ITEA-2018-17030
DayTiMe

Digital Lifecycle Twins for Predictive Maintenance

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D6.4 Final dissemination and standardization plan

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RE	Restricted to a group specified by the consortium (including the Commission Services)	
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Table of Contents

Executive summary

The document describes the plan for using and disseminating the knowledge in the context of the DayTiMe project, through various means including internal and external communication channels, the distribution of dissemination material and participation in dissemination activities. More specifically, the document includes the DayTiMe dissemination strategy, describing the target audience active in digital twins for predictive maintenance and smart services. and the means for communicating with them. Furthermore, the planned and performed dissemination activities are presented, including the participation in conferences and other relevant events and the publications in scientific journals.

1 Introduction

Dissemination is an important element of the DayTiMe project. It is carefully planned and implemented in order to spread awareness about this ITEA3 labeled project to a wide audience, including its end-users. This will help guarantee an optimal exploitation of the project results and the long-term sustainability of the DayTiMe vision. For this reason, the DayTiMe participants have formulated an initial dissemination plan that describes the objectives and foreseen channels for the dissemination of the knowledge generated by the project.

This plan is in compliance with the DayTiMe full project proposal CR#5 (ITEA3 17030), the DayTiMe Project Consortium Agreement, and the ITEA Rules and Regulations version 18, August 2019. This plan is an updated version of D6.2 Initial Dissemination and Standardization Plan.

Table 1: List of DayTiMe Participants

No	Partners	Country
1	Centre for Factories of the Future	GBR
2	Datenna	NLD
3	Eindhoven University of Technology	NLD
4	Havelsan	TUR
5	Mangoda	TUR
6	Philips Electronics Nederland	NLD
7	Philips Consumer Lifestyle	NLD
8	Philips Medical Systems Nederland	NLD
9	PS-Tech	NLD
10	Simeks	TUR
11	Target Holding	NLD
12	Tazi	TUR
13	Triatech	TUR
14	Turkcell	TUR
15	University Groningen	NLD
16	VAS	TUR
17	Yazzoom	BEL

2 Dissemination strategy

2.1 Means of communication

In order for dissemination to be effective, multiple communication channels are used in order to be able to effectively reach the desired target audiences. In this section an impression of the dissemination strategy and results over the project execution period (see Figure 1) are given while in the remainder of this deliverable a more detailed account will be presented.

One focus of dissemination will be on scientific publications and to address the academic research community. Publications within the area of interest of the project include both technology-oriented journals and conferences. Published results naturally tend to fall into one of the two categories, with some overlap between the two in case conference proceedings are published as journal paper.

Figure 1: Impressions of external dissemination activities

2.2 Target groups

As mentioned, the communication and dissemination approach of DayTiMe is implemented at different levels. It is based on solid project-level sharing of knowledge and communication patterns and it extends gradually to different target-users groups, from the DayTiMe network to the general lay public. This approach is illustrated in Figure 2.

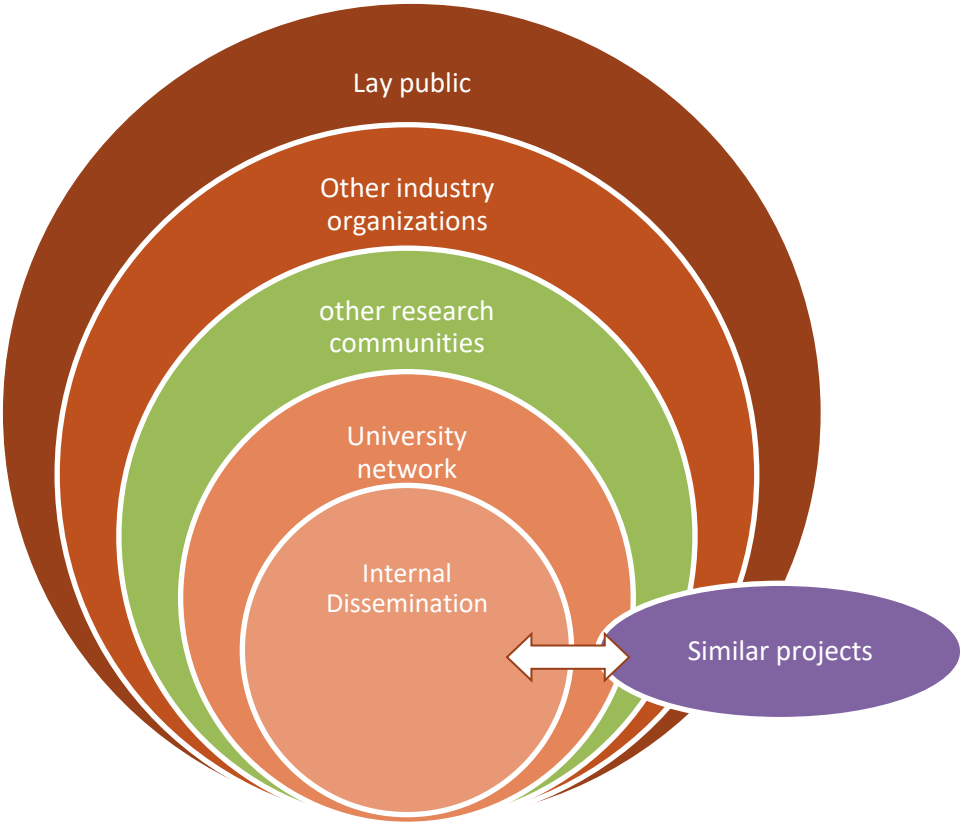


Figure 2: DayTiMe dissemination strategy

Several important target audiences for dissemination activities have been identified; these include academic researchers, manufacturers, maintenance providers, service providers as well as the general public. Different dissemination products appeal differently to each of these categories, and therefore it is necessary to be aware of what the focus of dissemination is during the different stages of the project, and how the results to be disseminated are to be best tailored to their target audience.

2.3 Timing

Concerning the timing of our dissemination strategy, three distinct phases of implementation can be identified (Figure 3). Year 1 is considered to be the first 18 Months of DayTiMe (on the total of 42 Months).

