain, a predominant component, while costs are less important, thus efficient transport services are needed, also allowing to deal with delays and interruptions. Thus, the preferred modes are taxi and car rental, limiting journey combinations, despite also trains are also used, if guaranteeing an efficient and qualitative service (e.g., high- speed trains with first class).

Non-Business

- For non-business passengers, usually the main driver is costs, submitting travel time and conform to them.
- Also, choice of modes and journey combinations will be submitted thus enlarging the range of options, with preference for public transport modes and also for shared services (car/bike sharing, Uber, etc.).
- Limitations, in terms of time and mode choice to those options, could be represented by specific travel purposes, type of luggage, eventual need assistance an constrains in payment methods.

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5.1.4 Scenario 2035

In general, travel demand in 2035 will be characterised by the pervasive presence of ICT technologies along all the D2D chain, leading to a growing passenger demand of “full control” of the entire journey trip. The demand of transportation from A to B will be not a simple demand of moving from an origin to a destination, but will be accompanied by a growing demand of services (as major comfort, possibility to arrange new paths in case of delays, productive and efficient use of travel time, etc), which will make the journey richer and rewarding.

From the social point of view, with reference to the transport business sector, it is likely that the social evolution toward growing equal opportunities for woman and the persistence of the social value of self-affirmation and a lean family structure (few children, late marriage, etc), will be confirmed, leading to a growing number of women travelling for business. This may have an implication in terms of user’s needs.

It is also likely that the awareness of climate change challenges will be a long-lasting feeling, and that the corresponding demand for eco-friendly journeys will grow, together with the willingness to pay for eco-friendly transport services.

As result of the growing passenger control of the overall D2D chain due to the ICT technologies and the more sophisticated demand of accompanying services, a certain modification of the common perception of travel time will occur.

Travel time will be conceived not just as a pure waste of time, which should be reduced at a minimum, but as a potential asset to exploit the journey at the best: with better entertainment (family groups), or opportunities of working remotely (business segment). Correspondingly, it may be said that the willingness to pay for such services may be high and that in any case the D2D price sensitiveness to such services will be significant.

The following implications in terms of demand requirements may be derived.

Business

- Personalised-on-demand services are required. In particular, the business segment requires efficient transport services, characterised by high flexibility to deal with delays and interruptions. The availability of on-line connections, mobile offices will be required. A growing demand from women needs more transport services (healthy and safety services).
- Travel time, i.e. its reduction, will still be an important requirement orienting the transport demand along the overall D2D chain, but growing attention will be put to the quality of travel time spent during the journey.

Non-business

- Passengers travelling for non-business purposes will anyway put a strong emphasis on service provision during the journey. The likely presence of older travellers, possibly with reduced mobility, will make the presence of services and facilities necessary. At airport, during interchanges, during the travel, transport demand will be characterised by services ensuring comfort and assistance.
- Travel time will still be a relevant requirement, even if the quality of time spent during the overall D2D will play an important role; in particular entertainment services during the journey.

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5.1.5 Scenario 2050

In 2050, the large-scale deployment and availability of Connected and Automated Mobility (CAM), which will give scope for the disclosure of potential significant impacts on transport demand, in different, but interconnected, domains:

1. New mobility services and solutions integrated into a single Mobility as a Service (MaaS) ecosystem, offering a combination of high-capacity public and private transport with individual solutions tailored to diverse and changing customer needs.
2. Major accessibility and social inclusion, with the possibility of providing access to mobility for people who are limited by physical constraints, such as those with reduced mobility, the elderly, or those living in remote areas. For these groups, automated vehicles can improve social inclusion, providing them with increased access to a range of services and a degree of social life that was previously denied.

From the social point of view, in 2050 there will be not significant differences concerning travel behaviour and demand as far as age is concerned. The older people and, more reasonably, the younger ones, will be indeed, already familiar with the use of information technologies. It is likely that in 2050 the D2D travel chain will be strongly integrated, making possible offering mobility services that are able to ensure the full control of the overall journey; i.e. rescheduling routes in case of interruptions.

In terms of demands, the impacts of the development of autonomous vehicles will be relevant: for instance, autonomous driving vehicles will be able to supply a vast array of personalized D2D service to different age groups. Consequently, the elderly or children traveling alone will have the possibility to travel in safety, providing the possibility to participate in D2D chain, even without the ability to drive a vehicle.

The competitive advantage in getting transport demand from passengers, both in the business and in the non-business sector, will be the possibility to offer integrated services.

The following implications in terms of demand requirements may be derived.

Business

- In 2050, travel time for business travellers will take stock of the flexibility in organising the D2D chain. All the available transport modes (shared, autonomous) will be used, e.g. car sharing model in urban areas, associated to (electric) micro mobility. The integrated services, regardless age and sex of the traveller, will address "mobile office" services, easy communication and connection and cost-efficiency of the transport solutions.
- The perception of travel time will change as a consequence: it is not anymore, a dead component of the journey: it may be possible a trade-off between the duration of travel time and its productivity. Sometimes, business traveller may undertake longer journeys, if they are filled-in with efficient services.

Non-business

- Passengers travelling for non-business purposes will benefit of a larger accessibility to D2D chains than in the past years. Transport demand from people with reduced mobility made available from autonomous vehicles will need to get services addressing assistance, flexibility in rescheduling routes and the full range of information concerning interconnections. Integrated tickets will be the standard approach.

- The duration of travel time will be important, as in the past years, but possible trade-off with the service provided may be considered, in particular of people with reduced mobility is involved.

5.2 Passengers characteristics analysis

Passengers deal with a large number of variables in planning a D2D multimodal travel as well as in rearranging travel plans in case of disruption. Each variable can be of different relevance or priority according to the specific passenger profile. On the other hand, passenger profile results from the combination of permanent personal characteristics (such as age, gender, permanent physical abilities), and contextual or temporary characteristics (such as the purpose of the travel, the number of people travelling with the profiled passenger, the knowledge of the sites and language of destination, the availability of enabled credit cards and much more). Each characteristic of a passenger profile recalls/brings specific needs or expectations that, to be matched, request that the mobility service in its whole provides specific tangible or intangible features (services/functions/…). Under the passenger's experience perspective, a set of high-level travel variables can be identified as relevant to shape the optimal travel pattern; each variable can be managed by the passengers through the functions or services available during the planning or execution of their D2D journey[18]. Each feature can match a basic need of a traveller (as is the case of a slider for people with walking impairments), representing a mandatory function or service for the passenger to succeed in his D2D journey or, under the inclusive design perspective, this feature can be an additional element providing a more satisfying travel experience to some passenger profiles (as is the case of a slider for a passenger with large and heavy luggage)[19].

The table below provides a picture of key travel variables and the corresponding features of mobility services matching basic or optional needs of specific passengers' characteristics.

Multimodal travel variables have been reviewed following the consultation of the Passengers Advisory Group.

[18] D Esztergár-Kiss (2019) Framework of Aspects for the Evaluation of Multimodal Journey Planners. *Sustainability*.

[19] R F Abenoza. O Cats. Y O Susilo (2019) How does travel satisfaction sum up. An exploratory analysis in decomposing the door-to-door experience for multimodal trips.

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Table 3 - Travel variables and needs per passengers' profiles

Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
Travel time	Sorting travel options per journey duration	- Business traveller - Travelling for personal reasons other than leisure	- Walking impairments - Family/group with children - Leisure traveller
	Confronting travel options per departure time	- Business traveller - Travelling for personal reasons other than leisure	- Walking impairments - Family/group with children - Leisure traveller
	Confronting travel options per arrival time	- Business traveller - Travelling for personal reasons other than leisure	- Walking impairments - Family/group with children - Leisure traveller
	Confronting travel options per service reliability/ punctuality	- Walking impairments - Business traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language - Low digital trust/personal devices availability	- Visual impairments - Auditory impairments - Women travelling alone - Family/group with children - Leisure traveller
	Getting advanced information (at proper time) on expected waiting time (i.e. taxi queuing, security check, luggage delivery, check-in/luggage drop, health check, visa check, gate/ terminal etc)	- Visual impairments - Auditory impairments - Walking impairments - Women travelling alone - Family/group with children - Business traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language	- Leisure traveller - Low digital trust/personal devices availability
Connections and single modes	Sorting travel options for number of connections	- Visual impairments - Walking impairments - Family/group with children - Business traveller	- Auditory impairments - Leisure traveller - Not mother tongue/not speaking local language

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
		- Travelling for personal reasons other than leisure	
	Selecting travel options for type of mode (i.e. no road journey, use car, bike, kick scooter sharing services etc.)	- Visual impairments - Auditory impairments - Walking impairments	- Women travelling alone - Family/group with children - Leisure traveller - Not mother tongue/not speaking local language
	Sorting travel options per length and walking time of pedestrian paths	- Visual impairments - Walking impairments - Women travelling alone - Business traveller - Travelling for personal reasons other than leisure	- Family/group with children - Leisure traveller
	Sorting travel options per length of outside walks	- Visual impairments - Walking impairments - Women travelling alone - Business traveller - Travelling for personal reasons other than leisure	- Family/group with children - Leisure traveller
	Sorting travel options per number of floor changes	- Visual impairments - Walking impairments	- Family/group with children
	Sorting travel options per availability and position of elevators	- Visual impairments - Walking impairments	- Family/group with children
	Sorting travel options per inclusive wayfinding infrastructures (audio and tactile for visually impaired, written/graphics for auditory impaired etc)	- Visual impairments - Auditory impairments - Walking impairments	- Women travelling alone - Family/group with children
	Provision of detailed directions in case of multiple entrance/exit point	- Visual impairments - Walking impairments - Women travelling alone - Business traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language	- Auditory impairments - Family/group with children - Leisure traveller

Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
	Pre-view of waiting/entrance/exit points and ways (i.e. google street view), audio description	- Walking impairments	- Auditory impairments - Women travelling alone - Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language
Accessibility and comfort of each travel segment	Availability of boarding/getting off aids (handrails, slides or elevating platforms, assisting personnel etc)	- Visual impairments - Auditory impairments - Walking impairments	- Family/group with children
	Seat reservation allowed/ avoidable	- Visual impairments - Walking impairments	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure
	Clearance for large luggage		- Visual impairments - Walking impairments - Family/group with children - Leisure traveller
	Slides/facilities for heavy luggage/strollers		- Walking impairments - Family/group with children - Leisure traveller - Travelling for personal reasons other than leisure
	Overcrowding alert	- Business traveller	- Visual impairments - Auditory impairments - Walking impairments - Family/group with children - Travelling for personal reasons other than leisure
	Wi-Fi/mobile connection available	- Visual impairments	- Walking impairments

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
		- Auditory impairments - Women travelling alone	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language - Enabled Credit Card holder (or no cash availability)
	Power recharge points	- Visual impairments - Auditory impairments - Women travelling alone	- Walking impairments - Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language - Enabled Credit Card holder (or no cash availability)
Cost and level and services provided	Sorting travel options per price	- Leisure traveller - Travelling for personal reasons other than leisure	- Family/group with children
	Clarity of fares: what is included and dot for luggage (limitations in number, size and weight, drop on/off rules, boarding)	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language	
	Clarity of fares: additional services included or selectable (extra-space, priority, assistance for children/elderly/impaired persons, luggage insurance, porter, etc)	- Visual impairments - Auditory impairments - Walking impairments	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
			- Not mother tongue/not speaking local language - Low digital trust/personal devices availability - Enabled Credit Card holder (or no cash availability) - No credit card/enabled card holder
	Clarity of fares: cancellation and change policy (timing for free change/cancellation, costs for change/cancellation, number of allowed changes, etc)	- Family/group with children - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language - Low digital trust/personal devices availability - No credit card/enabled card holder	- Business traveller
	Fares comparison tool	- Not mother tongue/not speaking local language	- Family/group with children - Leisure traveller - Travelling for personal reasons other than leisure - Low digital trust/personal devices availability - No credit card/enabled card holder
	Passengers help desk available by multiple means (phone, chat, email, physical assistant) and languages	- Visual impairments - Auditory impairments - Walking impairments - Not mother tongue/not speaking local language - Low digital trust/personal devices availability	- Business traveller - Travelling for personal reasons other than leisure - No credit card/enabled card holder -
	Continuously available assistance for vulnerable passengers (not subject to pre-booking)	- Visual impairments - Auditory impairments - Walking impairments	- Business traveller - Travelling for personal reasons other than leisure

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
		- Not mother tongue/not speaking local language - Low digital trust/personal devices availability	- No credit card/enabled card holder
Personal security	Operating surveillance /security service	- Women travelling alone	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language
	Possible under-crowding (isolated areas)	- Women travelling alone	- Not mother tongue/not speaking local language - Low digital trust/personal devices availability
	Controlled access area vs free access area	- Women travelling alone	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language
	Available shops (opening hours) & lights	- Women travelling alone	- Not mother tongue/not speaking local language - Low digital trust/personal devices availability
Luggage security	Luggage storage (availability, opening hours, cost)		- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure
	Luggage boarding constraints (i.e. shuttle bus to airport allowing or not luggage in the cabin)	- Visual impairments - Auditory impairments - Walking impairments - Family/group with children - Business traveller	

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
		- Leisure traveller - Travelling for personal reasons other than leisure	
Environmental impact	Sorting travel options for CO2 emissions		- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure
	Sorting travel options for % of renewable energy source used		- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure
Ticketing	Advanced ticket buying	- No credit card/enabled card holder	- Family/group with children - Business traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language
	Just in time ticket buying (physical)	- Low digital trust/personal devices availability	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Enabled Credit Card holder (or no cash availability) - No credit card/enabled card holder
	Ticket reservation with later payment		- Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
			- Enabled Credit Card holder (or no cash availability) - No credit card/enabled card holder
	Alternative paying means available (credit cards + PayPal + Apple pay +Google pay, …)	- Low digital trust/personal devices availability - Enabled Credit Card holder (or no cash availability) - No credit card/enabled card holder	
	Fully digital ticketing system	- Business traveller	- Family/group with children - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language - Enabled Credit Card holder (or no cash availability)
	Integrated ticketing		- Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language
Early and real time information provision	Prompt alert and display relying on multiple senses of alternative travel paths in case of delay and/or service disruption	- Visual impairments - Auditory impairments - Walking impairments - Not mother tongue/not speaking local language	- Women travelling alone - Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure
	Prompt alert and guidance provision relying on multiple senses in case of safety emergency	- Visual impairments - Auditory impairments - Walking impairments - Not mother tongue/not speaking local language	- Women travelling alone - Family/group with children - Business traveller - Leisure traveller

Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
		-	- Travelling for personal reasons other than leisure
	On board information provision (audio and tactile for visually impaired, written/graphics for auditory impaired etc)	- Visual impairments - Auditory impairments - Not mother tongue/not speaking local language	- Low digital trust/personal devices unavailability
	Information provision at hub/connection (audio and tactile for visually impaired, written/graphics for auditory impaired etc)	- Visual impairments - Auditory impairments - Not mother tongue/not speaking local language	Low digital trust/personal devices unavailability
	Automatic ticket conversion to alternative travel paths in case of delays and/or service disruption		- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language - Enabled Credit Card holder (or no cash availability)
	Real time update of expected travel time in case of delays and/or service disruption n		- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure
	Contextual notification alerting for next travel step (at proper time and proper geographical position, including boarding time, ETOT etc)	- Visual impairments - Auditory impairments - Walking impairments - Not mother tongue/not speaking local language	- Family/group with children - Business traveller - Leisure traveller - Travelling for personal reasons other than leisure - Low digital trust/personal devices unavailability
	Getting real-time information on expected	- Visual impairments	- Leisure traveller

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Multimodal travel variable	Feature enabling the management of the variable	Mandatory for passengers which are/which have	Appreciated by passengers which are/which have
	waiting time (i.e. taxi queuing, security check, luggage delivery, check-in/luggage drop, health check, visa check, gate, etc)	- Auditory impairments - Walking impairments - Women travelling alone - Family/group with children - Business traveller - Travelling for personal reasons other than leisure - Not mother tongue/not speaking local language	- Low digital trust/personal devices availability

5.3 Passenger centred requirements for multimodal D2D journey

When planning and undertaking a trip, passengers have different needs and priorities to fulfil. These needs and proprieties are presumed to affect the tasks and decisions, as well as expectations about the quality of the transport services, and can be assigned to three different stages of a journey, roughly in conformity with three steps: pre-trip, wayside, and on-board[20]. To execute its Door to Door journey, the passenger interacts with a series of information and tangible and intangible infrastructures composing the mobility as a service in its whole. This happens in one or more travel steps, from the planning to the completion: as consequence, passenger centred requirements for multimodal D2D journeys can be elicited with reference to both the journey steps and the components of the mobility service. In this framework, the service design perspective supports[21] the passenger centric approach sought by X-TEAM D2D project, allowing the definition of requirements aimed at fitting the variety of characteristics and needs of any type of passenger. In order to fully match this scope, the definition of the X-TEAM D2D passenger centred requirements was driven by the following principles:

- inclusion of physical, social, cognitive differences, to ensure equal access to D2D mobility services
- autonomous and independent living, to safeguard human dignity and personal freedom in the use of D2D mobility services
- transparency of the mobility services provided, to protect passengers' rights and awareness.

The tables below provide a list of high-level requirements of the multimodal D2D journey, elicited according the abovementioned methodology. The requirements are defined with reference to the mobility service components, namely:

- Requirements of applications and devices enabling the use of the mobility service (organizational part of the service)
- Requirements of wayside spaces (hubs, nodes, built infrastructures)
- Requirements of vehicles

Passenger centred requirements for multimodal D2D journey have been reviewed following the consultation of the Passengers Advisory Group.

[20] J Hine. J Scott (2000) Seamless, accessible travel: users' views of the public transport journey and interchange.

