Dissemination Report

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DART

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Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
D. Scarlatti, E. Casado, P. Costas / BR&T-E	Project Member /Researcher	19/05/2018

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
George Vouros/UPRC	Project Coordinator	19/05/2018
George Fuchs/FRHF	Project Member	19/05/2018
Jose Manuel Cordero/CRIDA	Project Member	19/05/2018

Approved for submission to the SJU By — Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date
George Vouros/UPRC	Project Coordinator	19/05/2018
David Scarlatti/BR&T-E	Project Member	19/05/2018
George Fuchs/FRHF	Project Member	19/05/2018
Jose Manuel Cordero/CRIDA	Project Member	19/05/2018

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

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DART

DATA DRIVEN AIRCRAFT TRAJECTORY PREDICTION RESEARCH

Abstract

This document presents the dissemination activities performed by the DART project within the first, second and third reporting periods. The document introduces the activities performed and provides an analysis of their impact and effectiveness.[1]

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[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."

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1 Introduction

1.1 Purpose and Scope

Dissemination represents the means used to provide efficiently to the open community the findings and results obtained throughout the project lifecycle and beyond. Moreover, dissemination allows to measure acceptance of the proposed concepts and to exploit the capability of reusing them in other projects.

Additionally, this deliverable provides an overview of the dissemination materials that are designed to exploit the accomplished results and outlines the exploitable components by:

• Informing stakeholders of the project development and encourage interactions/ networking.

• Coordinating all levels and types of exploitation of the knowledge produced by the project.

• Ensuring that information is shared with appropriate audiences on a timely basis and by the most effective means.

These objectives have been enriched with the project's achievements and contributions from all partners.

1.2 Intended readership

This document summarizes the activities performed by the DART consortium regarding the exploitation and dissemination of the project's results. As such, its intended audience is the SESAR JU and the consortium members.

1.3 Acronyms and Terminology

Term	Definition
AAMAS	Autonomous Agents and Multi-agent Systems
AC	ATM Community
AMAN	Arrival Manager
ARC	ATM Research Community
ART	Agency Research Team
ATACCS	Application and Theory of Automation in Command and Control Systems

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ATC	Air Traffic Control
ATM	Air Traffic Management
BR&T-E	Boeing Research & Technology - Europe
CRIDA	Centro de Referencia de Investigación, Desarrollo e Innovación
COPTRA	COmbining Probable TRAjectories
DART	Data-driven AiRcraft Trajectory prediction research
DCB	Demand & Capacity Balance
DST	Decision Support Tool
FRHF	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung
GP	General Public
Horizon 2020	EU Research and Innovation programme implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness.
ICRAT	International Conference on Research in Air Transportation
IPR	Intellectual Property Rights
KPA	Key Performance Area
KPI	Key Performance Indicator
LTER	Long Term Exploratory Research
PMP	Project Management Plan
RC	Research Community
R&D+i	Research, Development and Innovation
RL	Reinforcement Learning
SESAR	Single European Sky ATM Research Programme
SID	SESAR Innovation Days
SJU	SESAR Joint Undertaking (Agency of the European Commission)
TBO	Trajectory Based Operations
TFM	Traffic Flow Management
TRL	Technology Readiness Level
UPRC	University of Piraeus Research Center
WAC	World ATM Congress
WBS	Work Breakdown Structure
WP	Work Package

CA	Consortium agreement
GA	Grant Agreement
ER	Exploratory Research

Table 1: Acronyms and Terminology

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2 Dissemination & Exploitation Activities

2.1 Papers, posters and presentations presented for publication (in journals or conferences)

This section describes the type of events (e.g., conferences; teachers' meetings; meetings with policy makers; articles; etc.), and the total number of people disseminated to ("Reach").