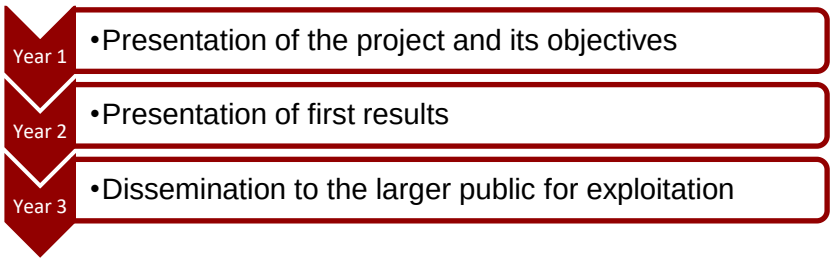


Figure 3: Focus of dissemination activities shifts over time.

Early on, focus was on building general awareness among industry and the general public, including potential customers, generating interest by communicating application

scenarios that appeal to a broad audience. As the project progressed, focus encompassed the predictive maintenance, smart services and tools that are being developed as well.

2.4 Internal dissemination strategy

Continuous and effective internal communication is key to the success of international projects such as DayTiMe. For this reason, internal dissemination is considered as an essential part of the dissemination strategy as a whole, in particular because partners joined to learn from each-other. Internal communication allows to:

- Keep track of project-related decisions and action points;
- Clearly communicate the role and responsibility of each project participant;
- Communicate on WP and demonstrator progress;
- Disseminate the right level of information to project participants;
- Identify problems and provide solutions.

2.5 External dissemination strategy

Much of the effort is aimed at 'external communication' to promote the project, and disseminate results. The major external dissemination objectives are to:

- Effectively use these communication channels to present the DayTiMe project's results;
- Establish links and encourage synergies with similar projects and initiatives;
- Provide the foundation of a comprehensive exploitation strategy.

Details of each dissemination activity/tool are provided in the section 4 ("Dissemination Tools").

3 Dissemination rules

3.1 Presentation and publication guidelines

All Partners contributed and will contribute to the publication policy, both at own initiative and upon request of other partners, work package leaders and the project managers.

When another partner is mentioned in a publication, written permission shall be requested from this specific partner. If a partner wishes to publish information generated in the DayTiMe project the approval of all partners has to be requested:

- This request shall be made preferably per e-mail;
- Reactions should be sent within 10 days;
- Without reaction permission is automatically granted after 10 days;
- In case of non-unanimous reactions the PM will take the final decision;
- A copy has to be send of the final publication to the project office for central archiving.
- The document will be published on the website until written indication is given that this is not allowed (e.g. due copyright rules from journals). In this case only the reference will be added;

3.2 Graphic identity

This section describes the features that contribute to giving a common graphic identity to all dissemination activities allowing for a better visibility and recognition of the project.

3.2.1 Layout and templates

Common/similar ***layouts*** are used for DayTiMe dissemination materials. ***Templates*** for project meeting minutes, deliverables and PowerPoint presentations were made available at the end of Month 2 of the project by the project coordinator, Philips.

3.2.2 Logos

In addition to the DayTiMe project logo the ITEA3 logo should be used when possible (both are shown on the frontpage of this document).

3.3 Compulsory acknowledgements

Any partner in the DayTiMe project will in their dissemination activities clearly acknowledge the ITEA3 Program with reference to the project “DayTiMe” and the grant number 17030.

Preferred reference:

"This work was labelled by ITEA3 and funded by local authorities under grant agreement "ITEA-2018-17030-Daytime" +include link to the project website

4 Dissemination tools

4.1 Internal dissemination tools

The project coordinator, Philips, together with the respective work package leaders, has put in place a variety of mechanisms to optimize the communication workflow.

4.1.1 Project meetings

As detailed in the DayTiME FPP CR#5, there are several types of project meetings:

- General Assembly meetings taking place at least three times a year;
- Regular project management team meetings;
- Regular work package meetings;
- Technical workshops;
- Additional telephone when needed for day-to-day coordination of the project.

In Table 1 an overview of consortium level gatherings is given. An impression of these meetings is given in Figure 4. Figure 1The General assembly meetings serve to update each other on project results, and to align the activities for the next period. Unfortunately, many meetings needed to be virtual due to Covid-19 restrictions.

Figure 4: Impression from General Assemblies

Table 1: Overview of Consortium level gatherings and activities

Date:	Meeting	Host (company)	Venue	Host (person)
CALENDAR 2017 - 2018				
6 – 8 Sep 2017	ITEA PO Event		Berlin	
May 2018	NL Meeting	Philips	HTC	
sep-18	Telco	Philips		
CALENDAR 2019				
16 – 17 April	Kick off meeting	Tazi	ITU University Istanbul	Ned Pamuk
25 June	Workshop NL	PEN	Eindhoven	QI Gao
27 – 28 Aug	General Assembly 1	Philips	Best	Mark van Helvoort
29 Oct	Workshop NL-BE		Drachten	Jan Post
17 – 18 Dec	General Assembly 2	Tazi	ITU University Istanbul TU	Nazire Bocu
CALENDAR 2020				
10 - 11 Feb (PM)	Rehearsal + Review 1	Philips	Virtual meeting	QI Gao
1-apr	GA	Philips	Virtual meeting	Ad de Beer
26-aug	GA		Virtual meeting	Jan Wytse van der Weit
9 - 10 Dec	GA	9-12 13:00 -16:30	Virtual meeting	Ipek Dorsun
		10-12 10:00 - 15:00		
CALENDAR 2021				
13-14 Januari	Review 2		Virtual meeting	All
6 - 7 April	GA		Virtual meeting	All
7 - 8 Sep	GA		Virtual meeting. Two afternoon sessions	All
1-2 December	GA	Tazi - Turkeys partners	Hybrid meeting	Ahmed
CALENDAR 2022				
23 February	GA	Philips PCL	Hybrid meeting	Jan Wytze vd Weit
30 March	Review rehearsal	Philips Medical Systems	Veenpluis 5 Best	Mark van Helvoort
31 March (PM)	Final review	Philips Medical Systems	Veenpluis 5 Best	Mark van Helvoort

4.1.2 Information sharing

DayTime consortium members use a file sharing and storage system to safely share project information, presentations and even photos. A link is given on the public website. Access is shielded by a user code and password. The user-friendly file transfer environment is structured around Documents (frozen) and Workspace (works in progress). The Documents section contains o.a. the current project plan and approved deliverables. Within the Workspace section different work packages (WPs) each have their own space.

4.1.3 Workshops

In addition to the general assemblies two smaller workshops were held (see Figure 5), e.g. with Dutch and funded Turkish partners and one with Belgium and Dutch partners. Due to COVID also hybrid meetings were implemented.

Figure 5 Impression from workshops

Furthermore bilateral workshops have been held. An impression is given in Figure 6.