[21] Nesta Ideo (2017). Design for Public Services *and Marc* Stickdorn. Jakob Schneider (2015) This is Service Design Thinking.

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Table 4 - Requirements of applications and devices enabling the use of the mobility service

Requirements of applications and devices enabling the use of the mobility services				
Requirement	Relevant journey step			
	pre-trip	wayside	on-board	post-trip
The access to mobility services shall rely on the lowest technological standards (to avoid any digital divide)	⊙	⊙	⊙	⊙
Personal data required to access and manage travel services shall be minimized	⊙	⊙	⊙	⊙
Multiple alternative payment/refund methods shall be allowed, including more than one currency. Cash payments shall always be possible.[22]	⊙	⊙	⊙	⊙
Search tasks shall allow to confront and order results by multiple criteria[23]	⊙	⊙	⊙	
Information shall be provided with symbols and graphics supporting the text	⊙	⊙	⊙	⊙
Information shall be accessible to personalized auxiliary tools (i.e. text to speech system) and fruition of information by more than one sense shall be allowed (i.e. reading as alternative to hearing)		⊙	⊙	⊙
Information shall be provided with relevance to the context (i.e. proper time and place for the requested action)		⊙	⊙	⊙
When applicable, information shall be offered with multiple level of details	⊙	⊙	⊙	
Information constituting contractual basis of travel services shall be accessible and retrievable anytime	⊙	⊙	⊙	⊙
Integrated ticketing of all travel legs shall be available				⊙
Seat reservation shall be available for travel legs longer than 30 minutes	⊙	⊙		
Automatic change of journey plan to manage travel disruptions shall be subject to confirmation. Further personalization of proposed change shall be allowed without extra costs (for equivalent services). Information on extra-costs shall be clearly provided and subject to confirmation.		⊙	⊙	

[22] https://www.ecb.europa.eu/press/key/date/2020/html/ecb.sp201022~d66111be97.en.html

[23] The criteria shall reflect the passengers related KPI to be defined in D5.1.

Information on available primary and secondary services shall be available from the ticketing/booking stage	◉			
If autonomous boarding and disembarking is not possible, assistance shall be available without prior request or booking		◉	◉	

Table 5 - Requirements of hubs, nodes, built infrastructures

Requirements of hubs, nodes, built infrastructures			
Requirement	**Relevant journey step**		
	pre-trip	**wayside**	**on-board**
Access, egress and turning points shall be easily locatable independently on physical, cognitive or sensorial abilities of passengers. If not fully accessible, assistance service shall be available without pre-booking.	◉	◉	
Long walking distances shall be served by moving aids (i.e. moving walkway, shuttle, etc.)		◉	
Slider, lift and any mean to overcome difference in floor height shall be available and included in the main walking path	◉	◉	
Walking times shall be indicated, with multiple figures referring to a variety of passenger characteristics	◉	◉	
Outside walking paths shall protect passengers from weather conditions (rain, cold, heat, wind)		◉	
Racks, stands for personal mobility means shall be directly connected to access/egress points	◉	◉	
Rack, stands, lay-by of shared mobility means shall be directly connected to access/egress points	◉	◉	
Healthy and comfortable indoor environmental conditions shall be assured (i.e. IAQ –Internal Air Quality, lighting, noise)		◉	
Resting/meeting points shall be available in long walking paths		◉	
Primary services (i.e. energy plugs, telecommunication network coverage, toilets, etc) shall be available in any sector of the buildings		◉	
If secondary services (i.e. passenger assistance, security point, ATM, pharmacy, etc.) are not available in the building, information on the nearest service location or access shall be provided		◉	

Table 6 - Requirements of vehicles

Requirements of vehicles			
Requirement	**Relevant journey step**		
	pre-trip	**wayside**	**on-board**
Autonomous/independent boarding and disembarking shall be ensured. If not fully accessible, assistance service shall be available without pre-booking.		⊙	⊙
Primary services (i.e. Wi-Fi, toilets) shall be available in case of travel legs longer than 30 minutes			⊙
Seats layout shall allow passengers' privacy			⊙
Seats layout and clearance shall allow to accommodate all personal belongings			⊙
Healthy and comfortable indoor environmental conditions shall be assured (i.e. IAQ –Internal Air Quality, lighting, noise)			⊙
Personalised levels of environmental conditions shall be possible in case of travel legs longer than 1 hour (i.e. IAQ – Internal Air Quality, lighting, noise)			⊙

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6 Technological enablers

6.1 Technological enablers in the 2025/2035 timeframe

<u>Barrier:</u> Definition of clear and transparent rules covering access to real time data for travel planners' platforms.

<u>Enabling projects:</u>

- European Strategy on Cooperative Intelligent Transport Systems (C-ITS)[24], a milestone initiative towards cooperative, connected and automated mobility. The objective of the C-ITS Strategy is to facilitate the convergence of investments and regulatory frameworks across the EU, in order to see deployment of mature C-ITS services in 2019 and beyond. This includes the adoption of the appropriate legal framework at EU level by 2018 to ensure legal certainty for public and private investors, the availability of EU funding for projects, the continuation of the C-ITS Platform process as well as international cooperation with other main regions of the world on all aspects related to cooperative, connected and automated vehicles.
- Commission Delegated Regulation (EU) 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide multimodal travel information services[25]. This Delegated Regulation provides for among others National Access Points gathering travel and traffic data from all type of transport from both private and public entities.

<u>Fulfilment of barriers:</u> The rules are under development mainly on policy making levels. The foundations are already established. There is a need to regulate the rules concerning access to real time data generated by transport operators (modes) by travel planners integrating information for passenger in order to enable him multimodal travel management. It is expected that in given time horizon the barrier will be addressed by appropriate regulatory framework.

<u>Barrier</u>: Regulation concerning establishment of common data syntaxes in order to make future exchange of digital data more efficient.

<u>Enabling projects:</u>

- INTER-IoT[26] project aims at the design, implementation and experimentation of **an open cross-layer framework,** an associated methodology and tools to **enable voluntary interoperability among heterogeneous Internet of Things (IoT) platforms.** The proposal will allow effective and

[24] European Commission – Mobility and Transport, Intelligent transport systems - Cooperative, connected and automated mobility (CCAM).

[25] European Commission. Mobility and Transport.

[26] IoT-EPI. European Platforms Initiative, INTER-Iot.

efficient development of adaptive, smart IoT applications and services, atop different heterogeneous IoT platforms, spanning single and/or multiple application domains.

- Big IoT[27] will address the interoperability gap by defining a generic, unified Web API for smart object platforms, called the BIG IoT API.
- The VICINITY[28] project will build and demonstrate a **platform and ecosystem that provides "interoperability as a service" for infrastructures in the Internet of Things.**
- LeMo[29] project aiming to produce research and policy roadmap towards data openness, collection, exploitation and data sharing to support European transport stakeholders in capturing and addressing issues, that range from technical to institutional, including legitimacy, data privacy and security.

Fulfilment of barriers: The barrier seems to be addressed well. It can be expected that transport dedicated solutions will be matured in considered time horizon.

Barrier: Identification of ways of acquiring data as well as identification of potential data predicted as necessary for efficient transport demand forecasting.

Enabling projects:

- SYN+AIR[30], collaboration among modes relates to data sharing among TSPs in the scope of facilitating a seamless D2D journey. The main objective of SYN+AIR is to generate common goals for TSPs that will justify data sharing, facilitating the user to execute a seamless D2D journey.
- Use of Big Data in Transport Modelling[31]. This paper guides transport planners in making the best use of mobile phone traces, derived either from mobile network data or from smartphone app data. It suggests combining such new data sources with conventional travel surveys whose sample size and cost could ultimately be reduced. In the context of a rapidly evolving mobility landscape, with new modes and new services available, big data can help monitor behaviour change, learn from quasi-experiments and develop next-generation travel demand modelling tools.

Fulfilment of barriers: The potential of various nature data for better transport demand prediction is seen and explored. However, the way to enabling use of the data is long it is expected that in given time horizon there will be possibility to use non-transport related data (e.g. privately generated) to better forecast/nowcast transport demand.

Barrier: Technologies for Big Data processing, related to data infrastructure as well as transport related data collection, processing and sharing.

Enabling projects:

[27] IoT-EPI. European Platforms Initiative, Big IoT.

[28] IoT-EPI. European Platforms Initiative, VICINITY.

[29] LeMo.

[30] SYN+AIR - Synergies between transport modes and air transportation.

[31] International Transport Forum (2021) Use of Big Data inTransport Modelling - Discussion Paper, Luis Willumsen, Nommon Solutions and Technologies.

- The symbIoTe[32] project steps into this landscape to devise an interoperability framework across existing and future IoT platforms. The framework will enable the discovery and sharing of resources for rapid cross-platform application development and will facilitate the blending of next generation of smart objects with surrounding environments.

- MONICA (Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal)[33] MONICA demonstrates a large-scale IoT ecosystem that uses innovative wearable and portable IoT sensors and actuators with closed-loop back-end services integrated into an interoperable, cloud-based platform capable of offering a multitude of simultaneous, targeted applications. All ecosystems are demonstrated in the scope of large-scale city events, but have general applicability for dynamically deploying Smart City applications in many fixed locations such as airports, main traffic arterials, and construction sites. Moreover, it is inherent in the MONICA approach to identify the official standardisation potential areas in all stages of the project.

- 5G-MOBIX[34] will develop and test automated vehicle functionalities using 5G core technological innovations along multiple cross-border corridors and urban trial sites, under conditions of vehicular traffic, network coverage, service demand, as well as considering the inherently distinct legal, business and social local aspects.

Fulfilment of barriers: The barrier is well addressed. The fact that technologies necessary for transport will be also demanded in other domains assures the appropriate development path.

Barrier: Regulatory framework covering standards and recommendations enabling unconstrained sharing data between operators and involved stakeholders.

Barrier: Regulatory framework concerning standards and recommendations assuring ethical, with equitable access as well as safe and secure collecting, processing and sharing of private data.

Enabling projects:

- Sustainable Mobility for All (SuM4All)[35] Sustainable Mobility: Policy Making for Data Sharing[36] report on a global policy framework and practical guidance for policy making, on data sharing. Recognizing the hyperlocal context of mobility needs and policies, the nascent state of the data sharing market, and limited evidence from regulatory practices, including multiple case studies from across the globe to document emerging good practices and policy suggestions.

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[32] IoT-EPI. European Platforms Initiative. SymbIoTe.

[33] IoT-EPI. European Platforms Initiative. MONICA.

[34] 5GMOBIX. Driving forward Connected & Automated Mobility.

[35] Sustainable Mobility for All (SuM4All) is the premier advocacy platform for international cooperation on transport and mobility issues. Established in 2017, and hosted by the World Bank, the global, multi stakeholder partnership, brings together more than 55 public organizations and private companies, including bilateral partners, multilateral development banks, U.N. organizations, inter-governmental organizations, and civil society with a shared ambition to transform the future of mobility.

[36] Sustainable Mobility for All (2021) GRA IN ACTION SERIES. Sustainable Mobility.

- CHARIOT[37] will advance state of the art by providing a design method and cognitive computing platform supporting a unified approach towards Privacy, Security and Safety (PSS) of IoT Systems, that places devices and hardware at the root of trust, in turn contributing to high security and integrity of industrial IoT.

Fulfilment of barriers: The SuM4All initiative supported by numerous projects assuring technical side of the issue allows for expecting that barrier will be overcome in given time horizon.

Barrier: Standards and recommendations concerning security of automated systems.

Enabling projects:

- SerIoT[38] aims to provide a useful open & reference framework for real-time monitoring of the traffic exchanged through heterogeneous IoT platforms within the IoT network in order to recognize suspicious patterns, to evaluate them and finally to decide on the detection of a security leak, privacy threat and abnormal event detection, while offering parallel mitigation actions that are seamlessly exploited in the background.
- SOFIE[39] facilitates the smooth creation of new IoT business platforms through secure open federation - powered by the SOFIE architecture, software framework, and reference implementation.
- SecureIoT[40] is an EU-funded project and a joint effort of global leaders in IoT services and IoT cybersecurity to secure the next generation of dynamic, decentralized IoT systems, which span multiple IoT platforms and networks of smart objects, through implementing a range of predictive IoT security services. SecureIoT will integrate its security services in three different application scenarios in the areas of: Digital Automation in Manufacturing (Industry 4.0), Socially assistive robots for coaching and healthcare and Connected cars and Autonomous Driving.

Fulfilment of barriers: The barrier concerning security of complex IoT networks is well addressed by both finalised as well as pending projects. Despite the fact that the main domain of activity is rather wider than described by the barrier it can be expected that elaborated solutions will support transport applications as well.

[37] The CHARIOT. Privacy, Security and Safety of IoT.

[38] The SERIoT. Secure and Safe Internet of Things.

[39] The SOFIE. Secure Open Federation for Internet Everywhere.

[40] The SecureIoT. Predictive Security for IoT Platforms and Networks of Smart Objects.

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6.2 Technological enablers in the 2050 timeframe

Barrier: IT technologies able to manage metropolitan (transport) ecosystems (Platforms for safe, transparent data management).

Enabling projects:

- Alcatel-Lucent Enterprise[41] The Internet of Things in Transportation - Build a secure foundation to leverage IoT for improved passenger experiences, safety and efficiency[42]. Alcatel-Lucent Enterprise activity aiming at connect transportation systems with ICT solutions.
- All projects addressing the topic of IoT and BiG Data as indicated for 2035-time horizon.

Fulfilment of barriers: There is a lot of initiatives / projects aiming at integration of IoT systems and Big Data solutions, also related to strictly transport purposes (integration). The effort represented behind the initiatives enable consideration of this barrier as overcome within 2050-time horizon.

Barrier: Dedicated software technologies to manage integrated transport system(s), appropriate data transfer technologies (beyond 5G), IT hardware systems with necessary computing power (quantum processors).

Enabling projects:

- CIVITAS - Developing integrated transport management systems[43]. With the ultimate goal of making public transport easier for travellers, the objective of this measure was to develop methods and a decision-making tool to help transport authorities to optimise the effectiveness and operational quality of their activities. Integrated transport management systems comprise three aspects: exploiting data (data analysis, data mining); creating interfaces between the various software and databases used by stakeholders; and developing decision aid systems.

- Agile[44] builds a modular and adaptive gateway for Internet of Things devices. Modularity at the hardware level provides support for various wireless and wired IoT networking technologies (KNX, ZWave, ZigBee, Bluetooth Low Energy, etc.). It allows fast prototyping of IoT Solutions for various domains (e.g. home automation, environment monitoring, wearables, etc.).

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[41] Alcatel-Lucent Enterprise provides an automated solution that efficiently and securely onboards IoT devices while protecting the network. No matter the industry, our solutions enable you to connect a growing number of devices in a smart, secure and optimized way to provide innovative services and enter the IoT-enabled communications paradigm.

[42] The Internet of Things in Transportation. Build a secure foundation to leverage IoT for improved passenger experiences, safety and efficiency.

[43] CIVITAS (2020) Mobility measure. Developing integrated transport management systems.

[44] IoT-EPI – European Platforms Initiative. Agile.

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- 5GZORRO[45] will develop envisaged solutions for zero-touch service, network and security management in multi-stakeholder environments (ubiquitous), making use of Smart contracts based on Distributed Ledgers Technologies to implement required business agility.

- All projects addressing the topic of IoT and BiG Data as indicated for 2035 time-horizon.

Fulfilment of barriers: The barrier addressed by appropriately directed effort. Expected to be overcome in 2050-time horizon.

Barrier Standards and regulations concerning rules of public transport service provision within integrated context has to be defined and implemented.

Fulfilment of barriers: The barrier does not have to and cannot be addressed at the moment as the rules are hardly identifiable due to long time horizon. Nevertheless, due to relatively low level of complexity it is expected that the barrier will be addressed and finally overcome enabling efficient deployment of integrated transport system.

Barrier: Appropriate regulations enabling easier access to new types of data as well as term of using it have to be defined.

Enabling projects:

- Sustainable Mobility for All (SuM4All) Sustainable Mobility: Policy Making for Data Sharing[46] report on a global policy framework and practical guidance for policy making, on data sharing. Recognizing the hyperlocal context of mobility needs and policies, the nascent state of the data sharing market, and limited evidence from regulatory practices, including multiple case studies from across the globe to document emerging good practices and policy suggestions.

Fulfilment of barriers: It can be assumed that this barrier will be overcome together with barriers enabling use of privately generated data or data coming from other than transport related sources.

Barrier: Development of algorithm technologies enabling better transport demand forecasting/modelling.

Enabling projects:

- International Transport Forum - Big Data for Travel Demand Modelling. The report examines how big data from mobile phones and other sources can help to forecast travel demand. It identifies the strengths and potential use-cases for big data in transport modelling and mobility analysis.

Fulfilment of barriers: The barrier is identified and addressed. It is expected that topic will be explored in near future assuring finally fulfilment of barrier.

[45] 5GZORRO. The Zero-touch security and trust for ubiquitous computing and connectivity in 5G networks.

[46] Sustainable Mobility for All (2021) GRA IN ACTION SERIES Sustainable Mobility. Policy Making for Data Sharing.

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6.3 Disruptions management

6.3.1 Transport system management

This section is devoted to define initial concept and algorithm with regard to management of disruptions in transport system.

As it was defined in D2.1 Future Scenarios and Barriers a set of trends and policies allow to consider a future transport system as fully integrated on the level of information exchange. These trends are (Figure 15):

- Digitalisation understood as capacity to generate accurate, real-time data by the system components (i.e. transport mode). It covers Internet of Things (IoT), Big Data processing, New communication technologies (5G and beyond), smart city applications as well as IT development (quantum computers). This trend is present in all modes of transport especially those which are prioritised to be integrated e.g. public transport but in personal mobility or transport related services as well. Digitalisation is seen as significantly contributing to the improvement in the area of reliability and operational efficiency. The example of big commercial aviation is supporting this thesis. As enabler for development of automation in transport digitalisation is strongly supported by the European Commission in the European Digital Strategy.

