

Implementation Strategies for the Gaia-X Federation Services: Project Progress and New Requirements

A Delta Study with Outlook

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Foreword

Dear Reader,

A year has passed since our first GXFS Connect event in 2022. A lot has happened this year – both the Gaia-X Federation Services (GXFS) and the Gaia-X funding projects have made great progress. In the meantime, visions and ideas have become concrete application examples and the technical framework for new digital business ideas is being rapidly established in many projects.

Many projects are intensively evaluating the Free and Open Source (FOSS) software components developed within the GXFS-DE project. The GXFS-DE project team did a lot last year to ensure that the FOSS components were applied in the projects: Low-threshold information offers were created by means of regular mailings and information events, various workshop formats were set up and the direct exchange with the projects was also intensively cultivated. In the course of this study, we not only received valuable feedback on the information already provided and the communication of this, but also identified additional success factors of the projects as well as requirements for successful implementation.

Opportunities to get involved with GXFS-DE were also further expanded last year. Among other things, the project has now been transferred to the care of the Eclipse Foundation under the name "XFSC – Cross Federation Services Components", in order to be further developed there as a FOSS project in the future by committed actors from the Gaia-X community.

This study forms the delta of one year between our first study "Strategies for Building Gaia-X Ecosystems using the Gaia-X Federation Services – In dialogue with the Gaia-X Projects" in which we interviewed the eleven projects of the Gaia-X funding competition of the German Federal Ministry for Economic Affairs and Climate Action (BMWK). We wanted to explore what has been achieved by the projects over the last 12 months, where and how the Federation Services components are being used and where there are still challenges in the implementation.

The results suggest: communication and cooperation with the projects are particularly important. The success of GXFS-DE is not only dependent on technical aspects, but also on effective interaction with the users. Therefore, for the remainder of the project, the focus lies specifically on ensuring transparent and constructive communication with the project participants by means of knowledge transfer measures.

The study results at hand are based on the analysis of an online survey and a series of extensive expert interviews conducted in the period from June to August 2023. In addition to the status quo, applications and requirements, special areas such as business models, law or documentation were addressed.

We would like to thank you for your continued interest and support and hope that you will gain valuable insights and knowledge from this study. Your opinion and feedback are important to us in order to continuously build the GXFS/XFSC FOSS community and to meet the needs of users.

We hope you enjoy reading this report and look forward to our continued cooperation.



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Executive Summary

This study, “Implementation Strategies for Gaia-X Federation Services: Project Progress and New Requirements – a Delta Study with Outlook” was designed and published as a follow-up study to the study “Strategies for Building Gaia-X Ecosystems using the Gaia-X Federation Services – In dialogue with the Gaia-X Projects”. The aim of this delta study is to gain insights into the status and challenges of implementing the Gaia-X Federation Services (GXFS) in the funding projects. The study is based on a two-stage survey consisting of online surveys and expert interviews to gain comprehensive insights into the projects and how they are progressing.

The results show that sufficient information on GXFS is available. The inclusion of user requirements from the beginning is seen as crucial in order to optimally design the GXFS concepts. Regular events and information platforms are identified as conducive to successful project work. Participation in cross-project events such as the GXFS Connect annual conference, GXFS Tech Workshops and Hackathons, and in-depth discussions are therefore seen as very helpful and recommended by the projects. Furthermore, the study emphasises the usefulness of white papers and recommends the retention and expansion of these resources, especially in relation to GXFS technical documentation.

The chapter “Developments in the last 12 months” discusses the progress of the funding projects compared to 2022. The results here show a growing understanding of GXFS, especially in the technical implementation. Increased communication, especially beyond technical issues, and legal support are mentioned as desirable to ensure the continued success of GXFS implementation.

Overall, the study highlights that the funding projects recognise the need to develop their concepts into business models and monetise them in the long term. Individual software developments and FOSS components are only partial aspects of this.

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GXFS – Status Quo 2023

The Gaia-X Ecosystem 2023

Gaia-X aims to promote innovation and strengthen users' control over their data. This is done by building a secure digital environment where data is provided, collected and shared in a trustworthy manner. The data owners always retain control over their information. In addition, Gaia-X supports the formation of self-determined Gaia-X Federations in which different participants cooperate in order to create added value for all participants and to open up new opportunities in the market.

Gaia-X defines the functional requirements that software components must meet for a interconnected system in which participants collaborate to create innovative products and services.

These systems consist of interconnected data and infrastructure ecosystems grouped into Federations and supported by individual orchestration and Federation Service operations.

The Gaia-X Federation Services (GXFS) form the fundamental technical basis for building and operating a self-managed data infrastructure ecosystem. Based on these technical specifications, open source services are developed, which are further maintained and continuously improved by the Gaia-X community.

Since the launch of the Gaia-X initiative and the institutionalisation through the Gaia-X AISBL and the Gaia-X Hubs in many countries, two important further development steps were presented at Hannover Fair in April 2023:

1. [Catena-X](#) has started [live operations](#)

Catena-X sees itself as a rapidly scalable ecosystem in which all participants in the automotive value chain are equally involved. The goal: The provision of an environment for the establishment, operation and collaborative use of end-to-end data chains along the entire automotive value chain.

2. Announcement of the [Manufacturing-X](#) initiative

The cross-industry initiative Manufacturing-X implements the [Industry 4.0 data space](#). Prerequisites for a functioning data space are easily available and continuous data networking and the willingness to share data multilaterally. Manufacturing-X creates trusted data ecosystems based on open standards. Concrete applications are to be demonstrated and scaled up.

These measures are flanked by the development of resilient decentralised infrastructures, which is being promoted jointly with the EU by 12 EU Member States via the so-called [IPCEI-CIS](#) (Important Project of Common European Interest – Next Generation Cloud Infrastructures and Services).

