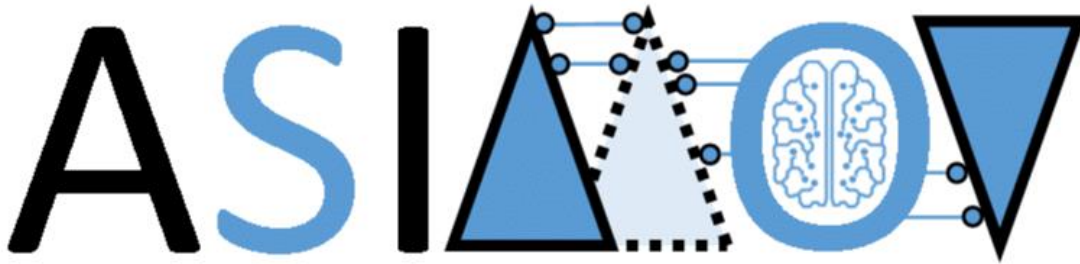


Exploitation Plan and Report

[WP5; T5.2; Deliverable: D5.2 version 1.3]

Non-Confidential



**AI training using Simulated Instruments for Machine
Optimization and Verification**

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1.0	2022.02.10	First version, based on the plans and reports of the Dutch and German partners, with some contributions from Finnish partners (pending the funding decision in Finland)

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1.1	2022.06.22	M12 update to plan, results and consortium (removal of Finland)
1.2	2023.06.18	M24 update to plan and achievements
1.3	2024.05.10	M36 updates from all consortium members

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Abstract

The ASIMOV-project develops technologies to combine Digital Twinning and Machine-Learning (e.g., Reinforcement Learning) to automate the calibration, optimization of Cyber Physical Systems. The project is centered around industry use cases to ensure that the technology developed in the project will meet actual industry needs. Exploitation of the ASIMOV-results in industry is one of the key drivers of the project.

This document provides an overview of the exploitation plans of the ASIMOV-consortium as well as reports on the actual achievements.

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1 Introduction

High-tech cyber-physical systems (CPSs) play increasingly important roles in our society. They are ubiquitous, and companies, organizations and societies depend on their correct functioning. CPSs need to have high up-times, be user-friendly, and economically to use. CPS suppliers must assure that their systems reliably deliver optimal quality in customers' environments, without bothering their customers with complex system optimisation tasks that require highly skilled staff. Systems need to be optimally tuned before delivery and at installation and re-adjusted during use. Such optimization can easily require many hours/days and this total time increases rapidly due to growing project diversity and complexity. To address this major problem, it is ASIMOV's vision that CPSs must be increasingly autonomous and self-optimising, which leads to the following central question:

How to build complex high-tech systems that select their optimal settings autonomously within minimal time and with minimal external expertise?

To answer this question, the ASIMOV project will develop innovative technologies to create self-optimising CPSs by combining AI and Digital Twinning. The consortium, consisting of large industrial parties, SME's with strong AI-expertise, and leading universities and research institutes, will deliver the following innovations:

- creating digital twins of systems to simulate realistic system behaviour;
- training an Optimisation-AI based on the digital twin to find optimal system settings;
- verifying the validity of the digital twin for training the AI;
- using the trained AI to perform the tuning and calibration tasks on actual machine configurations.

This will lead to AI-based software that autonomously performs system optimisation tasks during manufacturing, installation, and system usage. Proof of concepts will be provided in two different industrial system domains (electron microscopes and automated driving) for which optimisation is crucial for system performance.

This document gives an overview of the plans to exploit the ASIMOV results by creating industrial and social added-value. In addition to the plan, the document also provides a report of the current exploitation status.