Dissemination Goal	Target Quantity	Target Group	Scheduled Activities
Publications (scientific Target Group)	Open access granted to all scientific publications resulting from DART, targeting not only ATM group but Big-Data Analytics, Interactive Visual Analytics, Machine Learning, Data and Information management groups.	Research Community	• Participation in the 1st International Workshop on Meteorology and Air Traffic Management hosted by University of Seville (October 25, 2017) - Integration of meteorological information in trajectory prediction (DART Project). • Participation in the Workshop on Uncertainty and Air Traffic Management hosted by Universidad Carlos III Madrid (May 24, 2017) - Multi objective operational planning optimisation considering the impact of uncertainties.
Papers at scientific conferences appearing in proceedings	At least 3. Potential conferences include: ATACCS, ATM SEMINAR (U.S.A. Europe), SESAR Innovation Days, DEBS, VLDB, ACMSIG Spatial, SSTD, EDBT, VAST, EuroVis, AAMAS and KDD	Research Community	**Conference**: SETN 2018 (Hellenic AI Conference) May, 2018. **Accepted Paper**: Multiagent RL for Real-World Interdependent Congestion Problems. **Authors**: C.Spatharis, H.Kravaris, K.Blekas, G.Chalkiadakis, G.Vouros **Conference**: 15th German Conference on Multiagent System Technologies, August 2017. **Paper**: Learning Policies for Resolving Demand-Capacity Imbalances

			during Pre-tactical Air Traffic Management. **Authors**: T.Kravaris, G.Vouros, C.Spatharis, K.Blekas, G.Chalkiadakis, J-M.Cordero Garcia
		Research Community	Participation in Visual analytics conference.
		Research Community	**Conference**: KDD 2018. **Accepted Paper**: Predicting Estimated Time of Arrival for Commercial Flights Samet Ayhan, Pablo Costas.
		ATM Research Community	**Conference**: SESAR Innovation Days, November 2017. **Paper**: A Machine-Learning Approach to Trajectory Prediction and Demand-Capacity Balancing. **Authors**: E. Calvo. J.M. Cordero, G.Vouros, N. Pelekis, H.Kravaris, H. Georgiou, G. Fuchs, N. Andrienko, G. Andrienko, E. Casado, D. Scarlatti, P. Costas, S. Ayhan. **Conference**: DASC 2018 - C.Spatharis et al: Multiagent Reinforcement Learning Methods for Resolving Demand-Capacity Imbalances, accepted. **Conference**: DASC 2018 – E. Casado, A. Muñoz: Data-driven Aircraft Trajectory Predictions using Ensemble Meta-Estimators.
Papers in Journals	At least 1 submissions to journals of high impact. Potential journal titles include: (AIAA), IEEE National Aerospace & Electronics Conference, IEEE TKDE, ACM ToCL, International Journal of Geographical Information Science, ,International Journal of Location-based Services, Computers Environment and Urban Systems, IEEE Transaction on	Research Community	**Journal**: IEEE Transactions on Visualization and Computer Graphics. **Paper**: Clustering Trajectories by Relevant Parts for Air Traffic Analysis. **Authors**: Gennady Andrienko, Natalia Andrienko, Georg Fuchs, Jose Manuel Cordero Garcia. **Journal**: IEEE Transactions on Intelligent Transportation Systems. 2017, vol. 18(8), pp.2232-2249. **Paper**: Visual Analytics of Mobility and Transportation: State of the Art and Further Research Directions.

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	Visualization and computer Graphics, Information Visualization, Computer Graphics Forum,		**Authors:** Gennady Andrienko, Natalia Andrienko, Wei Chen, Ross Maciejewski, and Ye Zhao.
Workshop organized at a scientific event	At least 1 concerning one of the following topics: Management of spatio-temporal big data in ATM Detection and forecasting of aircraft trajectories Recognition and forecasting of events concerning aircrafts	ATM Research community	Data-Enhanced Trajectory Based Operations Workshop organized alongside ICRAT'18 conference (June 2018). Workshop in coordination with COPTRA , ATM Big Data, datAcron … projects at World ATM Congress 2018 (March 2018). Links to the workshop pages. http://icrat.org/icrat/upcoming-conference/data-tbo-workshop/ https://www.sesarju.eu/node/2971
Publications (technically interested community as large)	At least 1: Management of spatio-temporal big data in ATM Forecasting of aircraft trajectories	Research Community	Gennady Andrienko, Natalia Andrienko, Georg Fuchs. Understanding Movement Data Quality. Journal of Location Based Services, 2016, vol. 10(1), pp.31-46.
DART white papers	At least 1: A "DART data-driven trajectory predictions" white paper	ATM Research community	DART Fact Sheet available at DART webpage. A "DART data-driven trajectory predictions" white paper. DART Newsletters available via the DART webpage.
Press releases	At least 1: For the technological developments and their impact in ATM.	ATM Research community	SJU dedicated webpage

