



H2020 5GASP Project
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D2.2 5GASP reference certification pipeline

Abstract

This deliverable aims to provide an initial definition, proposed structure, and reference for the framework for automation of certification as part of the reference architecture. 5GASP aims at shortening the idea-to-market process through the creation of a European testbed for Small and Mid-size Enterprises (SMEs) that is fully automated and self-service, to foster rapid development and testing of new and innovative Network Applications (NetApps) built using the 5G Network Functions Virtualization (NFV) based reference architecture. Building on top of existing physical infrastructures, 5GASP intends to focus on innovations related to the operation of experiments and tests across several domains, providing software support tools for Continuous Integration and Continuous Deployment (CI/CD) of VNFs in a secure and trusted environment for European SMEs capitalising in the 5G market.

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Contents

ABSTRACT	1
DOCUMENT PROPERTIES	2
DOCUMENT HISTORY.....	2
DISCLAIMER	2
CONTENTS	4
LIST OF FIGURES.....	5
LIST OF TABLES	5
ACRONYMS.....	6
DEFINITIONS	7
1 INTRODUCTION	8
1.1 OBJECTIVES OF THIS DOCUMENT.....	8
1.2 INTRODUCTION TO THE 5GASP NETAPP CERTIFICATION (5GASP-C)	8
1.3 SUMMARISED 5GASP-C PIPELINE (WORK FLOW)	8
1.4 DOCUMENT ORGANISATION.....	9
2 NETAPP ONBOARDING NETAPP VERSIONING	10
2.1 EXPERIMENTAL TRIPLET (NETAPP, NEST, TESTS)	11
2.2 PREFLIGHT TESTS (NETAPP, NEST, TESTS)	12
2.3 SERVICE DEPLOYMENT PROCESS.....	14
2.3.1 5GASP facility registration	14
2.3.2 Service deployment order	14
2.3.3 Service teardown	14
2.4 NETAPP ORCHESTRATION.....	15
3 CI/CD PIPELINE AND TESTING	16
3.1 CENTRAL CI/CD MANAGER	16
3.2 TEST RESULT COLLECTION	17
4 5GASP CERTIFICATION	21
4.1 CERTIFICATION PROCESS	21
4.1.1 Roles and Responsibilities	21
4.1.2 Formal certification process at a Testbed	22
4.1.3 Certification challenges and questions to be addressed	23
4.1.4 Selection of Test Cases; KPIs; Certification grading	24
4.2 5GASP-C RESULT ANALYSIS	24
4.3 PUBLISHING TO NETAPPSTORE	25
4.4 FINAL REPORT/DOCUMENTATION	26
5 CONCLUSIONS	27
6 REFERENCES	28
APPENDIX	29
TESTBED FACILITIES CAPABILITIES.....	29
5GASP CERTIFICATION PROCESS WORKFLOW.....	30
TEMPLATE OF CERTIFICATION REPORT	31

List of Figures

Figure 1 High-level workflow of a NetApp through 5GASP-C program	8
Figure 2. Example of versioning in 5GASP	10
Figure 3. 5GASP experimental triplet model.	12
Figure 4. Preflight check procedure	13
Figure 5. Preflight check service activity diagram	13
Figure 6. NetApp orchestration steps.....	15
Figure 7. 5GASP Automation Testing workflow.....	16
Figure 8. 5GASP CI/CD Service's Architecture.	16
Figure 9. Report.html File, Generated by Robot Framework.	18
Figure 10. Metrics Repository Dashboard.	18
Figure 11. TRVD - Validation Process Stages.	19
Figure 12. TRVD - Tests Performed Outputs.....	20
Figure 13. NetAppStore portal sitemap.....	25
Figure 13. 5GASP Certification process workflow	30

List of Tables

Table 1. Characteristics of each version category.	11
Table 2. Testbed capabilities per facilities site.	29

Acronyms

3GPP	3rd Generation Partnership Project
5GASP-C	5GASP Certification
API	Application Programming Interface
CI/CD	Continues Integration Continuous Development
ETSI	European Telecommunications Standards Institute
KPI	Key Performance Indicator
LTR	Local Test Repository
NEST	Network Slice Template
NFV	Network Function Virtualization
NODS	NetApp Onboarding and Deployment Services
NS	Network Service
NSD	Network Service Descriptor
OSM	Open Source MANO
TRVD	Test Results Visualization Dashboard
VNF	Virtualized Network Function
YANG	Yet Another Next Generation

Definitions

This document contains specific terms to identify elements and functions that are considered to be mandatory, strongly recommended or optional. These terms have been adopted for use similar to that in IETF RFC2119 and have the following definitions:

- **MUST** This word, or the terms "REQUIRED" or "SHALL", mean that the definition is an absolute requirement of the specification.
- **MUST NOT** This phrase, or the phrase "SHALL NOT", mean that the definition is an absolute prohibition of the specification.
- **SHOULD** This word, or the adjective "RECOMMENDED", mean that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- **SHOULD NOT** This phrase, or the phrase "NOT RECOMMENDED" mean that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
- **MAY** This word, or the adjective "OPTIONAL", mean that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation which does not include a particular option **MUST** be prepared to interoperate with another implementation which does include the option, though perhaps with reduced functionality. In the same vein an implementation which does include a particular option **MUST** be prepared to interoperate with another implementation which does not include the option (except, of course, for the feature the option provides).

1 Introduction

1.1 Objectives of this document

The main objectives of this document include introducing the 5GASP certification process for NetApps, and providing a guide to the NetApp developers to use the 5GASP platform and the ecosystem by briefly explaining (i) the NetApp onboarding and deployment process on creating the 5GASP experimental triplets (NetApp, NEST and Tests), (ii) writing the onboarding tests and (iii) the service deployment order. Also, this document gives a brief know-how guide to the NetApp developers on the CI/CD pipeline and how it supports the NetApp development. Finally, this document is aimed to be used by the NetApp developers as a supporting guide throughout the NetApp certification and deployment process.



Figure 1 High-level workflow of a NetApp through 5GASP-C program

1.2 Introduction to the 5GASP NetApp certification (5GASP-C)

One of the 5GASP project goals is to create a specific yet practical technical and governing framework for certification of Network Applications (NetApps) as defined and applied in the context of 5GASP. We discuss henceforth the 5GASP Certification (5GASP-C), or the 5GASP NetApp certification as a process for confirming the compliance of NetApps to the established baseline technical and non-technical requirements by the authors and the certification environment of the testing sites, as described in the document. A NetApp would be considered certified by the 5GASP-C program if a testing facility (lab) that has passed the 5GASP accreditation can conduct the mandatory, conditional, and optional tests defined by the application. The successful validation of the NetApp through onboarding to the conclusion of such testing would result in a suite of results, and the pass or failure of individual categories of such tests would determine if the app is compliant with the 5GASP-C certification. Most importantly, the resultant certificate for an application would bear all necessary details for an independent third-party assessment of the properties of a NetApp with its mark, as discussed in Section 4.

