

# 5G end-to-end experimentation by verticals in EU projects

Online workshop 9 June 2020

End-to-end service specification and  
deployment in 5G-VINNI

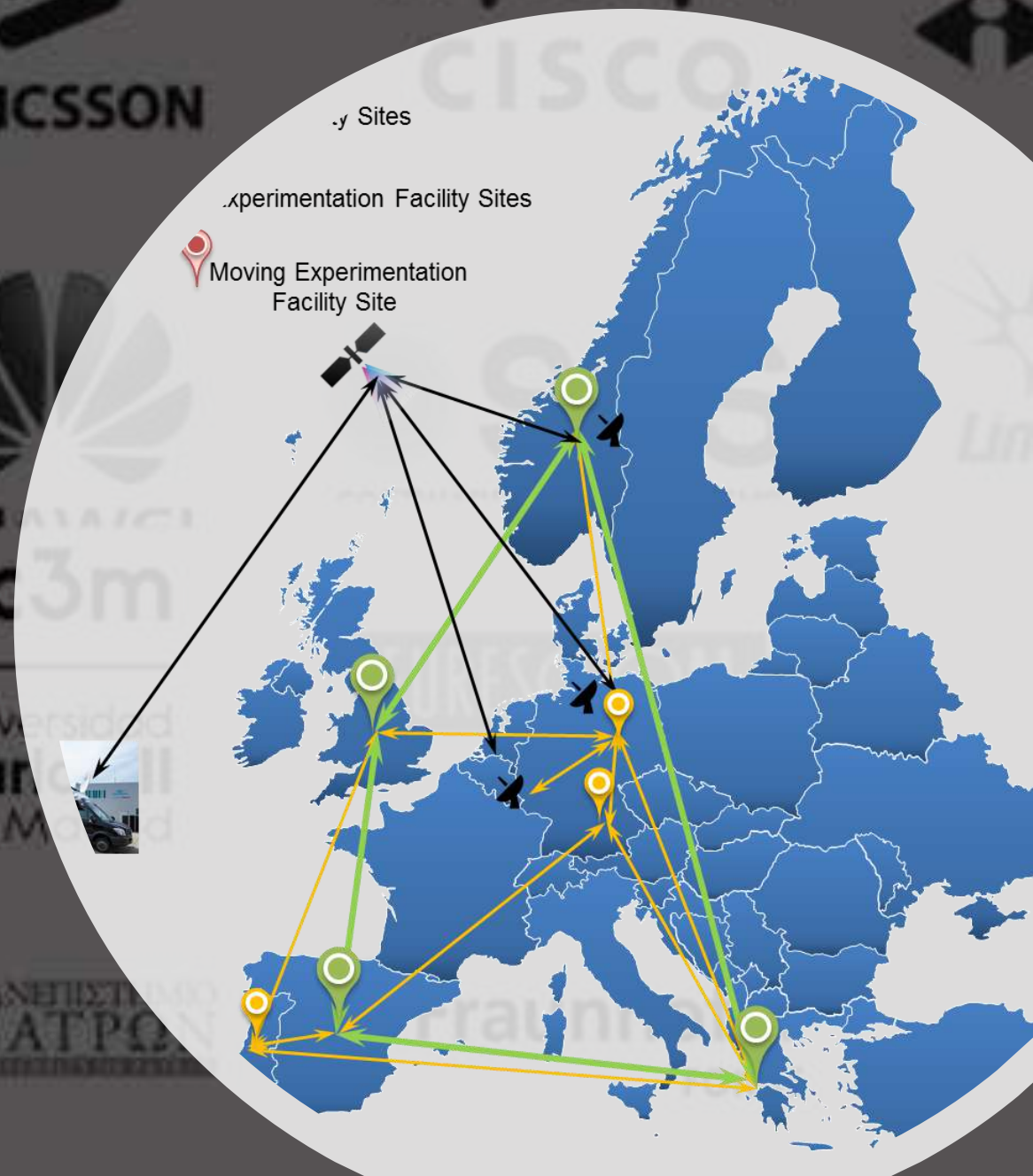
**Christos Tranoris**

University of Patras, Greece

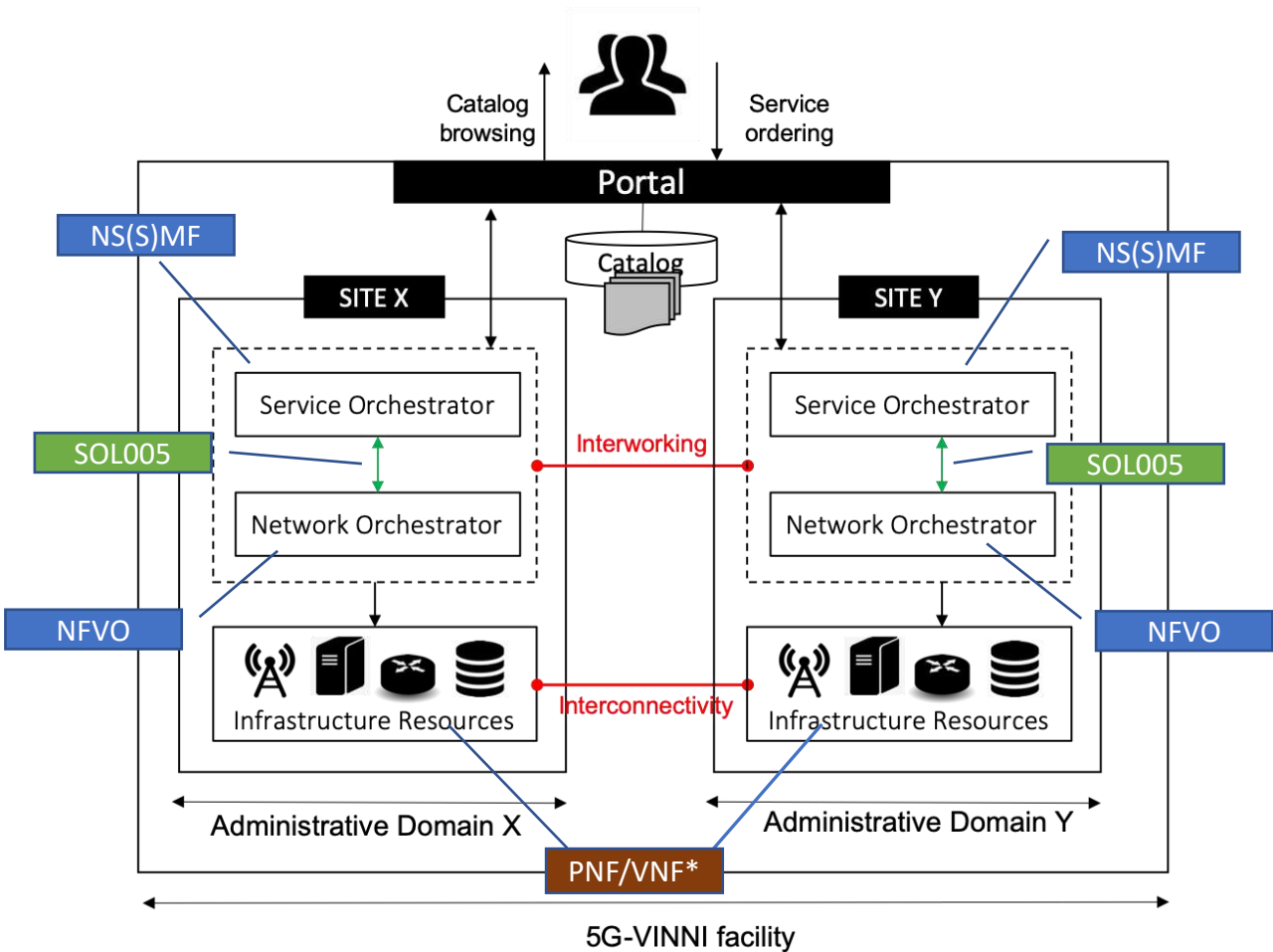
# 5G-VINNI (5G Verticals INNOvation Infrastructure)