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2 Consortium Overview

Company Name (Project coordinator first)	Country	Role *)	Type of organisation **)				
			I	S	U	R	O
FEI Electron BV (TFS)	The Netherlands	C	x				
Netherlands organization for applied scientific research (TNO)	The Netherlands	M				x	
Eindhoven University of Technology (TUE)	The Netherlands	P			x		
CQM B.V. (CQM)	The Netherlands	P		x			
OFFIS e. V. (OFFIS) until December 31, 2021	Germany	M				x	
Deutsches Zentrum für Luft- und Raumfahrt (DLR) per January 1, 2022	Germany	M				x	
AVL Deutschland GmbH (AVL)	Germany	P	x				
NorCom Information Technology GmbH & Co. KGaA (NORCOM)	Germany	P		x			
LiangDao GmbH (LIANGDAO)	Germany	P		x			
RA Consulting GmbH (RAC)	Germany	P		x			
TrianGraphics GmbH (TG)	Germany	P		x			

Table 1 - Consortium Overview

*) C = Coordinator; M = country's Main participant contact; P = Participant

***) Type of organisation: I=Industry; S=SME; U=University, R=Research Institutes, O=Other

NOTE:

The German consortium has changed since submission of the FPP. The table above reflects the current composition of the consortium, i.e. OFFIS is converted to DLR. A CR will be submitted to ITEA to reflect the change. It is in progress for submission in September 2022.

NOTE:

All Finland participation is removed in version 1.1. of this document and their withdrawal from the consortium was reflected in the CR.

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3 Exploitation Plan

3.1 Exploitation Prospects

This section gives a high-level overview of the exploitation prospects:

- exploitation by consortium members;
- joint exploitation opportunities for consortium members;
- exploitation opportunities beyond the consortium.

In section 3.2, an overview is given of concrete exploitation plans.

Most concrete exploitation results are expected from the industry partners in the consortium. Since academic and research partners are also encouraged to exploit the results from the project, their plans and results are included too.

3.1.1 Exploitation by Consortium Members

3.1.1.1 AVL and NorCom

For the successful implementation of research projects, several new jobs were created at the Karlsruhe and Stuttgart locations of AVL Deutschland GmbH. There is a specific focus on the development methodology for highly automated vehicles and their implementation in efficient tools. The already very close cooperation with research institutes such as OFFIS/DLR (Institute of Systems Engineering for Future Mobility) will be significantly expanded in the field of highly automated vehicles, thus ensuring a systematic training and qualification of junior staff in this new field. At the same time, the development and testing solutions developed in the joint project will also be deployed in the European TechCenters of AVL, where they will be available for further demonstrations and customer projects. Due to the planned publications in the joint project, it is expected that the results will be well received by the relevant industrial and academic users already in the third year of the project, thus making a significant contribution to the state of the art. The planned AI-based optimisation method using digital twins will enable AVL and NorCom to significantly extend the current product and service portfolio in the areas of advanced simulation, smart testing and big-data analysis. An overall annual growth of 15% is expected in this portfolio when exploiting the results of this project.

3.1.1.2 CQM

By participating in the project, CQM has extended its knowledge and experience in Digital Twinning and Artificial Intelligence. We have reserved time to explore the field, have had many valuable discussions with the consortium partners, and have had access to material on definition, development and exploitation of DT and AI including guidelines, strengths, weaknesses. This has helped us tremendously in building up our knowledge, our talks with existing and potential customers, exploratory activities, and finally exploitation in concrete customer projects.

For our two fields of activities, we have reformulated our offerings to the market.

Firstly, for support of innovation in product and process development: integrating DT and AI technology in our Model Based System Engineering and Surrogate Modelling activities in the field of product development both for high tech cyber physical systems and consumer products.

Secondly, for support of design and control of supply networks: revolutionize the landscape of supply chain management through seamless integration of advanced mathematics, data science and artificial intelligence and the transformative power of digital twin technology to pave the way for a new era of effectiveness, efficiency, resilience and sustainability in the supply chain.

3.1.1.3 LiangDao

With Asimov LiangDao plans to develop its expertise in machine-learning based algorithms and processes, as well as utilization of digital twins and twinning between physical and digital systems. To ensure the project success, LiangDao will acquire new software and engineering talents from all over the world, who will come to LiangDao's development centre in Munich, which is near to Stuttgart and project partners. The planned output of the project will improve the efficiency of LiangDao's existing solution

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significantly: with machine-learning based approaches for post processing of perception data, processing time will be shortened to a few hours instead of taking days. Training and validation of machine-learning based algorithms as well as calibration and planning of customized solutions can be speed up by utilizing digital twins. . LiangDao is confident to achieve a huge license revenue growth of ML-based testing and validation tools of up to 20%, and more than 30% growth of software maintenance and data operation business as the solutions will widen the market e.g. for LiangDaos smart city solution.

