Architectural proposal for Federated Satellite/Terrestrial Software Networks in the 5G Context

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Structure of Presentation

- Introduction / Concept
- Use Cases and Requirements
- Architectural Proposal
- Technical Evaluation/Experimentation end Economic Assessment
- Roadmap and Recommendations

Introduction / Concept

Use Cases and Requirements

Architectural Proposal

Technical Evaluation/Experimentation end Economic Assessment

Roadmap and Recommendations

The CloudSat project at a glance

Programme

- ESA ARTES Future Preparations (form. ARTES 1)

Overall objective

- To study and assess the interplay of cloud networking/virtualization technologies with satellite telecommunications, highlighting opportunities, issues and perspectives.

Duration

- 15 months (September 2014 – November 2015)

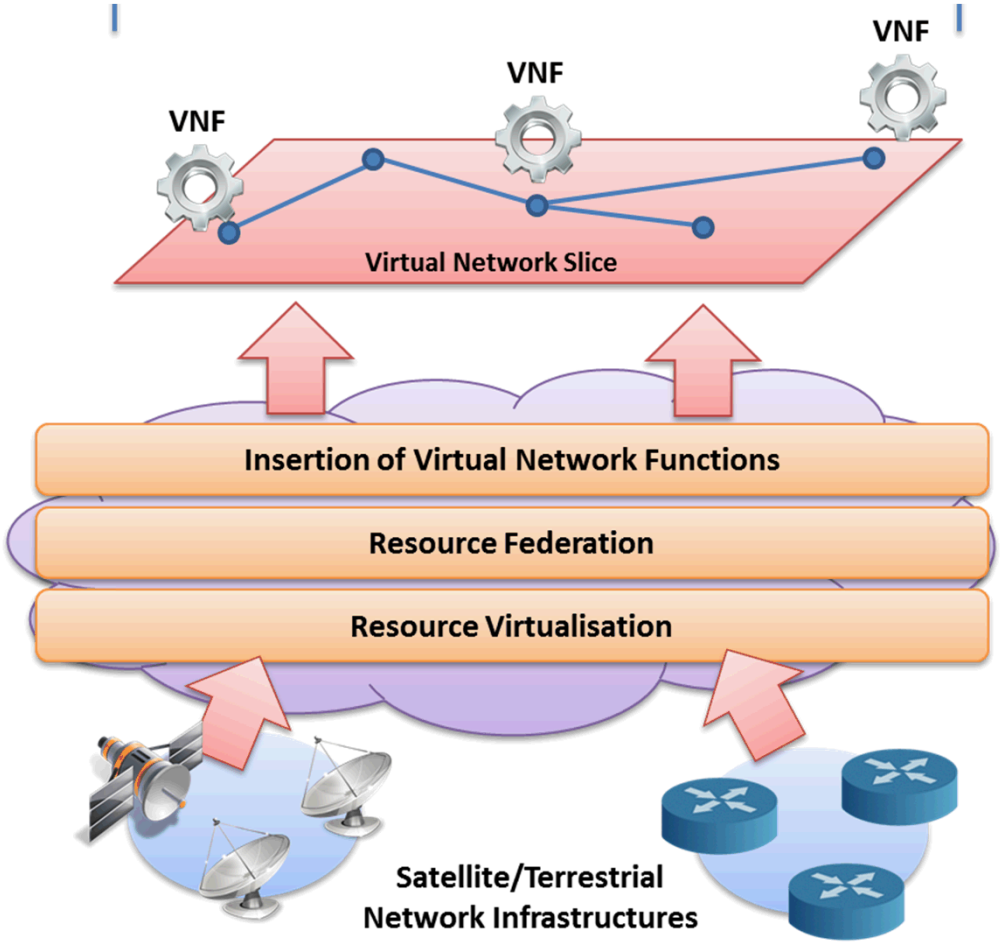
Team

- Space Hellas S.A. – Prime Contractor (GR)
- Thales Alenia Space France (FR)
- Telefonica I+D (ES)
- NCSR “Demokritos” (GR)

Federated Satellite/Terrestrial Software Networks

- Network abstraction, slicing and federation via softwarisation techniques (SDN/NFV)
- In-network Virtual Network Functions (VNFs)
- Over heterogeneous terrestrial and satellite infrastructure