- Build an open large scale 5G End-to-End facility that can
  - demonstrate that key 5G network KPIs can be met
  - be validated, accessed and used by vertical industries (e.g. in ICT-19 projects) to test use cases and validate 5G KPIs.
  - Provide user friendly zero-touch orchestration, operations and management systems for the 5G-VINNI facility.
  - Validate the 5G KPIs and support the execution of E2E trial of vertical use cases for ICT-19 projects.
- Duration: 3 years, budget: 19,998 M€
- Consortium: 23 partners (operators, vendors, academics, SMEs)

<https://5g-vinni.eu/>



# 5G-VINNI facility



- 5G-VINNI facility site architecture is standards-compliant (e.g. 3GPP; ETSI NFV) to facilitate interoperability in multi-site slicing scenarios
- 5G-VINNI is an E2E facility providing advanced 5G capabilities that are made available to industry verticals for use case trialing.
- 5G-VINNI facility provides every vertical with an isolated service experimentation, in the form of a slice -> Network Slice as a Service (NSaaS).
- 5G-VINNI facility architecture
  - **Catalog:** publication of 5G-VINNI service offerings, i.e. network slice services.
  - **Portal:** single-entry point for the vertical. It allows catalog browsing and service ordering operations.
  - **Multiple interworking sites**, each deployed at a different geographic location and defining a single administrative domain.



This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 815279.

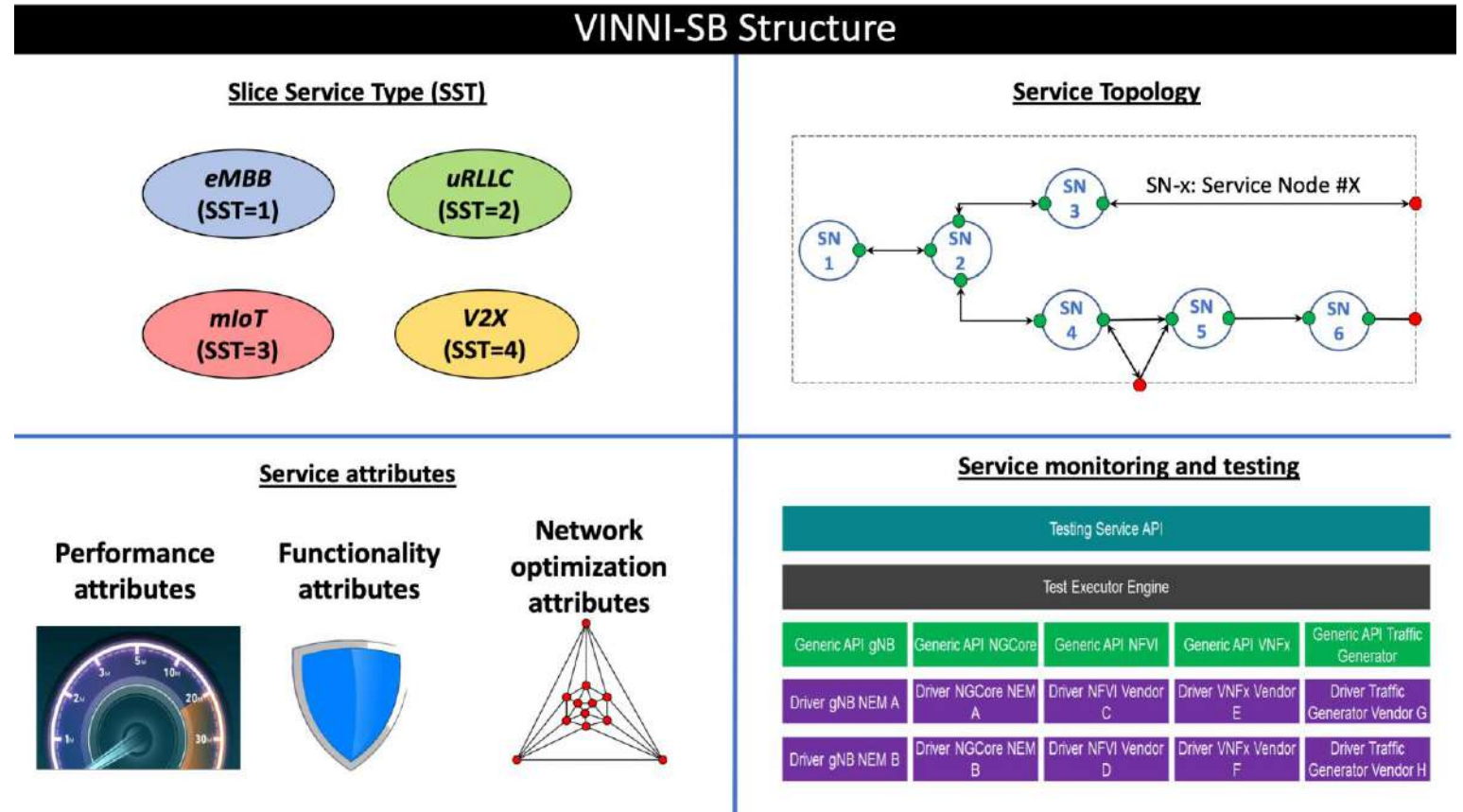
(\*) Multi-Vendor Network Functions across domains, e.g. RAN, CN, TN.