1.3 Summarised 5GASP-C pipeline (work flow)

The certification pipeline is an integral part of the life-cycle of a NetApp. For each certification process, there is a pipeline of activities: Collecting applicability statement information about parameters and supported options; conducting static conformance review against this information supplied; carrying out an actual set of conformance tests with the NetApp; analysing the results; deciding about results submission for formal certification; and assessing the submitted results for issuance of a certificate. In contrast to other industry certifications, this pipeline is intended to be entirely automated and executed in real-time during

onboarding procedures. The CI/CD testing pipeline, a part of the certification pipeline, is described in Section 3.

Section 4 of this document outlines the certification pipeline, explaining the building blocks of the certification which are put in place to ensure dependable and reproducible results. The section touches on the variations of the certification workflow for different types of workloads as well. Initially, the certification focuses on the network service aspects, i.e. the integration with the underlying infrastructure platform. Additional, optional certification modules could be attached to the pipeline subsequently, focusing on the application-layer behaviour or on VNF management and network management in general, to name a few options. Finally, the certification pipeline may slightly differ for new certifications or re-certifications. The latter may have a reduced scope if a new certification run is required to maintain NetApp certified state only.

1.4 Document organisation

This document is organised into five different sections. Starting with the introduction, it focuses on providing a brief insight into the 5GASP NetApp certification process and the pipeline. Section 2 focuses on the NetApp life-cycle starting from the NetApp versioning and going through NetApp/NEST/Tests triplet and the preflight tests, up to the NetApp orchestration with a brief overview of the service deployment process. Section 3 provides a summary of the CI/CD pipeline, followed by the 5GASP certification process in Section 4 with further insight into the challenges and the certification grading. Finally, the document is concluded in Section 5.

2 NetApp onboarding NetApp versioning

The life cycle of a successful NetApp development can be very long. In that case, changes in the developed NetApp can be very different - from error correction to complete rewriting. In most cases, the name of the NetApp remains the same, the subtitle is changed. This process is the NetApp versioning.

It is the process of assigning either unique *version names* or unique *version numbers* to unique states of NetApps.

Several strategies can be applied for the NetApp versioning. A version of the NetApp can be an:

- integer (for example, NetApp name 1);
- a fractional number (for example, NetApp name 1.1);
- a sequence of numbers (NetApp name 1.0.1);
- a year (NetApp name 2021);
- a text (NetApp name XE).

In any case, the versioning system has to be selected by several criteria:

- Support of one or another system by software for development (compiler, version control system, etc.).
- The frequency of new versions and their readiness level.
- The degree of compatibility of third-party network protocols, documents, or add-ons.
- Marketing considerations.

5GASP proposes three main categories of software versions: **[major].[minor].[build]**.

The version categories convey the significance of the software changes from one version to another. As the versions are released, you can infer the scope of the changes by their version number. For example:

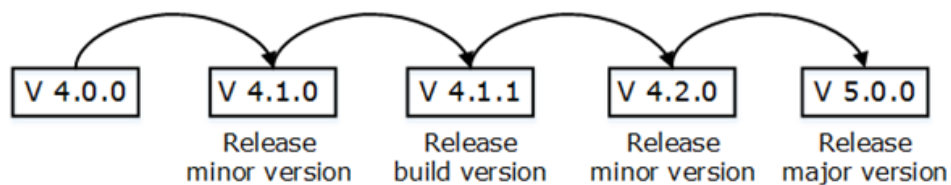


Figure 2. Example of versioning in 5GASP

They are defined as follows:

- **Major:** The major number increases (for example, from 1.2.0 to 2.0.0) when there are significant changes in the functionality or its components that require an essential deployment upgrade. A new major software version may introduce changes that are not compatible with the configuration of an older version. In this case, an upgrade procedure is provided.
- **Minor:** The minor number increases (for example, from 1.0.0 to 1.1.0) to introduce new important features. A minor update may require configuration changes and upgrades of the components. A new minor software version may introduce changes

that are not compatible with the configuration of an older version. In this case, an upgrade procedure is provided.

- **Build:** The build number increases (for example, from 1.1.0 to 1.1.1) to introduce bug fixes, which may require minor updates to the components. No significant upgrades are required. Minor configuration changes may be needed and are documented in the Upgrade Guide. Any change in the software must be backward compatible.

The following table describes the characteristics of each version category:

Table 1. Characteristics of each version category.

CHARACTERISTICS	VERSIONS		
	Major	Minor	Build
NEW FEATURES	Yes	Yes	No
BUG FIXES	Yes	Yes	Yes
OS UPGRADE	Maybe	No	No
CONFIGURATION CHANGES	Yes	Yes	Maybe
DOCUMENTATION UPDATES	Yes	Yes	Maybe

2.1 Experimental triplet (NetApp, NEST, Tests)

The overall 5GASP facility is composed of several interworking sites, each deployed at a different geographic location and defining a single administrative domain. To provide a unified abstraction for all sites, the necessary experiment modelling and transformations need to be defined so that onboarding, activation and testing can be properly performed not only on any 5GASP facility but also on any NFV/3GPP compliant 5G System, regardless of the internal details. To achieve this, in the context of this project, we propose a unified standards-based model that has the form of a "triplet" of entities triggering a service deployment order, as depicted in Figure 3.

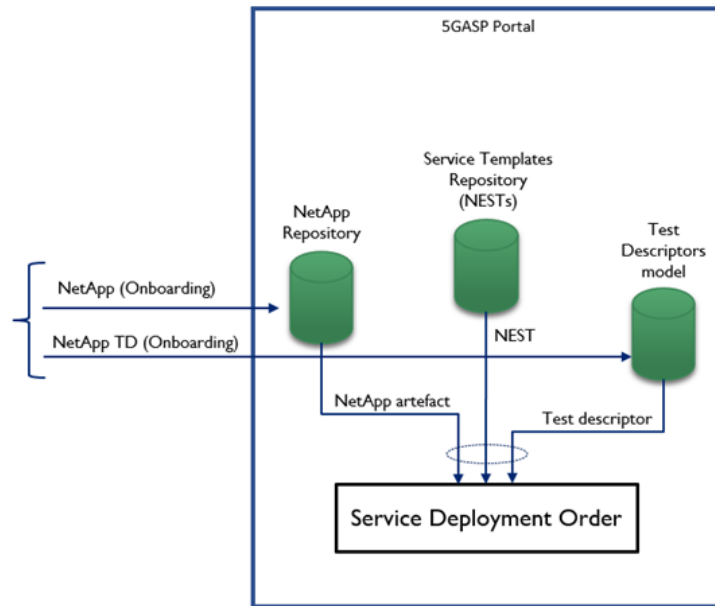


Figure 3. 5GASP experimental triplet model.

As seen, the "triplet" consists of the following entities:

- The NetApp Artefact, bearing the link to the actual NSD(s) comprising the NetApp.
- The Network Slice, that is activated by a target 5G facility and provides the host to facilitate the NetApp's requirements.
- The Test Suite, represented in terms of a test descriptor model, that is executed after the activation of the NetApp.

To end up, extensive reference to the aforementioned experimental model can be found in D3.1 [1].