Figure 6: Impression from bilateral workshops (left: PS-Tech at Philips; right: Yazzoom at Philips)

4.1.4 Other Tools

Other internal communication tools include mailing lists (participant, WP and at the consortium levels), internal staff meeting and meeting minutes, web conferencing etc.

4.2 External dissemination tools

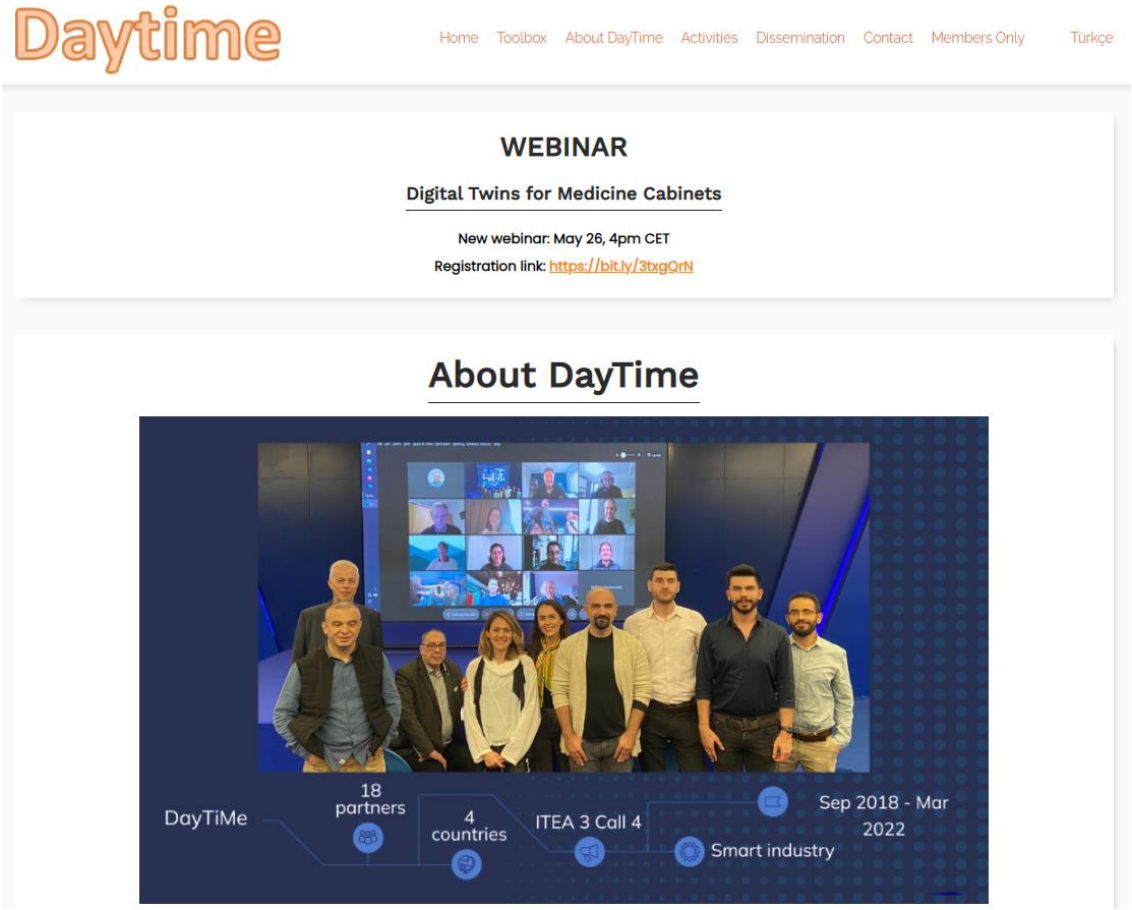
External dissemination designates actions aiming at ensuring the visibility and awareness of the results outside the Consortium borders, i.e., in the scientific community, in academic institutions, in other research organizations, or among the lay public. These tools include:

4.2.1 Project Public Website

The DayTiMe public website presents general project information, participant information, downloadable publications and deliverables. Furthermore, it informs viewers about previous and forthcoming events and activities of the project as well as of other relevant projects and collaborations. Philips Healthcare (NLD) designed the initial

website of DayTiMe. Later a new and improved design was made by Mangoda (TUR). The website was updated on a continual basis by Mangoda who as the WP6.1 leader is responsible for the website content until end of the project. The website will remain available up to at least three years after project closure. Other DayTiMe participants' contributions will be requested throughout the project.

Link to the DayTiMe public websites:
https://daytimeproject.com/



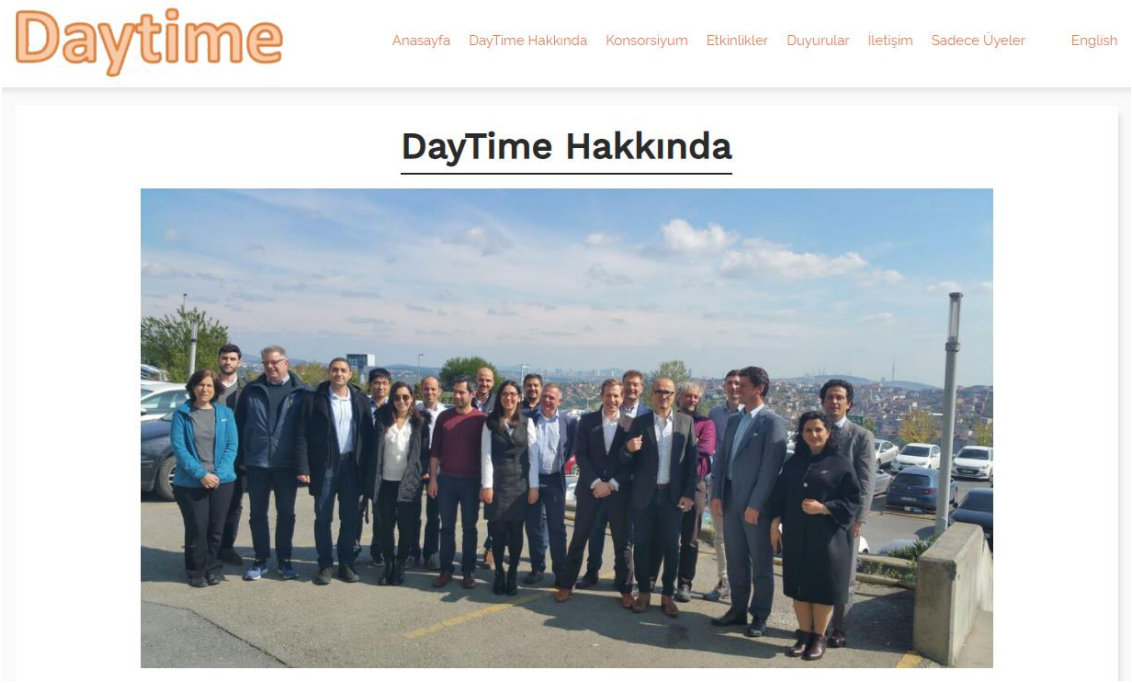


Figure 7: Public website (English and Turkish version)

4.2.2 Toolbox demonstration website

For the more research/technology related audience a dedicated website has been established with Toolbox Demonstrators: https://daytimetoolbox.com/.

