

26-03-2024

Deliverable D6.1

Network eAcademy

Contractual Date:	31-03-2024
Actual Date:	26-03-2024
Grant Agreement No.:	101100680
Work Package:	WP6
Task Item:	Task 4
Nature of Deliverable:	R (Report)
Dissemination Level:	PU (Public)
Lead Partner:	CSUC/RedIRIS
Document ID:	GN5-1-24-69a4c3
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Abstract

The Network eAcademy is an umbrella of activities to help individuals and organisations advance their knowledge in specific technical domains related to network technologies and services. The service provides a wealth of resources, knowledge-sharing activities and training programmes to foster digital transformation and skills enhancement within the GÉANT and NREN community.



Co-funded by
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Executive Summary

The Network eAcademy is an umbrella of activities aimed at helping individuals and organisations advance their knowledge in specific technical domains related to network technologies and services. The service provides a wealth of resources, knowledge-sharing activities and training programmes to foster digital transformation and skills enhancement within the GÉANT and NREN community.

The Network eAcademy began its work with a strategic focus on Orchestration, Automation and Virtualisation (OAV), offering architecture analysis and mapping, training materials, an OAV Maturity Model, terminology documentation, and a knowledge hub through the NETDEV Wiki. Recognising the potential applicability of this model to other critical domains, dedicated training tracks for Quantum Technologies and Optical Time and Frequency Networks (OTFN) were subsequently introduced. The available topics can be further adapted or added to in response to emerging needs.

A high-level architectural blueprint (the TM Forum Open Digital Architecture, or ODA), provides R&E institutions with an easy way to understand and compare the architectures of their Network Management (NMS), Operations and Business Support Systems (OSS/BSS) and to help guide community efforts towards the creation of interoperable systems and operations. This mapping of architectures facilitates the future development of dynamic multi-domain services, supporting organisations in their pursuit of digital innovation.

The training programmes in the Network eAcademy offer targeted, self-paced courses for the research and education community, along with external links, exercises, and consultancy services. A “metro map” (Figure 3.1) provides a key visual resource to guide the trainees along their learning path on the OAV track (also called Network Automation eAcademy) as if they were following metro lines. This tailored approach ensures that participants can enhance their knowledge in alignment with their specific requirements and goals, by either following the metro lines adapted to the ODA architecture, or creating their own training path.

Recognising that different NRENs are at varying levels of maturity in the implementation of OAV solutions, the Network eAcademy also makes available an OAV Maturity Model which enables organisations to assess their OAV capabilities against a series of predefined dimensions, sub-dimensions and stages through a comprehensive survey. Responding R&E organisations are issued with a report containing the information they need to empower them to evaluate the current state of their OAV evolution, and set objectives and establish roadmaps to increase their OAV maturity levels.

All Network eAcademy resources can be accessed in the NeA area [[NETDEV NeA](#)] of the NETDEV wiki. The Wiki [[NETDEV Wiki](#)] and OAV Terminology document [[OAV_TERM_v0.2](#)] are regularly updated and are a cornerstone of information dissemination relating to the work of the Network eAcademy. The learning units are also made available in the GÉANT Learning and Development (GLAD) eAcademy portal [[GLAD eAcademy](#)] where they can be accessed using eduGAIN, SSO or social networks credentials.

The Network eAcademy is committed to continuous development and to ensuring ongoing support is provided to the R&E community in upgrading their skills and navigating the evolving landscape of digital transformation. By providing valuable resources, knowledge-sharing activities, and specialised training, the Network eAcademy contributes significantly to the community's journey toward enhanced knowledge, digital transformation, and the development of cutting-edge technologies.

1 Introduction

In its earliest form, the Network eAcademy (NeA) brought together the specific outputs of a series of consensus-building Focus Groups active in the previous GÉANT project (GN4-3), including the OAV Training Portal [\[OAV_TP\]](#), and architecture, terminology and other related products.

The contents of the OAV Training Portal have since also been made available in the Network Automation eAcademy in the GÉANT Learning and Development (GLAD) eAcademy Moodle portal [\[GLAD eAcademy\]](#) and the Network eAcademy has evolved into a service providing resources and knowledge-sharing activities around Network Development topics to support R&E communities in their journey towards digital transformation.

In the GN5-1 project, the work of the Network eAcademy continues with the same aim of improving the knowledge of the research and education community in the areas of network technologies and services, with activities including architecture analyses of digital systems, new and updated training programmes, and maturity assessments, supported by the latest version of the *OAV Terminology* document [\[OAV_TERM_v0.2\]](#) and the [\[NETDEV Wiki\]](#), which collates and publishes all relevant material from the Network Development Work Package (WP6).

Initially, the focus of the Network eAcademy was specifically on Orchestration, Automation and Virtualisation. However, community interest in the eAcademy has been such that it had become evident that it would be beneficial to expand its approach to other topics, such as Quantum Technologies and Optical Time & Frequency Networks (OTFN). Work on setting up separate tracks on these subjects has started and the first Quantum Technologies units have already been published. The list of available topics will be further adapted or added to based on evolving requirements.

This report provides an overview of the resources available under the Network eAcademy umbrella in different areas.

Section 2 explains the work done on architecture analysis for orchestration, automation and virtualisation (OAV): several NREN and service architectures have been mapped to the TM Forum Open Digital Architecture and the mappings published.

Section 3 gives an overview of the training activities that started with the OAV learning units in the Network Automation eAcademy, followed by descriptions of the new Quantum Technologies and OTFN tracks of the eAcademy.

Section 4 outlines the OAV Maturity Model and its dimensions, sub-dimensions and stages, against which organisations can assess their current OAV status.