2.2 Preflight tests (NetApp, NEST, Tests)

Following the successful onboarding process, modelled by the experimental triplet mentioned in the section above, preflight check service is utilised before the service order fulfilment can be initiated. This service, acting as the actuator of the remaining process, ensures that computationally expensive procedures, like network services' deployments, are not triggered before some elementary standards are met, as described in Figure 4 [comment].

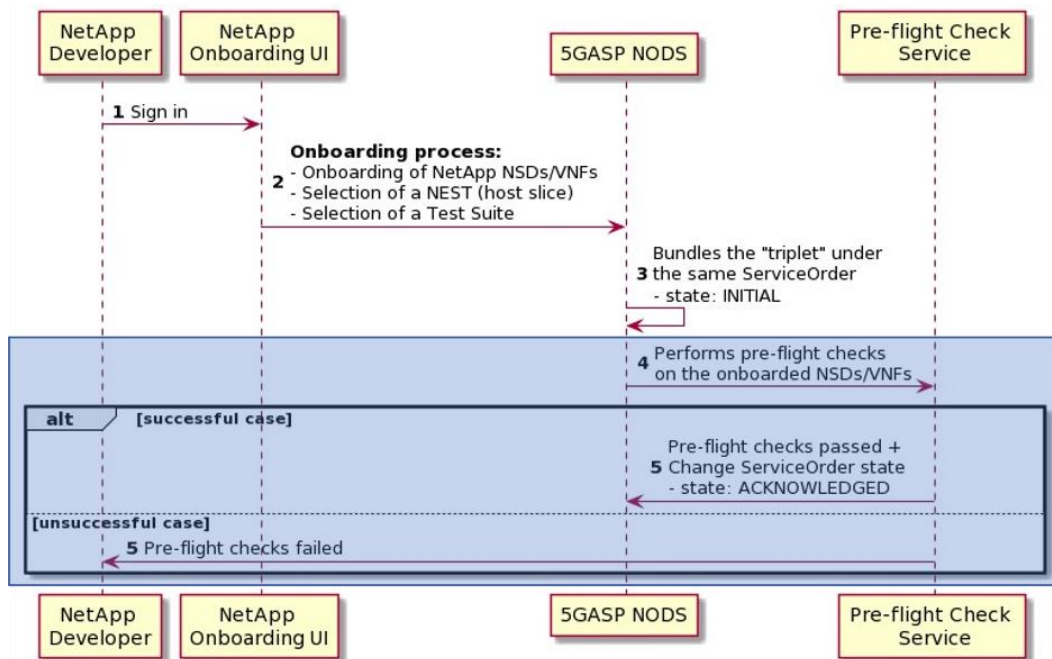


Figure 4. Preflight check procedure

The central portal, i.e. 5GASP NODS, integrates a preflight check service but can also incorporate external ones exposed by APIs. The preflight check service will check the requirements against the limitations of the testbeds, with the latter being summarised in Table 3 in the document appendix. Currently, the internal service is implemented in terms of OSM version recognition and syntax checking. As for today, OSM supports VNF/NS Descriptors designed towards YANG model [2]. Since Release 9, OSM is fully aligned with ETSI NFV SOL006 [3] featuring some augmentations. On that notion, the preflight check service can distinguish SOL006 modelling and thus, identify the corresponding OSM version. Specifically, the uploaded archived is unzipped (expected packaging format is .tar.gz), and the descriptor is parsed and checked upon SOL006 model formatting. Subsequently, depending on the model formatting and assuming correct syntax, information is acquired about VNFs, such as name, image utilised etc. Finally, the archive is onboarded on the respective OSM. This overall process is depicted in Figure 5.

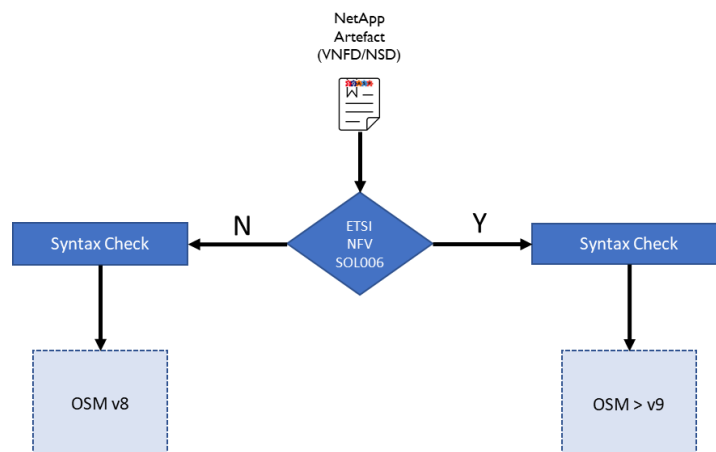


Figure 5. Preflight check service activity diagram

2.3 Service deployment process

After successful validation of the NetApp, through Preflight tests, the NetApp can enter the Service deployment process on one or more 5GASP facilities according to a matching process handled by the 5GASP portal. The matching process checks the NetApp requirements, including vertical-specific aspects such as infrastructure capabilities to support Automotive and PPDR specific functionality, against the information provided by the 5GASP facility upon registration. In addition, a directory service will be developed to list facilities and capabilities, providing an API for testers to list and discover the desired facility.

2.3.1 5GASP facility registration

Before the matching process can occur, it is necessary that each facility can describe and register its capabilities in the 5GASP directory service. The directory service will be constituted by a semantically rich document written in YAML format containing available computational, network and vertical-specific resources available for NetApp deployment.

2.3.2 Service deployment order

Whenever possible, NetApps will be automatically deployed without any time/resource constrain. Whenever NetApp tests require local facility support, a Scheduling Service (using iCal protocol) will provide the means to programmatically schedule local collaboration (e.g. operating the UE). The Scheduling Service will notify all parties involved by replying with an agenda appointment and URL to the collaboration platform (e.g. Google Meet). NetApp requiring such support will only be deployed in the scheduled timeslot. All requests in the platform are processed First-In-First-Out without any privileged access.

2.3.3 Service teardown

NetApps will be automatically shut down after a grace period of 24 hours. All resources allocated will be freed and all data deleted. NetApp developers/testers are the sole ones responsible for retrieving test information data after they finish testing.