In all these areas, the conceptual and content-related foundations for the development of federated and decentralised data infrastructure ecosystems are anchored and are gradually being transferred into practical application.

The Gaia-X Federation Services



GXFS consists of five work packages in which the GXFS components were initially developed based on technical specifications over the last years. Since then, the individual components have been implemented with the help of implementation partners and have been available as FOSS code since autumn 2022.

The Federation Services are not provided by a central entity. All projects have the independent mandate to develop use cases and technical architectures and then, on the basis of these, to make use of the GXFS offer in the form of the free and open source reference code of the Gaia-X Federation Services Toolbox to develop applications and services.

These services were grouped into five work packages and surveyed both in last year's study and this year.

These packages are shown below. Details of the respective Federation Services can be found in the Annex.

Identity & Trust	Federated Catalogue	Sovereign Data Exchange	Compliance	Gaia-X Portal as integration layer
<ul style="list-style-type: none"> Authentication/ Authorisation Organisation Credential Manager Personal Credential Manager Trust Services 	<ul style="list-style-type: none"> Catalogue (storage, exchange format, cryptographic signatures) Self-Descriptions 	<ul style="list-style-type: none"> Data Contract Service Data Exchange Logging 	<ul style="list-style-type: none"> Onboarding and Accreditation Workflow Continuous Automated Monitoring for cybersecurity, data protection, etc. Notarisation 	<ul style="list-style-type: none"> Orchestration API Management Workflow Engine Compliance Documentation

Graph 1: GXFS Toolbox and Components

In the present study, the consortium and technical managers of the BMWK funding projects were asked about their progress in implementing the work packages, as in the 2022 study. After a summary of the results of last year's study, the latest developments are discussed in detail below.

Core results of the 2022 implementation study

The study “Strategies for Building Gaia-X Ecosystems using the Gaia-X Federation Services – In dialogue with the Gaia-X Projects” was presented at the GXFS-DE annual conference GXFS Connect in September 2022 and discussed with selected interviewees from the funding projects. The aim of this delta study is to gain insights into the status and challenges of implementing the Gaia-X Federation Services (GXFS) in the BMWK funding projects. The study was based on a two-stage survey of the project leaders in the funding projects. An online survey was conducted to find out about awareness, planned use and preparation for implementation of the GXFS. In the second step, interviews with consortium leaders followed in order to discuss and refine the results.

The study found that sufficient information on GXFS is available, but it should be structured and ideally presented in a clear “reading list”, as sifting and prioritising information is time-consuming. Participation in cross-project networking events, GXFS conferences, hackathons and deep dives was recommended.

The project leaders asked for earlier disclosure of the necessary codes to be able to build prototypes and simulate the interaction of the services. It was recommended that as long as codes were not yet available,

preparations for basic software architectures should be carried out on the basis of existing software components. This ensures rapid implementation once GXFS codes are made available – by replacing existing components with GXFS components or integrating them.

Another recommendation was to include user requirements in the concept development at an early stage, for example through accompanying research, user studies and direct involvement of users (especially SMEs and private individuals).

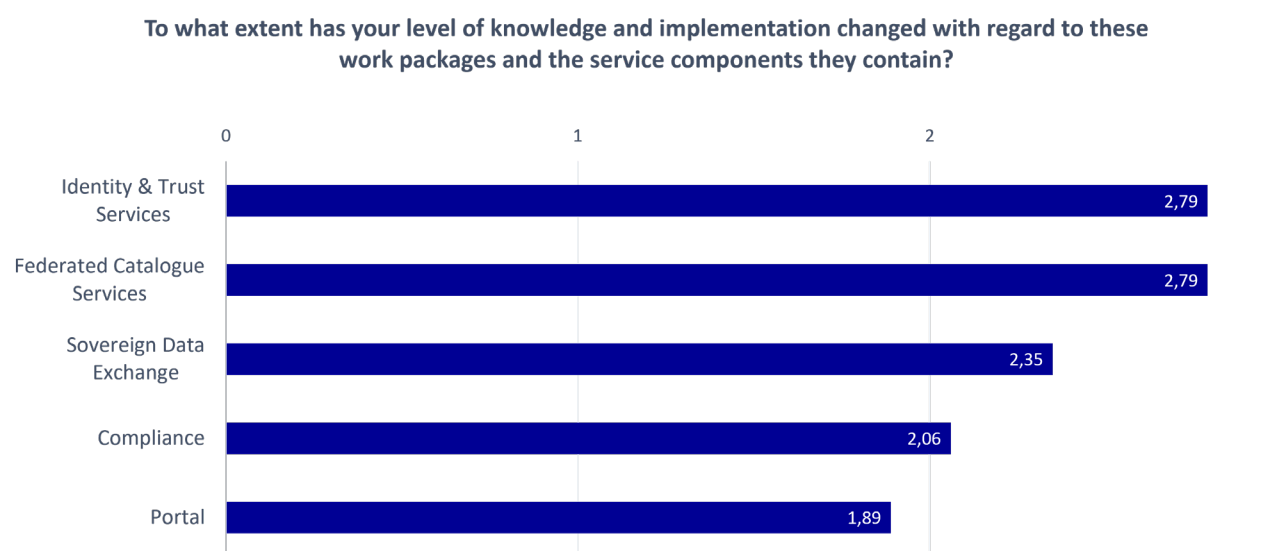
Regular team meetings, a fixed meeting schedule, joint committees, information platforms and team events were regarded as being conducive to successful project work. The interaction of the different companies in the Federations is an important building block in the implementation of the GXFS. Cooperation across projects also makes sense in order to promote know-how transfer and exchange.