3.1.1.4 DLR / OFFIS

The results of ASIMOV are used to extend our consultancy offer on the efficient transfer of research results to industry applications. OFFIS supports the foundation of spin-off companies and has set up specific guidelines for that. In the past, several spin-off companies have been founded out of OFFIS. Also, for ASIMOV, if there is a market and the results have reached an appropriate maturity level, then founding spin-off companies is an opportunity. OFFIS has a long history of cooperation with AVL and is working together with AVL in ASIMOV, therefore this cooperation is the preferred channel to exploit our common results. Furthermore, OFFIS is reusing the methods and tools developed within ASIMOV to assemble a tool collection for the optimisation of cyber-physical systems.

Through its status as a so-called “An-Institute” to the University Oldenburg, OFFIS has close collaborations with researchers from the interdisciplinary research centre on Safety Critical Systems. Topics addressed within ASIMOV are incorporated into Master level courses at the University of Oldenburg on Embedded Systems and Microrobotics, and support PhD and Master theses.

The OFFIS transportation department became a new institute of the German Aerospace Center (DLR e.V.) as of 2022, January, 1. This new institute focusses on systems engineering and a major part of the vision is to assure technical trustworthiness of CPS. A special challenge will be the technical trustworthiness of AI based components. Results of this project will be therefore part of the fundamental basis of the future research strategy and cross-project technology demonstrators of the new institute.

3.1.1.5 RAC

For the successful implementation of the research project, 3-6 new jobs will be created in Bruchsal, Germany.

By participating in the project RAC will expand their knowledge and expertise in digital Twinning and Artificial Intelligence. This will strengthen the offering to the current customer base and allow RAC to expand their offering to new customers in existing and new markets.

The business model of RAC is based on several types of income or business models:

- License income for the individual products in the product family.
- Income from maintenance and service contracts: The software components must be maintained. It is assumed that the majority of the licenses ordered with maintenance are approximately 15% of the license costs annually.
- Product-bound services: Experience shows that accompanying consulting services as well as extension and adaptation services are to be provided for the various customer applications.

RAC estimates a medium-term revenue share of 5-15% through the exploitation of results from this project, with an annual growth rate of 5-10% for this product and service area.

An increase of components and services is mainly expected by joint exploitation opportunities of ASIMOV partners in the automotive industry.

3.1.1.6 FEI Electron Optics/Thermo Fisher Scientific

There is a clear market demand for making Thermo Fisher Scientific’s sophisticated electron microscopy (EM) systems easier to operate, more productive and keep them operational, with less user expertise required. Artificial intelligence, including using digital twins, and the results from the ASIMOV project are expected to play a pivotal role to this end. The project outcomes will furthermore improve the speed of

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research, development, manufacturing and installation of EMs. Finally we foresee a reduction in maintenance of EM systems. This will enable larger market penetration in the customer areas mentioned in section 3.1, and enable market expansion from wider non-expert user adoption. If this were to boost the 2019-2024 market growth by an additional 8.5% to 18.5% (Figure 3-4), it would equate to around \$300M in additional incremental revenue growth, of which Thermo Fisher Scientific would expect to capture 40% to 60% as EM market and innovation leader.

Thermo Fisher Scientific envisions exploiting ASIMOV project results to enable more efficient R&D, increased automation of pre-ship, post installation and operational system alignments leading to greater productivity for our customers and for Thermo Fisher Scientific. An important improvement for higher productivity is realized by creating shorter set-up and calibration procedures. For instance, in the TakeMI5 EU ECSEL subsidy project aimed at the semiconductor industry, the application of AI in a Metrios TEM (Transmission Electron Microscopy) to script-free sample navigation, feature recognition and data acquisition, reduced the total experimental time by a factor of 5. A key result from ASIMOV will be to verify the potential improvement in productivity of identifying optimum individual system or sub-system alignment settings. Furthermore, advances from the ASIMOV project are expected to cascade across Thermo Fisher Scientific's product and service ranges.