Project Web Site http://dart-research.eu/	600 p.a. with 1/3 spending more than 2 minutes on the site	General Public	Project Website Launch and periodic update
Social Media Presence	Established groups in at least 2 networks (e.g. LinkedIn, Twitter) with regular updates. Evidence of engagement with target audience – demonstrated via comments, sharing of relevant content, RTs etc.	General Public	Linkedin Group Launch (Social Network 1) and periodic updates
		Research Community	Researchgate Project Launch (Social Network 2) and periodic updates
Stakeholders interest groups	At least 1 presentation at WP-E networks events	ATM Research community	DART Working Group: - 1st meeting (September 22, 2017) with participation of Airspace Users, EUROCONTROL Network Manager representatives, SJU members and DART partners. - 2nd meeting (January 2018) - 3rd meeting (tentatively May 2018) Presentations in WAC & SID
Demonstrations of prototypes at ATM-dominated events	At least 1. (i.e., SID, WAC...)	ATM Research community	Workshop in coordination with COPTRA project at World ATM Congress 2018 (March 2018).

Table 2 Dissemination and Communication Activities

2.2 Dissemination results

This section provides quantitative information on the different initiatives undertaken by DART regarding the dissemination and exploitation of results.

Indicator	Indicator	Achieved
Results	Number of conferences and seminars celebrated	2
	Meetings with the Eurocontrol Network Manager representatives	1
	Number of publications released	8
	Workshops	2
	Number of patents	1
	User Group meetings	3
	Number of experts reached	150

Table 3 Dissemination results

2.3 Communication and Dissemination Analysis

Based on the previous information, the Consortium has analysed the impact and effectiveness of each activity. The following paragraphs describe for each one of the different actions performed by the Consortium the impact that has been obtained, the aspects that worked best and also those that could be improved.

2.3.1 Web Site: http://dart-research.eu/

The website is intended to be used as a repository of DART related information that can be used by the general public to access the project's public information. The number of hits reflect a moderate to high impact of the results produced by DART.

2.3.2 LinkedIn Group: https://www.linkedin.com/groups/12011500

This group has had a medium impact on the community with 23 members. However, even though the membership and the participation levels are acceptable, they could have been higher. The impact of social media such as LinkedIn is based on the level of implication of the group members and is used to provide exposure to new ideas, developments or updates. To ensure a stronger participation, DART has several actions that have increased the participation levels:

- Provide detailed information about DART communication channels (i.e., webpage and researchgate group)
- Provide information about workshops organized from the DART project.

- Disseminate DART white Paper and Newsletters.

2.3.3 Research gate Project Page:
https://www.researchgate.net/project/Data-Driven-Aircraft-Trajectory-Prediction-Research

The project page is intended to be used as the platform to deliver the research papers that are presented at the conferences and published in the journals/magazines, and establish a connection with the research community in the field.

2.3.4 Conferences, publications and patents:

With regard to dissemination activities the following DART related articles have been or are in progress (have been accepted) to be published:

•**DART Facts Sheet:** http://dart-research.eu/wp-content/uploads/2017/01/DART_fc.pdf

•T.Kravaris, G.Vouros, C.Spatharis, K.Blekas, G.Chalkiadakis, J-M.Cordero Garcia "**Learning Policies for Resolving Demand-Capacity Imbalances during Pre-tactical Air Traffic Management**", to appear in 15th German Conference on Multiagent System Technologies, Leipzig, Germany.

•G Andrienko, N Andrienko, W Chen, R Maciejewski, Y Zhao. "**Visual Analytics of Mobility and Transportation: State of the Art and Further Research Directions.**" IEEE Transactions on Intelligent Transportation Systems, 2017.