This makes the role of the GXFS as an enabler and necessary foundation for the digitalisation of industry and society very relevant. The GXFS enable the controllable use of data for each data owner. This is a great innovation and a success factor for GXFS. It was understood that the GXFS are a “minimum requirement” and additional sector- and project-specific functionalities can be programmed by the projects as needed.

Developments in the last 12 months

This chapter focuses on the developments in the funding projects compared to the previous year. The responses of 14 online survey participants form the basis of this analysis. In order to gain deeper insights, five participants of the online survey were selected for expert interviews. This combined approach, consisting of quantitative evaluation and qualitative questioning, sheds light not only on opinions but also on the motivations behind the participants' views. The results of this double analysis are presented in the following chapters.

The graph below shows assessments of change in the knowledge and implementation status of work packages and GXFS components. The level of knowledge on the Portal and Compliance work packages can be categorised as being in the evaluation phase. Sovereign Data Exchange shows more significant improvement and is between the evaluation and implementation stages, while Federated Catalogue Services and Identity and Trust Services show the strongest gains and are close to the implementation stage. Overall, the ratings reflect an increased understanding and more active evaluation and application of these work packages compared to the previous year.



Graph 2: Knowledge and implementation status of the work packages

The reassessment of the relevance of the GXFS work packages compared to the previous year paints a nuanced picture, as shown in the following graph.

Within the framework of a statistical variance, comparable statements were made on the relevance of the GXFS components. It can be seen that identity and data exchange procedures are at the highest level of relevance. Identity and Trust services have increased in importance. This development reflects a growing understanding of their central role in the projects.

Accordingly, there is no explanatory deficit regarding the functions. Instead, the question is how they can be applied in the respective projects. The first three categories receive the most attention because this is where the primary technical innovations for federated data infrastructure ecosystems are.

The rating of the Federated Catalogue Services has declined slightly. One possible reason for this is that the specification work for service descriptions at the Gaia-X AISBL is still ongoing and there are other catalogue implementations and offerings such as EDC and Pontus-X in the Gaia-X ecosystem that are currently being evaluated by many projects.

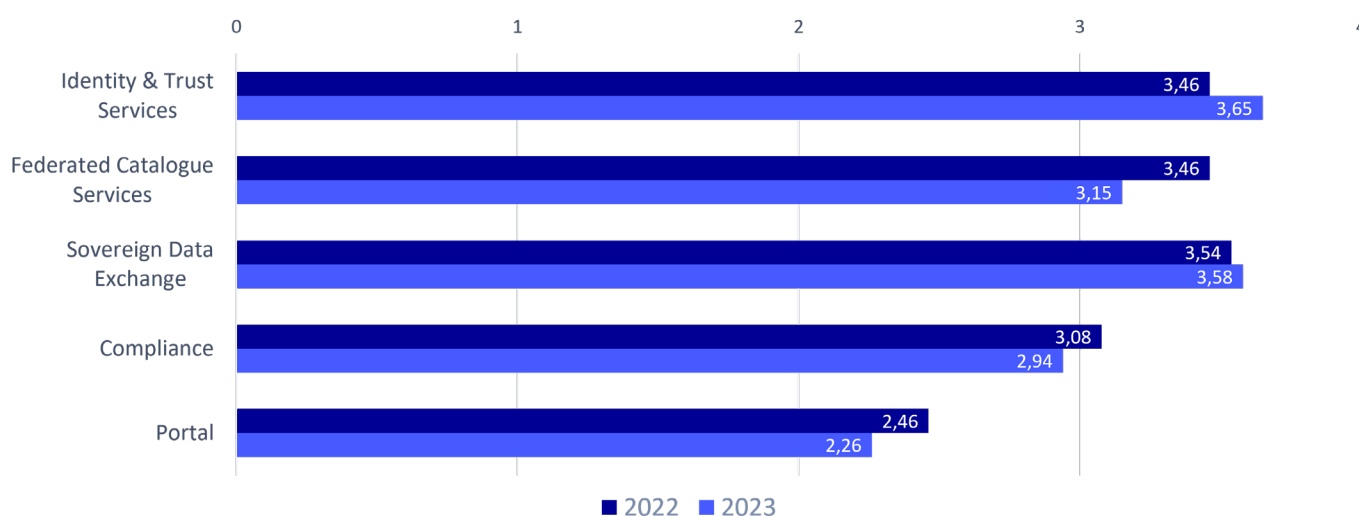
Basically, the question of interoperability between different federated catalogues is in the foreground here. Sovereign data sharing has remained almost constant and, according to respondents, directly relates to

Gaia-X's core value proposition.

In the area of regulatory compliance, there are still open questions that first need to be clarified in the Gaia-X AISBL working groups. Here, especially the questions around onboarding processes and label requirements are not finished.

The Portal work package has the lowest relevance, as there are highly individual requirements here. Currently, the Portal is only intended as a demonstrator for the integration of the general functions and will take on a stronger role in the future through the integration of the GXFS Workflow Engine as a low-code platform.

Please reassess the relevance of the GXFS work packages for your project from today's perspective.



Graph 3: Relevance of the GXFS work packages 2022 and 2023

Overall, the work packages are also described in the interviews as belonging together and being of high importance, thus complementing the results from the quantitative survey.