# 5G-VINNI Service Blueprint (VINNI-SB)

- Model-based service template for service ordering in NSaaS.
- Extending GSMA's Generic Slice Template (GST), including experimentation related attributes:
  - **Monitoring**
  - **Testing**

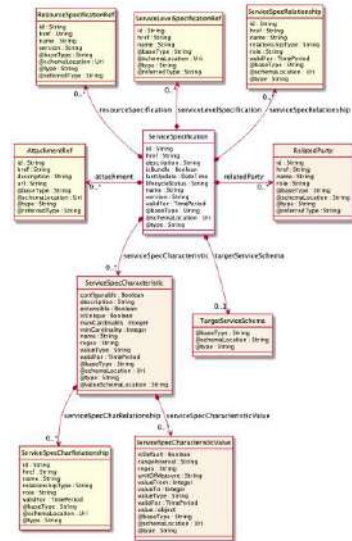


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# GSMA GST to TMF SID

- Availability
- Area of service
- Delay tolerance
- Deterministic communication
- Downlink throughput per network slice
- Downlink throughput per UE
- Energy efficiency
- Group communication support
- Isolation level
- Location based message delivery
- Maximum supported packet size
- Mission critical support
- MMTel support
- NB-IoT support
- Network Slice Customer network functions
- Number of connections
- Number of terminals
- Performance monitoring
- Performance prediction
- Positioning support
- Radio spectrum
- Reliability
- Root cause investigation
- Session and Service Continuity support
- Simultaneous use of the network slice
- Slice quality of service parameters
- Support for non-IP traffic
- Supported device velocity
- Synchronicity
- Terminal density
- Uplink throughput per network slice
- Uplink throughput per UE
- User management openness
- User data access
- VX communication mode