3.1.1.7 TNO

The results from the ASIMOV project will contribute to strengthening the knowledge and experience of TNO (ESI) on their strategic program lines Exploiting System Context, System Performance, System Evolvability, and System Architecting, especially in the area of applying industrial AI in complex high-tech systems. TNO (ESI) will be able to leverage this knowledge in future applied research projects for the Dutch high-tech industry. This will result in additional turn-over for TNO (ESI), but more importantly it enables TNO (ESI) to fulfil its mission to strengthen the Dutch high-tech industry by embedding leading-edge methodologies into the Dutch high-tech systems industry to cope with the ever-increasing complexity of their products.

3.1.1.8 Eindhoven University of Technology

TU/e/EAlSI has the ambition to reinforce its already prominent role in university-industry co-operation and strengthen its position as a leading research institute in transferring cutting-edge technology to industry. This project will provide the opportunity to develop key innovative technological tools within AI and digital twinning and transfer it to leading industrial partners. Regarding human capital: We will hire 2 PhD students [2 positions for 4 years] that will be trained in this vital area for the high-tech area. Moreover, several master students will conduct their internship and final thesis projects within context of Asimov and form important human capital for the labour market.

3.1.1.9 TrianGraphics

In the course of the project TrianGraphics (TG) has gained a higher market visibility with the industrial use case and the new capabilities related. We could improve technically and in efficiency in the automatized creation of Digital Twins. Hereby, we have introduced new method for testing and validating the output. We have moved the generation core on new platforms and made it suitable for server & cloud generation. We see especially high market value in the automated variation of Digital Twins in the automotive industries, as was demonstrated in the project. For the future we are further evaluating on more flexible and versatile variation approach to make is feasible as off-the-shelf solution for numerous customers.

For machine learning applications require large amounts of training data that can be generated by simulations and flexibly varied, e.g. with regard to weather and lighting conditions. TG intends to intensify their market access in this respect and also sees high value in other markets besides automotive. We are hereby operating on the military simulation market, where very similar requirements are placed on the development of autonomous actors such as unmanned aerial vehicles (UAVs) etc.

TG will use the acquired know-how, software and high-level components to further improve their products and service portfolio within 2 years after the project.

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3.1.2 Joint Exploitation Opportunities for Consortium Members

In addition to the exploitation by individual partners in the consortium, joint exploitation opportunities are foreseen (as already indicated in some of the descriptions above). The clearest opportunities are formed by the strong consortia formed around the two industrial use cases in the project. In section 3.1 Market value chain, the relations between the partners in these use cases have already been described. These descriptions indicate opportunities for joint exploitation. In the follow paragraphs, these opportunities have been summarized.

3.1.2.1 The Electron Microscopy case (CQM and Thermo Fisher Scientific – TNO and TUE)

The electron microscopy use case will be developed by a consortium of four partners: Thermo Fisher Scientific, CQM, Eindhoven University of Technology and TNO. For CQM and Thermo Fisher Scientific, the cooperation in the ASIMOV-project gives the opportunity to further enhance their cooperation. CQM will have the opportunity to deepen their understanding of electron microscopy and of the applicability of digital twinning an AI in TEMs. This will give CQM the opportunity to enhance their added-value for Thermo Fisher Scientific. Thermo Fisher Scientific will benefit from the cooperation within CQM to potentially speed-up their innovation based on advanced digital twinning and AI applications.. This way, both partners will benefit from their close cooperation in the ASIMOV-project. TNO and the Eindhoven University of Technology will contribute to these joint exploitation opportunities with the results from their research.

3.1.2.2 The Unmanned Utility Vehicle case (AVL, LiangDao, Norcom, RAC and TrianGraphics – OFFIS, DLR)

Similar to the cooperation and joint exploitation opportunities for the Electron Microscopy use case, the consortium for the Unmanned Utility Vehicle has been formed to create opportunities for joint exploitation. Together with AVL, the industrial partners working on this case (LiangDao, Norcom, RAC, TrianGraphics) will create opportunities for extending their joint business based on the results from the ASIMOV-project. OFFIS and DLR, being existing research partners of AVL, will contribute to these joint exploitation opportunities with the results from their research.