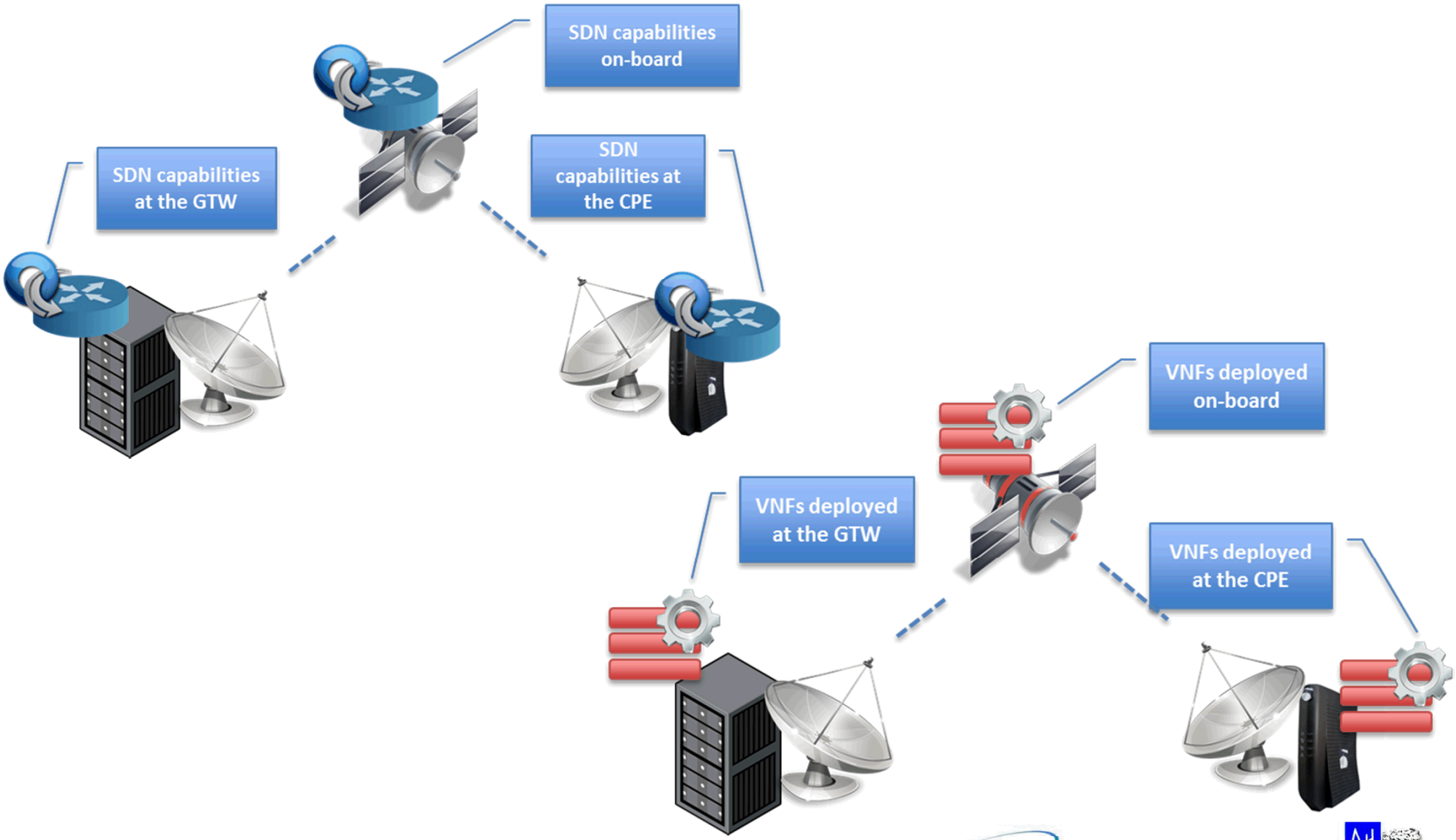
- **Main Goal:** Inclusion of the satellite component, with its inherent benefits (global coverage, high bandwidth etc.) in 5G software-based networks.
- **Main Challenge**: Application of software network technologies (SDN/NFV) to satellite networks



The CloudSat approach

Definition of functional architectures representing integrated satellite/terrestrial cloud networks and their interfaces; assessment of the proposed architectures from a technical and economic point of view.