- Automation. Allows for independence on human operators often limiting operational flexibility. It is developed with regard to nearly all modes of transport and types of vehicles (autonomous car, bus, ferry, train, aircraft etc.), Automation through elimination of human error significantly contribute to improvement of reliability and operational efficiency of transport systems. Progress in automation deployment requires development of technologies in the IoT, and BigData and communication domains

- Sharing of Transport Service Providers' data. Regulated but unconstrained access to accurate, real-time and reliable transport data generated by all system components both transport vehicles as well as infrastructure and other related facilities (e.g. energy providers) will enable efficient coordination between modes, assure resources for travel planning and execution tools (e. g. portable device applications) making multimodal travel less demanding for passenger and creates opportunity to consider multimodal transport as one system (System of Systems perspective)

- Access to passenger data. Regulated but unconstrained access to passenger's data both related to the transport processes but also indicating on transport need in near future will allow for better adaptation of transport supply to passengers' temporary needs and will create opportunity to deploy efficient flexible timetable and routing.

- Algorithmic governance – introduction of regulations which will be understandable for machines is considered as necessary to sustain efficient control over highly complex multimodal transport systems and to apply transport policy in efficient way.

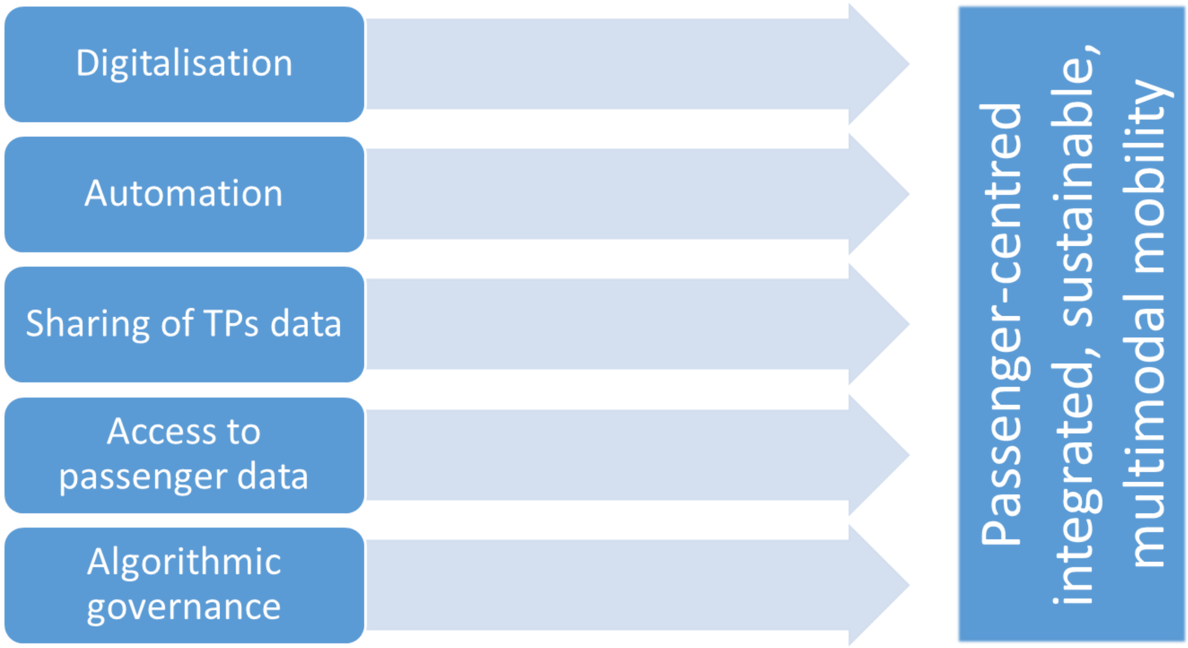

Figure 15 – Trend shaping the future integrated multimodal transport systems[47]

Reaching the goals indicated by all the process paths listed above will allow for creation of transport system which will be fully integrated and personalised – passenger centred. In detail it can be described by the following features (Figure 16):

- Higher efficiency, flexibility and reliability. Digitalisation and automation will allow for better control over overall system and reduction of human factor as a most frequent reason of disruption.
- Tailored transport supply. Automation will unconstraint flexibility progress in public means of transport by independence on human resources as well as increased infrastructure capacity.
- Near-real time demand modelling. Unconstrained access to private data in regulated, secured, equal approach, both concerning travel execution as well as indicating on expected need for travel (e.g. about vacation plans, reaching place of work or visiting doctor) will allow for better modelling of near future demand for transport services.
- Broaden, accurate real time information about travel for passengers. Data coming from various sources (e.g. modes of transport) providing real time transport alternatives with information about congestion (e.g. number of free seats in a bus or train), carbon footprint of selected route/combination.

[47] EUROCONTROL (2018) U Space Services - Implementation Monitoring Report.

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- Efficient, real-time disruption management. Flexibility of transport supply being a one of pillars of future integrated multimodal transport systems creates opportunity for efficient dealing with any disturbances appearing in transport systems independently on source of disruption.

- Managed from the level of regulations and efficient implementation of appropriate transport policy (priorities, tariffs, etc). Algorithmic governance will allow for direct management of integrated transport system from the level of regulations understandable for machines.

Figure 16 – Multimodal transport system management, data management[48]

6.3.2 Disruption management

Presented system architecture which is highly oriented on meeting personal and- temporary needs of passengers as well as optimising multimodal transport on multimodal level is in nature optimised for disruption management at the same time. Algorithm presented on Figure 17 depicts high-level procedure of multimodal transport system management including management of unexpected events of various reason.

Generally, the system work logic can be divided in 9 main steps complemented by sub steps dedicated to detection of disruptions and definition of mitigation actions.

1. Continuous monitoring of passenger (and traffic) data (private, TSPs, current and forecasted). Demand scanning. Steps dedicated to specification of demand for transport, both current and

[48] EUROCONTROL (2018) U Space Services - Implementation Monitoring Report.

future. Two main types of data provided by passengers (directly or indirectly) can be distinguished: Current data on carried travels in order to identify current status and performances of the transport system from the passenger point of view (e.g. load factor) and data identified as indicating (or being correlated) with the need for transport services in near future. This data can result from individual needs as well as special events organised, holiday starting or forecasted weather phenomena (see steps 2. and 3.). Both types of data are used for building the near-future/ near real-time demand for transport service in given area. If the system detects significant discrepancy between current data and forecasted it might indicate on unexpected event resulting with disruption and requiring dedicated effort in order to efficiently meet significantly different (e.g. locally) transport demand.

2. Identification and continuous monitoring of the status of available transport resources (nominal - both vehicles as well as infrastructure). Supply scanning. Digitalised and automated transport systems allow for generating data about the status of the system components both related to transport vehicles as well as infrastructure. Continuous monitoring allows for adaptation of available resources according to its limitation and identified demand tailoring optimised system to the aggregated and generalised individual temporary needs of current and incoming travellers. It allows as well for quick detection of failures disabling continuation of transport processes (disruptions).

3. Analysis of external conditions potentially affecting transport performances (weather, policy, public events, infrastructure exclusions, other disruptions, etc.). Current and forecasted. Continuous monitoring. Numerous external factors can be identified which affect efficiency of transport systems. Most significant should be forecasted and continuously monitored for coherency (plans/forecast vs. execution/proceeding). Discrepancy can result with phenomena leading to decreased transport efficiency of even disruptions (e.g. adverse weather).

4. Definition of the regular multimodal transport supply scenario based on input data about passengers, available resources, capacities and external conditions. In situation the current data are consistent with forecasted (no disruption detected) multimodal transport management system builds temporary transport supply scenario optimised for given input data.

5. Implementation of transport supply scenario. (Deployment of optimised resources). Scenarios is deployed affecting step 2.

6. After defined period of time with adequate interval – taking into account system inertness system can verify efficiency of applied scenarios. If results do not meet identified criteria modification to the scenario can be introduced. Anyway, after defined period of time all steps are repeated in order to define new matched to the current situation transport supply scenario.

7. Definition of the scenario for the recovery of the multimodal transport service after a disruption is based on the data of passengers, available resources, capacities and external conditions. If a disruption is detected in steps 1, 2 or 3, then a scenario is generated that aims to mitigate the consequences of the disruption according to the defined criteria. Disruption dedicated scenario is generated aiming at mitigation of disruption results according to specified criteria.

8. Implementation of disrupted transport supply scenario. (Deployment of optimised resources). Scenarios is deployed affecting step 2. Analogic to the step 5.

9. After defined period of time with adequate interval – considering system inertness system can verify efficiency of applied disruption scenarios. If results do not meet identified criteria

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modification to the scenario can be introduced. Anyway, after defined period of time all steps are repeated in order to define new one, matched to the current situation transport supply scenario.

6.3.3 Conclusions

The system defined in such way needs to be limited in terms of available resources, number of modes, vehicles as well as passenger and deployment area as well as number of interfaces (e.g. with other transport systems). The limitations can come from:

- Requirements that have to be met in order to include a given component to the system, Requirements can concern level of digitalisation and automation implemented as well as area of operation, scale of operation, number of interfaces with other modes of transport.
- Computing power of devices dedicated to optimise and manage the systems. Envisioned amount of data to be managed is large and require dedicated solutions in the fields of Information Technologies.
- Policy applied as well as structure of transport systems and availability of appropriate regulatory solutions as indicated above or in D2.1 Future Scenarios and Barriers.

In addition to that application of presented solution require developed transport network with a number of transport alternatives available (e.g. in different mode). The metropolitan transport systems due to its local up to regional activity concentration seems to fit this definition well. However other transport systems can be adapted as well.

When multimodality in long distance travels is considered the following conclusions can be derived:

- High ability of adaptation to changing and urgent demand for transport services allows for consideration of metropolitan transport system as an able to be resistant on disruptions appearing in other systems or long-distance modes of transport (air transport or HST).
- Potential capacity to quickly mitigate internal disruptions by complex metropolitan transport systems suggests that when long distance multimodal travel is considered main effort (if not all) related to mitigation of disruptions appeared should be moved to metropolitan multimodal transport system.
- Data about air traffic, railway traffic as well as data related to the movement inside the passenger terminals (both concerning railway, bus or air long distance travels) should be available for metropolitan multimodal transport management system (as a one of sources of data monitored in step 3 in section 6.3.2.) in order to enable its adaptation to disruptions or delays in long distance modes of transport). Similarly, information about status of passengers reaching airport or railway terminal should be accessible for long distance TSPs in order to enable traffic optimisation e.g. in the area of terminal.

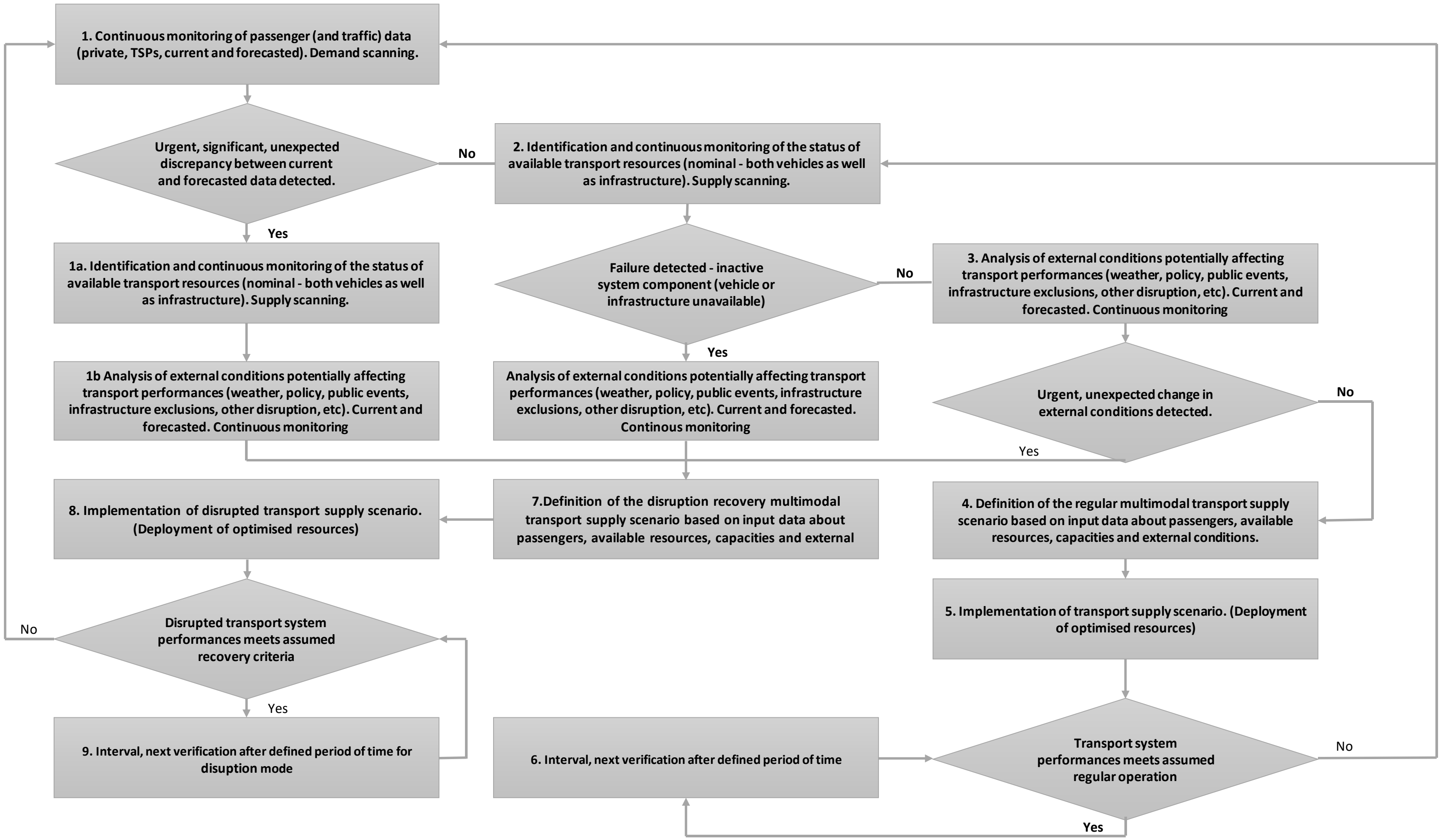

Figure 17 – Algorithm of disruption management of integrated multimodal transport system

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7 Extended ATM Concept of Operations for services to passengers

This section of the document describes the elements of the Concept of Operation and their relationships according to the planned architecture of the intermodal transport system. The time horizons from 2025, 2035 to 2050 considered in the project are differentiated

In addition, the existing and future management systems, instruments and applications for this extended ATM operating concept for services for passengers are taken into account: these include air traffic management, urban air traffic management, traffic management, fleet management, infrastructure management, mobility as a service, security (risk) management/safety management, emergency management / response system, energy management, resource management, baggage and passenger tracking system, booking platform operator, authoritative weather information platform and big data.

Given the nature of the X-TEAM D2D project "eXTEnded AtM for Door2Door travel", the proposed ConOps tries to find solutions for the future without obviously being involved in design work.
The management systems, the tools and of course the “intelligence” of the algorithms, which will become the intermodal system, play a decisive role in achieving the ambitious goal of providing complete traffic management for a door-to-door connection in up to 4 hours manage. The elements are to be viewed in a broad sense, as service tools are also included, for example. While new technologies will improve the means and infrastructures, it is also evident that the functioning of the system depends heavily on the quality of the services.

Since the development of air and traffic technologies, the multimodal mobility should support a total traffic management. Has a corresponding ConOps (Chapter 4) been created for the implementation. In the following, the operating concept for passenger services is presented with regard to the change of ATM, UATM and MaaS over the three identified time horizons (Fig. 17).