2.4 NetApp orchestration

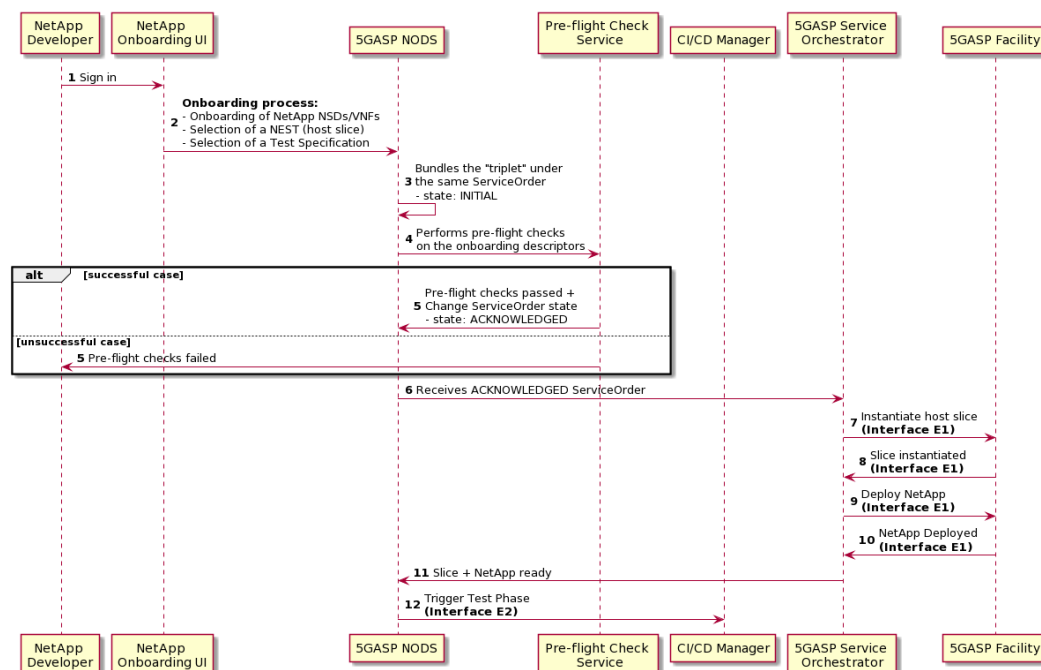


Figure 6. NetApp orchestration steps.

The 5GASP Service Orchestrator is responsible for creating a host network slice and for deploying a NetApp based on corresponding descriptions. Both the network slice and the NetApp are described using the *onboarding model* (based on standardised data model) passed to the NODS during the onboarding process (Figure 6 – steps 1 and 2). Unified standards-based onboarding model provides NEST information, NetApp Artifact and Testing Descriptor. Before the description of a certain NetApp and its corresponding network slice is passed to the orchestrator (Figure 6 – step 6), NODS performs necessary preflight checks (Figure 6 – steps 3 to 5). To create a host network slice and deploy the NetApp, the orchestrator communicates with the facilities involved using the interface E1 (Figure 6 – steps 7 to 10). Finally, when the orchestration process is finished (Figure 6 – step 11), the NetApp enters the test phase (Figure 6 – step 12).

3 CI/CD pipeline and testing

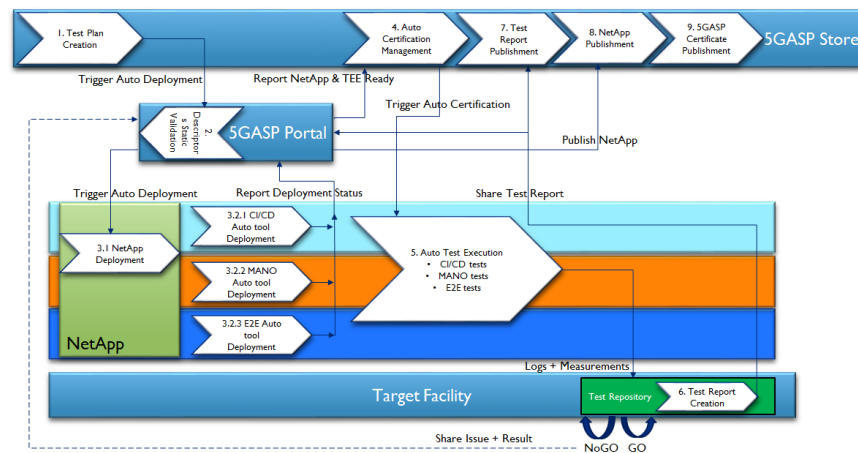


Figure 7. 5GASP Automation Testing workflow

3.1 Central CI/CD manager

5GASP's CI/CD Framework enables automated testing and validation of NetApps, being a key element in the certification pipeline. This framework is composed of the following entities: (i) a CI/CD Manager, (ii) a Test Results Visualisation Dashboard, (iii) a Metrics Repository, (iv) CI/CD Agents, and (v) LTRs. Both the CI/CD Agents and LTRs live inside the testbeds. Figure 8 presents the overall architecture of the CI/CD Service.

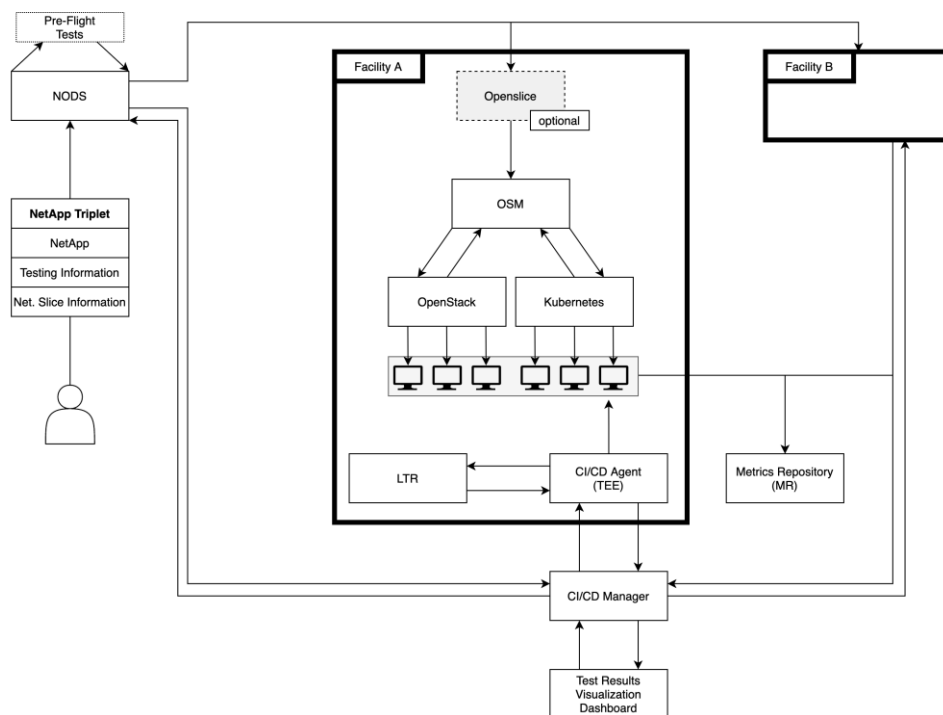


Figure 8. 5GASP CI/CD Service's Architecture.

The LTR stores the tests that will be executed on the testbed where it is deployed, while the CI/CD Agent, located on the same testbed, receives tasks from the CI/CD Manager and conducts the test performing phase, obtaining the tests from the LTR.

On the other hand, the CI/CD Manager is a global entity located outside the testbeds. This entity is triggered by the 5GASP NODS, once the NetApps under test are fully deployed. To trigger a validation process, the NODS will have to submit to the CI/CD Manager a TMF653 ServiceTest. Then the CI/CD Manager will request the TMF653 ServiceTestSpecification, regarding that specific ServiceTest. During these interactions, the CI/CD Manager will gather the Testing Descriptor that will guide the validation process, so as several other information needed to validate a NetApp. As described in D3.1 and D5.1, the Testing Descriptors will be submitted to the NODS by the NetApp developers.

Once it has all the needed information, the CI/CD Manager will dynamically create a configuration file detailing all the validation stages and submit it to the CI/CD Agent located on the testbed where the NetApp was deployed.