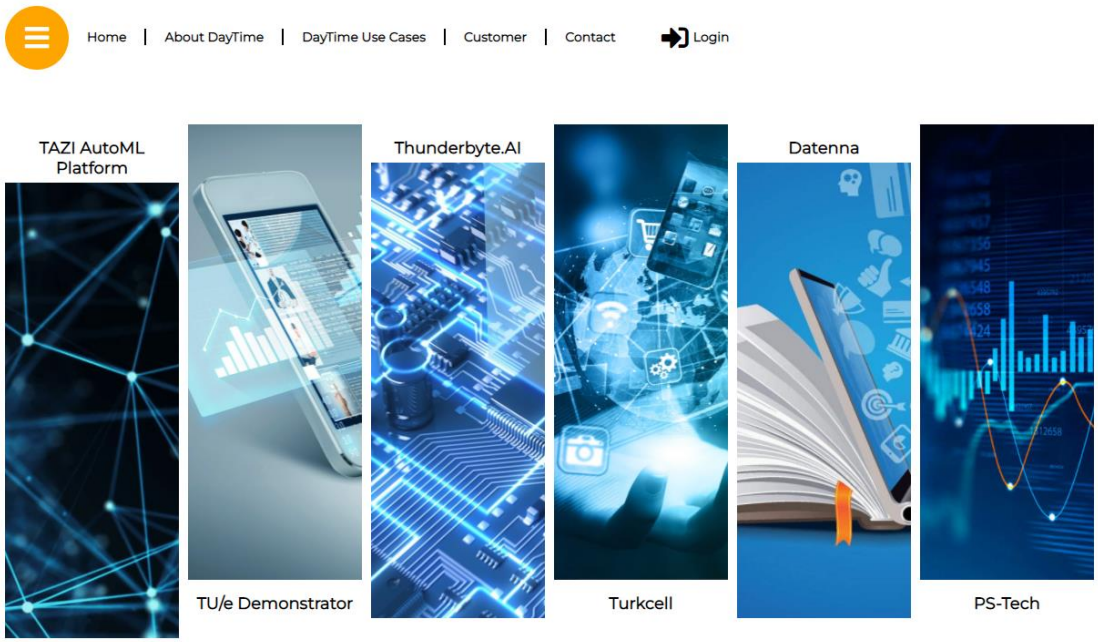


Figure 8: Toolbox demonstration website)

4.2.3 Patents

The University of Groningen submitted one patent as result of DayTiME:

- EPO for a novel fabrication process for polymeric microstructures which was used for sensor fabrication.

4.2.4 Publications and presentations

DayTiMe project results have been and will be submitted for publication in scientific journals, conferences, and workshops. The submission of papers jointly written by project participants is encouraged.

Given the diversity of use cases and tools being addressed in DayTiMe, a wide variety of national and international journals, conferences and workshops is targeted to disseminate DayTiMe results. The selection of a certain dissemination platforms will, apart from the topic, depended on the timing. Not all conferences are held every year, and also the timing within the year may vary. In particular also Covid-19 had a negative impact on dissemination possibilities.

- Dursun, Ipek and Akçay, Alp and van Houtum, Geert-Jan, Age-Based Maintenance under Population Heterogeneity: Optimal Exploration and Exploitation - ScienceDirect Doi: https://doi.org/10.1016/j.ejor.2021.11.038
- R. Rocchetta, L. G. Crespo, “A scenario optimization approach to reliability-based and risk-based design: soft-constrained modulation of failure probability bounds”, Reliability Engineering and System Safety
- Gray, A. Wimbush, R. Rocchetta, M. De Angelis, P. O. Hristov, D. Calleja, E. Miralles-Dolz, “From inference to design: a comprehensive framework for uncertainty quantification in engineering with limited information”, Mechanical Systems and Signal Processing
- ‘Dursun, Ipek and Akçay, Alp and van Houtum, Geert-Jan,Optimal Maintenance Planning under Population Heterogeneity with Data Retrieved from Multiple Systems’ Online Event: 11th IMA International Conference on Modelling in Industrial Maintenance and Reliability (MIMAR) - IMA
- Zheng, X., Kamat, A. M., Harish, V. S., Cao, M., & Kottapalli, A. G. P. (2021). Optimizing harbor seal whisker morphology for developing 3D-printed flow sensor. In 2021 21st International Conference on Solid-State Sensors, Actuators and Microsystems (TRANSDUCERS) (pp. 1271-1274). [B3-344j] IEEE.
- Roberto Rocchetta, Qi Gao, Milan Petkovic, “Soft-constrained interval predictor models and epistemic reliability intervals: A new tool for uncertainty quantification with limited experimental data” Mechanical Systems and Signal Processing, Vol 161, 2021,
- 107973, https://doi.org/10.1016/j.ymssp.2021.107973
- Kamat, A. M., & Kottapalli, A. G. P. (2021). 3D printed graphene-coated flexible lattice as piezoresistive pressure sensor. In 2021 21st International Conference on Solid-State Sensors, Actuators and Microsystems (TRANSDUCERS) (pp. 888-891). [B4-411d] IEEE.
- T. Li, B. Jayawardhana, A. M. Kamat and A. G. P. Kottapalli, "Source-Seeking Control of Unicycle Robots With 3-D-Printed Flexible Piezoresistive Sensors," in IEEE Transactions on Robotics, doi: 10.1109/TRO.2021.3076964. A video summary of the work can be found here: https://www.youtube.com/watch?v=y3OoRu5GX3M