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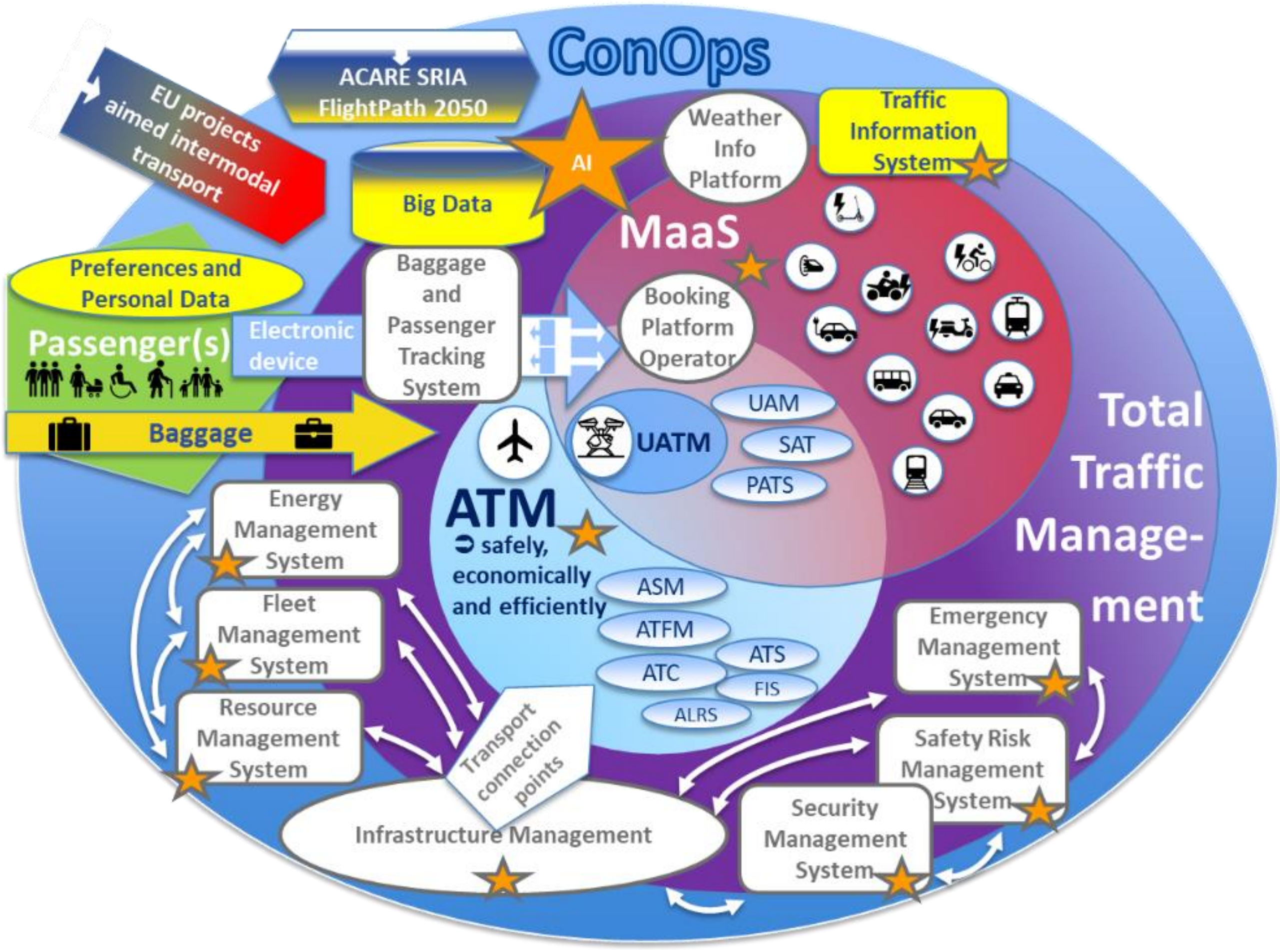

Figure 18 – The ConOps version for the concept status to be considered in the following.

7.1 The 2025 timeframe

In Horizon 2025, the implementation of eVTOLs for UAM operation will take place. Only on some specific routes will UAM be implemented for testing and demonstration purposes. These UAM operations will be managed with procedures and technologies available within the current ATM paradigm (either local or international). New mobility services (NMS), i.e. car sharing, ride-hailing, bike sharing, e-scooters, e-bikes, will gain user interest and take a significant share in the transport system. Some possible services could have an important impact on multimodal mobility. The quality of the services will have a major impact on the achievement of the expected goals. First light MaaS activities (e.g. single ticket, pricing by optimising travel costs of different modes, ticketing interoperability (flexible in case of disruptions) and integrated tickets will be available in some areas. There is still a high level of complexity to integrate the ATM and UTM system.

7.1.1 Architecture outline in the 2025 timeframe

In the immediate future, there is still a lack of tools for the exchange and use of data between the different transport modes, which must also benefit the passenger. The efficiency of the transport process still depends on the passenger's ability to manage their journey. Unfortunately, ATM operations have not yet become passenger-centric, partly because performance targets did not consider the impact on passengers. In addition, the complexity of the ATM network does not allow for the desired response in the event of a disruption. The existing ATM works with a well-established and proven safety management system, but it does not allow for rapid developments and implementations. In contrast, UTM is innovative and fast, but its level of security and robustness is not defined and validated.

The fact that airspace will be shared between manned aircraft and UA when UTM is introduced makes it necessary to identify and confirm the roles of UTM and ATM in terms of airspace and traffic management responsibilities and functions. Although it is likely that these services will need to interact, there must be no overlap of conflicting or incompatible services or areas of responsibility. During horizon 2025, conformance monitoring will rely on currently available Air Traffic Management - Communication, Navigation and Surveillance (ATM CNS) capability as well as ATM and regulatory reporting mechanisms. In Horizon 2025, there will be an opportunity to increase surveillance and communications coverage through additional implementation of systems such as Automatic Dependent Surveillance–Broadcast (ADS–B) and other communications infrastructure. ADS-B does not necessarily scale well with high traffic density, and coverage is possibly insufficient for all phases of flight. Onboard UAM vehicle systems will be able to collect and disseminate additional information that can be used to inform conformance monitoring. However, a data collection system will need to be implemented. It will be necessary to define where and/or under what scenarios Conformance Monitoring will be necessitated during the early phases of Horizon 2025. Scenarios could include adherence to routes in accordance with noise abatement procedures. Conformance Monitoring capabilities established in Horizon 2025 would provide evidence that would support the safety case and/or community acceptance for moving UAM operations to Horizon 2035 (and similarly between Horizon 2035 and 2050). MaaS will only be available in some regional areas for a part of the transport modes. The continuation of the C-ITS strategy for Cooperative Intelligent Transport Systems will promote international cooperation with other major regions of the world on all aspects of cooperative, connected and automated vehicles and will decisively advance further development for a Traffic Information System. Urban transport (light rail, metro, but also trams and regional commuter trains) is still characterised by a highly diversified landscape. At least a certain convergence in architectures and systems can be observed. In some cases, these points are linked to the safety of urban transport systems. In this context, "safety" is seen as anything that deals with the methods and techniques used to prevent accidents. "Security" is concerned with the protection of people and the system from criminal acts. The state of the art has been brought together and extended in harmonised and agreed common security packages. Thus, a coherent and coordinated hazard and risk analysis was established and agreed security requirements were defined for the security-relevant functions of an urban managed transport system. In order to achieve such an allocation of safety requirements, it is necessary to create a functional and object-related safety model of an urban guided transport system.

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European Commission Policy - UAM (ATM integration):

- Initial U-Space services
- Airspace re-configuration
- Capacity on demand service
- Enabling framework for data service providers (ADSP)
- First ADSP certified, advance network operations and services, Simulators
- Specification for ATM Validation Platforms
- First harmonized standards for UAS, first certified UAS in controlled airspace

7.1.2 Main elements of the intermodal system in the 2025 timeframe

The following elements of the intermodal system will be integrated in the 2025 timeframe:

- **Air Traffic Management**:
  - ATM with all components in the known orientation
  - ATM Update under development
  - Level of automation increasing
- **Urban Air Traffic Management**:
  - UATM will only be used for test and demonstration purposes
  - UATM still experimental and object of research
  - At least first levels of U-Space Services implemented
- **Mobility as a Service**:
  - Maas-like elements will only be offered in some regional areas for a part of the transport modes
- **Traffic Information System**:
  - C-ITS strategy is being intensively built up and decisively improved

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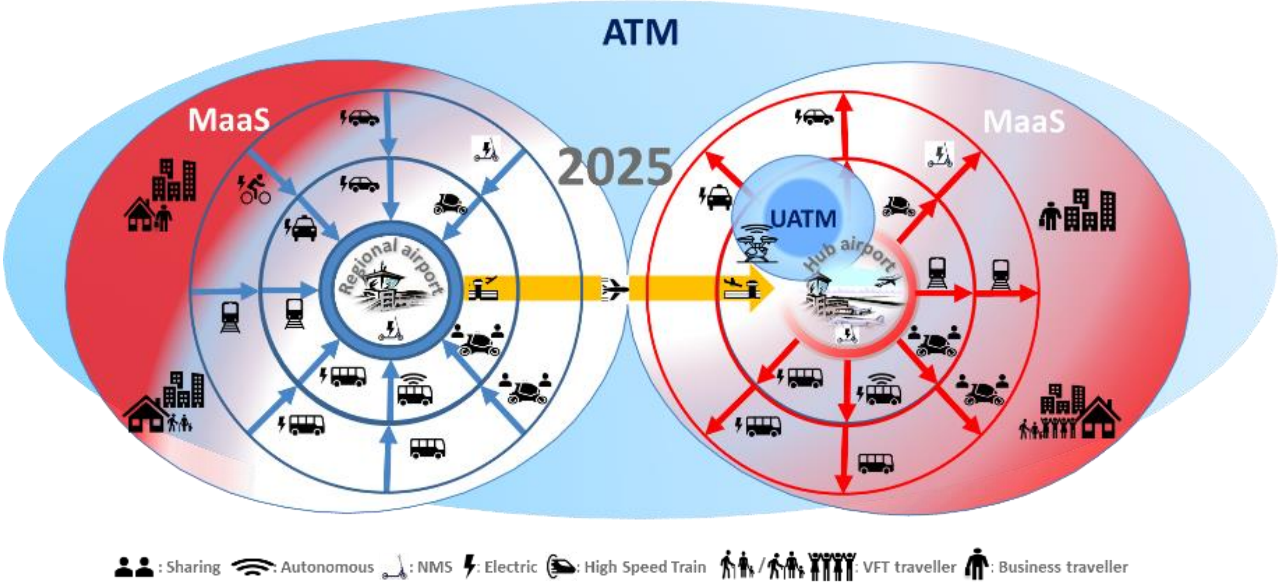

Figure 19 – Time horizon 2025 on the way to total traffic management

7.2 The 2035 timeframe

Horizon 2035 requires new ATM procedures and/or technologies that are not currently used by ATM and will introduce UATM Services to support UAM operations. These services will vary in service type and maturity, from initial procedures and services to full implementation. Horizon 2035 will come quickly in some places due to the inability to reduce Air Traffic Control (ATC) workload using existing means. Trials of new procedures and technologies will be needed during Horizon 2025 to support the case for Horizon 2035 operations.

7.2.1 Architecture outline in the 2035 timeframe

In Horizon 2035, a new ATM model will emerge with the support of new technologies and standards. Fundamental to this will be support for ATM Data Services Providers (ADSP). The terrestrial component of air-to-ground communications will require high bandwidths. The new architecture will allow resource sharing across the network and more stable service delivery to all airspace users.

The Advanced U-Space services will be operational across Europe. In contrast to the time horizon 2025, a passenger preparing for an intermodal journey in 2035 will be able to use a UTM for his or her journey. In Horizon 2035, Conformance Monitoring will provide an ongoing set of information to manage the operational safety risk of UAM operations. There will be an opportunity to increase surveillance and communications coverage for all stakeholders (including the pilot) through the implementation of current and new communications and surveillance infrastructure (e.g. new cooperative surveillance technology).

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European Commission Policy - UAM (ATM integration):

- high level of automation
- U-space testing
- Advance U-Space services
- New ATM data service provision model
- Virtual centres
- Dynamic airspace configuration
- Certified UAS integrated in all classes of airspace
- Airport integrated with UAS and into ATM network

7.2.2 Main elements of the intermodal system in the 2035 timeframe

The following elements of the intermodal system will be integrated in the 2035 timeframe:

- **Air Traffic Management**
  - ATM upgraded to more resilient model
  - ATM data services providers fully operational
  - High bandwidth connection between air to ground
- **Urban Air Traffic Management**
  - UATM will be available in most areas
  - Integration of UAS into all classes of airspace
  - Advanced U-Space services ready
- **Mobility as a Service**
  - Maas elements will be offered in nearly all regional areas in the orgin and destination airport area.
- **Traffic Information System:**
  - C-ITS strategy is being intensively built up and decisively improved

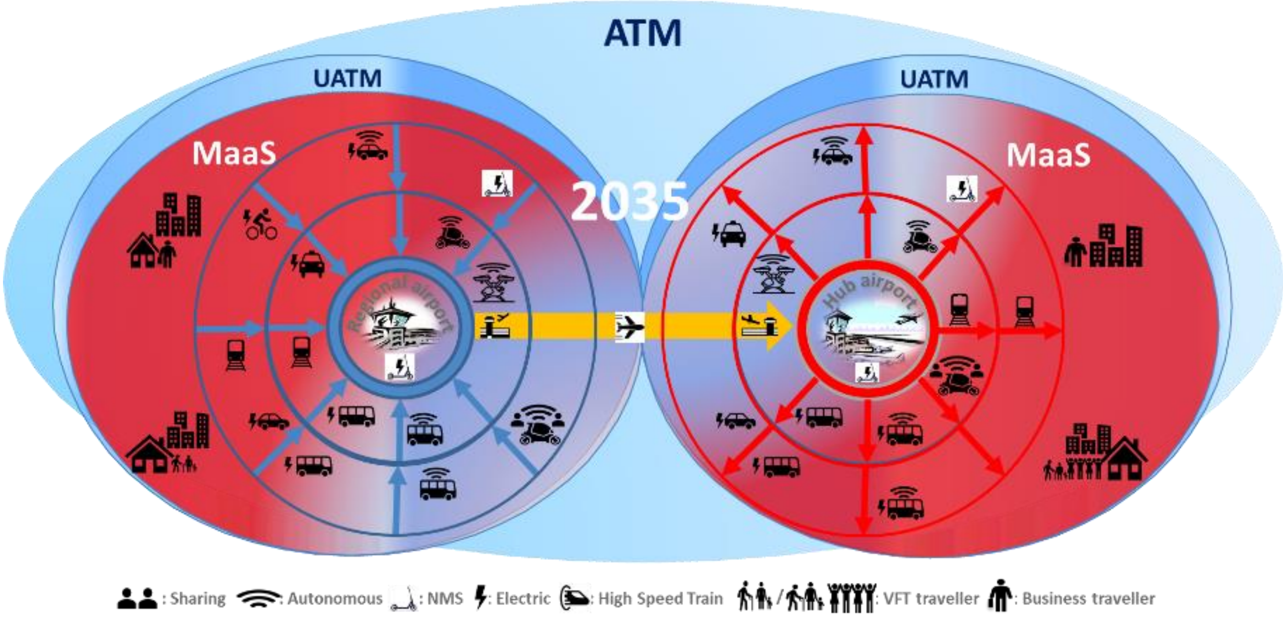

Figure 20 – Time horizon 2035 on the way to total traffic management

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7.3 The 2050 timeframe

For the 2050-time horizon, intermodal travel is characterised by a full range of services. The management systems will bring traffic management to a much higher level. By 2050, about 70 percent of the world population is expected to live in urban areas. That's where urban air mobility can make a significant impact. UAM could transform how people travel.[49]

7.3.1 Architecture outline in the 2050 timeframe

By the 2050-time horizon, a highly automated ATM system with all-weather operation and a safety level above today's will be available. It will be service- and passenger-oriented management, relying on high connectivity, automation and digitalisation.

U-space full services will be available. C-ITS traffic systems will use all aspects of cooperative, connected and automated vehicles. The collected data will bring the traffic information system to an excellent level. In addition, strategic planning of traffic flows will be improved, reducing the imbalance between capacity and demand. Based on accurate and complete data, changes and disruptions can be resolved without loss of travel time.

For the 2050-time horizon, intermodal travel is characterised by a full range of services. The management systems will bring traffic management to a much higher level. Mobility as a Service will be possible for every traveller for a door-door-travel including a flight segment (Figure 20).

European Commission Policy - UAM (ATM integration):

- Digital European Sky
- full U-space services and deployed with shorter lifecycles
- scalable and highly automated ATM
- service-oriented ATM
- trajectory-based operations
- passenger-centric
- multimodality
- zero inefficiencies due to ATM
- Digital Voice communications

[49] Deloitte (2019) Urban Air Mobility Consumer Perceptions.

7.3.2 Main elements of the intermodal system in the 2050 timeframe

The following elements of the intermodal system will be integrated in the 2050 timeframe:

- **Air Traffic Management:**
  - ATM is highly automated
  - ATM is Passenger-centric
  - ATM is services oriented
- **Urban Air Traffic Management:**
  - UAS will avaiable and functional in all areas
  - High level of connectivity and digitalisation
  - All automated functions
  - U-space full services available
- **Mobility as a Service:**
  - Maas will be possible from door-door-travel including the flight segment
- **Traffic Information System:**
  - C-ITS will be fully effective
  - Collected data will bring the system to an excellent level

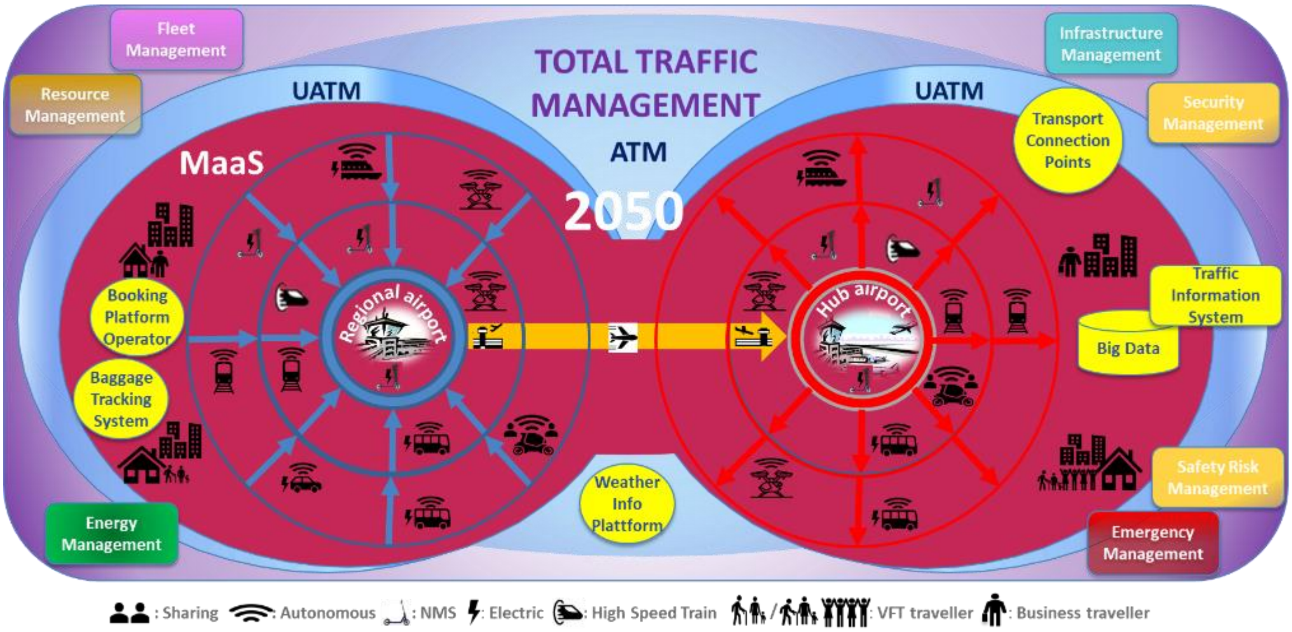

Figure 21 – Concept to Total Traffic Management in time horizon 2050

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8 Preliminary legal, regulatory and economic aspects of mobility information exchange – High level

The intermodality or multimodality[50] definitions cause a lot of confusion when applying the freight logistics terminology to passenger transport. Yet, putting aside the exact definitions, information exchange and its active use among different modes of travel for improving passenger mobility bears several advantages. First step of integration, i.e. combining coordination efforts of SESAR (air transport), ERTMS (rail), SafeSeaNet (sea) and RIS (rivers, canals) has been in agenda for many years since the EU White Paper 2011[51]. Its purpose is reducing stops and delays at system intersections, it improving speed control and travel time as well as capacity and incident management. On roads, one of the initiatives objectives (CCAM[52]) is to enable trustworthy interaction between all road traffic participants which could lead, in a longer perspective, to a road traffic information services (it could be called "RTIS") coordinating automated and human-driven vehicles.