3.1.2.3 Cross-Use case opportunities

As described above, the ASIMOV-consortium was shaped around two industrial use cases to maximize joint exploitation opportunities for the partners. Therefore, the clearest joint exploitation opportunities follow from this multifaceted approach. We will seek joint exploitation opportunities by groups of consortium partners beyond these two cases during the execution of the project.

As described in the FPP, the ASIMOV-partners will cooperate in WP2, WP3 and WP4 to develop shared technologies and processes for digital twin creation, training AI and for the industrial embedding.. Although the partners have been selected for their contribution to one of the use cases, we envision many opportunities for cross-overs. By bringing the partners together within these three WPs, we will stimulate and enhance exchange of expertise amongst all partners and amongst both use cases

3.1.3 Exploitation Opportunities beyond the Consortium

The results from the ASIMOV-projects are expected to be applicable in a wide range of industries, next to those represented within the project. To enhance the exploitation of the results, consortium members will seek cooperation with interested industries from their networks. Two concrete initiatives can be mentioned in this plan at this moment:

- the German consortium will work with associate partners;
- the Dutch consortium will create reference groups of companies from other application domains that have expressed their interest in the results of the project: (i) a reference group – companies (3) that have expressed their intention to validate and exploit the outcomes of the ASIMOV project for their own risk/cost; (ii) an audience group – companies (3) that will be actively informed about the results of the project, as they have expressed a clear interest in learning about the applicability of the outcomes of the ASIMOV project for their own businesses.

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3.2 Concrete Exploitation Opportunities

3.2.1 Industrial Partners

Exploitation Description	Measurable Effect	Planned date
AVL		
Industrial usability of developed methods and tool applications.	Alignment and positive feedback from associated partners in Germany.	M24
Improve efficiency of digital twinning for use-case "Unmanned Utility".	Cost reduction by 20%. Time reduction by 30%.	M24
Improve efficiency for calibration of Vehicle-in-the-Loop test system for use-case "Unmanned Utility".	Cost reduction by 30%. Time reduction by 50%.	M36
CQM		
Apply DT and AI to improve the product development process and production	+10% in turnover	M36 and later
Improve supply chain design, planning, and control by applying DT and AI in customer projects; e.g., warehousing, production, inventory, transportation	+20% in turnover	M36 and later
Support development of new products (e.g. consumer product, or complex devices in B2B) that contain AI for their operational use as a CPS.	+10% in turnover	M36 and later
LIANGDAO		
Upgrade of conventional environment perception by AI based perception algorithms	Faster and more reliable perception process, object perception can be applied to more specific use cases/situations. Number of potential customers will grow, estimated revenue increase is +30%.	M36
Digital Twin concept will be used for configuration and validation of sensor systems.	This will save preparation time and costs, also estimated revenue increase is +20%	M36
Setup of a new product and service portfolio in the field of unmanned utility vehicles (UUV)	The work in Asimov allows LiangDao to enter the UUV market and approach a new type of customers,	M12-M48
NORCOM		
Extension of data management platform with focus on automotive use cases	Positive feedback from existing and new partners. Extended support for two more data formats incl. time series data (mf4 and csv)	M18
Integration of results into AI platform and AI service portfolio	AI models can be stored, documented and served on our platform. New modules are available for time series analysis	M24
Increased turnover for platform licenses and AI services	+15% turnover	M24 - M48
Extension of data analytics platform for enabling new use-cases	Parts of the ASIMOV architecture, tools and methods are reused in other use-cases	M36 - M48
RAC		
Increase in sales of DiagRA-X licenses	+10% in turnover	after 2024
Increase in sales of MCD-AI components	+20% in turnover	after 2024
Increase in sales of new services	+15% in turnover	after 2024