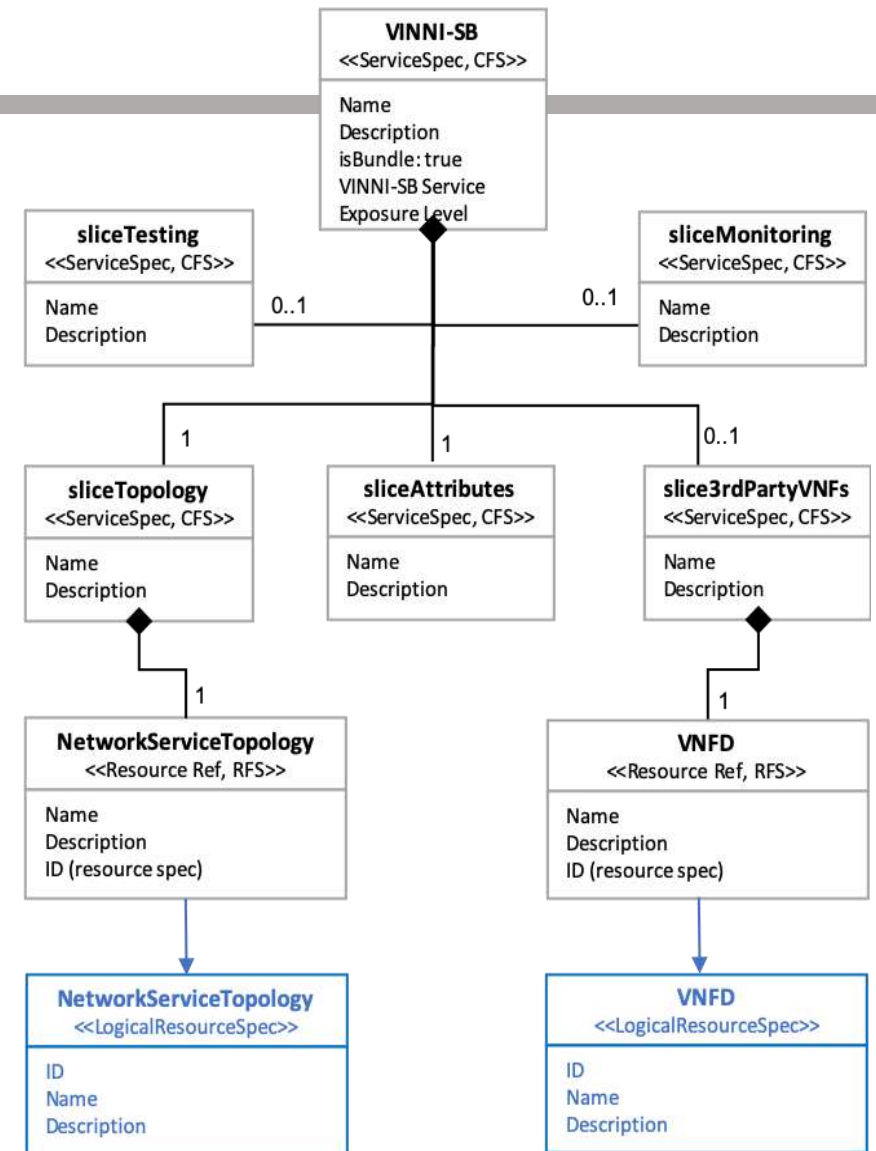
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      "description": "This attribute specifies the area where the terminals can access a particular network slice. Therefore, the attri",
      "extensible": null,
      "isUnique": true,
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  "serviceSpecCharacteristicValue": [
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        "unitOfMeasure": "N/A",
        "valueFrom": null,
      }
    ]
  }
  ],
}

```

# Model of VINNI-SB

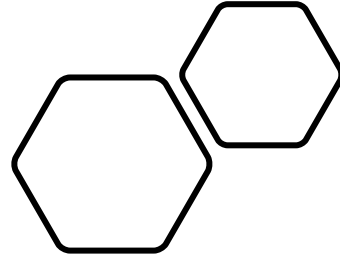
- Definition of a common information model for the entire 5G-VINNI facility:
  - **Site-agnostic design of network slices.**
  - Ensures **reproducibility and facilitates cross-site slice deployments.**
- Model following TM Forum's information Framework (SID)



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# Onboarding a Vertical for 5G experimentation

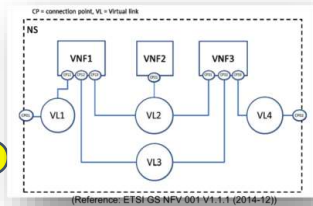


Onboarding a vertical in a 5G experimentation infrastructure involves various **iterative and parallel steps**. **Different stakeholders** (customer, facility provider) must co-design and co-develop different parts for a successful operation and KPI testing on top of a 5G facility.

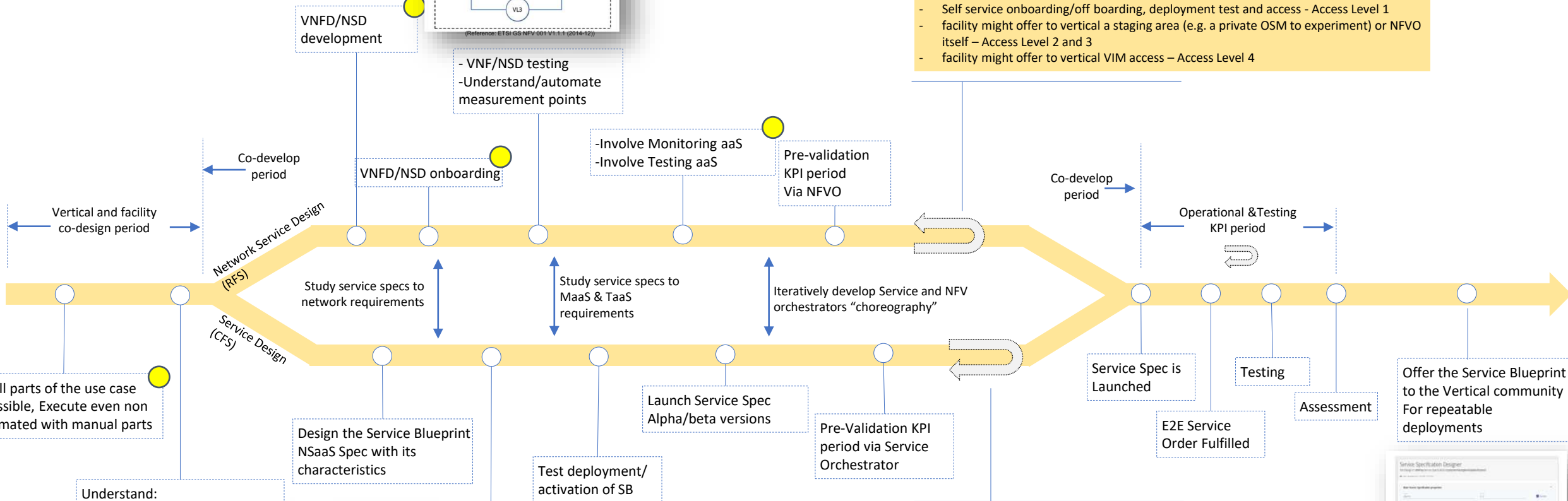
We defined three periods of the onboarding process:

- i) a **co-design** period,
- ii) an iterative **co-development** period and
- iii) the **Operation and Testing KPI** iterative period.

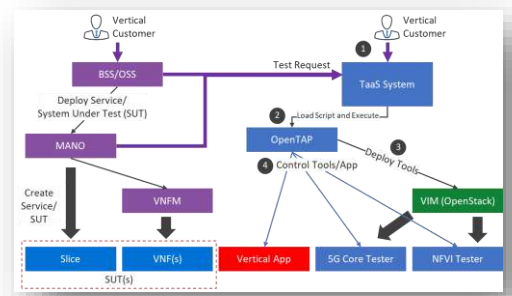
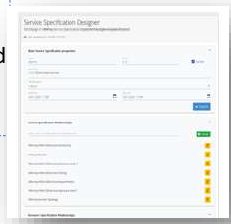
# The onboarding process



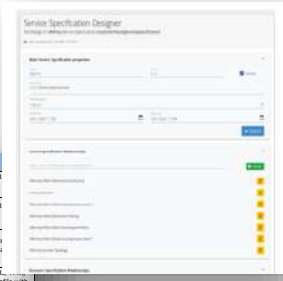
- This cycle might be repeated multiple times
- NFV orchestration is key part to repeatability of NF deployments/testing
- Self service onboarding/off boarding, deployment test and access - Access Level 1
- facility might offer to vertical a staging area (e.g. a private OSM to experiment) or NFVO itself – Access Level 2 and 3
- facility might offer to vertical VIM access – Access Level 4



- This cycle might be repeated multiple times
- Service and NFV orchestration is key part to repeatability of NF deployments/testing

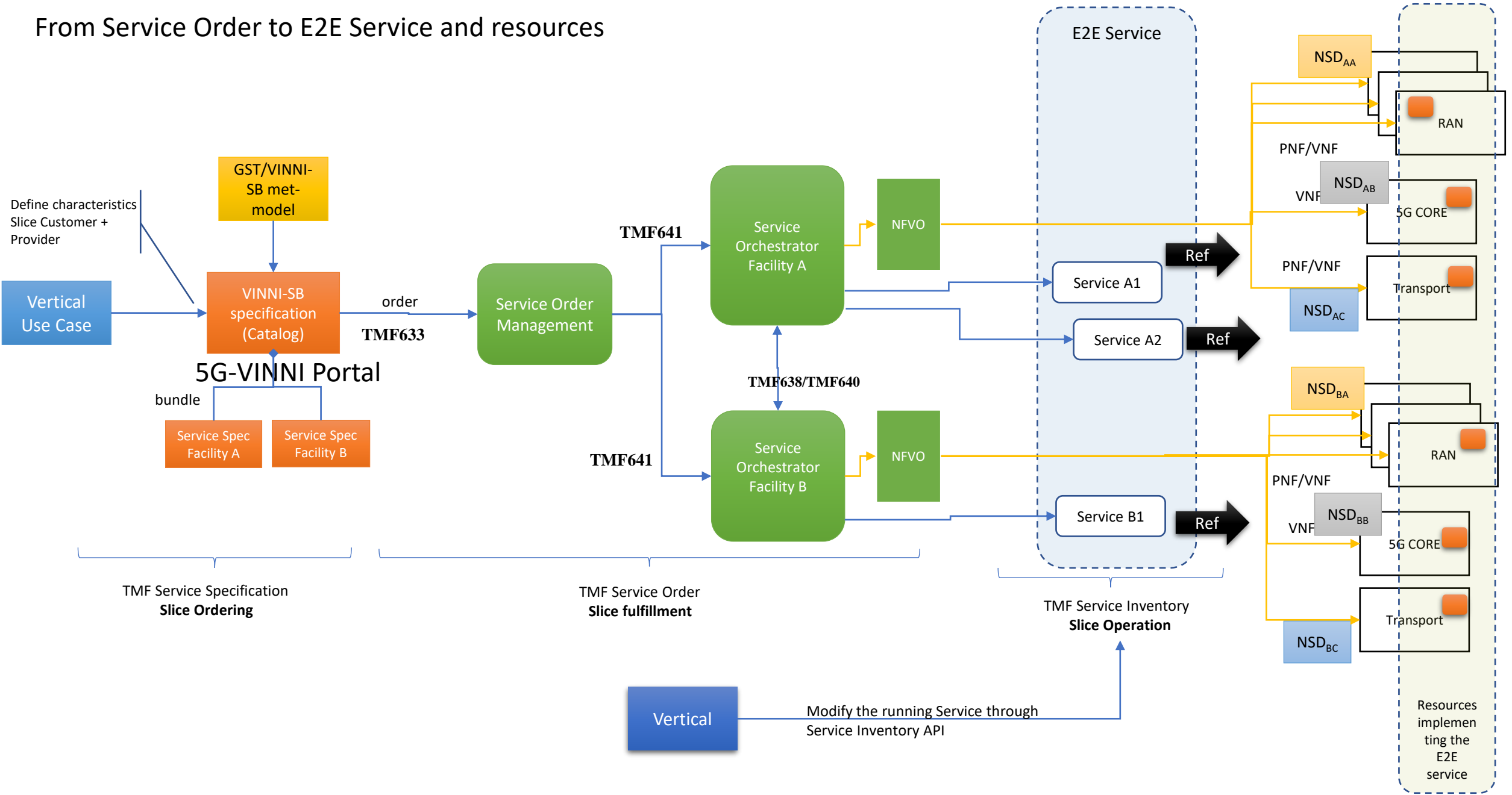


Category	KPIs	Achieved Values	Description
E2E Network Performance	UL Maximum Throughput (Mbps)	104.27 Mbps	minimum, 27.3-27.5 GHz stream
	DL Maximum Throughput (Mbps)	883.69 Mbps	minimum, 27.3-27.5 GHz 40 streams
	UL Latency (ms)	13.77 ms	3.65ms, low foot-print traffic profile with 1000kb/s bandwidth
	DL Latency (ms)	9.15 ms	
	UL Jitter (ms)	1.01 ms	minimum, 27.3-27.5 GHz, low foot-print traffic profile with 1000kb/s bandwidth
NFV Network Performance	DL Jitter (ms)	0 ms	
	DL Frame Loss (%)	0.01%	
	DL Frame Loss (%)	0%	3.65ms, low foot-print traffic profile with 1000kb/s bandwidth