SDN/NFV applicability to satcom



SDN/NFV in satcom: SWOT analysis consolidation

Key strengths

New services to customers

CAPEX/OPEX reduction

Smoother integration for 5G

Evolutionary deployment possible

Key weaknesses

Stability and security issues for virtualised services critical for satcom

SDN not suitable for PHY/MAC configuration

SDN/NFV capabilities at payload and terminal require considerable resources

Key opportunities

SDN and NFV markets rapidly growing (>50% CAGR by 2023)

SDN and NFV technologies are evolving and supported by wide community initiatives

Key threats

SDN and NFV proven in testbeds but not yet deployed in production networks

SDN and NFV landscape is still evolving; TRL still low

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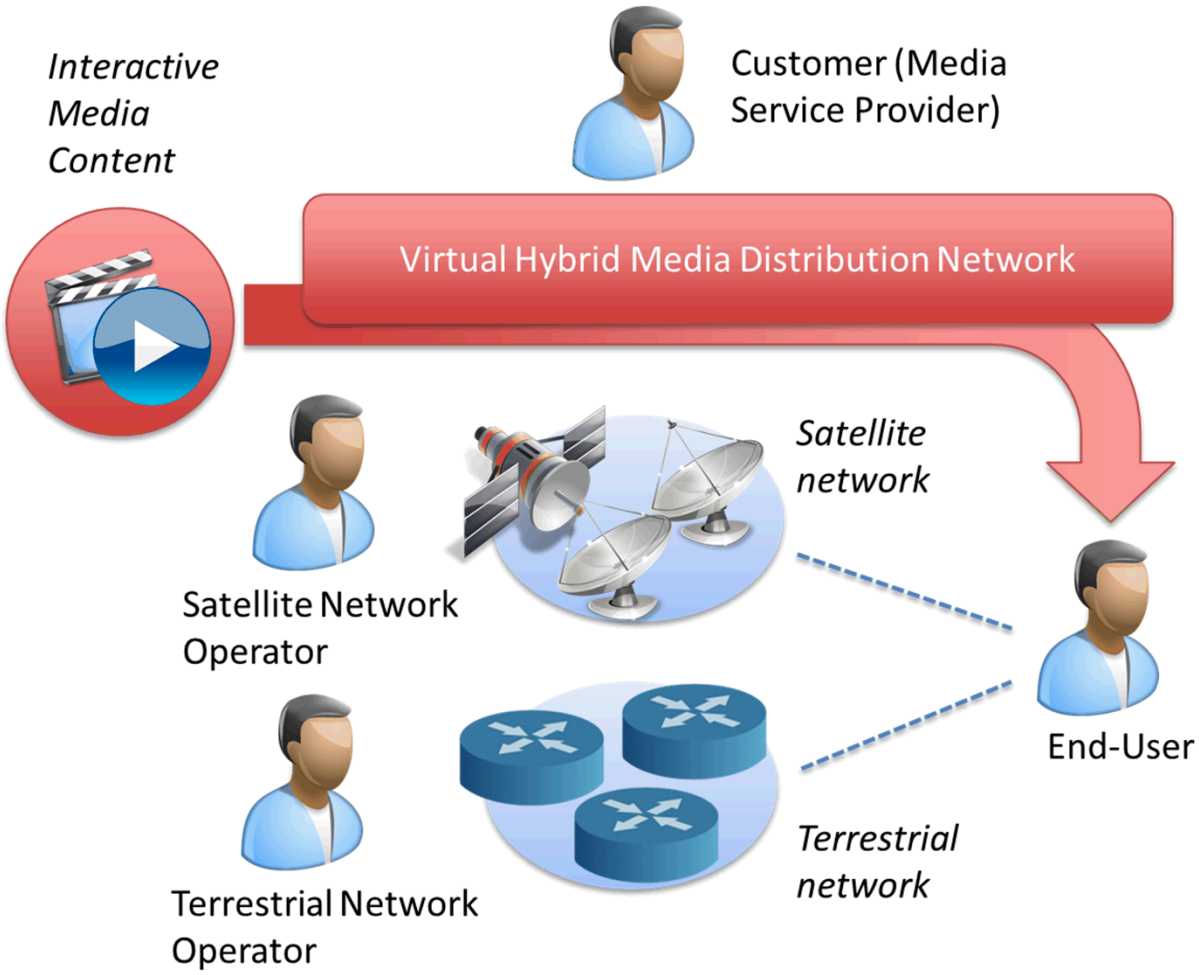
Use Cases for Satellite SDN/NFV