On top of information exchange benefits among other modes, by merging with the potential "RTIS", we could expect not only further synergy, but also mode specific improvements (e.g. occupancy rates in vehicles), as well as legal, regulatory and economic consequences. Further extensions to mobility management (like e.g. UTM - the analysed by XTEAM D2D urban air mobility management or soft modes traffic common management) are potentially important complementary ingredients of a holistic mobility system within mobility-as-a-service framework. Numerous initiatives try to address the challenge and enable benefits (e.g. ATIS, MMPs/MSP, Open Mobility Platform[53], Smart Contracts Framework[54]).

8.1 Information exchange aspects in mobility

Technological and cultural progress called Industry 4.0 enables such advanced digitisation and data analytics. A mature holistic mobility ecosystem would be a part of the end-to-end digitization of the overall

[50] See Definitions for "Multimodality in freight transport" and "Multimodality in passenger transport (not to be confused with multimodality)"

[51] WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system /* COM/2011/0144 final */

[52] Connected Cooperative Automated Mobility (CCAM) – a R&I partnership to accelerate the implementation of innovative CCAM technologies and services in Europe, https://www.ccam.eu/library

[53] ATIS - Advanced Travel Information Systems "are intended to meet travellers' information needs, help them make more informed travel decisions, and moderate the effects of traffic congestion on both themselves and other travellers"; MMPs - multimodal mobility platforms, MSP - Mobility Service Platforms for "services such as carsharing, e-hailing, ridesharing and bikesharing"; Open Mobility Platform - "intermodal mobility service platforms with a special focus on the specification of business model aspects".

[54] See Definitions for "Smart Contracts"

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human activity value chain. Some of the services could, and most probably will be, non-mobility related (e.g. payment systems, monetary incentives, e-heath, e-learning, e-government). See Figure 22

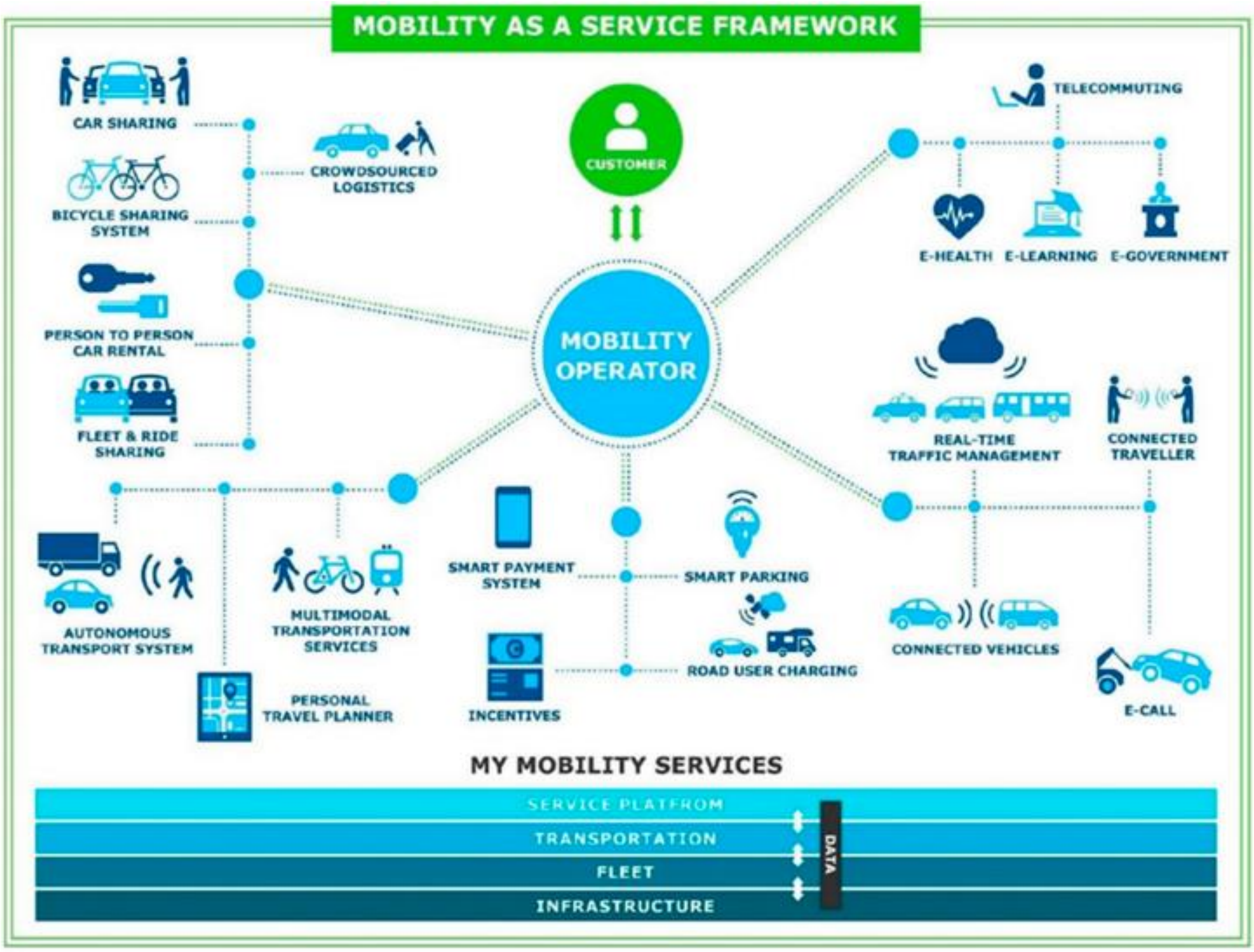

Figure 22 – MaaS framework.[55]

Advantages of the integration heavily depend on common denominator, i.e. quality, openness and, especially, type of mobility data. Poor quality of data disqualifies nearly any automating. The identified by the Tim Berners-Lee five-star deployment scheme[56] characterizes data openness. Type of data is related to its openness and includes: static, historic, instantaneous and predictive data.

- static data

[55] Kivimäki, M. (2014) MaaS-Finland on the leading edge. In Proceedings of the Mobility as a Service Seminar and Networking Event; Ministry of Transport and Communications: Ventaa, Finland, 2014.

[56] 1-star: Data are available on the web in any formats under an open license; 2-star: Data are available as structured data, e.g., using an Excel sheet for a table instead of a scanned image of it; 3-star: Data are available in a non-proprietary open format, e.g., using comma-separated value (CSV) file instead of excel file; 4-star: Uniform Resource Identifier (URI) is used to denote the source of resource that users can easily access; 5-star: Data should be linked to related context.".

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Until recently, mobility information, with certain exceptions, has been static (e.g. about the network distances, speed limits) and siloed. See Figure 23

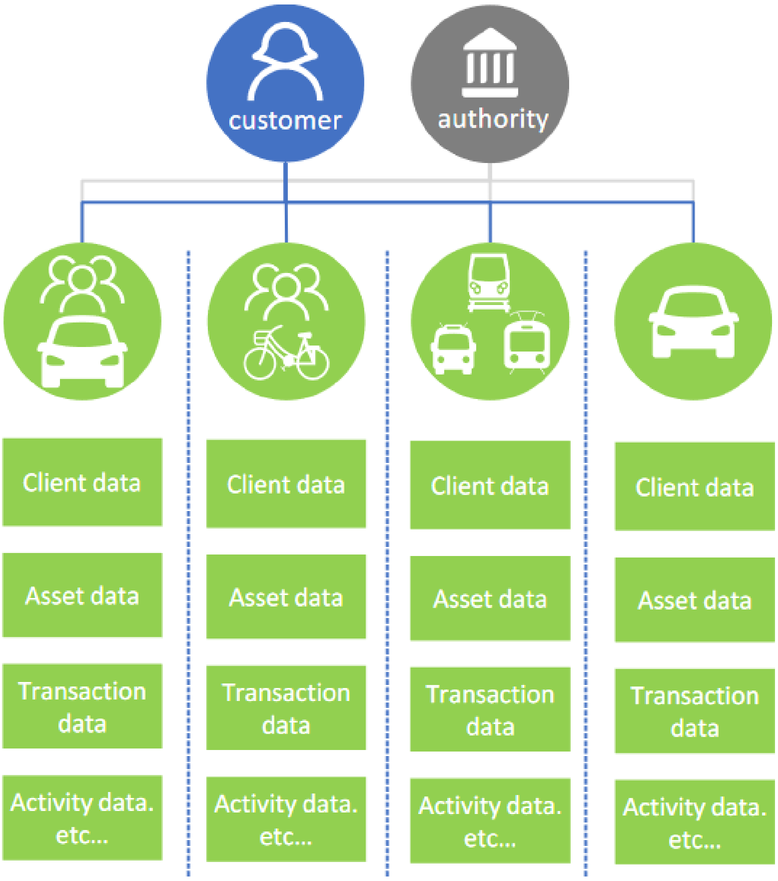

Figure 23 – Traditional, siloed mobility services[57]

All-mode system coordinating was very difficult or hardly feasible, not to mention automating. Analysis of such data could not capture the effects of demand patterns, congestion, energy use or emissions. Information exchange was limited to combining data from infrastructure maps, time schedules or services availability announcements that could help develop some pre-trip or en-route support for users in mainly manual way (paper atlas, static offline electronic map or ticket sale websites).

- historic data

Making available historic data representing past traffic of all modes or collecting travel surveys enables inductive inference, which is typically applied while preparing strategic decisions. Yet, information provided at this level captures, only, the average prevailing traffic conditions. Day-to-day variability that may be caused by fluctuations in demand and by events, such as incidents and maintenance work, is not

[57] Blockchain and Beyond: Encoding 21st Century Transport, OECD/ITF, 2018

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visible. Certain automated recommendations could be given to pre-trip and en-route management phase, but drawing, only, from historic data would be too unreliable to manage the holistic system automatically.

- instantaneous data

Instantaneous data exchange and real-time estimates, in contrast with historic data exchange using e.g. blockchain technology[58] (see Figure 24) offer certain level of improvement and enable automation at a cost of much higher computational requirements. In this case, historic data is also used and real-time information compensates for variability (incidents, maintenance work and other on-going events)[59]. Yet, fully automatic execution of tactical planning of multimodal traffic is limited due to dynamic evolution of events.

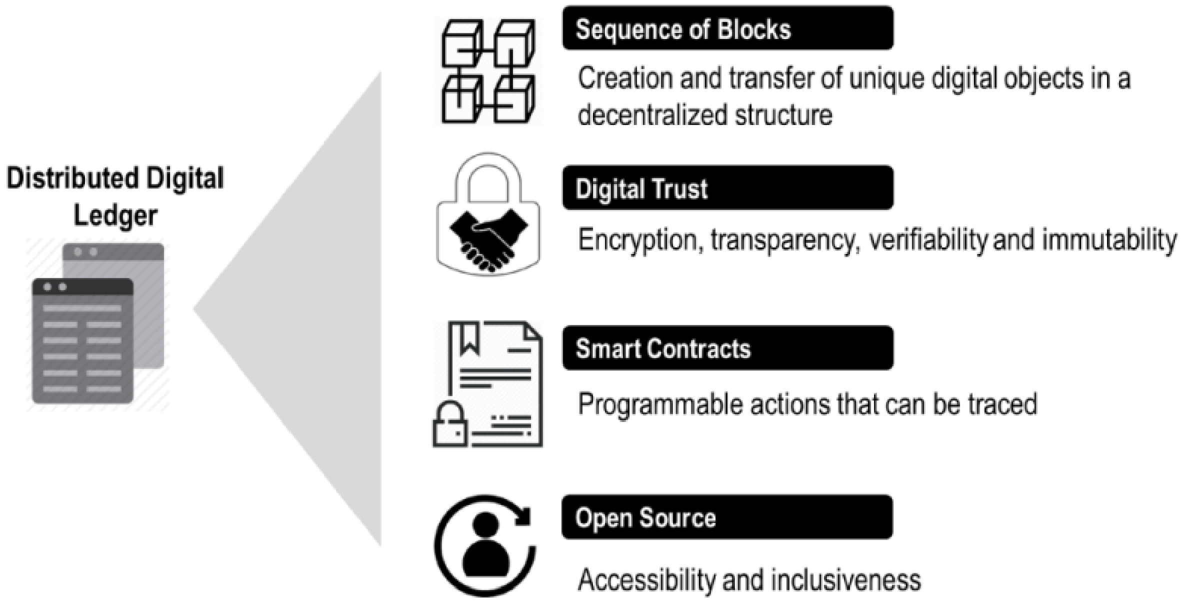

Figure 24 – The Core principles of blockchain technology[60]

- predictive data

Dynamic predictive guidance (or even control) is the final level of information exchange and traffic management enabled by linked systems based on open and standard cloud technologies. Fed by big data streams from different sources that are automatically processed with advanced analytics tools with data fusion capability – from business intelligence to machine learning – predictive guidance enables managing

[58] See Definitions for “Blockchain”.

[59] Real-time data use examples: design public transport networks, estimation of route travel times, model the route choice of bicyclists, travel time prediction, traffic incident and anomaly detection, anticipatory vehicle routing, dynamic congestion charging, demand responsive parking pricing, predicting bus bunching in network using smart card data, analysing trajectories extracted from video data, understanding the volatile behaviours of drivers, self-driving vehicles real-time detecting of traffic signs, predicting crash.

[60] Jean-Paul Rodrigue (2020) The Geography of Transport Systems FIFTH EDITION New York, Routledge, ISBN 978-0-367-36463-2, doi.org/10.4324/9780429346323

all-mode traffic as one system[61]. Yet, human in the loop makes inductive reasoning less reliable even with all data available due to subjectivity of interpreting and the reflexivity[62]. Thus, only full automation of traffic would enable predictive simulations to optimize the integrated mobility system in terms of chosen indicators (e.g. time, costs, emissions, energy use, etc.).

For what concerns passengers' related dimension of MaaS, it should be considered that data sharing should imply a holistic view resulting from a wider data strategy that covers data governance, the data sharing culture and risk assessments, with a broader perspective than the GDPR[63] 's one. In the X-TEAM D2D context, the data strategy should set the foundations not only of how each organization, within the MaaS ecosystem, interacts with data but also how data shared shall be selected to be meaningful to passenger personal (priorities, abilities, etc.) and contextual (purpose of the travel, number of passengers, etc.) characteristics, thus shaping the passenger centeredness of multimodal transport services provision.

A further aspect relevant under passengers' perspective, is the source of data to be integrated, as we should also consider the challenge of integrating data generated by private citizens (playing or not the role of passengers) among the overall data shared by multimodal transport service providers in order to provide more inclusive, and more personalised mobility services (meaning services optimized on the basis of passenger specificities).

8.2 Legal and regulatory aspects information exchange in mobility

The goals for sustainable multimodal transport and multimodality for passengers have been set up in 'The European Green Deal'. There are a lot of amendments needed in the field of standards and regulations in order to achieve these goals. Sustainable and Smart Mobility Strategy – putting European transport on track for the future[64] is supported by Multimodal Passenger Mobility Forum[65] (MPMF). MPMF will be involved in the preparation of policy initiatives in the field of sustainable multimodal mobility for passengers to achieve the goals of 100 climate cities by 2030 (the Strategy and the EU mission on climate-neutral and smart cities). Multimodal Digital Mobility Services have to establish an EU framework to

[61] Current examples of big data technologies in urban planning: a microscopic traffic simulation and its optimization using mobile phone call detail records (Dhaka, Bangladesh), identifying and predicting of frequent patterns of movements from anonymized mobile phone locations to redesign transport network (Abidjan, Ivory Coast), inferring possible paths and estimating travel times of taxi cabs GPS data streams (New York City, USA), identifying mobility patterns of bike-sharing system GPS-data for optimal distribution of bikes (Munich, Germany).

[62] See Definition for "Reflexivity".