- Roberto Rocchetta, The Twelfth International Symposium on Imprecise Probability: Theories and Applications (ISIPTA 2021), https://drive.google.com/file/d/1yDGx8lJvKI6jocwpy3lYmtdHRYwIaT-W/view?usp=sharing
- Shaochuan Feng, Amar M. Kamat, Soheil Sabooni & Yutao Pei (2021) Experimental and numerical investigation of the origin of surface roughness in laser powder bed fused overhang regions, Virtual and Physical Prototyping 16, DOI: 10.1080/17452759.2021.1896970.
- Link to paper (open access): https://www.tandfonline.com/doi/full/10.1080/17452759.2021.1896970
- Shaochuan Feng, Amar M. Kamat, & Yutao Pei (2021) Design and fabrication of conformal cooling channels in molds: Review and progress updates, International Journal of Heat and Mass Transfer 171, 121082, DOI: 10.1016/j.ijheatmasstransfer.2021.121082. Link to paper (open access): https://www.sciencedirect.com/science/article/pii/S001793102100185X
- A Bachelor student, Mart Veenstra, from the Industrial Engineering and Management program at the University of Groningen will perform his final year project with us to develop pressure sensors on shavers. His project runs from April to June 2021.
- Our Abstract titled '3D-printed Flexible Piezoresistive Sensors-based Source Seeking Control of Unicycle Robots' has been accepted for presentation at the Benelux Workshop on Systems and Control 2021. The work describes the development of control algorithms for autonomous steering of robots towards an airflow source using 3D-printed airflow sensors. The paper will be presented in the conference in Jun 2021. A video demo of the robot source seeking can be publicly accessed here: https://www.youtube.com/watch? v=y3OoRu5GX3M
- Dursun, LNMB (Landelijk Netwerk Mathematische Besliskunde) conference in January 22, 2021 with topic: ‘Age-Based Maintenance under Population Heterogeneity Optimal Exploration and Exploitation’: https://drive.google.com/file/d/1Nt1oz0CyuDbfvUpojw7Qp0SVcEsUQcAj/view
- M. Kamat, Y. Pei, B. Jayawardhana, A. G. P. Kottapalli, Biomimetic Soft Polymer Microstructures and Piezoresistive Graphene MEMS Sensors Using Sacrificial Metal 3D Printing, ACS Applied Materials and Interfaces (2021). doi:. 10.1021/acsami.0c21295 Link to paper (open access): https://pubs.acs.org/doi/10.1021/acsami.0c21295
- U. Saha, A.M. Kamat, D. Sengupta, B. Jayawardhana, A.G.P. Kottapalli, A Low-Cost Lung Monitoring Point-Of-Care Device Based On A Flexible Piezoresistive Flow Sensor, 2020 IEEE Sensors Proceedings, Rotterdam, NL, Oct 25-28. (2020)
- A.M. Kamat, B. Jayawardhana, A.G.P. Kottapalli, PDMS Flow Sensors With Graphene Piezoresistors Using 3D Printing and Soft Lithography, 2020 IEEE Sensors Proceedings, Rotterdam, NL, Oct 25-28. (2020)
- Fabrication of polymeric microstructures, PCT/EP2020/082304, filed Nov 16 2020 Patent applicant: University of Groningen Inventors: Kamat, A.M., Kottapalli, A.G.P, Pei, Y.

- A.M. Kamat, X. Zheng, B. Jayawardhana, A.G.P. Kottapalli, Bioinspired PDMS-graphene cantilever flow sensors using 3D printing and replica moulding, Nanotechnology. (2020). doi:10.1088/1361-6528/abcc96.
- Roberto Rocchetta, Qi Gao, Milan Petkovic “Scenario-based generalization bound for anomaly detection support vector machine ensembles”, submitted to ESREL 2020 PSAM 15 conference. https://www.rpsonline.com.sg/proceedings/esrel2020/pdf/5708.pdf
- Gray, R.Rocchetta, A. Wimbush, M. DeAngelis, P. O. Hristov, E. Miralles-Dolz, D. Calleja “Solution framework for black-box uncertainty quantification: addressing the 2020 NASA Langley’s UQ challenge on optimization under uncertainty”, submitted to ESREL 2020 PSAM 15 conference. https://www.rpsonline.com.sg/proceedings/esrel2020/pdf/5520.pdf
- R. Rocchetta, L.G. Crespo “An Empirical Approach to Reliability-based Design using Scenario Optimization”, e-proceedings of the ESREL 2020 PSAM 15 conference. https://www.rpsonline.com.sg/proceedings/esrel2020/html/4775.xml
- Grishina, M. Stolikj, Q. Gao, and M. Petkovic, “Improving Spare Part Search for Maintenance Services using Topic Modelling,” in Proceedings of the CIKM 2020 Workshops, Galway, Ireland (online) http://ceur-ws.org/Vol-2699/paper13.pdf
- Kamat, A. M., Zheng X., Jayawardhana B., Kottapalli, A. G. P. (2020) Bioinspired PDMS-graphene cantilever flow sensors using 3D printing and replica moulding, IOP Nanotechnology, under review
- Kamat, A. M., Pei, Y. T., Jayawardhana B., Kottapalli, A. G. P. (2020) Sacrificial metal 3D printing for biomimetic soft polymer microstructures and MEMS sensors with embedded graphene piezoresistors, ACS Applied Materials and Interfaces, under review
- Saha, U., Kamat, A.M., Sengupta, D., Jayawardhana, B., Kottapalli, A.G.P., A low-cost lung monitoring point-of-care device based on a flexible piezoresistive flow sensor,IEEE Sensors 2020, Oct 25-28 2020, Rotterdam, NL
- Kamat, A.M., Jayawardhana B., Kottapalli, A. G. P., PDMS flow sensors with graphene piezoresistors using 3D-Printing and soft lithography, IEEE Sensors 2020, Oct 25-28 2020, Rotterdam, NL
- Jan Verhasselt, Managing Director Yazzoom & Koen De Bauw Chief Technologist Engie - Laborelec Hybrid (AI & Human) Condition Monitoring of Combined Heat and Power Plants on Asset Performance 4.0 Conference www.assetperformance.eu
- DayTiMe Consortium, “DayTiMe: State-of-the-art on use cases and enabling technologies”, public deliverable. PDF
- DayTiMe Consortium, “DayTiMe: State-of-the-art on use cases and enabling technologies”, public deliverable. PDF
- Roberto Rocchetta, Qi Gao, Milan Petkovic “Scenario-based generalization bound for anomaly detection support vector machine ensembles”, (accepted) ESREL 2020 PSAM 15 conference.
- Gray, R.Rocchetta, A. Wimbush, M. DeAngelis, P. O. Hristov, E. Miralles-Dolz, D. Calleja “Bayesian calibration and probability bounds analysis solution to the Nasa 2020 UQ challenge on optimization under uncertainty”, (accepted) ESREL 2020 PSAM 15 conference.