	Maximum Throughput (0 Frame Loss)	4.573 Gbit/s	Two compute nodes, DPDK was configured in the test environment
	Latency between VIMs	0.067 ms	
NFV Compute Resource Performance	CPU Benchmarking Score	3.510	
	Memory Read Latency	7.97 ns	
	Memory r/w Bandwidth	25.641 GB/s	
	Storage r/w IOPS	5.65 / 4.21 s	Harddisk CPU/Memory/Storage tests
	Storage r/w Latency	188 / 621 ms	
Storage r/w Bandwidth	1.018 / 425 MB/s		





# From Service Order to E2E Service and resources



# Supporting the onboarding-process



Welcome to Openslice!

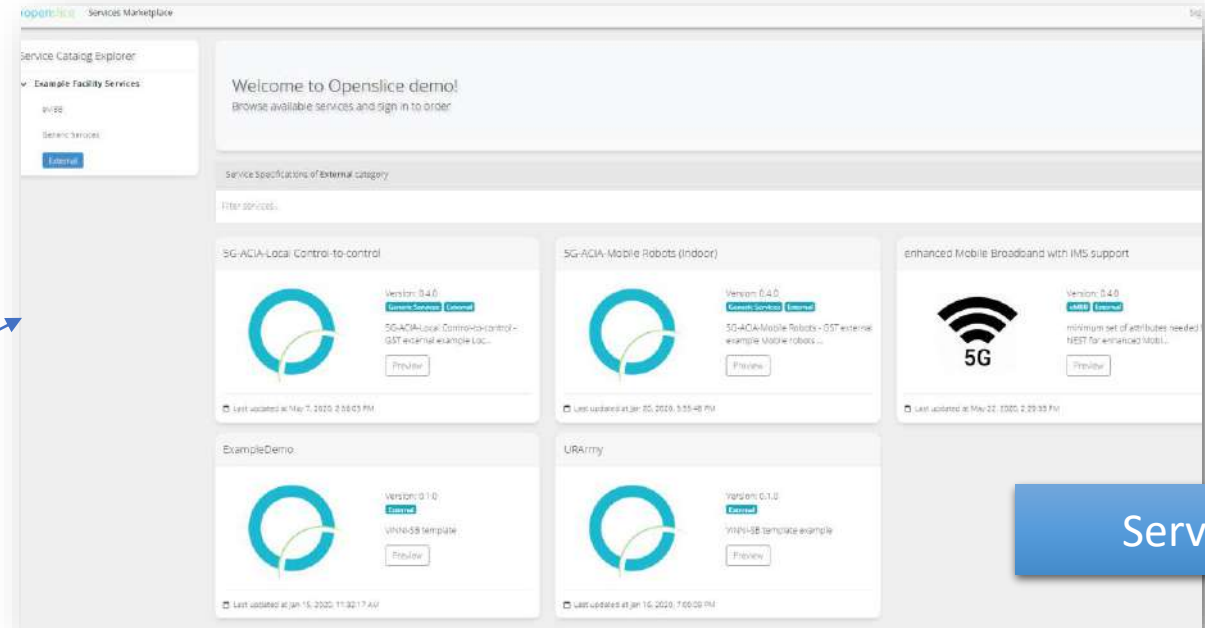
Openslice is a prototype open source, operators support system. It supports VNF/NSD onboarding to OpenSourceMANO (OSM) or NSD deployment management, it also supports TM-FORUM OpenAPI regarding Service Catalog Management, Ordering, Resource Check. <http://openslice.io> for further documentation.

Deploy Services by using Standard Open APIs!

Design Catalogs, Services specifications and manage Service orders!

Deploy VNFs and NSDs to target NFV Orchestrator!

Onboard, manage and share VNFs and Network Services over the target infrastructure.



Service Catalog Explorer

External

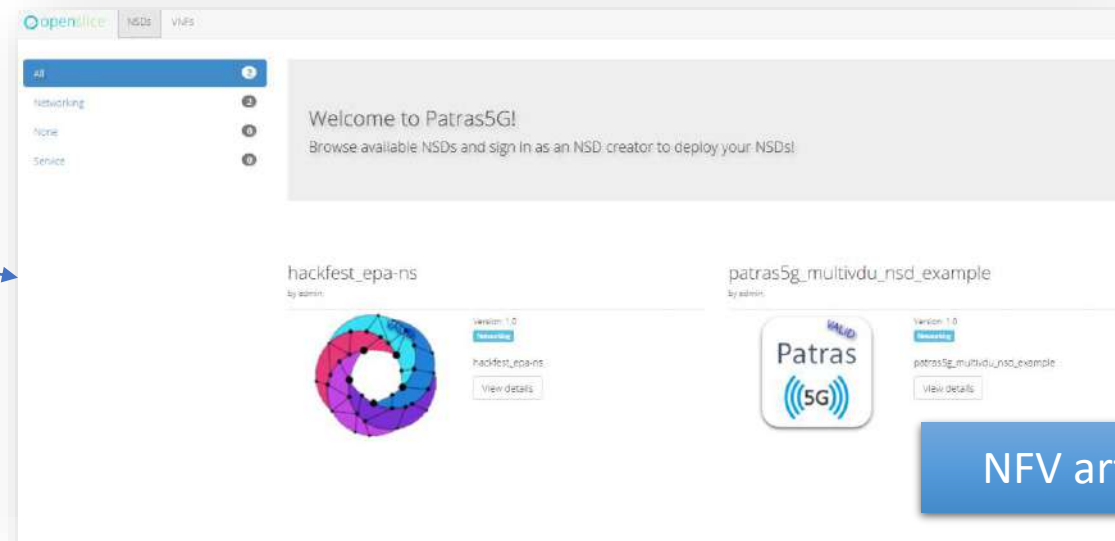
Welcome to Openslice demo!  
Browse available services and sign in to order

Service Specifications of External category

Filter SERVICES

- 5G-ACIA-Local Control-to-control  
Version: 0.4.0  
5G-ACIA-Local Control-to-control - GST external example Loc...  
Last updated at Mar 7, 2020, 2:04:03 PM
- 5G-ACIA-Mobile Robots (Indoor)  
Version: 0.4.0  
5G-ACIA-Mobile Robots - GST external example Mobile robots...  
Last updated at Jan 30, 2020, 5:55:48 PM
- enhanced Mobile Broadband with IMS support  
Version: 0.4.0  
Minimum set of attributes needed NEST for enhanced Mobil...  
Last updated at Mar 22, 2020, 2:29:33 PM
- ExampleDemo  
Version: 0.1.0  
VNFv58 template  
Last updated at Jan 15, 2020, 11:32:17 AM
- URARmy  
Version: 0.1.0  
VNFv58 template example  
Last updated at Jan 16, 2020, 7:00:00 PM

Services



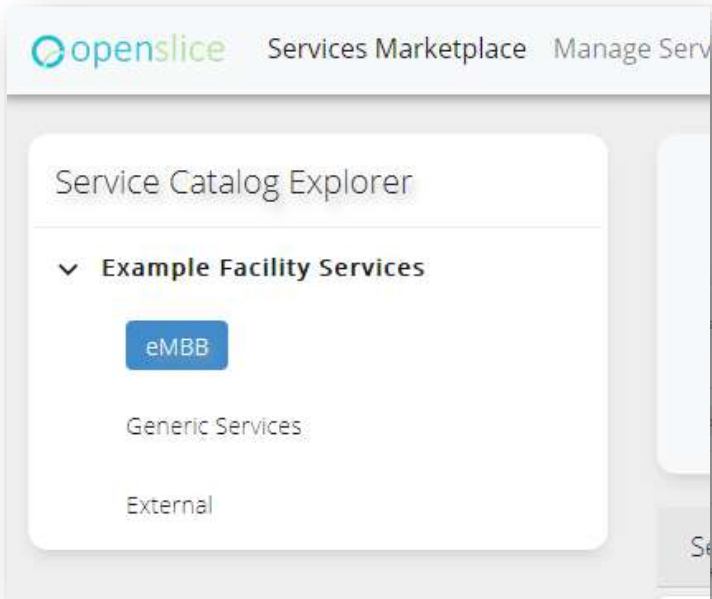
NSDs VNFs

Welcome to Patras5G!  
Browse available NSDs and sign in as an NSD creator to deploy your NSDs!

- hackfest\_epa-ns  
Version: 1.0  
hackfest\_epa-ns  
View details
- patras5g\_multivdu\_nsd\_example  
Version: 1.0  
patras5g\_multivdu\_nsd\_example  
View details

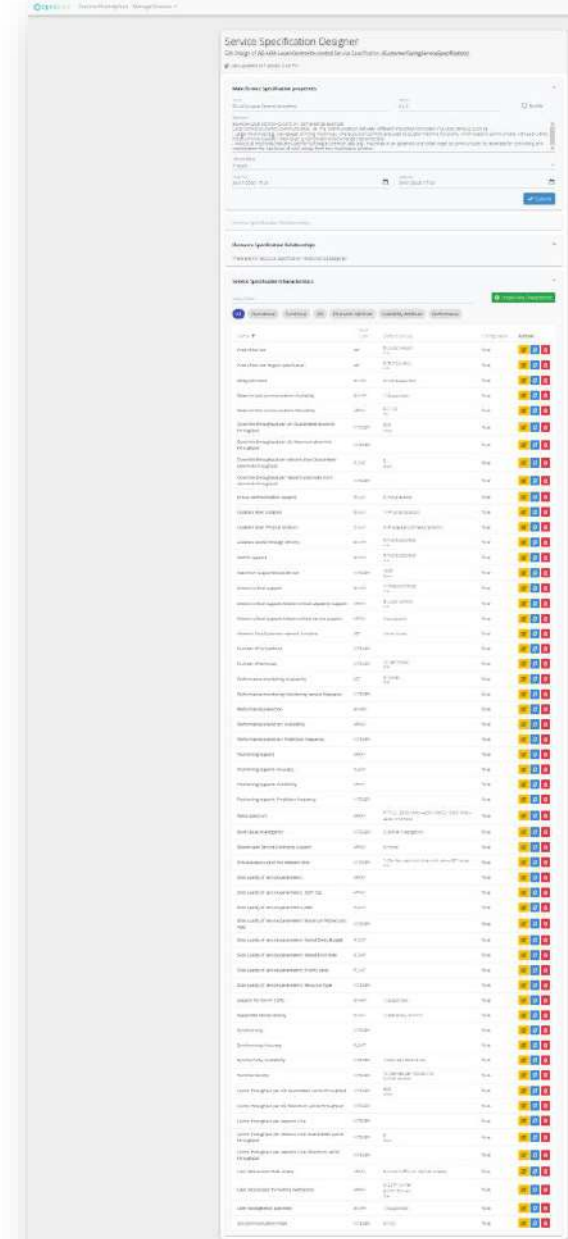
NFV artifacts

# Service Catalog/Service Specification Design



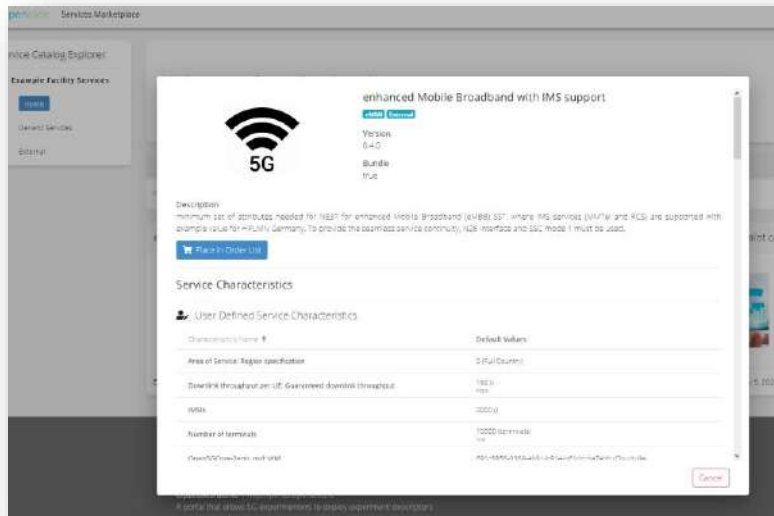
The screenshot shows the Service Specification Designer interface. At the top, there is a "Create New Characteristic" button. Below this is a navigation bar with tabs for "Functional", "KPI", "Character Attribute", "Scalability Attribute", and "Performance". The main content is a table of characteristics.