[63] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)

[64] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Sustainable and Smart Mobility Strategy – putting European transport on track for the future, COM/2020/789 final; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

[65] COMMISSION DECISION of 3.12.2021 on setting up the Multimodal Passenger Mobility Forum; https://transport.ec.europa.eu/news/call-applications-selection-members-multimodal-passenger-mobility-forum-2021-12-09_de

improve multimodality, inclusiveness and sustainability. The goal for 2022 is to prepare a new proposal to support the development of multimodal digital mobility services, which will be coherent with TAP –TSI and CSR –Code of conduct (aviation).

The Action Plan[66] sets out the goals for i.e. smart mobility - two flagships: making connected and automated multimodal mobility reality (Flagship No 6) and Innovation, data and AI for smart mobility (Flagship No 7) and *indicates areas, where* some improvements are still needed at European level:

FLAGSHIP 6

1. Revise Delegated Regulation 2015/962 on real time traffic information services to extend geographical coverage and datasets; revise Delegated Regulation 2017/1926 on multimodal travel information services to include mandatory accessibility of new dynamic datasets
2. Assess the need for regulatory action on rights and duties of multimodal digital service providers and issue a recommendation to ensure public service contracts do not hamper data sharing and support the development of multimodal ticketing services, together with an initiative on ticketing, including rail ticketing
3. Assess the need for an agency or other body to support safe, smart and sustainable road transport operations[67]
4. Adopt railway technical standards and specifications package on ERTMS/Control-Command and Signalling (CCS); and develop mandatory deployment plans for automatic train operation, automated traffic management and advanced CCS
5. Revision of the Directive on Harmonised River Information Services (RIS)

FLAGSHIP 7

1. Further develop the regulatory framework for drones and unmanned aircraft, including U-Space; adopt a Drone Strategy 2.0
2. Set up a high-level group (‘New Mobility Tech Group’) as a first step toward the development of a coherent EU approach and a set of recommendations on facilitating testing and trials of emerging mobility technologies and solutions in the EU (‘European Mobility Test Beds’)
3. Review the regulatory framework for interoperable data sharing in rail transport (ERTMS, rail telematics applications)
4. Propose the rules on a trusted environment for corridor data exchange to support collaborative logistics

[66] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Sustainable and Smart Mobility Strategy – putting European transport on track for the future Action Plan, 9.12.2020

[67] This action has relevant aspects for flagship 10 in particular.

Urban Mobility Package (UMP) - the coherence with digital EU policy is important for information society services (MaaS platforms, ride-hailing platforms) and urban mobility data sharing.

The two relevant legislative proposals are: Regulation (EU) 2019/1150 on promoting fairness and transparency for business users of online intermediation services and Digital Markets Act[68].

The legislative framework European strategy for data[69] has an increasing relevance to the mobility as the strategy announces a number of measures to be implemented in the coming years.The Data Governance Act will boost data sharing, data availability, data reuse across sectors and EU Member States[70]. The Data Act will harmonised rules on fair access to and use of data ensure fairness by setting up rules regarding the use of data generated by Internet of Things (IoT) devices[71].

Similarly, the governance of common European data spaces[72] and the common European mobility data space will facilitate to cover also the urban mobility field. The sourcing of data is particularly important.[73]

The initiative aims at creating a legislative framework for the governance of common European data spaces. It proposes the following measures (i) to publicly unlock data held for research, which serve the common good, (ii) support voluntary data sharing by citizens ('data altruism') and (iii) set up an EU-level governance structure to prioritise standardisation needs and improve data interoperability[74].

In conclusion, the EU digital policy is an area being intensively and rapidly developing, therefore it is not possible to state that UMP is coherent with it and/or beyond the coherence with the ITS Directive. It will only rise in importance and relevance for the urban mobility sector, in particular, when it comes to the impact of online platforms, indicating the need to ensure more coherence between these two policies in the future. The digital and data-related aspects – many of which are subject to ongoing policy and legislative processes in the EU – will have to be better captured.

Taking into consideration *that* EU wants to be a leader in the blockchain technology[75] the Blockchain strategy put emphasis on: Building a pan-European public services blockchain and European Blockchain Services Infrastructure (EBSI)[76], **Promoting legal certainty,** Promoting blockchain for sustainability;

[68] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en

[69] Commission Communication: A European strategy for data, COM (2020)66 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593073685620&uri=CELEX%3A52020DC0066

[70] mobility data: saving more than 27 million hours of public transport users' time and up to €20 billion a year in labour costs of car drivers thanks to real-time navigation [https://digital-strategy.ec.europa.eu/en/policies/data-governance-act]

[71] Regulation of The European Parliament and of The Council on harmonised rules on fair access to and use of data (Data Act) 2022/0047 (COD) https://digital-strategy.ec.europa.eu/en/policies/data-act;

[72] Opinion of the European Economic and Social Committee on 'Proposal for a Regulation of the European Parliament and of the Council on European data governance (Data Governance Act)' (COM (2020) 767 final) EESC 2020/05545 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020AE5545

[73] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021SC0047

[74] Legislative framework for the governance of common European data spaces https://eur-lex.europa.eu/legal-content/PL/PIN/?uri=COM:2020:767:FINOn-going procedure

[75] https://digital-strategy.ec.europa.eu/en/news/overview-eu-funded-blockchain-related-projects

[76] The European Blockchain Services Infrastructure (EBSI) is a blockchain based infrastructure currently piloted in cooperation with the European Blockchain Partnership (EBP). Since 2020, EBSI is deploying a network of distributed nodes across Europe, supporting applications for selected use-cases.

Supporting interoperability and standards (e.g. ISO TC 307, ETSI ISG PDL, CEN-CENELEC JTC19 and IEEE and in ITU-T)

The EU recognizes the potential of blockchain and supports the use of blockchain technology in fostering sustainable economic development, addressing climate change, and supporting the European Green New Deal77.

The Urban Mobility Package has not yet managed to bridge the gap in translating EU-level policy on sustainable urban mobility to tangible national action. As a result a very divergent situation with regard to national SUMP frameworks and related support to cities in designing, financing and implementing of their local mobility plans and measures can be observed.

According to the eveluation of the UMP:

- there is a general lack of systematically collected, comprehensive, coherent, gender disaggregated and comparable data, at the city level in the EU (for example on the use of active modes, motorised or public transport, length of trips, etc.). This makes the progress of tracking and comparison very challenging, and risks to undermine policy making at European, national and local levels of government. Currently, there is no legal basis (i.e. no requirement) for the Member States, to report data on urban mobility to the European Commission.

- high quality data are instrumental in identifying trends, evaluating the impact of locally implemented urban mobility measures and planning future policy. That is not possible to achieved without reliable mobility development data delivered by Member States.

The Directive 2010/40/EU[78] on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport will be revised to maximise the benefits of emerging ITS solutions, including in the fields of C-ITS, CCAM and MaaS.

In order to tackle the potential shortcomings of the current regulatory framework for ITS, the two documents have been elaborated: Draft of the Commission Delegated Regulation on the provision of EU-wide multimodal travel information services and Specifications for the provision of cooperative intelligent transport systems (C-ITS).

The delegated Regulation (EU) 2017/192679, which supports the development of multimodal travel information services (the accessibility, exchange and reuse of static travel and traffic information data) from the legal perspective, however there is still a lack of services facilitating payment and booking. The emphasis is put on lack of cooperation in the market and complexity of transportation system, in which the digital mobility services and access to information are limited. The revision of Commission Delegated

[77] https://digital-strategy.ec.europa.eu/en/policies/blockchain-strategy

[78] Opinion of the European Economic and Social Committee on 'Proposal for a Regulation of the European Parliament and of the Council on European data governance (Data Governance Act)' (COM(2020) 767 final) EESC 2020/05545 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020AE5545

[79] Commission Delegated Regulation (EU) 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide multimodal travel information services (OJ L 272, 21.10.2017)

Regulation (EU) 2017/1926[80] with regard to the provision of EU-wide multimodal travel information services indicated the need of establishing of the necessary measures to ensure that multimodal travel information services are accurate and available across borders to the users and include mandatory accessibility of new dynamic datasets.

Delegated Regulation 2015/962 on the provision of real-time traffic information services provision of EU-wide real-time traffic information services. The objective of Revision of Delegated Regulation 2015/962 on the provision of real-time traffic information services provision of EU-wide real-time traffic information services is further facilitation of the exchange and reuse of data needed for the development of real-time traffic information services in order to extend geographical coverage and datasets81.

That may be the most challenging task to forecast a new law regulation, which can be suitable for emerging trends. In general, the Multimodal Digital Mobility Services will be optimised to be coherent with TAP –TSI and CSR – Code of conduct. Optimising of the MDMS and Multimodal Interchange Nods (MID) have to facilitate the passenger transport (interurban, suburban and urban) by giving a common and transparent rules of interoperability, common or integrated pricing system, harmonization of safety and regulatory standards, internet of Logistic and data-crunching capabilities. Future regulation should be comprehensive, flexible and prone to embrace new technologies and resulting legal issues.

Mobility as a service (MaaS), which is the growing trend, will boost after establishing a single law of data exchange across the EU (and further development beyond the EU geographic area). Between operators and multimodal digital mobility services, while establishing safeguards to ensure that these new services underpin the transport policy objectives outlined in the Commission's Communication 'The European Green Deal', is essential to shift more activity towards more sustainable transport modes and seamless multimodality for passengers.

In the aspects of data exchange, blockchain may be the crucial technology that can revolutionize transport and mobility through the new way of sharing information and carrying out transactions online.

Under the passenger's point of view, it has to be considered that multimodal journeys including air travel legs imply the management of passengers' identity. Covid-19 has somehow forced the air travel sector to use technologies including biometrics, AI and digital identity management to ensure a 'contactless' provision of services, such as self-check in, drop-off, automated identity verification etc. to reduce the risk of spreading pathogens. In long term scenarios, the sought of the seamless travel experience might lead to the consolidated use of personal identification technologies, including biometrics, which are of particular concern for passengers.

Regulation principles in this field are still at a very early and controversial stage of development, being ethical issues and fundamental human rights tackled by the use of passenger identity systems under development. The core legislative act for biometric data is the General Data Protection Regulation (GDPR).

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[80] Commission Delegated Regulation (EU) 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide multimodal travel information services (OJ L 272, 21.10.2017) https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX%3A02017R1926-20171021

[81] relating to the proposal for a Regulation of the European Parliament and of the Council amending Regulation (EC) 261/2004 establishing common rules on compensation and assistance to passengers in the event of denied boarding and of cancellation or long delay of flights and Regulation (EC) 2027/97 on air carrier liability in respect of the carriage of passengers and their baggage by air in chronological order.

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GDPR does not provide clear rules but provides principles for a subjective and use-based approach for Member States as they are not technically forbidden to process biometric data, but maintain the right to adopt, modify or introduce more specific national rules and ensure their enforcement.

GDPR applies to many other personal data: type, granularity and sensitivity of data provided by passengers to enable highly personalized travel services are expected to increase over the time (as is the case of physical or cognitive abilities/needs, payment system for single ticketing, etc.). Delivering a seamless travel experience to passengers will then require significant sharing of personal data, in real-time, between transport operators; in case of personal information, where consent is not practical, a key issue will be whether the data can be de-identified at source. De-identification could be especially challenging given the significant level of data sharing that must occur between organizations, and the instantaneous manner in which it is collected. Nonetheless, passengers tend to appreciate their personal, even sensitive, data sharing if this can lead to a more satisfying Door to Door journey, making the travel easier, cheaper, more comfortable and pleasant. In this framework, regulation will get increasing relevance in building a trusted framework for passengers' data exchange, to provide high value travel services.

Finally, innovations using big data, artificial intelligence and machine learning will gain an increasing role in door to door journeys, to dynamically adapt travel paths and information provision to passengers' specific characteristics. Also, in the field of Artificial Intelligence, passengers concern and fundamental rights need to be accommodated into an appropriate regulatory framework. In April 2021, the European Commission proposed a regulation laying down harmonised rules on artificial intelligence, the Artificial Intelligence Act, aiming at addressing risks of specific uses of AI, recognizing that the same elements and techniques that power the socio-economic benefits of AI can also bring about new risks or negative consequences for individuals or the society. The EU is committed to strive for a balanced approach, to ensure that Europeans can benefit from new technologies developed and functioning according to Union values, fundamental rights and principle, categorizing 4 different levels of risk: unacceptable risk, high risk, limited risk, and minimal risk. In fact, the proposal sets harmonised rules for the development, placement on the market and use of AI systems in the Union following a proportionate risk-based approach. It proposes a single future-proof definition of AI. Certain particularly harmful AI practices are prohibited as contravening Union values, while specific restrictions and safeguards are proposed in relation to certain uses of remote biometric identification systems for the purpose of law enforcement. The proposal lays down a solid risk methodology to define "high-risk" AI systems that pose significant risks to the health and safety or fundamental rights of persons. Those AI systems will have to comply with a set of horizontal mandatory requirements for trustworthy AI and follow conformity assessment procedures before those systems can be placed on the Union market. Predictable, proportionate and clear obligations are also placed on providers and users of those systems to ensure safety and respect of existing legislation protecting fundamental rights throughout the whole AI systems' lifecycle. For some specific AI systems, only minimum transparency obligations are proposed, in particular when chatbots or 'deep fakes' are used.

The proposed rules will be enforced through a governance system at Member States level, building on already existing structures, and a cooperation mechanism at Union level with the establishment of a European Artificial Intelligence Board.

In the context of definition of regulation and requirements for AI application, also the European Ethics Guidelines for Trustworthy Artificial Intelligence (AI) will apply and will have a key role in developing a passenger–centred Door to Door mobility. This is a document prepared by the High-Level Expert Group on Artificial Intelligence (AI HLEG), an independent expert group set up by the European Commission in June 2018. Based on fundamental rights and ethical principles, the Guidelines list seven key requirements that AI systems should meet in order to be trustworthy:

- Human agency and oversight
- Technical robustness and safety
- Privacy and Data governance
- Transparency
- Diversity, non-discrimination and fairness
- Societal and environmental well-being
- Accountability.

8.3 Economic opportunities of information exchange in mobility

What may be the economic advantages/benefits of a multimodal or intermodal integrated approach in which ATM (Air Transport Management) takes an important role, over a fragmented one? In the X-TEAM D2D project, the multimodal/intermodal integrated approach has been specified through three scenarios at 2025-2035 and 2050, each one with a different (gradual) penetration of ATM and UAM services and a given level of integration with other transport modes (Use Cases[82]).

The three Use Cases are “ATM-centered” (i.e. including an important role of ATM in multimodal transport in all scenarios) and, at 2050, with a most important role of UAM transport services. In general, the assumptions are based on irregular multimodal travels (other than i.e. daily travel to work or school).

More specifically, Table 7 summarises the characteristics of the three Use Cases in terms of ATM and UAM services, their integration with other transport modes and the development of other transport and mobility services.

[82] See for details, X-TEAM D2D “D2.1 Future Reference Scenarios and Barriers”

Table 7 - Characteristics of the three ATM/UAM scenarios

	2025	2035	2050
ATM/UAM services	Electric vertical take-off and landing aircraft (eVTOL) for UAM operation occur only episodically. Only on some specific routes, UAM is implemented for testing and demonstration purposes.	New ATM procedures and/or technologies are introduced, including new Urban Air Traffic Management (UATM) Services to support UAM operations. As consequence, new ATM model emerge with the support of new technologies and standards. UAM starts to emerge.	Urban Air Mobility (UAM) dedicated to passenger transport will be available in Europe offering direct access to densely populated city areas. However, UAM will not gain significant impact on mobility in metropolitan areas but will be considered as important and often necessary from social interest point of view.
Integration of ATM/UAM with other transport modes	There is still a high level of difficulty to integrate ATM and U-Space system.	Hub airport is connected with the city by numerous modes (dominating is collective transport means train, bus connections,).	Hub airport is connected with the city by numerous collective, autonomous transport modes, complemented by electric (autonomous) car-sharing services
Development of other transport and mobility services	New mobility services (NMS), i.e. car-sharing, ride-hailing, bike-sharing, e-scooters, e-bikes, start to gain user interest and take a significant share in the transport system.	Electric shared cars or NMS services, including e-bikes or e-scooters, are commonly used as airport cities develop (depending on the location and size of the airport).	For the 2050-time horizon, intermodal travel is characterised by a full range of services. Intercity traffic will be supplied by high-speed rail transport, CCAM (connected, cooperative, automated mobility) and zero-emission large aircraft.

Looking at the economic aspects, the assessment of benefits from multimodal/intermodal passenger transport vs fragmented options may be subjected to a wide array of indicators and domains. According to a critical literature review on approaches and indicators in the matter, the comparison between intermodal passenger transport and fragmented solutions discloses a wider array of benefits, as showed in Table 8.

Table 8 - Comparison between fragmented and intermodal passenger transport options[83]

Benefits	Fragmented transport chain	Intermodal passenger transport
Quality of other modes		
convenience, comfort, safety and affordability of walking, cycling, commuting on public transport	Considers public transit speed but not comfort. Non-motorised access is often ignored.	Multi-modal performance indicators that account for convenience, comfort, safety, affordability and integration
Transport network connectivity		
density of connections between paths, roads and modes, and therefore the directness of travel between destinations	Traffic network models consider regional road and transit networks but often ignore local streets, non-motorised networks, and intermodal connections	Fine-grained analysis of path and road network connectivity, and connections between modes, such as the ease of walking and biking to transit stations
Land use accessibility		
development density and mix, and therefore travel distances	Often ignored. Some integrated models consider some land use factors	Fine-grained analysis of how land use factors affect accessibility by various modes

From an economic perspective, the economic opportunities resulting from the comparison "quality of other modes" and "transport network connectivity". The economic opportunities arising from a different land use accessibility are more uncertain.