Regarding the tests used to validate a NetApp, two types are defined in 5GASP's scope:

- (1) **Platform-Specific tests**, which might assess the connectivity and the performance of the communication between VNFs or CNFs of a NetApp.
- (2) **NetApp-Specific tests**, which the developers of each NetApp shall upload. These tests intend to examine the behaviour and/or performance of specific functionalities of the NetApp and evaluate NetApp-specific KPIs.

After the validation phase is completed, its results will be sent to the NetApp developers so they can get feedback on the testing of their NetApps. The process of obtaining and exposing the validation phase results is further addressed in Section 3.2.

By allowing an automated validation of NetApps, the 5GASP CI/CD Service is crucial to enabling a smoother development life-cycle of the NetApps. Besides, this service ensures that all the 5GASP NetApps are compliant with several quality standards, providing more trust to the Network Operators who wish to use them.

3.2 Test result collection

After performing all the tests, several results will be gathered. Regarding these, we can define two types of results: (i) the actual results from the performed tests and (ii) the metrics collected during the validation phase.

The test results are collected by the CI/CD Agents when the validation phase ends. These results are generated by Robot Framework, and each test will have three different outputs: (i) log.html, (ii) report.html, and (iii) output.xml. Figure 9 presents the content of a report.html file generated by Robot. All these files will then be submitted to the CI/CD Manager's Results Repository.

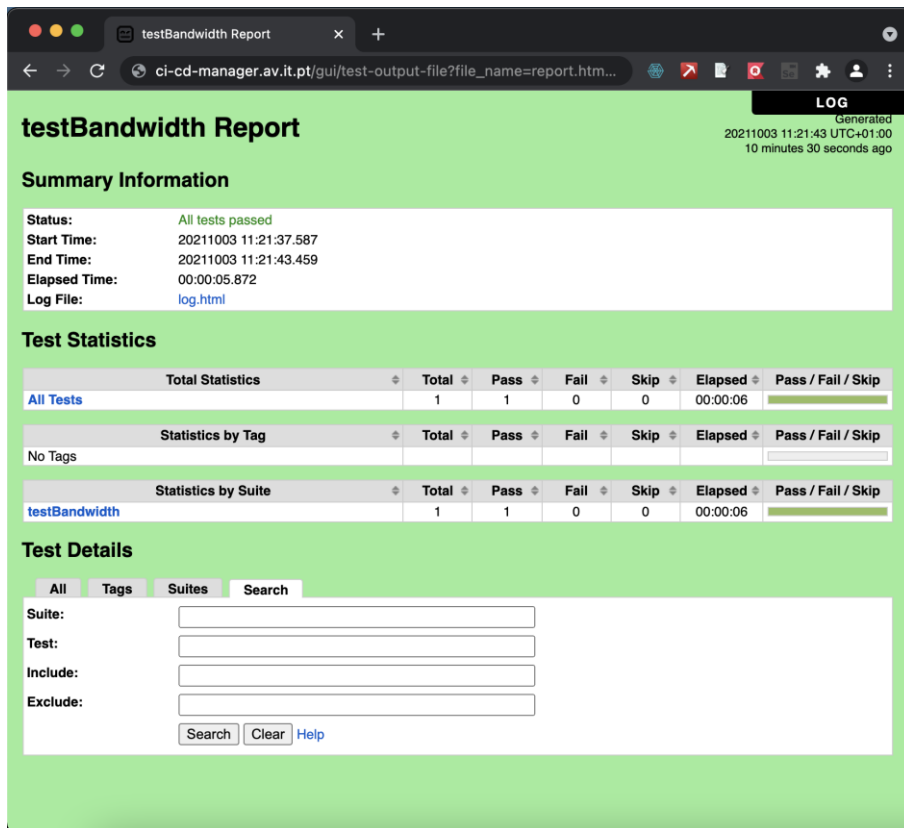


Figure 9. Report.html File, Generated by Robot Framework.

The metrics gathered during the validation phase are constantly being stored in the Metrics Repository database - InfluxDB - and will be available via Chronograf's Dashboard. Figure 10 displays an example of this dashboard.

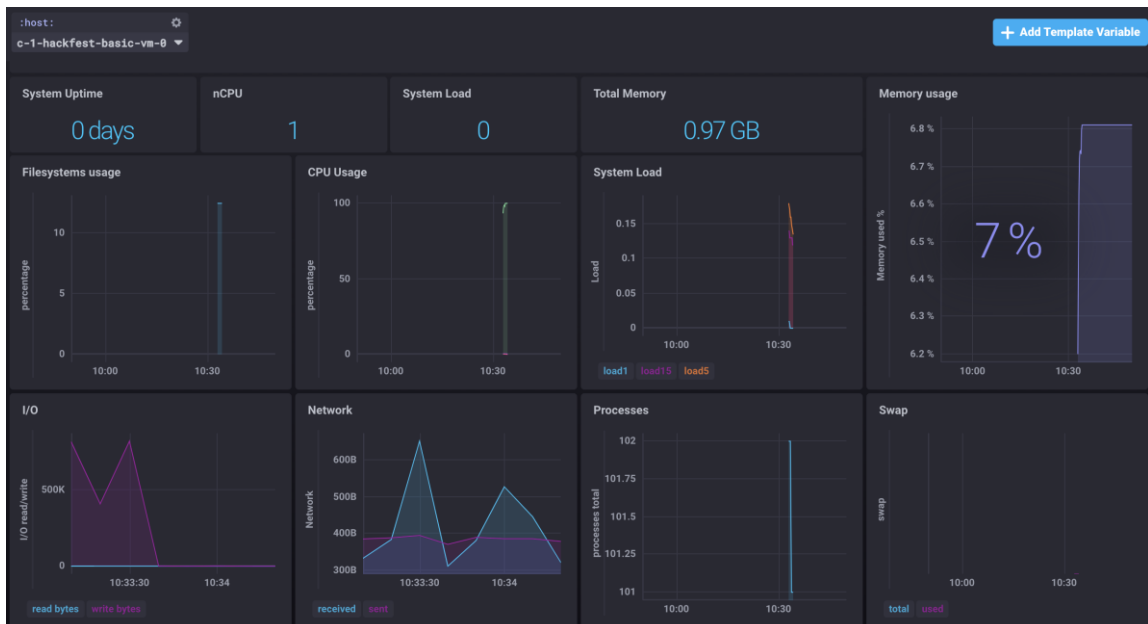


Figure 10. Metrics Repository Dashboard.

After all the results are gathered, it is necessary to make them available to the NetApps' developers. To do so, the CI/CD Service provides a Test Results Visualisation Dashboard (TRVD). This component consumes the outputs and result files via the CI/CD Manager's API and provides a visual and interactive presentation of these.

Via the Test Results Visualisation Dashboard, it is possible to observe all the stages of the validation process, as well as their output. Besides, it also makes each test's specific outputs and results available and provides a URL to access Chronograf's Dashboard.

Next, Figure 11 and Figure 12 present the web interface of the TRVD.