Name	Value Type	Default Values	Configurable	Actions
Region specification	SET	0 (Local indoor) N/A	false	[Edit] [Copy] [Delete]
Delay tolerance	BINARY	0 (Not supported)	false	[Edit] [Copy] [Delete]
Deterministic communication: Availability	BINARY	1 (Supported)	false	[Edit] [Copy] [Delete]
Deterministic communication: Periodicity	ARRAY	0 (1-10) ms	false	[Edit] [Copy] [Delete]
Downlink throughput per UE: Guaranteed downlink throughput	INTEGER	500 Mbps	false	[Edit] [Copy] [Delete]
Downlink throughput per UE: Maximum downlink throughput	INTEGER		false	[Edit] [Copy] [Delete]
Downlink throughput per network slice: Guaranteed downlink throughput	FLOAT	5 Gbps	false	[Edit] [Copy] [Delete]
Downlink throughput per network slice: Maximum downlink throughput	INTEGER		false	[Edit] [Copy] [Delete]
Group communication support	ENUM	0 (not available)	false	[Edit] [Copy] [Delete]

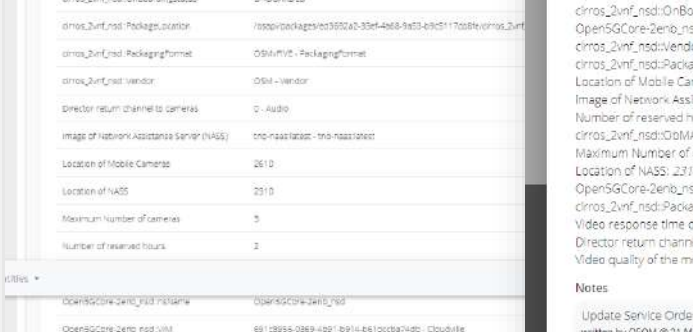
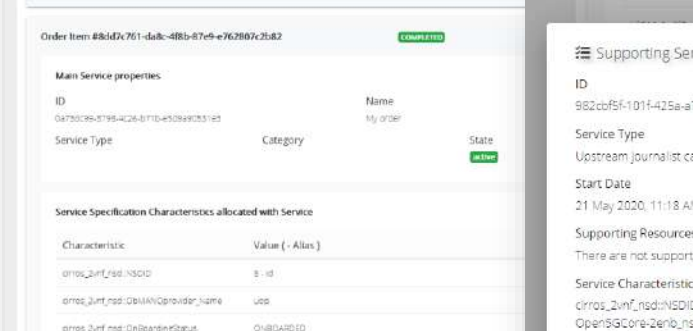


**TMF633 - Service Catalog Management**  
**TMF634 - Resource Catalog Management (no UI currently)**

# Service Order and SOM



TMF 641 - Service Ordering Management



TMF 638 - Service Inventory Management  
TMF 640 - Service Activation and Configuration



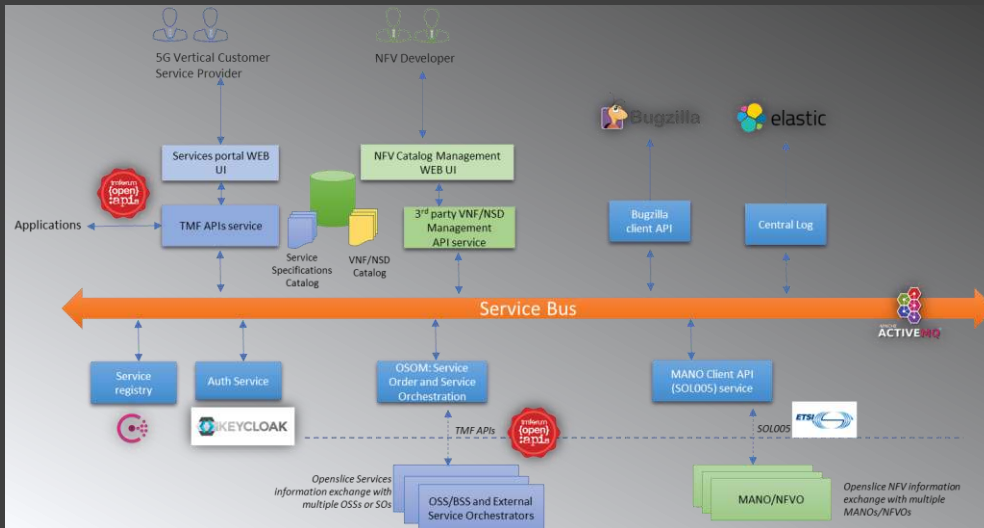
# Openslice Open API access

- Supported TMF OpenAPIs for programmatic access by Vertical Application
- For a quick access check our swagger links:
- TMF APIs: <http://portal.openslice.io/tmf-api/swagger-ui.html>
- API for VNF/NSD management: <http://portal.openslice.io/osapi/swagger-ui.html>

## Service Catalog Management

TMF API Reference: TMF633 - Service Catalog Management ### Release: 18.5 - December 2018 Service Catalog API is one of Catalog Management API Family. Service Catalog API goal is to provide a catalog of services. ### Resource - serviceCatalog ### Operations Service Catalog API performs the following operations on the resource: - Retrieve an entity or a collection of entities depending on filter criteria - Partial update of an entity (including updating rules) - Create an entity (including default values and creation rules) - Delete an entity (for administration purposes) - Manage notification of events

export-job-api-controller-633	the exportJob API	>
hub-api-controller	the hub API	>
import-job-api-controller	the importJob API	>
listener-api-controller	the listener API	>
service-candidate-api-controller	the serviceCandidate API	>
service-catalog-api-controller	the serviceCatalog API	>
service-category-api-controller	the serviceCategory API	>
service-specification-api-controller	the serviceSpecification API	>
exportJob		>
events subscription		>
exportJob		>
listeners (client side)		>

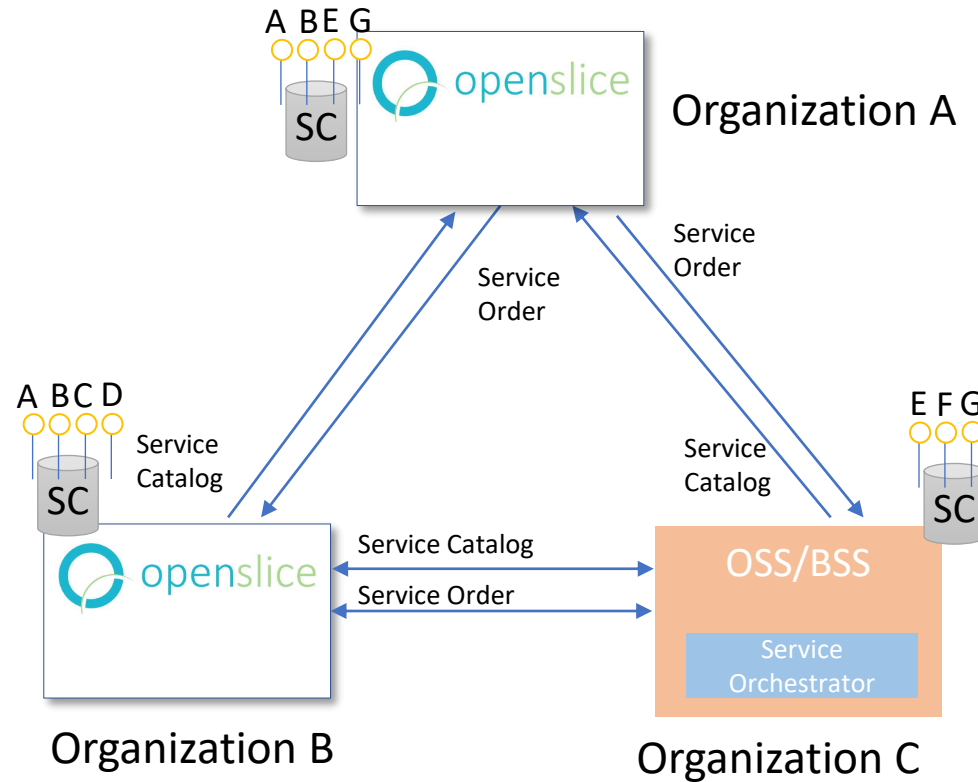