The work done to achieve a consensus regarding OAV, Artificial Intelligence, and Maturity Model terminology in the R&E community is summarised in Section 5.

Section 6 gives details of the dissemination activities carried out by the Network Development team to promote the usage of the resources available in the Network eAcademy.

Finally, some conclusions are given in Section 7.

2 Architecture Analysis

The TM Forum Open Digital Architecture [ODA] was selected as the high-level reference architecture in the Network eAcademy, to be used as a blueprint to help develop solutions that can easily be automated and orchestrated and to facilitate interoperability and multi-domain collaboration. This architecture was chosen because it is flexible enough to be used by European NRENs as a reference for the creation of digital platforms, new services and workflows, while at the same time allowing them to maintain independence in the choice of technical architectures, processes and tools to be used within their domains.

As a functional architecture, the TM Forum Open Digital Architecture uses service abstraction with building blocks, separate components and open application programming interfaces (APIs). More details on the ODA can be found in previously published documents [GN4-3 D6.6], [WP_OAV_ARCH]. Its functional blocks are represented in Figure 2.1 [ODA_FA].

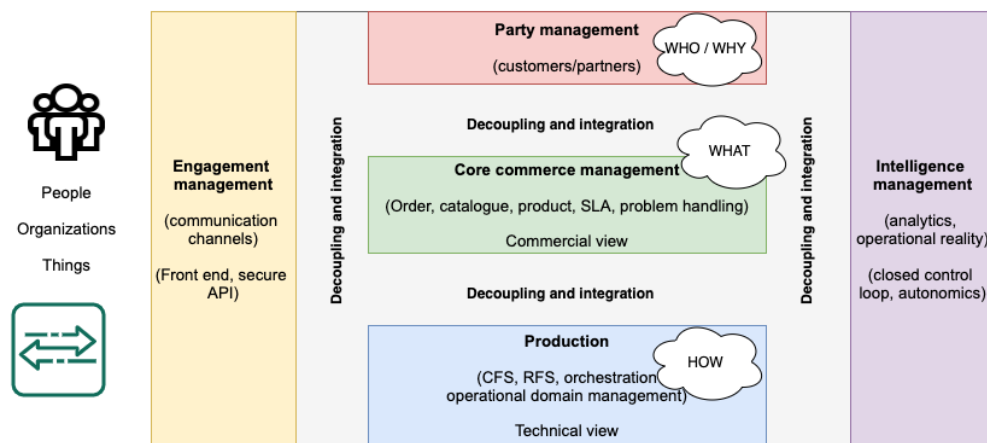


Figure 2.1: ODA Functional block grouping based on the ODA Functional Architecture

Two architecture analysis templates have been made available: a template graph including the functional blocks (that can be filled in using the tools used by any NREN or service) [ODA_GRAPH] and a template document containing the structure, definitions and sections that any architecture analysis should include [ODA_TEMPL]. These templates are published in the [NETDEV Wiki] in editable format to facilitate the analysis of new architectures, including analysis of NREN network management systems and OSS/BSS/digital architectures, and of network services and solutions architectures.

The analyses are jointly carried out by the NREN and/or service managers and the WP6 T4 team. NRENs or Service managers wishing to map their architectures to the blueprint can contact the Network eAcademy team at network-eacademy@lists.geant.org.

The following NREN digital architectures mappings have been published so far:

- SURF OAV Architecture Analysis [MAP-SURF] (2020)
- CYNET OAV Architecture Analysis [MAP-CYNET] (2020)
- CARNET OAV Architecture Analysis [MAP-CARNET] (2021)
- HEAnet OAV Architecture Analysis [MAP-HEANET] (2021)

- GRNET OAV Architecture Analysis [[MAP-GRNET](#)] (2022)
- PIONIER OAV Architecture Analysis [[MAP-PIONIER](#)] (2022)
- GÉANT OAV Architecture Analysis [[MAP-GEANT](#)] (2022)

The service architecture analyses published to date are:

- NMaaS OAV Architecture Analysis [[MAP-NMaaS](#)] (2022)
- Argus OAV Architecture Analysis [[MAP-ARGUS](#)] (2023)
- PMP OAV Architecture Analysis [[MAP-PMP](#)] (2023)

Additionally, the analyses of several architectures have been published in a white paper [[WP_OAV_ARCH](#)] (2021) which covers a number of mappings:

- 5G
- EOSC
- ETSI GANA
- ETSI OSM
- ETSI ZSM
- GVM
- MEF LSO
- Open Baton
- ONAP
- SENSE
- SPA
- TALENT

Figure 2.2 below presents a mapping of the PMP architecture using the selected TM Forum ODA architecture blueprint. For each of the blocks from the reference architecture – engagement, party, core commerce, intelligence management, production or decoupling and integration – it is easy to see which of the PMP architectural components perform each functionality. Observing the digital architectures of different systems through the lens of the ODA blueprint makes it easier to understand the constituent parts of each of the systems based on the functionalities they perform. Such an approach can help organisations towards their future development, automation and integration, and to advance the single- or multi-domain digital transformation of their network and network operations.