"We work iteratively in terms of work packages."
 – Harald Wagener, Health-X

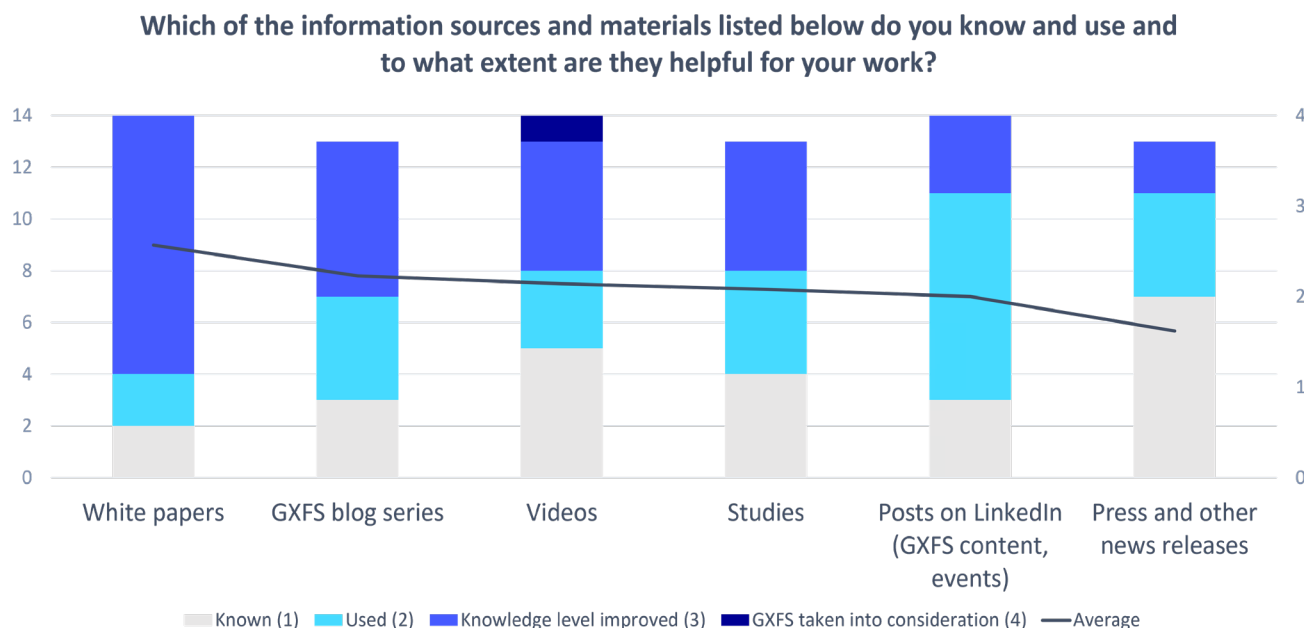
"The different work packages are very relevant!"
 – Jann Wendt, Marispace-X

Likewise, with a view to the future, there is an additional desire for a more intensive exchange with the projects during the development of the components. With the transition of GXFS to the Eclipse Foundation, all projects have the opportunity to collaborate directly on the GXFS components.

Information and events

This chapter of the study focuses on information and events related to the implementation of the GXFS in the funding projects. Here, too, the analyses refer to the online survey of 14 participants from the funding projects conducted by Böcker-Ziemen, as well as the subsequent in-depth interviews.

This presentation shows that the survey participants use a variety of information sources and materials for their work and consider them useful:



Graph 4: Relevance of information sources and materials

White papers stand out with the highest rating compared to the other sources mentioned. The GXFS blog series also has a high average score, followed by videos and posts on LinkedIn in the context of GXFS content and events. Press and other news releases as well as studies are also perceived as useful sources of information. The technical depth, which is conveyed for example with the help of explanatory videos, is particularly emphasised as positive. In the overall view, a multifaceted application of diverse sources of information manifests itself for intensifying the level of knowledge and for targeted support of project-related activities.

“We are very satisfied with the events, especially considering the technical depth. In addition, we find the video contributions particularly helpful as a source of information, especially the shorter 5-minute videos, which we can use for innovation forums.”
 – Harald Wagener, Health-X

In addition, the participants were asked to indicate how they perceive the monthly GXFS newsletter (available in German and English) in particular. Here it can be seen that a significant number of respondents are familiar with the newsletter, whether through regular or selective reading. Only very few people do not read it or don't know the newsletter.

“The newsletters are a starting point to go deeper.”
 – Jann Wendt, Marispace-X

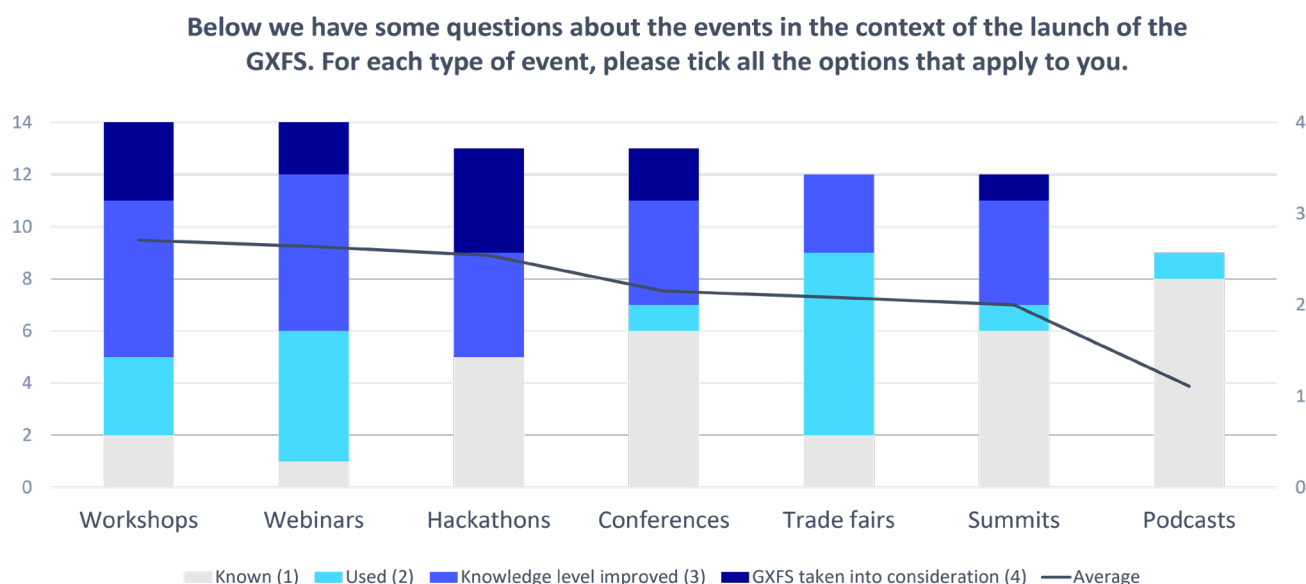
In terms of content, the newsletter is particularly convincing due to its usefulness as an introduction to the subject matter, as well as the continuous announcements of future events; this was confirmed by the majority of the interviews. According to the respondents, this content should be maintained. Examples of