TMF API Reference: TMF641 - Service Ordering Management ## Release: 18.5 - Dec 2018 The Service Order API is a standardized mechanism for managing Service Order, a type of order which can be used to place an order between a customer and a service provider or between a service provider and a partner and vice versa. ## Service Order resource A service order will describe a list of service order items. A service order item references an action on an existing or future service. By service we designed Customer Facing Service (CFS) as well as Resource Facing Service (RFS). From a component perspective, a service order should be available - from a Service Orchestration Component (and it could mix CFS and RFS) - from an Infrastructure Control & Management component (and it would have only RFS) ## Service Order API performs the following operations on service order: - Retrieval of a service order or a collection of service orders depending on filter criteria - Partial update of a service order (including updating rules) - Creation of a service order (including default values and creation rules) - Deletion of service order (for administration purposes) - Notification of events on Service order Copyright © TM Forum 2018. All Rights Reserved

hub-api-controller	the hub API	>
listener-api-controller	the listener API	>
service-order-api-controller	the serviceOrder API	>
events subscription		>
notification listeners (client side)		>
serviceOrder		>
GET	/api/v2/serviceOrder/{id}	Retrieve a service order
POST	/api/v2/serviceOrder	Create a service order
PUT	/api/v2/serviceOrder/{id}	Update a service order
DELETE	/api/v2/serviceOrder/{id}	Delete a service order
DELETE	/api/v2/serviceOrder/{id}/cancel	Cancel a service order

## Multidomain scenarios and federation

Openslice can be used to exchange service specifications/catalogs and make service orders between Organizations





Openslice is a prototype open source, operations support system. It supports VNF/NSD onboarding to OpenSourceMANO (OSM) and NSD deployment management. It also supports TMFORUM OpenAPIs regarding Service Catalog Management, Ordering, Resource, etc.

Microservices based architecture

<http://openslice.io>

### Demo

- Openslice demo: <http://portal.openslice.io/>
- Openslice Service Catalogs and ordering: <http://portal.openslice.io/services/>



Service Specification Designer

Edit: Design of URArmyServiceSpecification (CustomerFacingServiceSpecification)

Last updated at: 1/16/20 7:00 PM

**Main Service Specification properties**

Name: URArmy Version: 0.1.0  Bundle

Description: VNFV-SB template example

Work Item: In study

Valid From: 16/01/2020, 17:39 Valid Until: 16/01/2040, 17:39

**Service Specification Relationships**

Apply Filter to related Service Specifications

- URArmy-VNFV-SB Service Monitoring
- clmns\_2uml\_md
- URArmy-VNFV-SB Service Exposure Level 2
- URArmy-VNFV-SB Service Testing