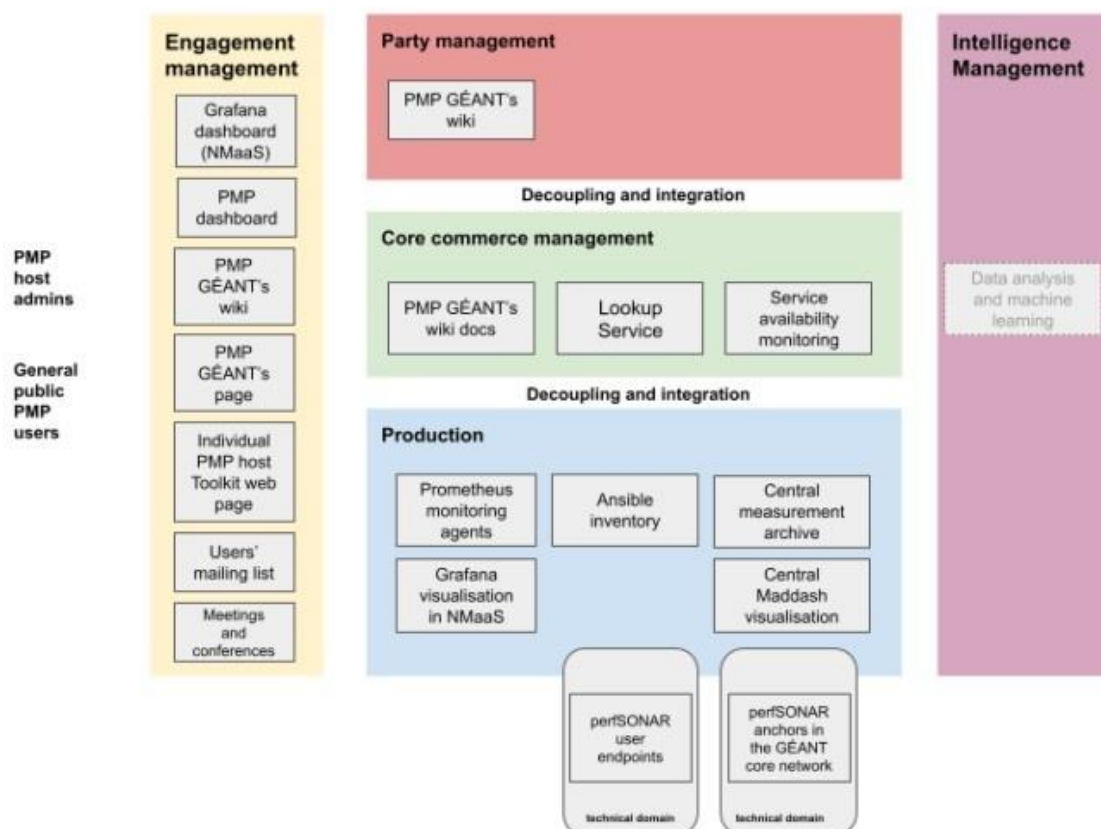


Figure 2.2: PMP OAV Architecture Mapping

The OAV architecture blueprint is also used as a reference for the structure and metro map [\[Metro Map\]](#) of the Network Automation training track of the Network eAcademy, also known as the Network Automation eAcademy (see 3.1.1).

3 Training Programmes

Network engineers, managers, and members of the R&E networking community need to add new theoretical and practical concepts and knowledge to their existing skillsets to be able to provision services through digital platforms. However, operating a network is demanding with the all-too-frequently scarce resources that are typically available. Based on the feedback collected following a survey of the OAV status of NRENs, summarised in deliverable GN4-3 D6.2 (*Automation and Orchestration of Services in the GÉANT Community*) [\[GN4-3 D6.2\]](#), a self-paced training programme on Orchestration, Automation and Virtualisation ‘by the community, for the community’ was created with the help of the GLAD team, called the Network Automation eAcademy [\[NA_eACADEMY\]](#).

The significant number of trainees following the Network Automation eAcademy, and the positive comments received about the learning units provided, have encouraged the Network eAcademy team to create more content: two new training series – on Quantum Technologies and Optical Time and Frequency Networks – have now been set up in collaboration with WP6 Task 1, all falling under the Network eAcademy umbrella. The new units use the same document templates, communications plan and collection of statistics as the Network Automation eAcademy.

All learning materials under the Network eAcademy are available through the GLAD eAcademy portal [\[GLAD eAcademy\]](#) using eduGAIN, SSO or social networks credentials. OAV training materials are also regularly updated in the OAV Training Portal [\[OAV_TP\]](#)

The training programmes currently available and/or under development in the Network eAcademy are described in the following sections.

3.1.1 Network Automation eAcademy

This programme introduces the principles of the functional blocks of the TM Forum Open Digital Architecture [\[ODA\]](#), DevOps concepts, protocols, tools, real-life examples, and resources from the R&E world to provide context and inspire innovation through short learning units and use-case studies. The available courses are presented in a visual guide in the style of a metro map (Figure 3.1 Network Automation eAcademy metro map

) accessible both via the OAV Training Portal [\[OAV_TP\]](#) and the GÉANT Learning and Development eAcademy [\[GLAD eAcademy\]](#), and which presents the published and planned units as different steps (or stops) with the learning paths shown as metro lines.

Learners can follow a variety of different paths at different levels (introductory, technical, or theoretical), change from one line to another or skip “stations”. Each learning unit includes a section listing the pre-requisites needed to take the course and links to recommended follow-on units.

Figure 3.1 Network Automation eAcademy metro map

shows a static snapshot of the metro map. The interactive metro map is constantly updated to ensure it remains current and the latest version can be viewed online [\[Metro Map\]](#).