suggested additions relate to the area of documentation on codes and software components in order to enable a lower entry threshold.

“The newsletter offers us great added value, especially in the content items events and publications.”

– Harald Wagener, Health-X

This chart addresses the participants' reactions regarding the various event formats within the framework of GXFS-DE:



Graph 5: Relevance of events

The results show a broad acceptance for webinars, hackathons, conferences, fairs and summits. Workshops are rated particularly positively, as they play an outstanding role in deepening knowledge as well as in exchange and are actively participated in. Hackathons have in some cases led to consideration of the use of GXFS – more so than other types of events. Overall, the data illustrates that the various event formats are perceived as effective means of gaining knowledge in the context of the GXFS roll-out. The role of the GXFS-DE project team at the eco Association as orchestrator of these events was emphasised in the discussions. The technical depth of the events in particular is positively highlighted and makes a clear contribution to the progress of the projects. This is important in order to eliminate any technical ambiguities, among other things.

“Workshops, explanatory videos and other events are helpful. Many ambiguities could be cleared up through them, they are extremely useful!”

– Gino Barnard, POSSIBLE

“The workshops are extremely important exchange platforms.”

– Jann Wendt, Marispace-X

“The technical depth of events and presentations has increased.”

– Helko Lehmann, Merlot

“Technically, for example, we have some difficulties with the code on our levels, but here we have direct contacts through GXFS Connect and work on them together, which we find to be a very solution-oriented approach.”

– Gino Barnard, POSSIBLE

The current desire to maintain and expand the events was made clear. This necessity was justified both by their indispensable role in terms of information exchange within the projects and as a means of problem solving. Especially hackathons, workshops, webinars and conferences could help participants to evaluate the GXFS components and their use. This also illustrates the important role of the many sources of information on offer.

Another question dealt with the issue of how the individual participants found out about the events. Here, the Gaia-X Hub Germany shows a high significance, closely followed by the GXFS newsletter and LinkedIn. The exact figures can be seen in the following diagram:



Graph 6: Information channels for events

It can be deduced from this that regularity plays a significant role, which is generated by recurring media such as mailings, LinkedIn or a newsletter and does not require active research on the part of the participants. This should be taken into account for future events, but also for announcements or important news.

*“What's missing in terms of information is the finished distribution,
which you can roll out and it works afterwards.”*
– Harald Wagener, Health-X

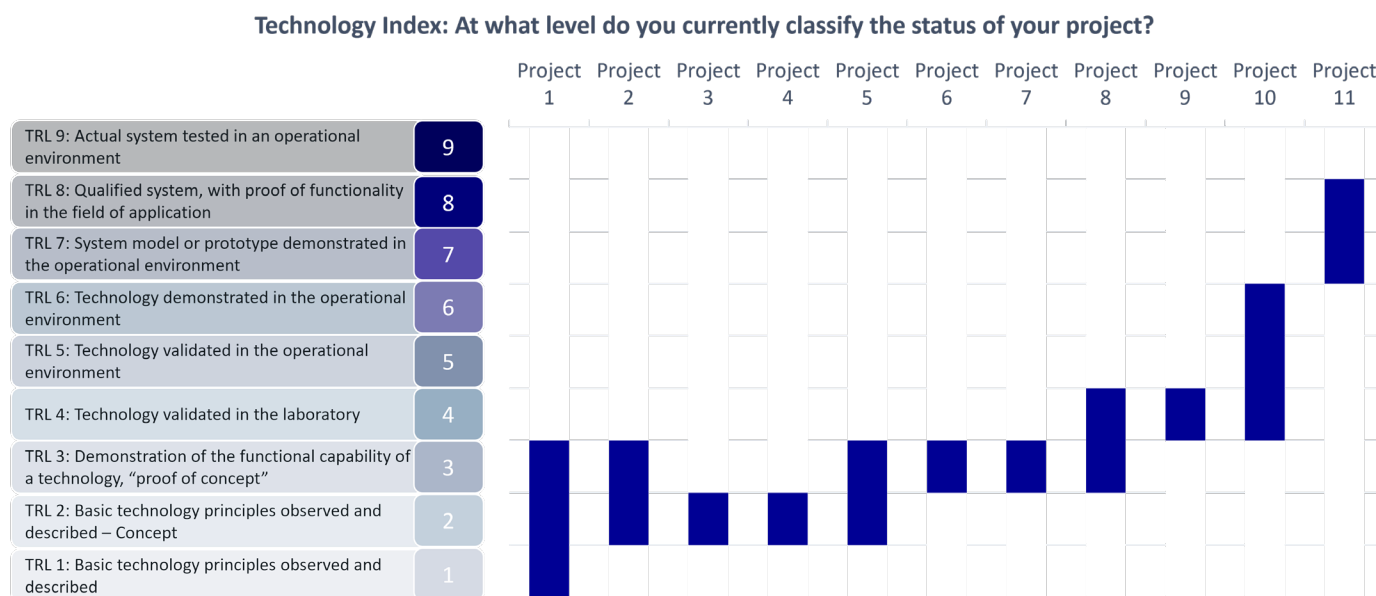
Clear preferences were expressed for the future course of the implementation of the GXFS. These refer both to the continuation of informal contacts and personal points of contact as well as to general information needs, independent of the communication medium. The results also suggest further potential of the communication channels used so far.