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Exploitation Description	Measurable Effect	Planned date
TFS		
STEM Aberration correction and calibration software	Robust method for STEM aberration correction. Reduced need for manual calibration	M18
Digital twin technology optimizing R&D processes	DT used in R&D for designing new components for electron microscopes	M24
AI-driven tool for calibration and alignments, trained on DT of relevant parts of the system	Significantly reduced need for user interaction with the tool regarding calibration and alignment	M36
RL+DT aberration correction methodology working on both amorphous as crystalline materials	Alignment not needing specific calibrations samples anymore, leading to easier TEM operation	M36
AI + DT solution for automated microscope calibration during factory build up	Reduced need for TEM engineers during build-up and pre-calibration of TEMS, leading to ~10% build time reduction.	After 2024
TG		
Integration into product portfolio (Trian3DBuilder)	Improved product optimized for AI training and database variation. +25% turnover	M36-M48
Optimized workflows and database generation pipeline for improved services (digital twins of 3D maps)	Time reduction 25% Cost reduction 15%	M36
Scriptable generation Core running under Linux in Docker container, marketed with script interface as separate product (targeting cloud and server generation)	+15% turnover	M36-M48
New formats for wider customer range gITF including 3D Tiles	+10% turnover	M36-M48
Scenario generation pipeline (including 3d map variation for reinforcement learning) Training data through variation	very high market potential, but further work on business case needed: <ul style="list-style-type: none"> • lack of flexibility of variations • QA of results (validation and verification) • Performance (more iterations in less time) +30% turnover potential	M36-M60
Procedural content generation (placement of vector templates along road)	Significant time reduction environment generation (30% when no environmental data on hand)	M36-M42

Table 2 - Exploitation Opportunities for Industrial Partners

3.2.2 Academic and Research Partners

Exploitation Description	Measurable Effect	Planned date
DLR		
Research assets of new DLR institute	- After transition of OFFIS' transportation division to a new DLR institute (see Exploitation Results), results from ASIMOV will significantly enter the institute's research assets on scenario-based verification and validation of automated/autonomous systems and DTs/system simulation	M8 - M36

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Exploitation Description	Measurable Effect	Planned date
	- Results from ASIMOV will be part of the fundamental basis of the future research strategy of the new institute	
Follow-up projects	Creation of/Involvement in new follow-up projects, based on achieved results in ASIMOV	M24 -M36
TNO		
Competence Development Programs	New course, training programs (or extension of existing ones) offered by TNO (ESI) to their partners.	M24, M36
New project proposals for DT/ML/RL technologies (for system calibration and in other areas) using the learnings from ASIMOV	Project proposals (impact and business for TNO)	M36
Engineering for AI support and research services		M36
TUE		
R&D developments for new technologies in the area of AI and digital twinning	Integrated in exiting courses on optimal control and reinforcement learning within TUEs curriculum	M30-36
Follow-up Projects	Creation of / Involvement in new follow-up projects, based on achieved results in ASIMOV.	M24 -M36
Human capital	Two highly trained PhDs for the high-tech industry, plus several MSc students	M20-...

Table 3 - Exploitation Opportunities for Academic and Research Partners

3.2.3 Joint Exploitation Opportunities

Partners	Exploitation Description	Measurable Effect	Planned date
TUE, TFS	Enhanced cooperation based on jointly developed technical achievements in ASIMOV. Enhancing added value of TUE's offering to TFS.		TBD
Germany	Improved solutions to other calibration tasks around vehicle testing can be developed, due to synergies and joint understanding between research and industry. Additionally, the scope can be widened to other mobility solutions, such as maritime.		TBD
All	Cookbook activity to consolidate the lessons learned and best practices from the project, and provides advice on getting started with developing an ASIMOV solution.	Cookbook document available	M36

Table 4 - Joint Exploitation Opportunities

3.2.4 Exploitation Opportunities beyond the Consortium

Partners	Exploitation Description	Measurable Effect	Planned date
TFS, TNO, CQM, TUE	Industry reference group: workshops with 6 (at this moment) industries outside the ASIMOV-consortium to align on potential industry value and to share ASIMOV results. [Canon Production Printing, Lely, Philips, Smart Robotics, UltiMaker, Thales, CBoost]	<ul style="list-style-type: none"> - Input from industry on requirements for added-value creation - Experiments by industry with ASIMOV-results (validation and identification of exploitation opportunities) - Early adoption in the broader industry 	M15, M18, M24, M30, M36