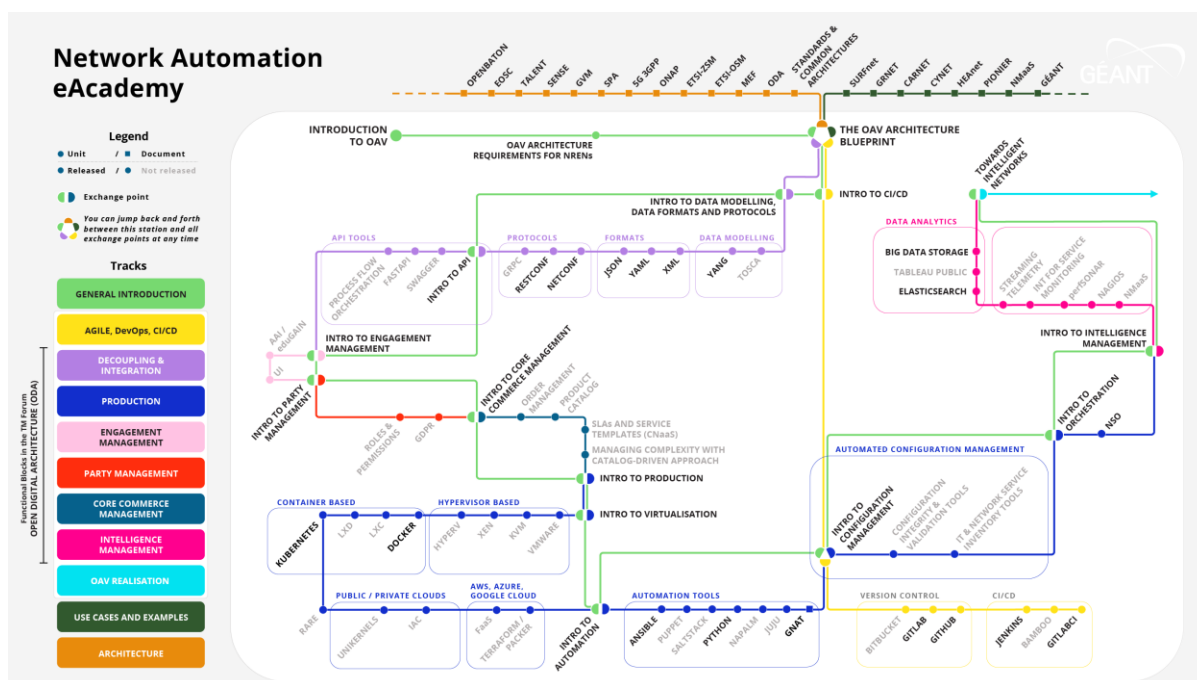


Figure 3.1 Network Automation eAcademy metro map

A circle at a station means this is a learning unit in the eAcademy, whereas a square means this is a document or an external website where more information on a relevant topic is available.

The learning units are also presented as packages classified according to the OAV blueprint functional blocks and related concepts, including:

- Open Digital Architecture
- Production
- CI/CD
- Intelligence Management
- Modelling
- Architecture Deep Dive
- Formats & Protocols
- Use Cases & Examples
- APIs
- OAV Architectures
- Engagement Management
- Virtualisation
- Party Management
- Automation and Orchestration
- Core Commerce Management

Great interest has been received from the global R&E community following the presentation of the Network eAcademy activities and resources at various meetings and conferences, as detailed in Section 6.3 (Dissemination Activities). This has led to the inclusion in the Network Automation eAcademy of new content from the GlobalNOC at Indiana University in several learning units and as external documents and links

[[CONNECT GlobalNOC](#)] as well as the planned addition of content from FCCN and Belnet. Some examples of this are a unit on the GlobalNOC Network Automation Tools (GNAT), which is included as an external collaboration in the programme, as well as documents also from the GlobalNOC included in the YAML, JSON, XML, Ansible and GitHub learning units and documentation from FCCN which will be included in the Streaming Telemetry learning unit once it is published.

Five new learning units were published under the Network Automation eAcademy with the help of the GLAD team in Period 1 of GN5-1 – Python, Gitlab, ElasticSearch, Restconf and GitHub. Work has started on twelve more learning units.

The contents of nine previously published units were also reviewed and updated where required during the first year of GN5-1: OAV Architecture Requirements for NRENs, Introduction to API, Formats: JSON, Data Modelling: YANG, Introduction to Engagement Management, Introduction to Production, CI/CD: Jenkins, Automation Tools: Ansible, and Towards Intelligent Networks

Table 3.1 lists the Network Automation eAcademy learning units published so far in the GÉANT Learning and Development platform (Moodle) [[GLAD eAcademy](#)], grouped by area, together with their publication or last update dates and the references linking to their content.

Area	Learning units	Publication / Last update
General Introduction to OAV	OAV - Introduction [NeA-OAV-IN]	2020
	OAV Architecture Requirements for NRENs [NeA-OAV-NREN]	2023
	The OAV Architecture Blueprint [NeA-OAV-ARCH]	2021
Introduction to TM Forum ODA Functional blocks	Introduction to Engagement Management [NeA-OAV-ENG]	2023
	Introduction to Party Management [NeA-OAV-PARTY]	2021
	Introduction to Core Commerce Management [NeA-OAV-CORE]	2023
	Introduction to Production [NeA-OAV-PRO]	2023
	Introduction to Intelligence Management [NeA-OAV-INT]	2021
DevOps	Introduction to CI/CD [NeA-CICD]	2021
	Version control: Gitlab [NeA-GITLAB]	2023
	Version control: GitHub [NeA-GITHUB]	2023
	CI/CD: Jenkins [NeA-JENKINS]	2023
	CI/CD: GitlabCI [NeA-GITLABCI]	2021