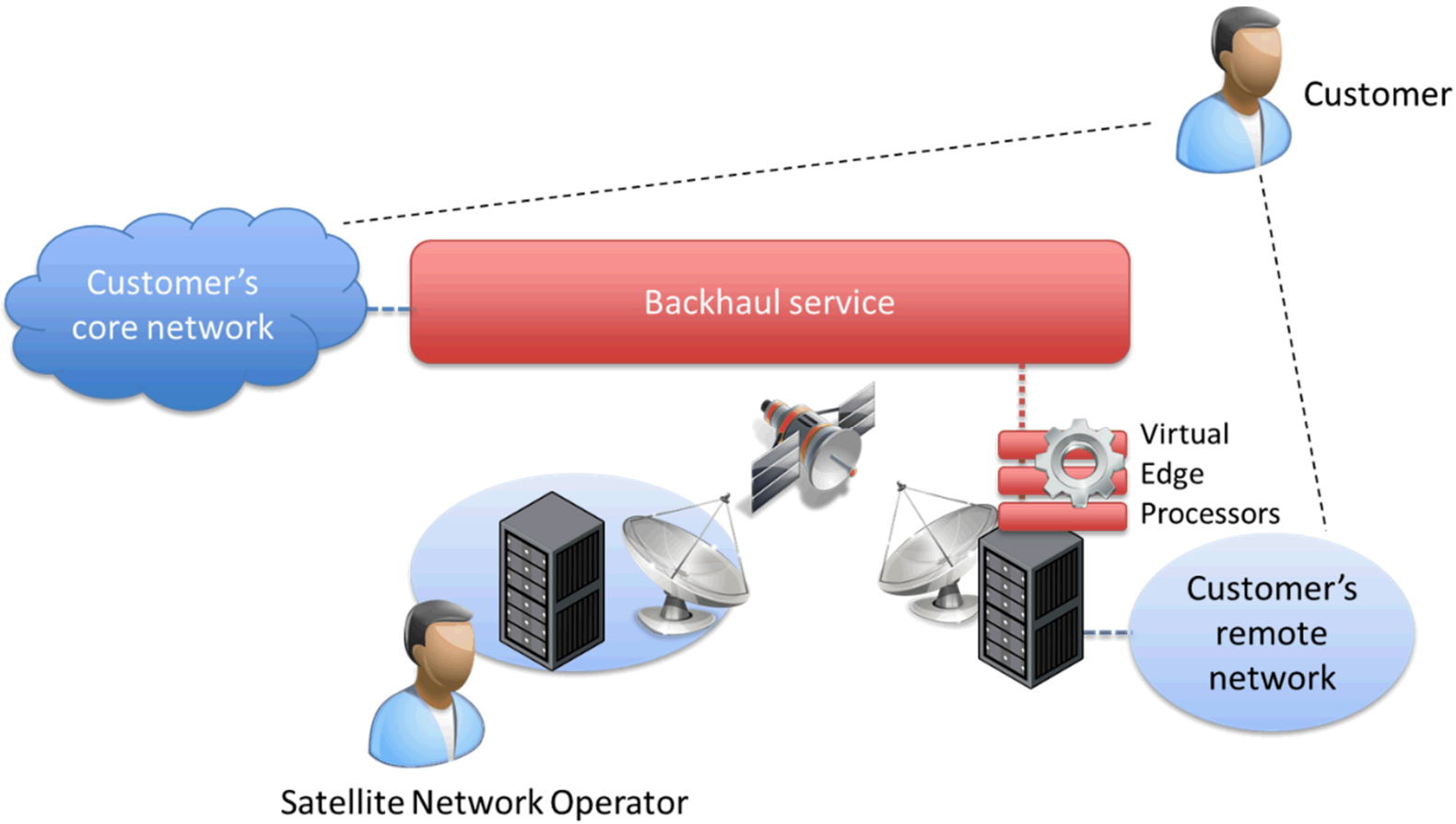
- Elastic Bandwidth-on-Demand
- Hybrid media distribution network as-a-Service
- Virtual CDN as-a-Service
- Federated Terrestrial-Satellite VPN
- Satellite Virtual Network Operator (SVNO)
- Programmable Payloads and flexible ISLs
- Dynamic backhauling with edge processing
- Customer functions virtualisation