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Partners	Exploitation Description	Measurable Effect	Planned date
All	Cookbook activity to consolidate the lessons learned and best practices from the project, and provides advice on getting started with developing an ASIMOV solution.	Cookbook document available	M36
TFS	Collaboration opportunity with LIACS for student training in advanced reinforcement learning.	<ul style="list-style-type: none"> - Better trained students - More RL algorithms evaluated for ASIMOV type use cases 	After end project

Table 5 - Exploitation Opportunities beyond the Consortium

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4 Exploitation Results

The table below gives an overview of the exploitation results.

4.1 Industrial Partners

Exploitation Description	Measurable Effect
AVL	
New internal cross-business unit wide collaboration on topic of AI-based system optimization	Regular internal alignment meetings at AVL Germany
New external collaboration activities with associated partners related to use-case "Unmanned commercial vehicles"	Regular meetings and workshops with associated partners in Germany (Cluster Commercial Vehicle, eMobil Baden-Württemberg)
CQM	
Design optimization for consumer products	Customer confidential
Projects for prediction algorithms in large physical systems	Customer confidential
Real time optimized replenishment process in warehouse of large retailer	Customer confidential
Real time optimal cutting of shapes using vision and AI algorithms	Customer confidential
Real-time scheduling of subsidized taxi rides for elderly and disabled citizens	Customer confidential
Use AI to optimize hyperparameter settings of simulated annealing algorithms for load carrier optimization at a large retailer	Customer confidential
Use of vision AI and ML to recognize degradation of train systems as wheels, pantographs and rails	Customer confidential
LIANGDAO	
New Collaboration with academic partner (TU Munich) related to use case UUV	External input on developing UUV product and service portfolio, developed network interested in LiangDao solutions
Use machine-learning based algorithms for LiDAR-based object perception	Processing time reduced from days down to hours or even real time (depending on use case) --> Access to a wider automotive and smart city market
Utilizing digital twins to test and validate machine-learning based perception algorithms	<u>Development and adaptation of machine-learning based algorithms can be speed up, also planning for customized solutions.</u>
Entering new market of autonomous shuttles for research and educational purposes	<u>New product</u>
NORCOM	
Extension of Data-Management-Platform	<u>Extended support for time-series data (mf4 files), improved data organization possibilities for all data including AI artifacts (models, training data, ..), improvements regarding a scalable architecture</u>
Extension of Data Analytics Platform	Support for model tracking, new data validation application
Preparatory work for scalable workflow applications	Proof of concept for an integrable workflow, preparatory work for Kubernetes support
Preparations for including digital twinning in product and consulting portfolio	Concept and architecture available

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Exploitation Description	Measurable Effect
RAC	
TFS	
New cross-business unit wide collaboration on the use of digital twins	Action towards centralized code base, regular meetings, formation of DT 'oversight' team
New activities in the field of Reinforcement learning	Newly identified use-cases where the use of RL could make a major difference
Investigation of factory cycle time improvement for TEM. ASIMOV technology may be used to automate and accelerate specific steps during manufacturing that are currently done by humans.	Faster production of TEMs, leading to revenue increase.
TG	
Generation core in docker container (Linux)	Internal: flexible server generation and CI pipeline
New testing capabilities of stock projects and through software update cycles	Internal: Automated testing based on the new scenario generation pipeline
Improved products through mature generation algorithms	content customers and future safety of products
Better Unreal Engine integration using import scripts (Blueprints)	customer interest generated