Area	Learning units	Publication / Last update
Decoupling and Integration	Introduction to Data Modelling, Data Formats, and Protocols [NeA-I-DATA]	2021
	Data Modelling: YANG [NeA-YANG]	2023
	Formats: XML [NeA-XML]	2022
	Formats: YAML [NeA-YAML]	2021
	Formats: JSON [NeA-JSON]	2023
	Protocols: NETCONF [NeA-NETCONF]	2022
	Protocols: RESTCONF [NeA-RESTCONF]	2023
	Introduction to API [NeA-API]	2023
Production	Introduction to Virtualisation [NeA-I-VIR]	2022
	Container-Based Virtualisation: Docker / Swarm [NeA-DOCKER]	2022
	Container-Based Virtualisation: Kubernetes [NeA-KUBERNETES]	2022
	Introduction to Automation [NeA-AUT]	2021
	Automation Tools: Ansible [NeA-ANSIBLE]	2023
	Automation Tools: Python [NeA-PYTHON]	2023
	Introduction to Configuration Management [NeA-CONFIG]	2021
	Introduction to Orchestration [NeA-I-ORCH]	2021
	Orchestration: NSO [NeA-NSO]	2021
Intelligence Management	Data Analytics: Elasticsearch [NeA-ELASTIC]	2023
OAV Realisation	Towards Intelligent Networks [NeA-TIN]	2023

Table 3.1: Learning units published under the Network Automation eAcademy

The Network Automation eAcademy team offers learners support and free consultancy services. Trainees can join trainers in video conferencing calls and ask questions related to training, the architecture blueprint and mapping, and/or suggest the creation of new units. Since the start of the Network eAcademy, more than 1700

users have followed more than 3000 learning units and visited more than 50,000 individual sections of the learning units. The team has also worked closely with the Marcomms team in WP2 to create and update the communications plan and the look & feel of the learning units, as explained in Section 6.2 (Branding and Visibility).

According to the responses provided by the 286 users who answered the feedback forms, the quality of the training and the structure are between very good and excellent, with most comments being largely positive.

3.1.2 The Quantum eAcademy

Three learning units covering the topic of Quantum Algebra have been published so far under the Quantum eAcademy – QuBits [[NeA-QUBITS](#)], Operator Multipliers: Variants [[NeA-VARIANTS](#)], and Mathematical Operators [[NeA-OPER](#)]. Work has started on eleven more learning units.

The team is working on presenting these materials under the Quantum eAcademy, in a similar style to that of the Network Automation eAcademy, using a metro map, in collaboration with graphic designers from WP2.

3.1.3 The OTFN eAcademy

Time and Frequency (T&F) services are both directly and indirectly critical to many civil and industrial sectors, including telecommunications, geo-positioning (autonomous vehicles), energy, finance, and advanced scientific use cases. Such techniques offer an alternative to Global Navigation Satellite System (GNSS) for end-users who cannot rely on broadcast signals due to, for example, security concerns such as GPS spoofing attacks or reception issues if they are located in an underground laboratory. Furthermore, new T&F services have the potential to respond effectively to the challenges of tomorrow.

Many NRENs are now either supporting T&F services for their users, such as National Metrology Institutes (NMIs), or considering how they might do so. In addition to WP6 Task 1's work on OTFN, an Incubator project was also developed under Task 4, resulting in the publication of a white paper including recommendations for building a GÉANT Core Time/Frequency Network (C-TFN) [[WP GÉANT C-TFN](#)].

Work in this area carried out in the GÉANT community and by the WP6 Technology task has highlighted a need to learn more about the technologies and services underpinning Optical Time and Frequency Networks. The group of experts currently working in the OTFN team in the WP6 Technology task (T1) have both the knowledge and the will to create the required training material in this field.

Building on the same approach used for the Network Automation and Quantum tracks of the eAcademy, the Network eAcademy team has joined forces with the Technology team in T1 to create training material in this area, including introductory and more advanced courses. The OTFN curriculum and list of courses have been defined and a new OTFN eAcademy space has been set up on the GLAD eAcademy learning platform [[GLAD eAcademy](#)]. Work is ongoing on preparing the first learning units for the programme as well as presentation and Moodle templates in the style of other Network eAcademy training materials, to ensure brand consistency and recognition.

4 OAV Maturity Model

Comparing and benchmarking levels of Orchestration, Automation and Virtualisation of network operations support processes and digital systems across different organisations presents a challenge, as within the GÉANT community there are significant differences at the level of served user groups and organisations as well as in approaches to the implementation of technologies and services, tools, systems, processes, etc. Such differences made it hard, if not impossible to compare different organisations and institutions, as well as to plan future steps for an individual organisation to advance further in the digital transformation of their network processes and services.

In order to help organisations overcome this challenge, an OAV Maturity Model (OAV MM) has been defined to assist the NRENs to measure their OAV capabilities, identify strengths, weaknesses, threats and opportunities (SWOT analysis), prioritise actions to advance to the next phase of their OAV journey and act accordingly. The model comprises six stages which have been mapped to actions as memorable cues:

1. None (Sit)
2. Ad-hoc (Crawl)
3. Reactive (Walk)
4. Integrated (Run),
5. Proactive (Fly)
6. Self-* (Energise)

These stages are illustrated in more detail in Figure 4.1 below.