Testing Process Stages			
Timestamp	Stage Name	Stage Status	Observations
2021-10-03 10:25:14	submitted_to_ci_cd_manager	Success	No Observations
2021-10-03 10:25:15	provisioned_ci_cd_agent	Success	No Observations
2021-10-03 10:25:15	authenticated_on_ci_cd_agent	Success	No Observations
2021-10-03 10:25:16	created_communication_token_between_manager_and_agent	Success	No Observations
2021-10-03 10:25:19	created_pipeline_script	Success	No Observations
2021-10-03 10:25:20	submitted_pipeline_script	Success	No Observations
2021-10-03 10:25:31	environment_setup_ci_cd_agent	Success	No Observations
2021-10-03 10:25:32	started_monitoring	Success	No Observations
2021-10-03 10:25:35	obtained_tests_on_ci_cd_agent	Success	No Observations
2021-10-03 10:26:14	performed_tests_on_ci_cd_agent	Success	No Observations
2021-10-03 10:26:15	ended_monitoring	Success	No Observations
2021-10-03 10:26:17	published_test_results	Success	No Observations
2021-10-03 10:26:19	cleaned_test_environment	Success	No Observations
2021-10-03 10:26:20	test_ended	Success	No Observations

Figure 11. TRVD - Validation Process Stages.

Tests Performed						
Test Name	Start	End	Test Status	Test Description	Test Log	Test Report
bandwidth	2021-10-03 10:21:37	2021-10-03 10:21:43	Passed	Test the bandwidth between the OBU and vOBU	Test Log	Test Report
transmission_speed	2021-10-03 10:21:44	2021-10-03 10:21:49	Passed	Test the transmission speed between the OBU and vOBU	Test Log	Test Report
packet_loss	2021-10-03 10:21:50	2021-10-03 10:22:09	Passed	Test the packet loss between the OBU and vOBU	Test Log	Test Report
open_ports	2021-10-03 10:22:12	2021-10-03 10:22:12	Passed	Test the open ports in the OBU VNF	Test Log	Test Report

Chronograf	
URL	http://10.0.12.266:8888/
Username	admin
Password	admin

Figure 12. TRVD - Tests Performed Outputs

To summarise, the NetApp developers will get the outputs and results of the validation process of their NetApps via the TRVD and will be able to obtain useful information on the performance and behaviour of their NetApps, which will accelerate the NetApps' development life-cycle.

There are plans to create a PDF file with all the results and outputs of the validation process in the future. This PDF would then be sent to the NetApp developers via e-mail, allowing a more straightforward way of consulting all the aforementioned information.

4 5GASP Certification

The 5GASP Certification is the technical, organizational, and administrative process executed to certify a NetApp.

4.1 Certification process

4.1.1 Roles and Responsibilities

The following parties are typically involved in a certification. The reader may also refer to the Figure 14. 5GASP Certification process workflow at the Annex of the current report.

- **Applicant** (Equipment Manufacturer providing a NetApp supporting the 5GASP requirements):
 - Select an authorised Testbed which meets the Applicant's needs and schedule a certification testing slot
 - Complete NetApp certification application and submit all required supporting documentation
 - Submit required materials to Testbed for certification testing
 - Coordinate with Testbed on monitoring/supporting the certification test execution
 - Coordinate with Testbed on investigation/debugging of NetApp test issues as required
- **Authorized Testbeds** (Independent Testbed which has 5GASP approval to provide test reports for NetApp certification):
 - Respond promptly to testing inquiries from Applicants
 - Coordinate with Applicant to schedule timely testing window
 - Coordinate with Applicant to complete all pre-testing logistics
 - Execute formal certification testing
 - Review testing results for test environment integrity and accuracy
 - Escalate abnormal test findings to 5GASP certification authority for disposition
 - Facilitate investigation/debug of product test issues with Applicant as requested
 - Communicate completed test results to the 5GASP certification repository
- **5GASP Certification Authority** (Logo owner and Program Administration)
 - Review/approve product certification application and supporting documentation
 - Collaborate with Testbeds on investigation/disposition of abnormal test findings
 - Review testing results for product compliance
 - Arbitrate any escalated issues from Testbed and Applicant
 - Issue certificate and associated logo
 - Maintain certified product listing

4.1.2 Formal certification process at a Testbed

Upon availability of NetApp for the Testbed, testing shall be scheduled and conducted by the Testbed in a semi-automated or an automated fashion, in accordance with 5GASP certification policies and procedures.

Certification testing may be considered as organized into "test runs", in which a unique combination of hardware and software undergoes the entire applicable test suite. 5GASP will only grant certification for a single, complete test run – a combination of different test run results is not accepted.

Test runs are carried out automated, and supervised by a Testbed personnel. Applicants may monitor certification testing, but may not physically interact with the NetApp throughout the duration of a test run.

While it is possible for a NetApp to successfully complete a test suite in one uninterrupted test run, failures may occur and shall be assessed in the following manner:

- The current test run shall be considered paused for the failing test(s), the Testbed will inspect harness logs and sniffer captures to validate that the test environment operated correctly
- If issues are suspected with the test environment (no NetApp modification made), the Testbed will address those appropriately and resume the execution of the current test run
- If the NetApp is believed to be responsible for the failure(s), the Applicant shall be informed and may choose to continue the current testing appointment and debug/resolve the issue(s) onsite at the Testbed or return later with a revised NetApp configuration
- The current test run is cancelled
- A new test run – with revised NetApp software and/or hardware details – must be executed in entirety; a mix of test runs is not accepted.
- In the event that a failure is disputed, the Testbed will notify the 5GASP consortium. The parties will then collaborate to understand, address and disposition the problem. Possible dispositions include, but are not limited to, NetApp workarounds, test workarounds and waivers.

The Testbed shall maintain comprehensive documentation of the certification testing, including:

- Any deviation from the submitted NetApp operation instructions
- A history of all test run definitions, including change logs
- All sniffer captures, console logs and debug logs from all test runs

Upon successful completion of all applicable testing, the Testbed shall submit test results for the final test run of the NetApp to 5GASP certification team for final review.

4.1.3 Certification challenges and questions to be addressed

In general, the NetApp certification is a procedure performed by a third party, independent of the manufacturer (seller) and consumer of software products, to confirm the compliance of a certain program or software package with the established requirements.

The third party should be a Testbed that has been authorized (accredited) for the purpose of 5GASP certification testing. During the accreditation, the Testbed's technical capabilities to conduct certification testing are assessed, and the Testbed's qualification to verify results and discriminate pass/fail criteria are reviewed. Each Testbed will need to agree with 5GASP regarding administrative and legal aspects of certification testing. This is typically done by entering into a Testbed agreement contract. The details of the testbed requirements can be found in D3.1 [1]. There are six accredited Testbeds in 5GASP at this moment, the current capability could be found in Table 2.

The technical (automated) certification testing will be conducted by software that needs to be accredited as well. The test software accreditation process is not described in detail here either; in short, reference testing with a known workload and known expected results will be conducted and results verified before the software can be used for formal certification testing.

At the same time, under the 5GASP NetApp certification we will consider a procedure performed by facilities, to confirm the compliance of a certain NetApp with the established requirements according to the 5GASP rules.