Table 6 - Exploitation Results of Industrial Partners

4.2 Academic and Research Partners

Exploitation Description	Measurable Effect
OFFIS/DLR	
Founding of DLR Institute upon OFFIS' transportation division	<ul style="list-style-type: none"> - By 2022-01-01 (M8) the OFFIS transportation division has been successfully transformed into a newly founded institute of the German Aerospace Center (DLR e.V.) - The new institute "Institute of Systems Engineering for Future Mobility" focuses on systems engineering with special focus on assuring technical trustworthiness of CPS (e.g., AI-based components), see: https://www.dlr.de/se/en/ - The involvement of OFFIS in projects like ASIMOV laid the foundation for this transfer and future assets of the new DLR institute (see Section 3.2.2)
The results of ASIMOV are used to extend our consultancy offer on the efficient transfer of research results to industry applications.	In ASIMOV, we identified results and knowledge on the application of AI-based optimization, testbeds and DT creation as such methods, that is beneficial for the industry and solve their needs. Partly the results and knowledge was used in the transfer project TASTE for establishing software development methods in the automotive sector. This is currently integrated into the offers that DLR supplies to the industry via the TASTE project.
DLR supports the foundation of spin-off companies and has set up specific guidelines for that. In the past, several spin-off companies have been founded out of DLR. Also, for ASIMOV, if there is a market and the results have reached an appropriate maturity level, then founding spin-off companies is an opportunity.	The methods and results have not reached a status sufficiently mature for the founding of spin-off companies.
DLR is reusing the methods and tools developed within ASIMOV to assemble a tool collection for the optimisation of cyber-physical systems.	DLR has developed tools and methods which haven't reached a maturity level adequate for the release to the public. However, they have been integrated into long-living product-like developments called "assets".
DLR employs one master student assistant for the development of Digital Twins and a	The master student is gaining knowhow on the development of Digital Twins and HiL-testbeds, equipping with valuable skills that will enhance their marketability in the job sector

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Exploitation Description	Measurable Effect
demonstrator in the context of the UUV use case	
DLR is interested in the transfer of results towards the industry. As such the "Testbed" (AMDevBed) has been developed to create an evaluation setup for the optimization, validation and testing activities (as developed in ASIMOV) and is also used and extended as a demonstrator within the Transformationhub Project "TASTE" for update and real-time activities (as developed in TASTE and other projects).	The AMDevBed has been showcased at the ESI Symposium receiving major attendance from the industry and is planned to be showcased on multiple industrial fairs soon.
TNO	
Engineering for AI support and research services	Knowledge is captured in the guide supported by experiment on the ASIMOV in a nutshell experimental platform
See the exploitation results in chapter 4.4	Future research opportunities that were identified with interested parties in the Netherlands
TUE	
Human capital	2 PhDs are hired.
Human capital	1 BSc student worked on a sensitivity analysis of the ronchigrams of the digital twin.

Table 7 - Exploitation Results of Academic and Research Partners

4.3 Joint Exploitation Results

Partners	Exploitation Description	Measurable Effect
All	ASIMOV cookbook	ASIMOV cookbook available for external parties beyond the consortium.

Table 8 - Joint Exploitation Results

4.4 Exploitation Results beyond the Consortium

Partners	Exploitation Description	Measurable Effect
TNO	ASIMOV demonstrator in Open Source	Open source implementation available to repeat results and experiment with RL and system optimization to understand key concepts
TNO	UltiMaker	Identify opportunities for optimization of 3d printer workflow- how to resolve pain points for the user and improve customer satisfaction
TNO	Philips IGT	Current focus is not on system optimization using AI due to health system certification challenges
TNO	CBoost	Interest in further collaboration with TNO ESI for robot optimization in for instance warehousing
TNO	Lely	Products are in development and the need for trust in autonomous vehicles for animal safety has been identified as challenge

Table 9 - Exploitation Results beyond the Consortium

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5 Terms, Abbreviations and Definitions

Table 10 - Terms, Abbreviations and Definitions

AI	Artificial Intelligence
ASIMOV	AI training using Simulated Instruments for Machine Optimization and Verification
DT	Digital Twin
ML	Machine Learning
RL	Reinforcement Learning
WP	Work Package
UUV	Unmanned Utility Vehicle
TEM	Transmitting Electron Microscope

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6 Bibliography

[1] ASIMOV-consortium, *ASIMOV - Full Project Proposal*, 2020.

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