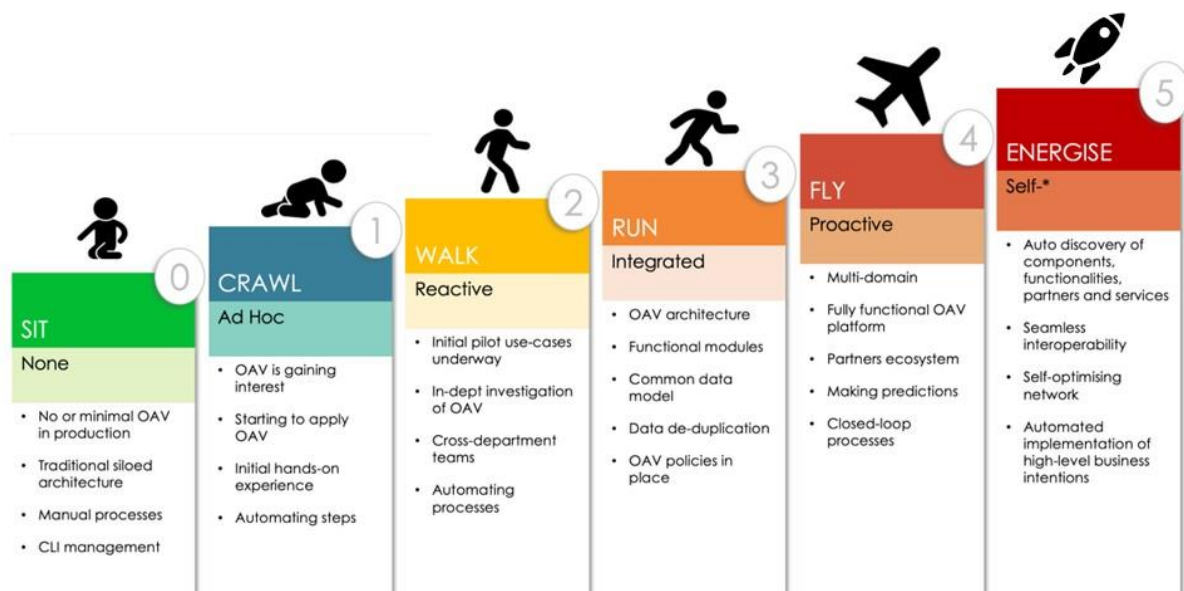


Figure 4.1 OAV Maturity Model stages

Organisational OAV capabilities are assessed in four dimensions – Architecture & Technology, Processes & Services, Vision & Strategy and People & Organisation. The four dimensions of the Maturity Model, briefly outlined in Figure 4.2, are further refined into 27 sub-dimensions [[OAV-MM-WIKI](#)].

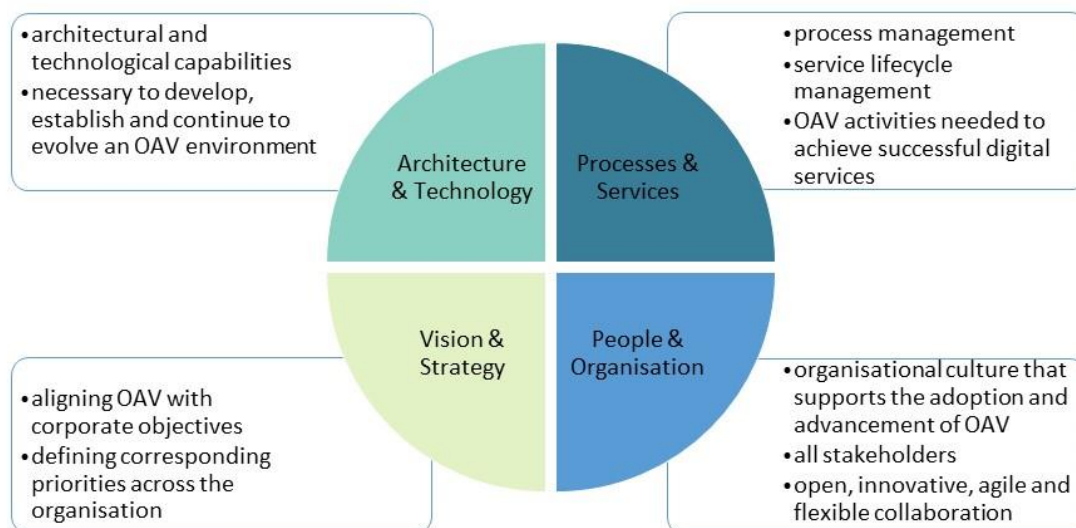


Figure 4.2 OAV Maturity Model dimensions

The OAV Maturity Model (OAV MM) is offered by the Network eAcademy service in the form of a survey [[OAV-MM-SURVEY](#)] with 31 questions, which through the dimensions and sub-dimensions cover all technological and organisational aspects that should be considered in any transition to OAV. Upon completion of the survey, respondents are issued a report providing a detailed analysis of their answers for each sub-dimension and a total maturity score for their organisation based on the defined stages – as well as an overall assessment of how their organisation compares to the average for the community in the various dimensions. The results for individual organisations are kept confidential and only aggregated and average results are published.

The OAV maturity assessment helps identify the areas which require more effort in order for an organisation to achieve an efficient and scalable OAV implementation that is aligned with its overall strategy and is supported by development and operations teams. Based on their maturity model reports, organisations are able to decide the desired stage they would like to achieve in each dimension and sub-dimension: while some possible actions may be seen as quick wins, others may be more complicated or time-consuming but may be worth the effort. Other areas may be marked as future tasks due to their lack of relevance to the organisation or amount of effort they require.

Figure 4.3 shows an example image from an OAV MM report for the “Architecture and Technology” dimension for an institution which is above average in Analytics, AI, Data, and Components, average in terms of Security and Compatibility, and below average in Modelling Abstractions, Virtualisation and API. Based on these results, this hypothetical institution would need to decide in which area to place more effort in the future (for instance, in improving their weakest sub-dimensions, or in others where they want to excel).