•Gennady Andrienko, Natalia Andrienko, Georg Fuchs. **Understanding Movement Data Quality. Journal of Location Based Services**, 2016, vol. 10(1), pp.31-46.

•J-M Cordero Garcia et al on "**Integration of meteorological information in trajectory prediction (DART Project)**", 1st "International Workshop on Meteorology and Air Traffic Management, hosted by University of Seville and funded by project TBO-MET.

•Gennady Andrienko, Natalia Andrienko, Georg Fuchs, Jose Manuel Cordero Garcia. **Clustering Trajectories by Relevant Parts for Air Traffic Analysis.** IEEE Transactions on Visualization and Computer Graphics, 2017 (accepted).

•Boeing Research and Technology Europe filed a patent in the European Patent Office:
Applicant: The Boeing Company
Application title: "**Method and system for autonomously operating an aircraft**"
Filing date: 29th June 2017
Filing number: EP17382412.9

•E.C. Fernández et al., **DART: A Machine-Learning Approach to Trajectory Prediction and Demand-Capacity Balancing**, SID 2017.

• G. Vouros et al., **Multiagent RL for Real-World Interdependent Congestion Problems**, accepted in SETN 2018 (Hellenic Artificial Intelligence Conference).

• C.Spatharis et al: **Multiagent Reinforcement Learning Methods for Resolving Demand-Capacity Imbalances**, accepted in DASC 2018.

• E. Casado, A. Muñoz: **Data-driven Aircraft Trajectory Predictions using Ensemble Meta-Estimators**, accepted in DASC 2018.

• Samet Ayhan, Pablo Costas, **Predicting Estimated Time of Arrival for Commercial Flights**, accepted in KDD 2018

Further dissemination activities include the organization of two workshops:
- WAC-2018 workshop: **DATA DRIVEN ATM: GOING DIGITAL** (in collaboration with COPTRA, BigData4ATM, UPM, datAcron).
- ICRAT 2018 Workshop on **Data Enhanced Trajectory Based Operations**, in collaboration with datAcron.

2.3.5 DART White Paper

This paper, released on April 2017 ([http://dart-research.eu/2017/04/03/dart-white-paper/)](http://dart-research.eu/2017/04/03/dart-white-paper/), presented challenges and opportunities regarding data-driven trajectory prediction research in the ATM domain: challenges and opportunities for exploiting disparate and heterogeneous data sources; challenges and opportunities towards increasing the capabilities of state-of-the-art methods for data-driven trajectory predictions to account for real-world and complex settings; and challenges and opportunities regarding the catalytic role information visualization and visual analytics can play in many phases of this research. In this context, the DART project positions itself as a key enabler towards the vision of the future ATM, contributing to a better understanding of how data-driven methods can increase our abilities to predict trajectories of aircrafts

2.3.6 Newsletters

The DART Newsletters have aimed at dissemination relevant activities to the community, highlighting short term achievements of the projects:
- 1st Newsletter (June 2017) presented the project scope and objectives and first algorithms selected with initial visualizations.
- 2nd Newsletter (December 2017) presented updates on project status, as well as, a description of the machine learning algorithms selected as most promising for aircraft trajectory prediction purposes.
- 3rd Newsletter (To be released May 2018) providing information on project outcomes and findings.

2.4 Conclusion

From the early beginning of the project a huge effort to align the DART research with stakeholders' needs has been conducted. As result of that effort the Eurocontrol NM flow management unit and airlines have expressed their needs in the DART Working Group.

Another good signal of the alignment with industry is that Boeing has filed a patent on the data-driven Reinforcement Learning techniques for trajectory prediction as result of the researches conducted in DART.

Papers have been submitted and accepted in several conferences, not only in conferences related to Air Traffic Management, what confirms the quality of the technical solutions derived from the DART research.

Finally, the number of ATM experts and researchers reached through the dissemination activities ensures that the ATM community if now aware of the improvements that data-driven techniques can add to the state of the art model-based systems using for trajectory prediction and Demand and Capacity Balance. This will ensure that the research of the most promising techniques proposed by DART will be followed-up so it can be matured enough to become operational.

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