NetApp certification aims to demonstrate the reliability and safety of a NetApp in such a way that it can be checked by a responsible body with minimal trust in the techniques and tools used in the certification process itself.

It builds on existing software assurance, validation, and verification techniques but introduces the notion of explicit software certificates, which contain all the information necessary for an independent assessment of the demonstrated properties.

Thus, building reliable software is a challenging task in itself, but there are several challenges specifically related to certification, e.g.,

- maintaining high reliability, especially when a combination of diverse development techniques is used;
- minimising certification efforts, especially for NetApp families and interconnected systems of systems;
- reducing certification and re-certification times, – linking between artifacts and certificates; and
- providing useful information (e.g., estimates of certification efforts).

5GASP claims that the solution to these challenges is an intelligent, automated, and highly customisable software certificate management system integrated into the development process.

4.1.4 Selection of Test Cases; KPIs; Certification grading

Each test case being a part of the certification schema will be defined as either mandatory (must be executed in any case), conditional (must be executed if selected i.e., the set of parameter preconditions is met), or ancillary/optional (may be executed at discretion of the NetApp vendor). The latter category is less interesting for certification because the results have no implication on certification assessment.

Different grades of certification may be created, starting with a minimum scope of test cases and/or a minimum set of KPI requirements for an initial step. Subsequently, the scope could be expanded and/or sets of KPIs could be strengthened. Different levels of certification (bronze / silver / gold etc.) could be created with different sets of criteria. This grading of certification requirements could be used to nudge NetApp vendors to improve compliance and increase performance criteria. The requirements of the certification levels are as follows,

- Bronze – all initial criteria
- Silver – all initial criteria and a minimum of 50 percent of available expanded criteria points
- Gold – all initial criteria and a minimum of 75 percent of available expanded criteria points

No certification would be issued when the initial criteria is not fully reachable. In this case, the NetApp Applicant could ask for a re-certification with a new software version. In the re-certification process, some workflows could be skipped (e.g., Certification Request, some could be only updated (e.g., Supporting documentation, and Test materials, and even someone could be re-used (e.g., select the same testbed). The re-certification process could be also used when a NetApp Applicant wants to have a higher level of certification (e.g., bronze was issued and then silver/gold is excepted with a new software version).

4.2 5GASP-C result analysis

The result of each executed test case can be PASS, FAIL, or INCONCLUSIVE. The test suite in total is considered to have achieved PASS criteria, and the NetApp eligible for a certificate, only if all executed mandatory and conditional test cases have been completed with PASS.

A test case is considered PASSED if all result data gathered matches the respective minimum criteria (I.e., the excepted value of the KPIs). KPIs can be functional or performance, and are typically not defined in a generic test suite, but in a certification requirements document. The test suite but with different sets of criteria for accepted values could be used for different categories of NetApps.

If a NetApp applying to get certified is found to have issues that appear to violate one or more certification requirements, the NetApp is considered non-conforming. Non-conformance may result from either an issue with the NetApp itself or an issue with how testing was conducted.

In case an issue with the NetApp implementation has been identified, the NetApp vendor must address it and re-submit the NetApp for certification subsequently. In the absence of a

successful resolution of the non-conformance issue(s), the NetApp will be de-certified. The NetApp certification will be removed from the certifications listing page and the NetApp vendor will be required to cease stating the product(s) is/are certified.

In the event the issue is with the Testbed's testing process, the process must be corrected and the Testbed will be audited. All corrections must be documented in the certification report and the certification report must be reissued.

4.3 Publishing to NetAppStore

One of 5GASP innovative solutions for business is a showcase portal of registered network applications (NetAppStore) providing operational information collected automatically during the NetApps independent testing on the 5GASP platform.

NetAppStore will operate similarly to the mobile app stores, where i) selected NetApps uploaded within the NetAppStore are provided for a fee, ii) some other NetApps are provided for free; and, iii) third-parties either gain visibility and/or make revenue when they upload their NetApp in the NetAppStore, under the condition that their NetApp had been deployed, tested and certified by the 5GASP platform. Finally, the certified NetApps, along with best practises for their implementation, shall be made available in the NetAppStore. Figure 13 represents an initial sitemap of the 5GASP NetAppStore portal.

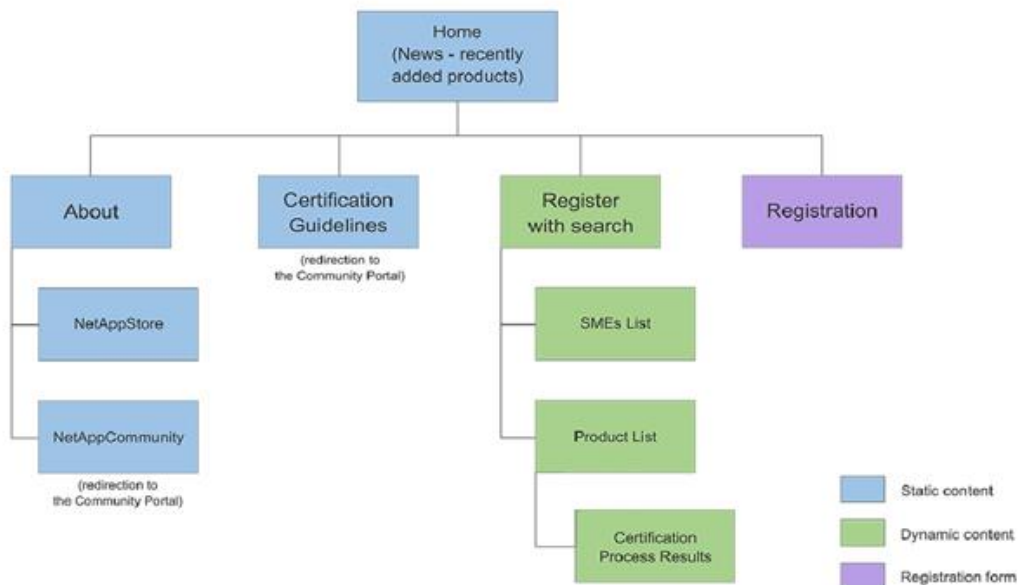


Figure 13. NetAppStore portal sitemap.

In order to publish a NetApp, NetApp developers first need to create their own Developer Account on the portal. Then, to publish a NetApp in the 5GASP NetAppStore, a NetApp developer must submit it to 5GASP portal for autonomous testing, validation and certification using 5GASP facilities and testing tools. After approving the NetApp, system administrators place it on the NetAppStore, where customers can purchase it and use it for their own needs.

Complete guidelines for publishing process of the NetApps in the portal will be published on the NetAppStore once it is available.