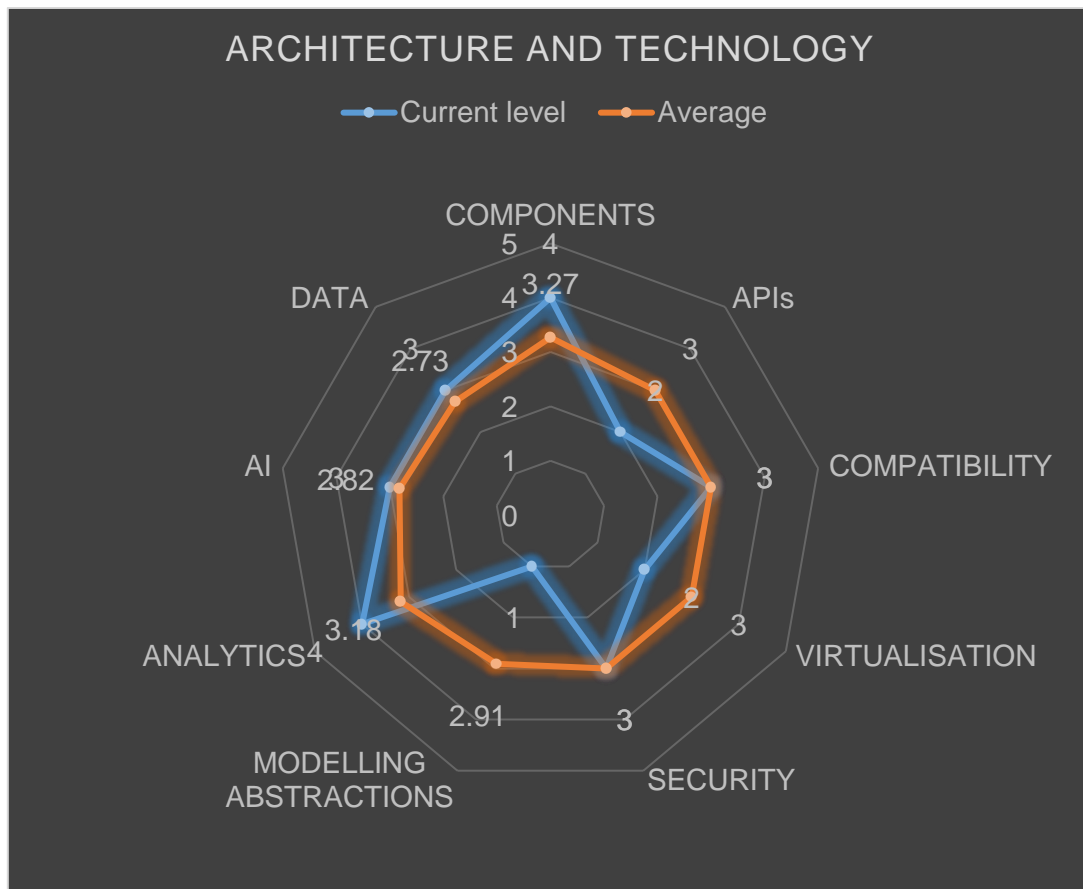


Figure 4.3 Example of OAV Maturity Model graph for the Architecture and Technology dimension

A white paper defining the OAV MM dimensions and sub-dimensions, including information for each of the stages, was published in the first year of the GN5-1 project [[WP OAV MM](#)].

An OAV Maturity Workshop took place in November 2023 [[OAV MM WS](#)], where participants were offered the opportunity to complete the OAV MM for their organisation through a deep dive into each of the stages by sub-dimension. During the first year of GN5-1, the OAV MM survey was completed by twelve organisations, bringing the total number of organisations whose maturity has been assessed so far to fifteen, two of which have taken the survey twice to assess their evolution.

5 OAV Terminology Document

While setting the context for Orchestration, Automation and Virtualisation in the GÉANT project, it was recognised that the use of different terms when describing specific OAV functions, services or elements introduces additional unnecessary difficulties for possible cross-domain collaboration which, as explained in the previous section, is already burdened by differences in technologies, structures, processes, and services.

In order to help with the understanding of the various terms in this area, an *OAV Terminology* document was compiled in the previous project to provide a set of common definitions and a shared understanding of these terms.

The second version of the document (v1.1) was also adopted by the Network Automation working group of the Global Network Advancement Group (GNA-G), with this joint work serving to promote the potential for international collaboration on OAV beyond the GÉANT community.

The document has since been expanded to include more terms relating to Artificial Intelligence and the Maturity Model [[OAV TERM v0.2](#)]. This latest version has also been endorsed by the GNA-G Automation Working Group [[GNA-G](#)].

As new terms are coming into use in the areas of Network Automation, Artificial Intelligence and Maturity Models, work on the document was recently restarted in order to collect the latest terminology for inclusion in a fourth version to be published in the second year of the project.

6 Communication and Dissemination

The Network eAcademy team is actively engaged in communicating and promoting its work within the community. These activities cover several aspects – the NETDEV Wiki, developing the Network eAcademy visual brand and presenting eAcademy activities and results at different community events.

6.1 NETDEV Wiki

The NETDEV Wiki is regularly updated with information about the work done in the Network Technologies and Services Development Work Package (WP6) [[NETDEV Wiki](#)]. Topics covered include production services, software, research and development, digital architecture and automation and applied automation use cases. The Wiki is kept up to date to include the latest information. Most recently, the following sections of the Wiki were updated:

- Dissemination and events pages
- Architecture Mapping pages
- OAV Training Portal
- Community Portal
- Interactive OAV training metro map
- OAV Terminology

A new section for the NETDEV Incubator has also been added [[NETDEV Incubator](#)].