- R. Rocchetta, L.G. Crespo “An Empirical Approach to Reliability-based Design using Scenario Optimization”, available on the e-proceedings of the ESREL 2020 PSAM 15 conference. https://www.rpsonline.com.sg/proceedings/esrel2020/html/4775.xml
- R. Rochetta, E. Patelli, "A post-contingency power flow emulator for generalized probalistic risks assessment of power grids", Reliability Engineering and System Safety 197 (2020), Elsevier
- Dursun, "Data-driven Maintenance Planning under Uncertainty", ITU
- M. van Helvoort, "Resonating Public Private Partnerships", European Alliance Summit
- Dursun, "Data-driven Maintenance Planning for Capital Goods", Data Science Summit
- Soleymanzadeh, K., "A Tool for Modeling JsonLogic based Business Process Rules", Proceedings of the 1st International Informatics and Software Engineering Conference
- J. van Etten, "DayTime - benefit of PPP for SME", JADS guest lecture, November 4, 2019.
- Dursun, "Maintenance Planning under Uncertainty", ESCF Workshop

4.2.5 Press releases and social media

Press releases are organized on an ad hoc base to disseminate special milestones and/or project results. Very often media coverage cannot be orchestrated but “happens” as a result related dissemination activities.

Social media gives more control over dissemination timing. Mangoda has established and maintains a LinkedIn account for DayTiMe:
https://www.linkedin.com/company/daytime/.

4.2.6 Alignment with other European Projects

DayTiMe builds on the results of the ECSEL Mantis project and the ITEA3 REFLEXION project. Close contacts are maintained with the ITEA3 IVVES project which focusses on verification and validation of artificial intelligence algorithms in evolving systems. Other links exist with the ECSEL ArrowHead Tools project which in turn had a close cooperation with ECSEL Productive 4.0. Furthermore, based on DayTiMe results and findings new public-private partnership initiatives have been and will be submitted.

4.2.7 Education and Innovation

Educating young scientists and involving them in innovation is an important aspect of the DayTiMe project. DayTiMe is actively involved in graduation assignments for M.Sc. and Ph.D. students which (partially) take place at industrial partner premises.

Several partners also employ company internal means to educate colleagues in the activities and results of the DayTiMe project (see Figure 9).

Figure 9: Impression of partner internal dissemination activities (Philips Healthcare)

5 Standardization

5.1 Compliance with existing standards

Obviously the demonstrators and products to be developed in DayTiMe to comply with the existing international standards in particular regarding the devices in the use cases and the tools in the integrated tool kit. Some of the most important standards are listed in Table 2 below.

Table 2 Standards most relevant for the DayTiMe use cases and the integrated tool kit

Standard	Description
CRISP-DM	Cross Industry Standard Process for Data Mining[1]
ISO 27001	Information Security
ISO 31000	Risk Management
ISO 13485:2016	Medical devices - Quality management systems - Requirements for regulatory purposes
IEC60601-1	Medical electrical equipment - Part 1: General requirements for basic safety and essential performance
IEC60601-1-33	Medical electrical equipment - Part 2-33: Particular requirements for the basic safety and essential performance of magnetic resonance equipment for medical diagnosis
IEC 60335-1	Household and similar electrical appliances - Safety - Part 1: General requirements
IEC 60335-2-8	Household and similar electrical appliances - Safety - Part 2-8: Particular requirements for shavers, hair clippers and similar appliances
IEC 62304	Medical device software

Apart from this, medical devices have to be approved by national and international regulatory agencies. In Europe this includes the CE Marking for medical devices while in the US the stringent FDA approval is required.

The healthcare OEM's owning the demonstrators in DayTiMe are long standing manufacturers of medical devices. They are all very aware and familiar with the regulations concerning the manufacturing of these devices and all have extensive experience in the procedures and steps required to get devices approved by the regulatory agencies.

5.2 Setting standards in DayTiMe

5.2.1 Survey and gap analysis

The DayTiMe project performed a survey of standards currently available or under development for the Digital Twin and Predictive Maintenance domain. An extensive report, including gap analysis, has been created by the project partners and is embedded as separate file in this document. Gaps between existing standards and areas for new industry standards are highlighted.

[1] C. Shearer, "The CRISP-DM model: the new blueprint for data mining," J Data Warehousing , vol. 5, pp. 13-22, 2000

5.2.2 Repository of potential standards

At present, predictive maintenance has obtained some research results and application cases in the field of military industry, and aerospace. From a standardized point of view, ISO, IEEE, MIMOSA Mechanical Information Management Open Standard Alliance, SAE Society of Automotive Engineers, (FAA, Federal Aviation Administration) FAA and the United States military have made and developed the standards and norms. In different fields, there are some standards and norms such as CBM/IVHM/PHM/HUMS. The overall status is shown in the following Table[2].

Standard Organization	Technical Committee	Typical Standard	Category
ISO	TC108	CM&D	CBM
MIMOSA	---	OSA-CBM, OSA-EAI	
SAE	G-11r	CBM	
	HM-1	IVHM	IVHM
	E-32	EHM	PHM
IEEE	SCC20	IEEE Std-1232	
	PHM	IEEE Std-1636	
SAE	HM-1	HUMS	HUMS
FAA	---	AC-29C MG-15	
U.S. Army	---	ADS-79-HDBK	
IEC	TC 56	IEC 60300, IEC 60706, IEC 60812	
	TC 65	IEC 62541 (OPC UA), IEC 62264 (MES), IEC 61158, IEC 62904	

5.2.3 *ISO/TR 24464:2020* (en) Automation systems and integration — Industrial data — Visualization elements of digital twins

This standard analyses visualization elements to be shared or integrated between an avatar (digital replica) and a physical asset. Three component models of the digital twin, which are physical asset, avatar, and real-time interface, are adopted and elaborated in this document. The fidelity measure of the interface between the avatar and the physical asset is discussed.

[2] Sino-German Industrie 4.0/Intelligent Manufacturing Standardization Sub-Working Group Standardization Council Industrie4.0(SCI4.0)2018-04, [online] Available: https://www.dke.de/resource/blob/1711308/ad04db2c91a6749c86e7311c1a294644/the-standardisation-roadmap-of-predictive-maintenance-for-sino-german-industrie-4-0-data.pdf

Scope

This standard analyses visualization elements that are key components of the interface between the physical asset and the avatar (digital replica of the physical asset).