4.4 Final report/documentation

The set of documentation for each certification attempt /application needs to be complete to a level that enables full reproducibility. The documentation must include:

- NetApp name, version, publication date and signature
- NetApp resource usage (CPU speed, RAM size, storage speed, virtual network type)
- Date of test run, involved parties, and test execution engineer identifier
- Test bed topology and test environment description
- Reference to test plan(s) utilised, and selection of test cases
- Reference to KPIs applied for the test run
- List of test case assessments (PASS/FAIL/INCONCLUSIVE)
- Test measured results with the respective minimum criteria for each test case
- Any issues and resolution (reference to previous certification attempts with the same NetApp and software version)
- Final assessment of the certification status (conforming or non-conforming)

5 Conclusions

This document introduces the reader to the fundamentals of the 5GASP NetApp certification process and the pipeline. It provides a consistent description of the process and pipeline with the goal of enabling a reproducible certification scheme that yields identical results independent of the parties, date, or location of test execution. The document explains the non-technical aspects to be taken into account (Section 1.3 and Section 4) when submitting a NetApp for certification testing. While the certification schema is primarily administrative, the technical certification process is triggered automatically within 5GASP. It is important to understand these two facets of the certification process.

The document also focuses on the NetApp life-cycle. Specifically, it outlines the NetApp onboarding process and defines the adopted NetApp versioning scheme (Section 2). In further, we discuss the experimental triplet that has been defined previously (NetApp/NEST/Tests): (i) NetApp Artefact (link to the actual NetApp NSD(s)); (ii) the Network Slice (activated by a target 5G facility to host/satisfy the NetApp's requirements; and (iii) the Test Suite (test descriptor model). Section 2 also overviews preflight tests following a successful onboarding process, which are conducted or could be conducted 1) by the preflight check service integrated to 5GASP NODS (the central portal) or - upon need - 2) by external ones exposed by APIs. Finally, Section 2 outlines the NetApp orchestration with a brief overview of the service deployment process (5GASP facility registration; Service deployment order; Service teardown; NetApp Orchestration).

Section 3 provides a detailed summary of the CI/CD pipeline, starting with the Central CI/CD manager, a key element framework in the certification pipeline enabling automated NetApp testing and validation. There is also a discussion of the test results collection process by the CI/CD Agents when the validation phase ends (see details in Section 3.2).

6 References

- [1] 5GASP Deliverable D3.1. Available online:
<https://www.5gasp.eu/assets/documents/deliverables/D3.1%20Experimentation%20Services,%20Middleware%20and%20Multi-Domain%20Facilities%20Continuous%20Integration.pdf>
- [2] IETF, "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)," 2010.
- [3] ETSI, "GS NFV-SOL 006; Protocols and Data Models; NFV descriptors based on YANG Specification," 2020.

Appendix

Testbed facilities capabilities

Table 3. Testbed capabilities per facilities site.

	<i>Aveiro</i>	<i>Murcia</i>	<i>Bristol</i>	<i>Ljubljana</i>	<i>Patras</i>	<i>Bucharest</i>
<i>Maximum number of Cores per VNF</i>	4	8	6	8	8	8
<i>Maximum RAM per VNF</i>	4GB	16GB	10GB	16GB	16GB	16GB
<i>Maximum Storage per VNF</i>	50GB	30GB	30GB	40GB	40GB	40GB
<i>Maximum number of VNFs</i>	40 (Total)	40 (Total)	2 per network service	20 (Total)	80	40 (Total)
<i>5G Release</i>	Release 15 - SA	Release 16 - SA	Release 15	Release 15	Rel.15/Rel.16 5G NSA/SA	Release16
<i>MANO Version</i>	OSM Release 10	OSM Release 10	OSM Release 10	OSM Release 10	OSM Release 10	OSM Release 10
<i>VIM</i>	Openstack Wallaby	Openstack Rocky	Openstack Wallaby	OpenStack Wallaby	Openstack Rocky	
<i>CIM</i>	-	-	K8s 1.21	K8s 1.21	K8s 1.23	
<i>Bandwidth available to reach testbed</i>	Approx. 1Gbps Mbps (GEANT)	Approx. 1Gbps (GEANT)	Approx. 70 Mbps	100Mbps	Approx. 1Gbps Mbps (GEANT)	100Mbps (Internet)
<i>Bandwidth available to UE</i>	DL: 1.1Gbps UL: 160 Mbps	DL: ~600 Mbps UL: ~160 Mbps	DL: ~700 Mbps UL: 150 Mbps	1000Mbps/100Mbps	DL: ~720 Mbps UL: 120 Mbps	1000Mbps/150Mbps
<i>Number of UE</i>	5	1 Smartphone + 5 USB Modems + 64 Simbox vUEs	20	4	12	5
<i>Number of CPE</i>	10	5 custom	-	2	6	5
<i>Support Automotive Vertical</i>	YES	Yes	Provisionally (under cross-use case scenarios with PPDR)	Yes (No RSUs or V2X devices)	Yes (No RSUs or V2X devices)	Yes
<i>Support PPDR Vertical</i>	YES	Yes	YES	Yes	Yes	Yes

30



Template of Certification report

A. GENERAL INFORMATION

A1 Name of NetApp under certification*	A2 Version of NetApp under certification*
A3 Status of certification [conforming / non-conforming]*	A4 Level of certification [bronze / silver / gold]*
A5 Publication date of certification*	A6 Signature (5GASP Logo owner)*
A7 Date of test run*	A8 Name of Testbed(s) – incl. the address A8.1 Name of partner 1* - A8.2 Name of partner 2 (optional in multi-testbed) -
A9 Involved parties* A9.1 Name of partner 1 - A9.2 Name of partner 2 - A9.3 Name of partner 3 - . . .	
A10 Engineer identifier (tester) – incl. Name, Organization, E-mail address*	
A11 Testbed topology and test environment description*	
A12 Summary of test results, conclusions	

*is mandatory

B. TEST INFORMATION

B1 Date of test run*	B2 Name of Testbed(s) – incl. the address B2.1 Name of partner 1* - B2.2 Name of partner 2 (optional in multi-testbed) -
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B3 Involved parties* B3.1 Name of partner 1 - B3.2 Name of partner 2 - B3.3 Name of partner 3 - . . .
B4 Engineer identifier (tester) – incl. Name, Organization, E-mail address*
B5 Testbed topology and test environment description*
B6 Summary of test results, conclusions

List of test cases

Test No.	Test Case*	Referenced Test Plan*	Test status [PASS/FAIL/INCONCLUSIVE]*
01			
02			
03			

C. TEST AND MEASUREMENT EQUIPMENT AND TOOLS

#	Equipment tool or	Manufacture	Open Source [Y/N]	Version (HW/SW)	Notes
01					
02					
03					

D. NETAPP UNDER TEST

D1 Total number of VNF/CNF*	D2 Usage of resource* D2.1 CPU speed (GHz) -
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	D2.2 RAM size (GB) - D2.3 Storage speed (MB/s) - D2.4 Virtual network type [OVS / DPDP /SR-IoV] -
D3 Description of NetApp	

E. TEST RESULTS

E1 Test No.	E2 Test Case*#
E3 Date(s) of test execution	E4 Reference to test plan*
E5 Test procedure – describe differences in comparison with the test procedure defined in test spec. – limitations	
E6 KPIs – incl. the minimum criteria in the test plan*	
E7 Test results – measured value of KPIs – incl. attachment of raw measurements & log file(s)*	
E8 Notes, incl. observed issues with the solutions	
E9 Conclusions – pass/fail/ inconclusive – assessment of measured KPIs (in comparison with the expected KPIs) – gap analysis	

Please repeat the above table for each test case