- URArmy-VNFV-SB Service Requirements
- URArmy-VNFV-SB Service Exposure Level 1
- URArmy-Service Topology

**Resource Specification Relationships**

There are no resource specification relationships assigned

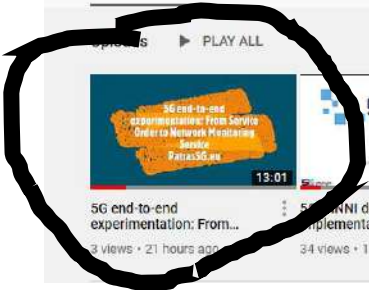
**Service Specification Characteristics**

Apply Filter

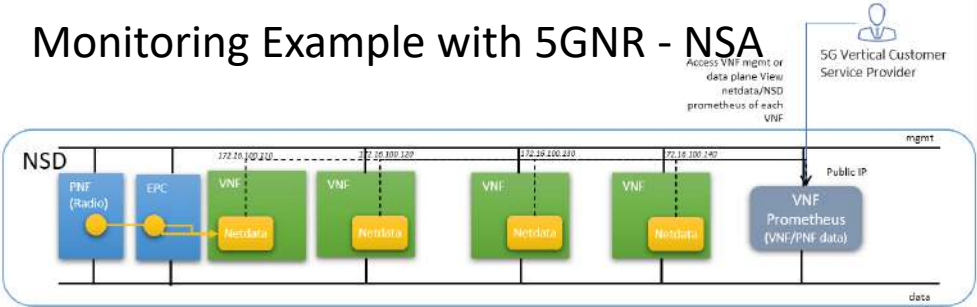
Name	Value Type	Default values	Configurable	Actions
5G-WiFi Service Type	SET	1 (4x100 MHz)	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Exposure Level 1:Exposure Level	SET	1 (Level 1)	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Exposure Level 2:Exposure Level	SET	2 (Level 2)	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Monitoring:On-demand monitoring support	BOOLEAN	1 (Yes)	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): DL Packet loss rate	FLOAT	10 %	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): DL Packet size	INTEGER	8 bytes	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): E2E latency	INTEGER	10 ms	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): Jitter	INTEGER	10 ms	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): One-way latency	INTEGER	10 ms	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): UL Packet loss rate	FLOAT	10 %	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:5G Quality of Service (QoS): UL Packet size	INTEGER	8 bytes	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>
URArmy-VNFV-SB Service Requirements:Access technology	ENUM	1 (4G)	Yes	<input type="button" value="Assign"/> <input type="button" value="Delete"/>



Use case examples  
 Test case training sessions



### Monitoring Example with 5G NR - NSA



5G end-to-end experimentation: From Service Order to Network Monitoring Service



<https://www.youtube.com/watch?v=X662lml0p8w>



# Challenges

- Understand the facility and offered services
  - Training sessions
- Automation of Services
  - NFV artifacts/ Service Templates
  - Orchestration
- Interconnection with APIs and Services (Commercial/Open source)
  - Standards
- Integration with new locations (NPNs)
- Definition of Service Parameters and KPIs
- 5G SA available in next months (orchestrated/shared slice support)
- Verticals expectations vs 5G System maturity (RAN, Core, UEs)
  - Orchestration and multiple slices ( research )
  - Only eMBB is available (URLLC or mMTC in future)



This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 815279.



End-to-end  
service  
specification and  
deployment in  
5G-VINNI

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Thank you!



**Dr. Christos Tranoris** is a Senior Researcher at the Electrical and Computer Engineering department of University of Patras, Greece. He currently participates in several Horizon 2020 European projects related to 5G.