5.2.4 *ISO 14224:2016*(en) Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment

This International Standard defines a minimum amount of data that is required to be collected, and it focuses on two main issues:

- data requirements for the categories of data to be collected for use in various analysis methodologies;
- standardized data format to facilitate the exchange of reliability and maintenance data between plants, owners, manufacturers and contractors.

The following main categories of data are to be collected:

a) a) equipment data, e.g. equipment taxonomy, equipment attributes;

b) b) failure data, e.g. failure cause, failure consequence;

c) c) maintenance data, e.g. maintenance action, resources used, maintenance consequence, down time.

NOTE Clause 9 gives further details on data content and data format.
The main areas where such data are used are the following:

1. reliability, e.g. failure events and failure mechanisms;
2. availability/efficiency, e.g. equipment availability, system availability, plant production availability;
3. maintenance, e.g. corrective and preventive maintenance, maintenance plan, maintenance supportability;
4. safety and environment, e.g. equipment failures with adverse consequences for safety and/or environment.
5.

5.2.5 ISO 13374-1:2003(en) Condition monitoring and diagnostics of machines — Data processing, communication and presentation — Part 1: General guidelines

ISO 13374 consists of the following parts, under the general title *Condition monitoring and diagnostics of machines — Data processing, communication and presentation*:

- Part 1: General guidelines
- Part 2: Data-processing requirements
- Part 3: Communication requirements
- Part 4: Presentation requirements

Introduction

The various computer software programs written for condition monitoring and diagnostics of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive integration effort. This makes it difficult to integrate systems and

provide a unified view of the condition of machinery to users. The intent of ISO 13374 is to provide the basic requirements for open software specifications which will allow machine condition monitoring data and information to be processed, communicated and displayed by various software packages without platform-specific or hardware-specific protocols.

Extensible Markup Language (XML) is a project of the World Wide Web Consortium (W3C), and the development of the specification is being supervised by their XML Working Group. XML is a public format written in the Standard Generalized Markup Language (SGML) (see ISO 8879[1] for details) for defining descriptions of the structures of different types of electronic documents. The version 1.0 specification was accepted by the W3C as a Recommendation in 1998. A W3C Recommendation indicates that a specification is stable, contributes to Web interoperability, and has been reviewed by the W3C membership, who are in favour of supporting its adoption by academic, industry and research communities. It is designed to improve the functionality of the Web by providing more flexible and adaptable information identification.

Scope

This part of ISO 13374 establishes general guidelines for software specifications related to data processing, communication, and presentation of machine condition monitoring and diagnostic information.

NOTE Later parts of ISO 13374 (under preparation) will address specific software specification requirements for data processing, communication and presentation.

5.2.6 ISO 13374-2:2007(en) Condition monitoring and diagnostics of machines — Data processing, communication and presentation — Part 2: Data processing

Introduction

The various computer software systems written for condition monitoring and diagnostics (CM&D) of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive integration effort. This makes it difficult to integrate systems and provide a unified view of the condition of machinery to users. The intent of Parts 1 to 3 of ISO 13374 is to provide the basic requirements for open CM&D software architectures which will allow CM&D information to be processed, communicated, and displayed by various software packages without platform-specific or hardware-specific protocols.

Scope

This part of ISO 13374 details the requirements for a reference information model and a reference processing model to which an open condition monitoring and diagnostics (CM&D) architecture needs to conform. Software design professionals require both an information model and a processing model to adequately describe all data processing requirements. This part of ISO 13374 facilitates the interoperability of CM&D systems.

5.2.7 ISO 13374-3:2012(en) Condition monitoring and diagnostics of machines — Data processing, communication and presentation — Part 3: Communication

Introduction

The various computer software systems written for condition monitoring and diagnostics (CM&D) of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive communication infrastructure. The lack of an all-purpose communication system makes it difficult to integrate various CM&D sub-systems and provide a

unified view of the condition of machinery to users. The intent of ISO 13374 is to provide the basic requirements for open CM&D software architecture in order to allow CM&D information to be processed, communicated and displayed by various software packages independent of platform-specific or hardware-specific protocols.
ISO 13374-1 gives a general overview of data processing, communication and presentation. ISO 13374-2 provides greater details of the data-processing methodology and requirements present in today's software-enhanced systems. This part of ISO 13374 provides the requirements of the data communication architecture for open CM&D systems.

Scope
This part of ISO 13374 specifies requirements for data communication for an open condition monitoring and diagnostics (CM&D) reference information architecture and for a reference processing architecture. Software design professionals require communications to be defined for exchange of CM&D information between software systems. This part of ISO 13374 facilitates the interoperability of CM&D systems.

5.2.8 ISO 13374-4:2015(en) Condition monitoring and diagnostics of machine systems — Data processing, communication and presentation — Part 4: Presentation

Introduction

The various computer software systems written for condition monitoring and diagnostics (CM&D) of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive communication infrastructure. The lack of an all-purpose communication system makes it difficult to integrate various CM&D sub-systems and provide a unified view of the condition of machinery to users. The intent of ISO 13374 is to provide the basic requirements for open CM&D software architecture in order to allow CM&D information to be processed, communicated, and displayed by various software packages independent of platform-specific or hardware-specific protocols.
ISO 13374-1 gives a general overview of data processing, communication, and presentation. ISO 13374-2 provides greater details into data processing methodology and requirements that should be present in today's software-enhanced systems. ISO 13374-3 provides the requirements of the data communication architecture for open CM&D systems. This part of ISO 13374 provides the requirements for the presentation of CM&D information for diagnostic analysis and decision support.

Scope
This part of ISO 13374 details the requirements for presentation of information for technical analysis and decision support in an open architecture for condition monitoring and diagnostics. Software design professionals need to present diagnostic/prognostic data, health information, advisories, and recommendations on computer displays and in written report formats to end-users. This part of ISO 13374 provides standards for the display of this information in CM&D systems.

5.2.9 ISO/TR 24464:2020(en) Automation systems and integration — Industrial data — Visualization elements of digital twins

Introduction

This document analyses visualization elements to be shared or integrated between an avatar (digital replica) and a physical asset. Three component models of the digital twin,

which are physical asset, avatar, and realtime interface, are adopted and elaborated in this document. The fidelity measure of the interface between the avatar and the physical asset is discussed.