In the former component, the intermodal passenger transport is able to improve convenience, comfort, safety, affordability and integration, thanks to the wider availability of transport services, which are usually overlooked in fragmented transportation options (usually solely focussed on speed).

As showed in the characteristics of the three ATM/UAM intermodal transport scenarios, the intermodal/multimodal passenger transport focuses on the optimisation of the multimodal travel experience, in terms of more efficiency and quality, both with reference to passengers and to the overall transport system, particularly in 2050, when the full operational benefits of multimodal transport are displayed.

[83] Litman, T., Towards More Comprehensive Multi-modal Transport Evaluation, in: Journeys (September 2013), https://www.vtpi.org/JOURNEYS_2013.pdf

The economic implications of these characteristics are evident:

- better value for money and willingness to pay for passengers (business and non-business segments), that during the intermodal transport can benefit of diminishing travel time (better management of disruptions), better comfort, additional transport services and in general higher level of safety and security;
- increase of revenues for new mobility shared services, that play an important role in making the interconnections among transport modes possible (e.g. between airport and rail station), in an environmental-friendly framework (e.g. electric vehicles);
- higher demand of technological and digital applications, e.g. sensors, data mining applications, travel planners, etc, which could represent a strong economic stimulus for the entire information and technology sector.

In the latter component (transport network connectivity), the economic opportunities of intermodal passenger transport vs fragmented options basically stem from the likely higher travel volumes, thanks to the higher accessibility of intermodal transportation options, both geographically (e.g. involving remote and rural areas) and with reference to the passenger's profiles, e.g. elderly, persons with disabilities, etc.

The economic opportunities of higher connectivity and accessibility may address the territorial local development, e.g. more connectivity leading to the development of new activities (e.g. tourism and housing) before not possible due to lack of connections[84]. Furthermore, economic opportunities may also arise from healthier styles of life and wellness (savings in health care), stimulated by multimodal/intermodal solutions that are going to increase active or soft modes, e.g. walking and cycling, and in general a better quality of life of travellers.

[84] However, it should be considered that in some specific cases, the development of new connections may simply shift the existing traffic flows from a given O/D to another.

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9 Summary and conclusions

The following is a brief summary of what was covered in the document and the conclusions drawn.

In the chapter "Operational Service Context Description", an introduction to air traffic management and current extensions as well as Urban Air Mobility for the design of ConOps was given. It was shown that the improvement of products and services as a prerequisite for economic success in the market means an increased need for efficient management systems. It was discussed that quality, safety and management systems represent a modern form of work organisation and company management, which should also have important functions in the transport sector. To this end, the components for possible management systems proposed for the creation of the Concept of Operations for ATM services for passengers in intermodal transport were presented (e.g. urban traffic management, fleet management, infrastructure management, mobility as a service, security (risk) management/safety management system, emergency management/response system, energy management systems, resource management system, baggage and passenger tracking system, booking platform operator and authoritative weather information platform).

The approach for these ConOps is based on a model operational concept for Urban Air Mobility (UAM) and Urban Air Traffic Management (UATM) where "Mobility as a Service" should be a decisive factor and the passengers with their preferences and optional baggage for a door-to-door journey are at the centre. The mobility of the future will be digitally networked and will provide individual, tailor-made mobility service offers. Artificial intelligence (AI) can make an important contribution here, on the one hand by being able to relieve infrastructure, the environment and resources in a sustainable and efficient way, and on the other by guiding travellers to their destinations in a time-saving and flexible manner. All this conveniently with the intelligent travel assistant as a travel terminal on the smartphone or on the laptop: combine different modes of transport with each other, plan optimally and, if desired, book them straight away. And as a further advantage: the intelligent travel assistant learns something new every time, so that personal preferences can be automatically considered when planning the next trip. However, the decisive factor for the use of such a travel assistant is how the handling of the data generated along the mobility service chain is regulated and guaranteed with regard to IT security and data protection.

In the chapter on the analysis of D2D mobility demand in the urban and extended urban and regional passenger-centred scenarios, it was shown that it is a complex task which combination of travel options and modes is actually preferred by customers. It was shown that each variable may be of different relevance or priority depending on the specific passenger profile. When planning and making a journey, passengers have different needs and priorities to meet. Several components, such as the purpose of the trip, the social composition of the travellers and the duration, whose interrelationships influence the final decisions were closely analysed. It is assumed that these needs and characteristics affect the tasks and decisions as well as the expectations of the quality of transport services. The analyses have confirmed, among other things, that traditional and well-known factors such as cost (price) and time efficiency, combined with flexibility and quality of the service offered, are among the most important factors influencing the choice of travel mode.

In the chapter on technological enablers it was shown that the defined system must be limited in terms of the resources available, the number of transport modes, the number of vehicles as well as the passenger and operational area and the number of interfaces (e.g. to other transport systems). The limitations may arise when certain components are integrated into the system that affect the level of digitalisation and automation. Problem to the computing power are seen in the foreseen amount of data to be managed, as

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they are very large and require specific solutions in the field of information technologies. Furthermore, the application of the presented solution requires a developed transport network with a range of available transport alternatives in the different modes.

In the Chapter 8, we considered high level aspects of mobility information exchange. It is clear that intensifying and disruptively improving process of data exchange between various stakeholders of mobility creates revolutionary progress in the area of multimodal efficiency. Human capabilities of data processing are inferior to machine, moreover, the circularity relationship between cause and effect is a typical problem in human agent generated data processing. Thus, to cross a certain threshold of efficiency, a complete automating of mobility operations and management is inevitable. The deeper automating and integrating, the higher need for accurate predictive data. At the same time, the deeper automating and integrating, the lower variability of data. Thus, climbing the Tim Berners-Lee five-star scheme of data openness and, at the same time, implementing advanced data exchange technologies (e.g. blockchain) together with automating of transport processes, are considered as main factors enabling further personalising of mobility, as well as increasing efficiency and sustainability. Multilevel benefits of integration are known and pursued as the EU policy objectives. From the passenger perspective – services are expected to be better adapted to her/his personal needs. At the systemic level – a consolidated management of services would result in substantial economic benefits (better value, increased revenues and higher demand). Yet, there are significant challenges related to the regulations and law with regard to data collecting, sharing and processing. The emerging long-term changes seem radical and they will not be limited to mobility systems. Both, at the technological and at the societal level, policymakers are considering current and have to consider potential ramifications of the change to secure the processes, respecting equal access, respecting privacy and all other rights.

Furthermore, the following conclusions can be drawn from the research:

- A high level of adaptability to a changing demand for transport services would allow to respond to disruptions. Internal disruptions should be mitigated quickly to ensure efficient long-distance transport within the multimodal urban transport system.
- Data from passenger terminals (both for long-distance rail, bus or air transport) should be available to the multimodal urban transport management system to reduce disruptions or delays in long-distance modes.

The management systems described in this document are intended to provide opportunities for total traffic management in the future. A Future Traffic management must meet a number of important requirements as it continues to develop:

- Traffic management of the future must respond more flexibly to changes in supply and demand
- Measures must be coordinated and deployed across networks
- Traffic management must be proactive and can serve to achieve a number of policy objectives
- Parties from the private and public sectors and research/education institutions need to strengthen their cooperation

Only then can we continue to make transport management a constructive contribution to the quality of the transport system. With the advent of more data, better forecasting models and smarter approaches to network-wide management, progress can be made towards proactive Total Traffic Management. In practice, this means preventing peaks and better distributing flow across the network, regulating inflow at certain vulnerable points on the network - all before problems really start. In order to steer traffic management in the right direction, stronger management in various areas will be required in the future than is the case today.

Traffic management must be part of an integrated approach in which traffic management takes its place alongside fleet management, infrastructure planning and resource management. For example, if it is necessary to influence travel demand to enable effective traffic management, this needs to be coordinated with fleet management measures aimed at influencing the number of trips in an area or on a particular route. Shifting to other modes of transport can also help. Linking, for example, traffic management with infrastructure management is important and can influence at the strategic level. A well-planned and managed network is the basis for effective traffic management. For example, considering traffic volumes across the network can help develop an understanding of where flexible measures are needed.

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10 Appendix

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X-TEAM D2D Passengers Advisory Group

Interviews Report

Interview to Fondazione Legambiente Italia (08/06/2021)

Scope	Discussion structure	Answers
Assess D2D mobility demand in extended urban and regional scenarios (2025, 2035, 2050)	Are passengers' trends realistic?	<u>Trends for 2025</u> • In 2025, it is likely that the COVID-19 impacts will still be operating, but in general the post COVID will not change the basic pre-COVID trends. For example, with reference to the electrification, it is likely that the medium EV will be convenient. • On the other hand, micro mobility and shared economy (already operating) will still be valid after COVID and are still operating. • It can be said that the problems in multimodality and interconnections (area of Naples) the problems will remain, unless policy will change the situation radically. The interplay of technology, the supply of new services and policy will shape the post COVID and the capability to take stock of the additional resources from the European Recovery plan. Taking stock of the best practices will be important: new services, new vehicles, etc… • Time factor in 2025: is still a cost? Yes, time has always been a component, together costs and comfort. Culture may shape the combination of the factors, and the decision about what transport mean to be used. If I take car despite the costs, it is because the generalised costs (including time) tend to support the use of car anyway. Looking at the policy side: restrictive circulation policies, banning dirtier Euro class, etc, may change the choice (the mix of transport means), moving the decisions towards more sustainable ways. <u>Trends for 2035</u> • We consider in 2035 that technological development determines the full control of the trip. Is that right? Yes, not just in 2035, but just nowadays, the ITC services provide the potential solutions. What is missing is the overall organisation of the transport means, that makes intermodality happens.

Scope	Discussion structure	Answers
		Information is available, but the public service is not smart or flexible. It is possible that the users will become smarter, taking stock of the potential services and capabilities offered. It is considered that in 2035 we will not benefit of a full CAM (a part maybe in the fright sector) Trends for 2050 • CAM if they are available, which implications from a social and mobility point of view? • Which type of vehicle will circulate in 2050? Maybe not vehicles as we are used to consider them now. They will be more efficient, probably not so heavy, e.g., using hydrogen will still be an efficient solution? It is likely that smaller and lighter vehicles will be the usual way of moving, e.g., motorbikes. In conclusion, looking at 2050, we will have different vehicles, depending on trip purpose, therefore more flexible and diversified. It is also likely that sharing will be the norm and ownership will not.
	What would you add to complete the description of business passenger demand?	
	What would you add to complete the description of VFT passenger demand?	Concerning population ageing, what implications on demand? It may be said that population ageing is still a problem, that maybe in 2030 will represent an issue. In the long run, 2050, the long trend (population shrinking) may offset the overall mobility (and demand).
Identify possible future barriers to passenger needs and expectations	Do you see any missing obstacle or barrier in passengers needs satisfaction within the X-TEAM D2D scenarios?	We believe that social divide is deemed to increase (new expensive mobility services): is that true? Yes, right now social problems do exist. In Milan, for example, targeted and dedicated supply policies (new services, sharing mobility) have been able to make population moving even during the COVID (the same for commuter and hinterland). It seems that social issue is not just economic divide (rich and poor), but between efficient and inefficient policy (good and bad administration). The example of Naples leads to the same conclusions: if well administered (provision of public services, metro and sharing services, which can improve intermodality) the results may be positive.

Scope	Discussion structure	Answers
	Do you see specific group of citizens that would benefit from X-TEAM D2D scenarios but are at risk of exclusion?	
	What can be done to enlarge the number/groups of citizens benefiting from UAM integration in urban mobility?	In conclusion, in the next future, flexibility of public transport supply and services will be the topic: because mobility is becoming fragmented and not systematic. The nowadays mobility patters is not systematic (the smart working may reinforce this trend) and it will be so in the future. Integration of different mobility solutions will be necessary (public and private, shared and not). If an appropriate urban redesign may support the current trend, cities will become liveable.
	Is poor trust in automation a potential issue in door to door journeys?	
Assess the credibility of passenger profiles (per years different nature of possible door-to-door travels (2025, 2035, 2050)	Is the description of BT characteristics complete? What is missing? (per time horizons)	
	Are the priorities and the criteria for choice among alternatives for BT credible?	
	Is there some other decision criteria to be considered for BT?	Rather than looking at 2050, the key policies must be implemented now: technologies will be available, even if in the air sector technologies will probably not be decisive.
	Is the description of VFT characteristics complete? What is missing? (per time horizons)	
	Are the priorities and the criteria for choice among alternatives for VFT credible?	

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Scope	Discussion structure	Answers
	Is there some other decision criteria to be considered for VFT?	
Assess intermodal air transportation service requirements with respect to personal passengers needs	Do the requirements match the needs and rights of any possible passenger?	
	Are there additional requirements that you wold like to add in order to offer a better door to door travel experience?	
Assess intermodal air transportation service requirements with respect to societal and individual core value	Are the inclusion and equity principles implemented by the proposed requirements?	
	Are there new emerging or reinforcing values that should be better considered? Can you provide an example?	

Interview to POLIS (21.06.2021)

Scope	Discussion structure	Answers
Assess D2D mobility demand in extended urban and regional scenarios (2025, 2035, 2050)	Are passengers' trends realistic?	<u>Trends for 2025</u> • In 2025, it is likely that the COVID-19 impacts will be recovered. Some effects will still exist in next 1-2 years, with increasing congestion and use of private mobility. • In the multimodal world there will be an impressive shift towards cycling and similar modalities.

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Scope	Discussion structure	Answers
		• A lot of progress on payments, information and integrated ticketing, even before 2025 (EU Directive on ITS). • Role of travel time is still important, as perceived as a cost. Trends for 2035 • We consider in 2035 that technological development determines the full control of the trip. Is that right? Yes, not just in 2035, but just nowadays, the ITC services provide the potential solutions. What is missing is the overall organisation of the transport means, that makes intermodality happening. And, in particular, the role or policies to promote flexibility and to exploit the added value of ICT. • Increased important of climate change influencing choice of travellers. Much more regulated system, no matters if travellers care or not about environment. Legislation will make it as binding. Trends for 2050 • CAM if they are available, which implications from a social and mobility point of view? 2050 as reasonable timing to have CAM largely deployed in different sectors (and both for passengers and freight). • Potential issues are on modalities for deployment for CAV, either in an integrated and linked way or in a completely independent and atomic manner.
	What would you add to complete the description of business passenger demand?	
	What would you add to complete the description of VFT passenger demand?	
Identify possible future barriers to passenger needs and expectations	Do you see any missing obstacle or barrier in passengers needs satisfaction within the X-TEAM D2D scenarios?	• There are possibilities that social divide will increase more in the future. • Public transport and cycling are the modalities to keep equality functioning. Moreover, in some

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Scope	Discussion structure	Answers
		cases, public authorities can proceed with financing MAAS in an individual perspective. • There is a divide between rural and metropolitan areas. • CAM can help for certain segments (e.g., rural areas), but the social divide is to take into strong consideration. • UAM is a modality potentially increasing inequalities, as being applicable only for few and wealthy ones (while spreading externalities among all, e.g., noise, security requirements, etc.). It should be applied only for very high added value services (not pizza delivery!). For example, it could be useful in remote areas (e.g., defibrillator in mountain areas).
	Do you see specific group of citizens that would benefit from X-TEAM D2D scenarios but are at risk of exclusion?	
	What can be done to enlarge the number/groups of citizens benefiting from UAM integration in urban mobility?	From social point of view, CAM can favour certain segments of the population (elderly, disables, etc.). It is also possible that new market segments may arise, e.g., working migrants, wanting to go back home after working abroad: the new possibilities from CAM might make that possible. On the other hand, affordability for these segments is not necessarily liked to CAM, as they could exploit more, e.g., public transport.
	Is poor trust in automation a potential issue in door to door journeys?	
Assess the credibility of passenger profiles (per years different nature of possible door-to-door travels (2025, 2035, 2050)	Is the description of BT characteristics complete? What is missing? (per time horizons)	The real integration needs to consider the different requirements of the passengers, before, during and once the destination reached (who, where and for what).
	Are the priorities and the criteria for choice among alternatives for BT credible?	

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Scope	Discussion structure	Answers
	Is there some other decision criteria to be considered for BT?	
	Is the description of VFT characteristics complete? What is missing? (per time horizons)	
	Are the priorities and the criteria for choice among alternatives for VFT credible?	
	Is there some other decision criteria to be considered for VFT?	
Assess intermodal air transportation service requirements with respect to personal passengers needs	Do the requirements match the needs and rights of any possible passenger?	
	Are there additional requirements that you wold like to add in order to offer a better door to door travel experience?	
Assess intermodal air transportation service requirements with respect to societal and individual core value	Are the inclusion and equity principles implemented by the proposed requirements?	
	Are there new emerging or reinforcing values that should be better considered? Can you provide an example?	