6.2 Branding and Visibility

The Network eAcademy branding is defined and created with the help of the Marcomms team in WP2 and the GLAD team in WP1. The communications plan for the Network Automation eAcademy and is currently under review to update it and adapt it to include the additional training tracks.

The plan covers branding for the units under the Network Automation eAcademy and the Quantum eAcademy. Figure 6.1 shows an example of an image used to illustrate one of the modules:



Figure 6.1: Example of Network eAcademy learning unit branding

The colour scheme helps users identify whether a learning unit belongs to an introductory or advanced training line, and to which metro line it belongs.

6.3 Dissemination Activities

To reach the research and education community around the world, the Network eAcademy team actively participates in R&E community working groups:

- The Automation Working Group of the Global Network Advancement Group [[GNA-G](#)]
- The Internet2 Automation working group [[I2 AUTOMATION](#)]

The Network eAcademy team participates in sessions related to relevant topics under its umbrella and has presented its work in several fora:

- Internet2 Technology Exchange: “Network Automation Tapas” [[I2 TECHEX TAPAS](#)] session together with Internet2, Indiana University, the University of Michigan, and the University of North Carolina-Chapel Hill.
- Internet2 Community Exchange [[I2 COMMEX](#)]: “Get Started with network automation” workshop [[I2 START](#)] [[I2 WS](#)], with Internet2 and the Indiana University.
- RIPE SEE 11 [[RIPE SEE](#)].
- INEX Member Meeting [[INEX M](#)].
- Croatian Network Operators Group meeting [[HRNOG 3](#)].
- RIPE student event as a part of the RIPE87 meeting [[RIPE STUD](#)].
- GÉANT Symposium 2023, in the side meetings “Maximising the potential of eAcademy” and “Security Human Factor – Sustainable Outputs” [[SYMPOSIUM](#)].
- TNC23 [[OAV MM TNC23](#)].
- GNA-G meeting at the Internet2 Technology Exchange [[I2 GNA G](#)].
- OAV Maturity Workshop (held back-to-back with the STF meeting in November 2023) [[OAV MM WS](#)].

The Network eAcademy team also contributed to the creation of content for the lab exercises presented at the Internet2 Community Exchange Workshop by Internet2, Indiana University and the GÉANT project Network eAcademy team, which is available in the Internet2 GitHub [\[I2 WS\]](#) and is linked from two learning units in the Network eAcademy [\[NeA-YAML\]](#), [\[NeA-ANSIBLE\]](#).

Resources to promote the usage of orchestration, automation and virtualisation for digital transformation have been created in collaboration with the Marcomms team:

- OAV video [\[OAV Video\]](#)
- OAV brochure [\[OAV-Brochure\]](#)

Articles on the Network Automation eAcademy have been featured in the CONNECT magazine [\[NeA_CONNECT38\]](#), [\[NeA_CONNECT39\]](#) and are published in CONNECT online [\[CONNECT_OAV\]](#). New learning units in the Network eAcademy are also announced in CONNECT online [\[CONNECT_eAcademy\]](#).

7 Conclusions

The Network eAcademy is a production service run as Task 4 within the Network Development Work Package (WP6) in the GÉANT project. With the aim of addressing the needs of the NREN community in advancing their digital transformation and adoption of advanced network technologies, the Network eAcademy provides resources in several areas: architecture analysis, training, maturity assessment, and terminology definition. To ensure that it reaches the R&E community, WP6 maintains an internet presence and publishes the results of its work on the NETDEV Wiki.

Different training programmes are provided to support further knowledge and skills development in the area of network technologies and services, currently including Orchestration, Automation and Virtualisation and Quantum Technologies, with plans for future expansion in other areas such as Optical Time and Frequency Networks, for which a training structure has already been set and work has started on the first learning units. Network eAcademy training programmes provide targeted, self-paced courses for the GÉANT community, as well as access to external links, exercises and consultancy services. Materials on the learning portal are accessible via eduGAIN login, including NREN authentication and authorisation infrastructure and social media accounts.

Recognising the differences in NRENs' architectures as well as in their levels of maturity in terms of both experience and implementation of OAV solutions, the Network eAcademy has made available a reference OAV architecture and an OAV Maturity Model – simple tools that enable organisations to assess their OAV capabilities. At the same time, the work being done on OAV terminology helps achieve a better alignment between different organisations and teams, starting with a better understanding of each other's solutions, processes and approaches, towards facilitating digital transformation and multi-domain collaboration.

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Glossary

API	Application Programming Interface
CD	Continuous Development
CI	Continuous Integration
GLAD	GÉANT Learning and Development
GN4-3	GÉANT Network 4 Phase 3, a project part-funded by the EC's Horizon 2020 programme under Specific Grant Agreement No. 856726
GN5-1	GÉANT Network 5, Phase 1, a project funded by the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101100680 and one of the projects implementing the actions defined in the GN5-FPA
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
NeA	Network eAcademy
NETCONF	Network Configuration
NETDEV	Network Technologies and Services Development
NREN	National Research and Education Network
OAV	Orchestration, Automation and Virtualisation
ODA	Open Digital Architecture
OTFN	Optical Time and Frequency Networks
QUBITS	Quantum Bits
R&E	Research and Education
SWOT	Strengths, Weaknesses, Opportunities, and Threats
WP	Work Package
XML	eXtensible Markup Language
YANG	Yet Another Next Generation