The results also show that there is a great need to clarify the respective responsibilities for the provision of software components, as well as the operation and overall design of the ecosystems.

Progress and other success factors

In this chapter of the study, technical requirements and realisations are examined in more detail. The analyses again refer to the survey of 14 participants conducted by Böcker-Ziemen and the subsequent in-depth expert interviews.

The participants were asked to classify their project according to the technology index "Technology Readiness Level" (TRL). The result is shown in the following graph:



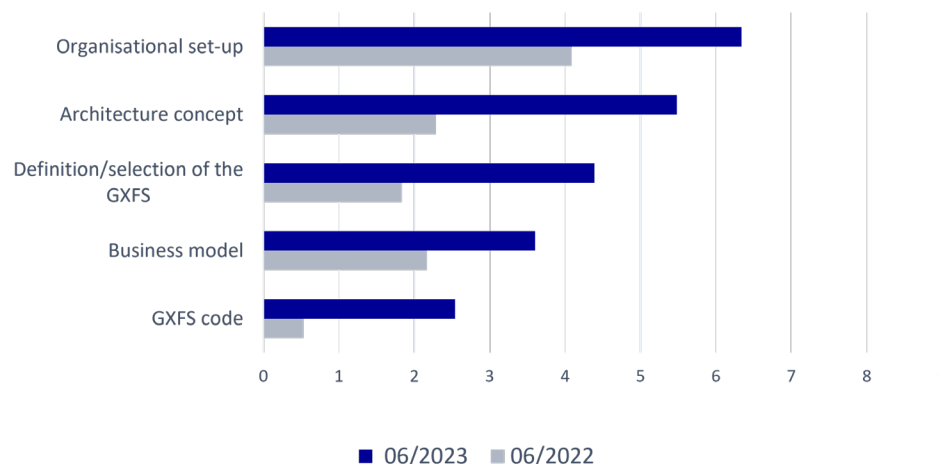
Graph 7: Self-assessment using the Technology Readiness Level Index

Only one project is still in transition from basic research (TRL 1) to industrial research. Five projects (projects 2 to 6) can be classified as industrial research, in which, for example, a "proof of concept" or a laboratory sample is already being manufactured. The remaining projects are currently in the experimental development phase, which is in the TRL 5 – 8 range. In addition to prototypes, demonstrators or pilot series are also produced or carried out here. None of the projects have yet reached market maturity (TRL 9).

*"The Health-X project was transformed into a data space demonstrator."
– Harald Wagener, Health-X*

In summary, the participants were asked to indicate how they assessed their own project progress over the last 12 months, which is illustrated in the following graph:

How would you rate the progress of the project over the last 12 months?



Graph 8: Project progress 2022 and 2023

Overall, there was progress in all areas, the greatest being in the development of architectural concepts and in the definition and/or selection of the GXFS components. The organisational set-up was already a trailblazer last year and has been developed further since. The development of business models was already an important topic last year, and there was further development here as well. The projects have also made strong progress here with the availability of the GXFS components from autumn 2022.

After some progress has been made in the funding projects with regard to technology integration, the focus continues to be on the development of business models according to the qualitative statements. With the aim of being able to monetise the projects, a structured process of transactions is also required, among other things.

The interviews revealed that priorities are shifting towards the development of business models, but only a few projects are able to operate the infrastructure components with their own business models.

“What we build here will only survive if it survives economically.”
 – Dr Jan Hendrik Schoenke, Car Repair 4.0

The importance of achieving economic sustainability is emphasised. Transaction security is also being asked for, which makes it possible, for example, to link actions. In general, the monetisation of data plays an important role for the future course of several projects.

*“We would like to see transaction security and to be able to bundle different actions.
 It should be possible to bill and monetise data within Gaia-X.
 Especially when you are in the home stretch of technology integration.”*
 – Dr Jan Hendrik Schoenke, Car Repair 4.0

The goal of increasing transparency can be effectively implemented by providing comprehensive documentation in the upcoming development of further codes. This way, the projects can track the developments.

According to the respondents, the exchange with developers in the GXFS/XFSC Matrix Channel supports the progress of the project, but should not have to be used for missing documentation. Furthermore, the participants would also like the Matrix Channel to be expanded organisationally. In their view, the expansion of the Matrix Channel holds great potential. An example of this are viewable tickets that not only show the current status and the agents, but also provide a clear overview of the progress of a topic. Such an expansion can not only increase transparency, but also offer the possibility to better distribute the workload and identify bottlenecks at an early stage.

The Matrix Channel is a very valuable tool for collaboration and technology exchange for the projects. Integrating both direct communication in the Matrix Channel and the development of robust documentation into the project process is recommended.

In order to make this possible for other projects, more work should be done towards the goal of a scalable data space solution. Use cases make the data space approach more concrete for the projects. Here, according to the interviewees, it is important to reduce the complexity of data spaces and to increase interoperability in order to ensure the future success of Gaia-X.

The establishment of transparent and clear communication should be aimed at, which shows clear time-tables for the planning of specifications and implementation processes ("strategic roadmap"). In addition, contact persons should be named who are available for this purpose.