Scope

This document analyses visualization elements that are key components of the interface between the physical asset and the avatar (digital replica of the physical asset).

5.3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

administration shell
bridge between a tangible asset and the IoT world

asset
economic resource, or something of value

avatar
digital replica of a physical asset

digital twin
compound model composed of a physical asset, an avatar and an interface

fidelity
level of accuracy whereby a copy reproduces its source

level of detail
decrease in complexity of a 3D model representation as it moves away from the viewer or according to other metrics such as object importance, viewpoint-relative speed or position

physical asset
asset which exist in the real world

accuracy
measurement deviation from true value and its scatter

Note 1 to entry: Accuracy consists of trueness (proximity of measurement results to the true value) and precision (repeatability or reproducibility of the measurement).

reality
sum or aggregate of all that is real or existent, as opposed to that which is only imaginary

realtime
guarantee response within specified time constraints

Note 1 to entry: Often referred to as "deadlines".

shape
form of an object or its external boundary, outline, or external surface, as opposed to other properties such as color, texture or material type

STEP model
product model which is described according to ISO 10303

synchronization
joining up of multiple processes at a certain point, in order to reach an agreement or commit to a certain sequence of action

visualization
technique for creating images, diagrams, or animations to communicate a message

5.4 Mapping of standards

During this activity, DayTiMe team started mapping process. In this process, the standarisation opportunities which were identified from the workshop, were mapped with related standards. As a result, a mapping table was produced. The final table has been presented below.

Table 3: DayTiMe Standardisation Opportunities and potential Standards

Opportunities	Related Standards
Pre-processing & structuring of the data • How to link tables (relation between data) • How to limit manual effort needed to explain the data • Data filtering • Meaning of data (semantic)	ISO 13374-1:2003 (en) Condition monitoring and diagnostics of machines — Data processing, communication and presentation Part 1: General guidelines Part 2: Data processing Part 3: Communication Part 4: Presentation
SWO (NLP) • Human written reports on maintenance • Standard words/keywords to be used while writing the text	ISO 14224:2016(en) Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment
Visualization • Allowing 3rd party tools to connect the predicative maintenance results • Including 3rd models, model outputs, sensor data	ISO/TR 24464:2020 (en) Automation systems and integration — Industrial data — Visualization elements of digital twins

GSM use case • Standards on Maintenance Metrics for GSM Base Stations (standardize terminology and definition)	ISO/IEC AWI 30173 Digital twin — Concepts and terminology (Status : Under development)
Digital Twin for predictive maintenance • Architecture picture • Maturity matrix to help industry maturing in the field of digital twin in a phased approach	ISO/FDIS 23247-2 Automation systems and integration — Digital twin framework for manufacturing — Part 2: Reference architecture (Status : Under development)

5.5 Potential benefits to DayTiMe tool providers

International Standards mean that consumers can have confidence that the products are reliable and of good quality. The ISO certificate can be great more for companies because an international recognition offers the possibility to operate beyond national borders, which means that companies can increase their sales and revenue. Companies with an ISO label use this improve their image and show the rest of the world that they work in conformity with international standards. For many buyers and customers this is a sign that the companies offer excellent products and services.

ISO standards attempt to ensure quality, consistency, and safety and show us how to check for quality. There are many benefits for businesses, which embrace these standards. Some of them are:

Demonstrate reliability - with following standards, companies have the opportunity to demonstrate their reliability to purchasers, suppliers, business partners and government. Reliability means quality, safety and durability of products and/or services. With an standard, companies demonstrate that they meet the requirements of international legislation and regulation and adhere to these.

Improved performance - by giving organizations the knowledge they need to optimize their operations in order to be able to perform at their best. This also help them to have satisfied customers and more efficient ways to work, as well as, the ability to implement new working practices more efficiently and faster.

Improve the quality of services, manage projects in the most effective way and access new markets due to products and services can be compatible with international standards.

Risk reduction - standards prepares organizations in advance to deal with risks and turn them into opportunities. These standards also ensure that you understand how to manage and mitigate risks. Therefore, if problems arise, organizations are better equipped to survive them and then recover faster.

Sustainability - By helping businesses to take a close look at how they are using resources, energy and controlling waste, standards help them to save money and improve their own image while benefiting the environment.

Innovation - standards benefit organizations that want to commercialize emerging technologies. These standards help businesses to establish the core characteristics of quality products or services. By implementing standards, companies can demonstrate their credentials to their customers, employees, and other stakeholders.

International Standards ensure safety and quality, showing consumers that businesses they buy from are operating in a safe way, producing reliable goods without unduly harming the environment.

5.6 Conclusion

The main vision for Standardisation in predictive maintenance and digital twin is to provide a standardized infrastructure. This infrastructure shall focus on providing a systematic and functional view of predictive maintenance, and shall provide appropriate interfaces to relevant functionalities like sensing, processing data from log files, prediction, and digital twin. This should include access to information of the entity, originating from different stages of its life cycle. Thus, a common framework shall be established, leaving room for easy embedding of new technologies. This will allow for future developments, and will be a basis for application domain specific specialization and implementation.

There is a lack of standards in industry, both for technology and for content and functionality. Much progress has been made here in recent years in health care. HL7-FHIR became the standard for data exchange. It combines technical standards and functional/contextual standards (like SNOMED, ATC, IDC,etc) making data exchange possible and also the exchange and reuse of tools. There is a need for comparable industry standards for predictive maintenance, standards for the following matters are important:

- Data from log files
- Data from sensors
- Test data from machines
- Configuration data from machines
- Process data from machines (service work orders)

6 Appendices

6.1 Appendix 1 - Standardisation Questionnaires used

Table 4 DayTiMe Partners Standardisation Questionnaire Template

Use-Case	<<Use-case-name>>
Tool provider	
Submitter Name and Company	
1. Describe the area of your work in DayTiMe that can be standardised e.g., any tool, process or interface? If yes, describe the tool, process or interface.	
2. Are you following any standard(s) in your work in DayTiMe? **i) If yes, please provide details of the standard(s) that you are following?** **ii) If no, do you see advantages in standardise your tools/processes/interfaces? If yes, go to Q3. If no, explain why not?**	
3. If your answer to Question 2 i) or 2ii) was affirmative are there any (other) standards you would wish to propose?	
4. If you wish to standardise any tools/processes/interfaces, are you aware of any appropriate standard(s)?	

5. Do the standards considered or proposed satisfy your requirements? If not, what are missing? Please suggest possible remedies, if any.	