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Interview to European Passenger Federation (21.06.2021)

Scope	Discussion structure	Answers
Assess D2D mobility demand in extended urban and regional scenarios (2025, 2035, 2050)	Are passengers' trends realistic?	
	What would you add to complete the description of business passenger demand?	- In order to answer this question, reference is made to the study published in August 2019 "EPF's priorities for future EU action, Ghent, August 2019", containing the results of the interviews made to the European Regions. It emerges that Passengers want a public transport system that is: • affordable • reliable • sustainable and • coordinated • accessibile not only from the point of view of infrastructure but also of services (even to those who do not own a smartphone)
	What would you add to complete the description of VFT (Visiting Friends Travellers) passenger demand?	
Identify possible future barriers to passenger needs and expectations	Do you see any missing obstacle or barrier in passengers needs satisfaction within the X-TEAM D2D scenarios?	- The changes taking place due to the pandemic must be considered. This will lead us to travel less or make the stay shorter but increase the number of trips (a shorter trip overall but using more means, frequently).
	Do you see specific group of citizens that would benefit from X-TEAM D2D scenarios but are at risk of exclusion?	- Bisogna consentire qualsiasi tipo di pagamenti per non escludere nessuno e tenere conto del benessere delle persone.
	What can be done to enlarge the number/groups of citizens benefiting from UAM integration in urban mobility?	- The first point to take into account is cost-effectiveness, both for BT and VFT. - customisation of the trip. - aftercare is a very important issue -The idea of using a single integrated ticket for the whole trip is

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Scope	Discussion structure	Answers
		theoretically valid but concretely difficult to implement because some trips and costs are blocked (have a time of use) and do not always include all the means you would like to use. There is still a lot to be done in this respect.
	Is poor trust in automation a potential issue in door to door journeys?	- Automated means should not be implemented much in rural areas due to the fact that the whole context should be automated and this only works well in overpopulated areas.
Assess the credibility of passenger profiles (per years different nature of possible door-to-door travels (2025, 2035, 2050)	Is the description of BT characteristics complete? What is missing? (per time horizons)	- More careful thought should be given to flexibility in organising travel for those travelling as Business Passengers. Moreover, with a time horizon of 2025, it will be preferable for business travellers to use last-mile means of transport that are less fast but allow them to comfortably consult documents and work. Travel time is time to be 'used'.
	Are the priorities and the criteria for choice among alternatives for BT credible?	- Make the journey as comfortable as possible by obtaining as much information about the route as possible (accidents, traffic, floods, etc.).
	Are there some other decision criteria to be considered for BT?	- With regard to digitisation, the hidden costs of digitisation and its social impact must be considered. - Need for harmonisation and interoperability -
	Is the description of VFT characteristics complete? What is missing? (per time horizons)	

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Scope	Discussion structure	Answers
	Are the priorities and the criteria for choice among alternatives for VFT credible?	
	Are there some other decision criteria to be considered for VFT?	
Assess intermodal air transportation service requirements with respect to personal passengers needs	Do the requirements match the needs and rights of any possible passenger?	- Consider the chain of responsibility in case something goes wrong during the trip. Define who will take care of the malfunctioning of a transfer from one means of transport to another, in the case of multimodal transport (reimbursement for taxis, hotels or insurance). - It is not easy to assume shared responsibility for a delay rather than an accident, not least because of legal issues and the way each company is structured. For ordinary people who do not speak foreign languages it can be very problematic to have their rights recognised.
	Are there additional requirements that you wold like to add in order to offer a better door to door travel experience?	- Implement trade agreements to encourage integration between transport mediums. The barrier to the development of intermodality is not technological but in the lack of ability to see new business opportunities.
Assess intermodal air transportation service requirements with respect to societal and	Are the inclusion and equity principles implemented by the proposed requirements?	- On average, people lower their barriers on the use of personal data when they find that a service offers them advantages. Then they are willing to make personal information available. - Having real-time travel information

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Scope	Discussion structure	Answers
individual core value	Are there new emerging or reinforcing values that should be better considered? Can you provide an example?	- In order to make an informed choice in terms of sustainability, one needs to have a lot of information about possible alternatives, in terms of time and costs.

Interview to CERPA Centro Europeo di Ricerca e Promozione dell'Accessibilità (July 1st 2021)

Scope	Discussion structure	Answers
Assess D2D mobility demand in extended urban and regional scenarios (2025, 2035, 2050)	Are passengers' trends realistic?	The trends are quite realistic. In the case of business passengers, however, people with specific needs who travel for work, including commuters, have not been considered.
	What would you add to complete the description of business passenger demand?	Considering the specific needs of business travellers, personalised and accessible services, efficient and accessible transport services and information not only in real time but also on real-time arrival/departure locations. Service, if required, also in shorter time frames and last minute (not 24 0 48 hours in advance or the obligation to show up 2 hours before). 2025 - Classic needs also commensurate with specific needs and safety (women with disabilities)
	What would you add to complete the description of VFT passenger demand?	Same considerations as for the Business passenger - Consider services, information and reception arrangements from access to arrival.
Identify possible future barriers to passenger needs and expectations	Do you see any missing obstacle or barrier in passengers needs satisfaction within the X-TEAM D2D scenarios?	Consideration should be given not only to accessing physical mobility but also to multiple modes of communication for information, orientation and safety across the board (hubs, infrastructures, services, digital solutions and systems).
	Do you see specific group of citizens that would benefit from X-TEAM D2D scenarios but are at risk of exclusion?	People with sensory and cognitive disabilities. People with specific needs

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Scope	Discussion structure	Answers
		who are not considered business travellers.
	What can be done to enlarge the number/groups of citizens benefiting from UAM integration in urban mobility?	Provide the above so that multimodality of travel is convenient from access to arrival.
	Is poor trust in automation a potential issue in door to door journeys?	Not if it is also used for a qualitative response in terms of comfort, accessibility and safety.
Assess the credibility of passenger profiles (per years different nature of possible door-to-door travels (2025, 2035, 2050)	Is the description of BT characteristics complete? What is missing? (per time horizons)	Provide for all time horizons for progress in accessibility. The single business traveller may have a temporary disability and/or a specific need that does not allow him/her to travel safely and comfortably.
	Are the priorities and the criteria for choice among alternatives for BT credible?	Priorities and criteria for credible BT - Only in view of BT with specific needs should the need for greater autonomy and adaptation to travel plans and limited budget be added.
	Are there some other decision criteria to be considered for BT?	Accessibility and assistance
	Is the description of VFT characteristics complete? What is missing? (per time horizons)	Generally speaking, it meets the needs of travellers' variability.
	Are the priorities and the criteria for choice among alternatives for VFT credible?	Yes, the priorities and selection criteria are close to reality.
	Are there some other decision criteria to be considered for VFT?	He needs to find clear and intuitive information if he books his own transport and easy access to the ticket office without further complications and/or unnecessary steps. (See Trenitalia website, Carta Blu, service request etc.)
Assess intermodal air transportation service	Do the requirements match the needs and rights of any possible passenger?	Yes, in general, the aspect of specific needs should be explored on several levels and scenarios.

Scope	Discussion structure	Answers
requirements with respect to personal passengers needs	Are there additional requirements that you wold like to add in order to offer a better door to door travel experience?	Attention to multimodality of information and communication at each stage Door the Door (Pre-trip - On the way - On board - Arrival)
Assess intermodal air transportation service requirements with respect to societal and individual core value	Are the inclusion and equity principles implemented by the proposed requirements?	Yes, in the most distant scenarios (2050). It is clear that a stepwise approach can be adopted for a progressive implementation of accessibility
	Are there new emerging or reinforcing values that should be better considered? Can you provide an example?	With reference to multimodality of information and communication at every stage Door the Door: possibility to have knowledge of places in advance, digital information accessible not only through subtitles but also audio/audio descriptions. Highlighting also with reference to safety during mobility: orientation in routes, hubs, means. System for communicating alarms and/or situations in real time through APPs that allow information in a multimodal and multi-channel way.

EUROPEAN COMMISSION

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ANNEX

ANNEX

to the

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Sustainable and Smart Mobility Strategy – putting European transport on track for the future

{SWD(2020) 331 final}

Action Plan[85]

[85] Unless otherwise indicated, the Action Plan lists Commission initiatives.

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SUSTAINABLE MOBILITY	
FLAGSHIP 1 - BOOSTING UPTAKE OF ZERO-EMISSION VEHICLES, RENEWABLE & LOW-CARBON FUELS AND RELATED INFRASTRUCTURE	
1. Revision of the recast Renewable Energy Directive	2021
2. Adopt relevant implementing legislation under the recast Renewable Energy Directive setting out methodologies for measuring GHG emissions savings and promotion of renewable and low-carbon fuels	2021
3. Revision of the CO_2 emission performance standards for cars and vans, for lorries and put in place CO_2 emission performance standards for buses	2021-2022
4. Revision of the Weights and Dimensions Directive	2022
5. Explore the benefits of retrofitting and renewal schemes in various transport modes	2021
6. Propose post-Euro 6/VI emission standards for cars, vans, lorries and buses	2021
7. Improve emissions testing in roadworthiness checks	2023
8. Develop coherent rules for environmental, energy and safety performance of tyres	2023
9. Foster development of energy efficiency and alternative fuel measures at IMO	2021
10. Revision of the Alternative Fuels Infrastructure Directive[86] and a roll-out plan with funding opportunities and requirements	2021
11. Revision of the Energy Performance of Buildings Directive including enhanced provisions on charging infrastructure for e-mobility	2021
FLAGSHIP 2 - CREATING ZERO-EMISSION AIRPORTS AND PORTS	
12. Launch FuelEU Maritime – Green European Maritime Space[87] and ReFuelEU Aviation – Sustainable Aviation Fuels	2021
13. Consider to establish the Renewable and Low-Carbon Fuels Value Chain Alliance[88]	2021
14. Revision of the Ship-source pollution Directive	2022
15. Revision of the EU Ship Recycling Regulation[89]	2023
16. Revision of the Airport Slots Regulation[90] and the Airport Charges Directive[91]	2021-2022
17. Establish sustainable taxonomy criteria for all modes[92]	2021

[86] This action has relevant aspects for flagship 2 in particular.
[87] This action has relevant aspects for flagship 1 in particular.
[88] This action has relevant aspects for flagship 1 in particular.
[89] This action has relevant aspects for flagship 10 in particular.
[90] This action has relevant aspects for flagship 5 in particular.
[91] This action has relevant aspects for flagship 5 in particular.
[92] This action has relevant aspects for flagship 1 in particular.

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FLAGSHIP 3 - MAKING INTERURBAN AND URBAN MOBILITY MORE SUSTAINABLE AND HEALTHY	
18. EU 2021 Rail Corridor Initiative - Action Plan to boost passenger rail transport	2021
19. Put in place measures to better manage and coordinate international rail traffic, including if necessary through revised rules for capacity allocation and infrastructure charging in rail[93]	2022
20. Revision of the Urban Mobility Package of 2013	2021
21. Zero pollution action plan for air, water and soil; revision of air quality standards and reduction of noise pollution	2021; 2022
22. Issue guidelines to support the safe use of micromobility devices	2021
23. Assess the need for measures to ensure a level playing field for local, on-demand passenger transport and ride-hailing platforms	2022
FLAGSHIP 4 - GREENING FREIGHT TRANSPORT	
24. EU 2021 Rail Corridor Initiative - Revise the Rail Freight Corridor Regulation	2021
25. Review of the regulatory framework for intermodal transport, including the Combined Transport Directive	2022
26. Launch NAIADES III to exploit the untapped potential of inland waterways transport	2021
27. Enable B2A multimodal data exchange through implementation of the e-FTI Regulation and Maritime Single Window environment	2025
28. Issue guidelines for operators and platforms on informing users about the carbon footprint of their deliveries and on offering sustainable delivery choices[94]	2023
FLAGSHIP 5 - PRICING CARBON AND PROVIDING BETTER INCENTIVES FOR USERS	
29. Revision of the EU Emissions Trading System (ETS), with respect to maritime transport; aviation; and CORSIA[95]	2021
30. Revision of the Energy Taxation Directive[96]	2021
31. Review VAT exemptions for international passenger transport	2022
32. Put forward market-based measures for shipping at IMO	2022
33. Establish EU framework for harmonised measurement of transport and logistics emissions	2022
34. Issue guidelines for operators and platforms to inform passengers about the carbon footprint of their trip and to enable passengers to voluntarily offset it, and for wider use of eco-routing for (in-built) navigation software	2023
35. Development of an environmental label programme for aviation by EASA	2022

[93] This action has relevant aspects for flagship 4 in particular.
[94] This action has relevant aspects for flagship 5 in particular.
[95] The action has relevant aspects for flagship 1-4 in particular.
[96] The action has relevant aspects for flagship 1-4 in particular.

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SMART MOBILITY	
FLAGSHIP 6 - MAKING CONNECTED AND AUTOMATED MULTIMODAL MOBILITY A REALITY	
36. Revise Delegated Regulation 2015/962 on real time traffic information services to extend geographical coverage and datasets; revise Delegated Regulation 2017/1926 on multimodal travel information services to include mandatory accessibility of new dynamic datasets	2021; 2022
37. Assess the need for regulatory action on rights and duties of multimodal digital service providers and issue a recommendation to ensure public service contracts do not hamper data sharing and support the development of multimodal ticketing services, together with an initiative on ticketing, including rail ticketing	2022
38. Revision of the Directive on Intelligent Transport Systems, including a multimodal ticketing initiative	2021
39. Complete the EU legal framework on the approval of automated vehicles	2021
40. Assess the need for an agency or other body to support safe, smart and sustainable road transport operations	2022
41. Adopt the implementing legislation for the approval of connected and automated vehicles	2021
42. Adopt railway technical standards and specifications package on ERTMS/Control-Command and Signalling (CCS); and develop mandatory deployment plans for automatic train operation, automated traffic management and advanced CCS	2022
43. Revision of the Directive on Harmonised River Information Services	2022
44. Propose measures on electronic documents for inland crew and vessels	2021
FLAGSHIP 7 - INNOVATION, DATA AND AI FOR SMART MOBILITY	
45. Develop/renew R&I partnerships: Connected, cooperative and automated mobility; Shift2Rail; SESAR; Waterborne; Clean Aviation; Clean Hydrogen Partnership; Smart Networks and Services; AI, Data and Robotics; and Key Digital Technologies.	2020-2021
46. Further develop the regulatory framework for drones and unmanned aircraft, including U-Space; adopt a Drone Strategy 2.0	2021-2023; 2022
47. Assess the need for regulatory actions to ensure safety and security of new entrants and new technologies, such as hyperloop	2021
48. Set up a high-level group ('New Mobility Tech Group') as a first step toward the development of a coherent EU approach and a set of recommendations on facilitating testing and trials of emerging mobility technologies and solutions in the EU ('European Mobility Test Beds')	2022
49. Develop a common European mobility data space and establish a stronger coordination mechanism for the national access points established under the ITS Directive	2021
50. Set out an AI roadmap for mobility	2021
51. Review the regulatory framework for interoperable data sharing in rail transport (ERTMS, rail telematics applications)	2022
52. Review the current EU type approval legislation to facilitate car data-based services including interaction with energy system	2021
53. Propose a new regulatory framework to open up access to car data to mobility services	2021

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54. Propose rules on a trusted environment for corridor data exchange to support collaborative logistics	2022
RESILIENT MOBILITY	
FLAGSHIP 8 - REINFORCING THE SINGLE MARKET	
55. Revision of the Regulation on the Trans-European Transport Network (TEN-T)[97]	2021
56. Assess the impacts of the COVID-19 pandemic on connectivity and competition in the market, and propose follow-up measures as appropriate	2021-22
57. Review the transport relevant State aid rules	2023
58. Prepare crisis contingency plan(s) for the transport sector, including health-safety and operational measures and setting out essential transport services	2021-2023
59. Revision of the Air Services Regulation	2021-22
60. Propose measures to encourage cross-border car rentals	2022
61. Guidance on climate proofing of transport infrastructure, networks and systems	2021
FLAGSHIP 9 - MAKING MOBILITY FAIR AND JUST FOR ALL	
62. Review of the interpretative guidelines on the Land PSO Regulation; revise rules on air PSOs; and provide guidance on freight PSOs	**2021; 2022; 2023**
63. Review of the passenger rights regulatory framework, including to ensure its resilience to extensive travel disruptions, and including options for multimodal tickets[98]	2021-2022
64. Assess the options and propose, if appropriate, an adequate financial protection scheme to protect passengers against the risk of a liquidity crisis or an insolvency regarding the reimbursement of tickets and if needed their repatriation.	2021-2022
65. Revision of the Code of Conduct for computerised reservation systems	2021-2022
66. Assess the need for a proposal to require efficient exchange of odometer readings across the EU	2021
67. Revision of the Directive on the certification of train drivers	2022
68. Launch initiatives to enhance living and working conditions for seafarers (including the revision of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers at the IMO)	2021
69. Issue recommendations for the transition to automation and digitalisation and their impact on the transport workforce	2023
70. Launch initiatives to increase the attractiveness of the transport sector	2021-2023
FLAGSHIP 10 - ENHANCING TRANSPORT SAFETY AND SECURITY	
71. Revision of the Directive on cross-border enforcement of traffic rules	2021-2022
72. Revision of the Driving Licence Directive to address technological innovation[99], including digital driving licences	2022
73. Consider new guidance on issues such as the maximum permitted blood alcohol content for drivers of motorised vehicles and on the use of alcohol interlocks	2022
74. Assess the need to propose rules for auditing, inspecting and reporting on infrastructure quality for bridges or other sensitive infrastructure	2023

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75. Adapt the eCall legal framework to new telecommunication technologies; consider the extension of eCall to powered two wheelers, trucks, buses and agricultural tractors	2021; 2022
76. Revision of the maritime safety framework (Directives on flag state responsibilities, port state control and accident investigation)	2021
77. Revise the mandate of the European Maritime Safety Agency	2022
78. Propose EU manning requirements for inland navigation	2023-2024
79. Consider setting up an EU rapid alert mechanism for security, including cyber threats	2022
80. Explore the need to adapt existing rules to address cyber risks and insider threats, in line of the toolbox on 5G cybersecurity	2022
81. Improve security for passenger rail travel by implementing the results of the action plan on rail security and the Rail Passenger Security Platform	2022
82. Establish a scheme under the cybersecurity certification framework for automated vehicles	2023

[97] This action has relevant aspects for flagships 1-4 in particular.
[98] This action has relevant aspects for flagship 6 in particular.
[99] This action has relevant aspects for flagship 6 in particular.

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JOINT UNDERTAKING

eXTEnded AtM for Door2Door travel
X-TEAM D2D

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