*"We would like to see further clarity in the future.
Which components will have the highest relevance?
We would like to have better insight into the roadmap."
– Gino Barnard, POSSIBLE*

The future concern of the projects goes beyond purely technical integration: The interviewees expressed the wish for further communication and for the basic framework conditions for the future design of Gaia-X to be defined.

More intensive legal support for the projects in the future is also very welcome, as legal aspects and the regulation of data spaces play a major role in the Gaia-X context.

Conclusion & Outlook

The following points can be derived from the online survey and the subsequent discussions with the implementation experts in the GXFS funding projects:

- **Positive development:** Compared to the previous year 2022, overall positive changes could be observed in terms of communication and organised events, the provision of diverse information sources and the emphasis on technical depth in various event formats.
- **Successful communication:** The information sources provided as well as the events organised received extremely positive evaluations. White papers and the GXFS blog series stand out in particular. Workshops and webinars are particularly appreciated as events formats.
- **Technology Readiness Level (TRL):** Most of the projects can be classified being in an intermediate phase of industrial research, two out of eleven are still in the experimental development phase.
- **Transparency and communication of future developments:** The projects would like regular and early communication on further planned developments in the GXFS (codes, software releases and updates) in the form of a strategic roadmap to ensure better planning for the participating projects.
- **Diversity of information sources should be used and maintained:** Using and retaining the various sources of information is recommended, especially highly rated sources such as white papers, GXFS blog series and short videos. It is important to ensure that access to content is simple and understandable and meets the needs of the participants.
- **Emphasis on technical depth at events:** Continuation of the various event formats such as workshops, hackathons, conferences, trade fairs and summits. Particular attention should be paid to technical depth and knowledge sharing to support projects in technical implementation.
- **Challenges for the future:** The projects would like to see an improvement in technology documentation, as well as further information and support on the topics of monetisation and legal issues.

Annex

Work package: Identity & Trust

Identity & Trust based on the concept of Self-Sovereign Identity (SSI) offers the possibility to manage decentralised identities and digital trusts for identities and assets. Decentralised identity management based on W3C-based verifiable credentials and distributed identifiers (DID) enables Gaia-X participants to maintain control over their digital identities. The following services are specified as part of the Identity & Trust Federation Service:

Authentication/Authorisation

The service functions enable Gaia-X participants to authenticate users and systems in a trustworthy and decentralised self-sovereign manner.

Organisation Credential Manager

The Organisation Credential Manager establishes trust between the different participants within the Gaia-X ecosystem by providing credentials to the participants and managing the organisation's credentials.

Personal Credential Manager

The Personal Credential Manager acts as a user representative, securely holding the acquired distributed identity credentials and identity attributes, providing the technical means to selectively disclose the attributes for authentication and service consumption. The Personal Credential Manager as a Gaia-X component is used by a natural person – typically in the form of a personal virtual wallet for a user. The service allows users to interact with the SSI-based ecosystem using verifiable credentials and DIDs in a privacy-preserving manner. The Personal Credential Manager will be implementable as a smartphone-based application as well as for browser-based applications/add-ons for stationary PCs and notebooks.

Trust Services

The Trust Services are the technical implementation for enforcing policies for the use of the decentralised and sovereign components of Gaia-X. The Trust Services use a cryptographic validation of the provided credentials. The scope of Trust Services includes the technological functionalities to ensure a consistent level of trust between all participants of Gaia-X. Other functions include verification through the application of standards such as LD Proof Chains/Sets, the establishment of rule-based trust, the provision of the necessary trust anchors and the assurance of trust chains between multiple participants.

Work package: Federated Catalogue

The Federated Catalogue is a directory of Gaia-X Self-Descriptions through which providers and their service offerings can be easily found and selected. Self-Descriptions are the information that participants provide about themselves and their services in the form of characteristics (properties) and Self-Declarations (claims).

Catalogue

A Catalogue stores Self-Descriptions both individually and aggregated in a graph data structure. The Self-Description storage 'Self' contains the raw published Self-Description files in the JSON-LD (JavaScript Object Notation for Linked Data) format, together with additional lifecycle metadata.

The exchange format for the self-descriptions is JSON-LD. JSON-LD uses JSON encoding to represent subject-predicate-object triples according to the W3C Resource Description Framework (RDF). The Self-Description Graph imports the Self-Descriptions from the Self-Description Storage into an aggregate data structure. This constitutes the basis for advanced query mechanisms that consider the references between and among Self-Descriptions.

Since Self-Descriptions are protected by cryptographic signatures, they are immutable and cannot be

changed once published. This means that the participant who created the Self-Description must re-sign it after each change and release it as a new version.

Self-Descriptions

Gaia-X Self-Descriptions express characteristics of resources, service offerings and participants that are linked to their respective Identifiers. Providers are responsible for the creation of Self-Descriptions of their Resources. In addition to Self-Declarations by Participants about themselves or the services they provide, a Self-Description may include verifiable credentials issued and signed by trusted parties. Such credentials contain information about the provider or resources claimed by the issuer of the Self-Description.

Self-Descriptions in combination with trustworthy verification mechanisms empower participants in their decision-making processes. Specifically, Self-Descriptions can be used for:

- Discovery and composition of service offerings in a catalogue
- Tool-assisted evaluation, selection, integration and orchestration of service instances and resources
- Enforcement, continuous validation, and trust monitoring together with usage policies
- Negotiation of contractual terms concerning the resources of a service offering and participants

Gaia-X Self-Descriptions are characterised as follows:

- Machine-readable and machine-interpretable
- Technology-agnostic
- Adherence to a general schema with meaningful semantics and validation rules
- Interoperable through compliance with standards in terms of format, structure and contained expressions (semantics)
- Flexible, expandable and future-proof, as new features can be easily added
- Navigable and referenceable from anywhere in a novel, decentralised way
- Accompanied by statements of proof (e.g., certificates and signatures), making them trustworthy by providing cryptographically secure verifiable information.

Work package: Sovereign Data Exchange

Data sovereignty services offer participants the possibility to decide on the exchange and sharing of their data themselves.

Informational self-determination for all participants encompasses two aspects within the data ecosystem: (1) transparency and (2) control of data use. Enabling data sovereignty when exchanging, sharing, and using data relies on fundamental functions and capabilities that are developed and later provided by Federation Services in conjunction with other mechanisms, concepts, and standards. Data sovereignty services build on existing concepts of usage control that go beyond traditional access control. Traditional access control typically focuses on the data access dimension but leaves aside the data processing angle. The Gaia-X data sovereignty services seek to extend this concept and fill existing gaps. As such, usage control deals with requirements that relate to future data usage patterns (i.e. obligations), rather than data access (provisions).

Data Contract Service

The Data Contract Service constitutes the formal data transaction initiation handshake between the data provider and the data consumer. It validates the entire contract. If the content is valid and both participants have successfully confirmed the contract, the data contract service adds its signature and sends the completed data contract to all parties involved. Thus, the service enables contract negotiations.

Data Exchange Logging

Data Exchange Logging provides evidence that data has been submitted and received, that rules and obligations (data usage policies) were enforced, and on whether these have been complied with or violated. This supports the clarification of operational issues as well as the clarification of transactions with a fraudulent background. The parties involved in the data exchange are the data provider and the data user; both

receive notifications of the transaction. In some use cases, it may also be necessary for an authorised third party agreed in the Data Contract to have access to the notifications.

Work package: Compliance

Gaia-X defines a compliance framework that manifests itself in the form of a Code of Conduct, third party certifications/attestations, or through the signing of Terms and Conditions. The compliance framework consists of rules (for example, for encryption, data protection standards and interoperability) to which participants must adhere. These rules are a combination of the rules set out in Gaia-X's Policy Rules document and other rules defined by the Labelling & Compliance Working Group within the Gaia-X Association (this Labelling & Compliance Working Group gathers input from the Association's three main committees: the Data Space Business Committee (DSBC), the Technical Committee (TC) and the Policy Rules Committee (PRC)). The main objective of the Compliance Federation Service is to provide Gaia-X users with verification of compliance to the stated characteristics for each of the specific Service Offerings. Federation services in the area of compliance consist of three components:

Onboarding and Accreditation Workflow

The Onboarding and Accreditation workflow ensures that all participants, resources and service provision go through a validation process before being included in a Catalogue. One objective of the Onboarding and Accreditation Workflow is to document the validation process and establish an audit trail to ensure compliance with generally accepted practices in conformity assessments.

Registration of a Gaia-X participant: After successful validation, a verifiable credential is issued to the entity, underpinning its status as a registered participant in the Gaia-X project. Subsequently, principals of those registered providers can register the service offerings for Gaia-X.

- A Self-Description and additional evidence of adherence to the Gaia-X policy rules (for example, through a code of conduct, through certifications/confirmations from third parties, through acceptance of the General Terms and Conditions) must be provided.
- Documentation of the validation process and the generation of an audit trail to guarantee adherence to generally accepted practices in conformity assessment.

In addition to the general onboarding workflow, the following special functions must be present:

- Monitoring of the relevant bases for Compliance
- Monitoring of updates to the Service Offerings that could trigger revisions/re-certifications
- Suspension of Service Offers
- Revocation of Service Offerings

Continuous Automated Monitoring

Continuous Automated Monitoring enables monitoring of compliance based on the above-mentioned Self-Descriptions within the framework of the Federated Catalogue. Continuous Automated Monitoring is achieved by automatically interacting with the service-under-test, using standardised protocols and interfaces to retrieve technical evidence.

Notarisation Service

The Notarisation Service is used to manage certification requests and issue digital, legally-binding and trustworthy certifications. To issue such notarised credentials (including eIDAS signatures and public keys in the verifiable credentials format), participants need to provide relevant legal and accreditation documents as defined in the Gaia-X Policy & Rules Compliance Framework.

Work package: Portal & Integration

The Gaia-X Portal serves as an example of an integration layer that introduces the Federation Services and provides user-friendly access to these services. It supports the onboarding and accreditation of participants, shows how services can be found and how the orchestration and delivery of services can work.

Orchestration

With the orchestration service, the Gaia-X consumer can instantiate services from the catalogue search results via the Portal. The orchestration provides a Life Cycle Management Engine (LCM Engine) and a standardised API for LCM services. While the former is a central Gaia-X service, the latter is managed by service providers. They serve as an interface between the LCM Engine and the infrastructure of the various service providers.

API Management

To orchestrate the various Gaia-X services with their associated APIs, an API framework will be introduced to create a unified user and developer experience for API access and lifecycle. An API gateway will ensure security (e.g. DDoS prevention) for all integrated services, including potentially connected external services such as authentication providers. The API portal will provide a single point of information in regard to available API services and version management. An analytics portal will provide short and long-term statistics on usage and quality.

Workflow Engine

The Workflow Engine is mainly used for the Onboarding and Accreditation process to approve and track the provision of services. It also manages the user interaction loop for user notifications. The main purpose of the engine is to enable the Federator to keep track of membership requests and confirmations from participants, to manage interaction with participants, to assign credentials to participants or approve other access, and to track the quality of service of the Self-Descriptions that are made publicly available via the catalogue function described above.

Compliance Documentation

In order to demonstrate that a Federation Service meets all defined requirements, the provision of appropriate evidence is necessary. This evidence can be provided in various forms (e.g. through specifications, concepts, test reports or certificates). The Compliance Documentation Service specifies how compliance with Security and Privacy by Design must be documented by each Federation Service.

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