Primary application domains: content distribution, broadband access, M2M/IoT, real-time communications

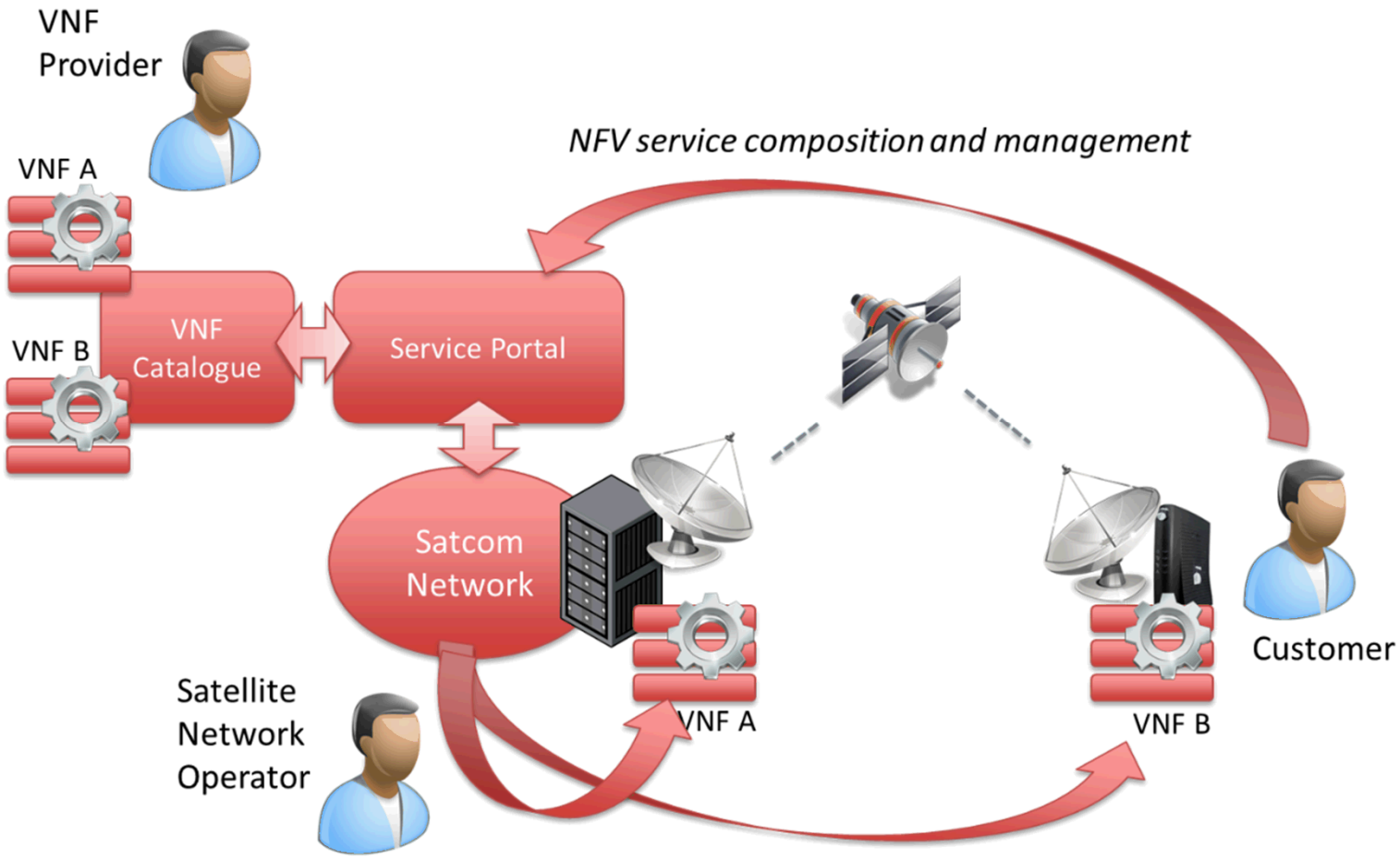
UC#1: Hybrid Media Distribution Network as-a-Service



UC#2: Dynamic backhauling with edge processing



UC#3: Customer Functions Virtualisation



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Key architectural concepts and components

Discrete satellite and terrestrial domains, maintaining administrative independency

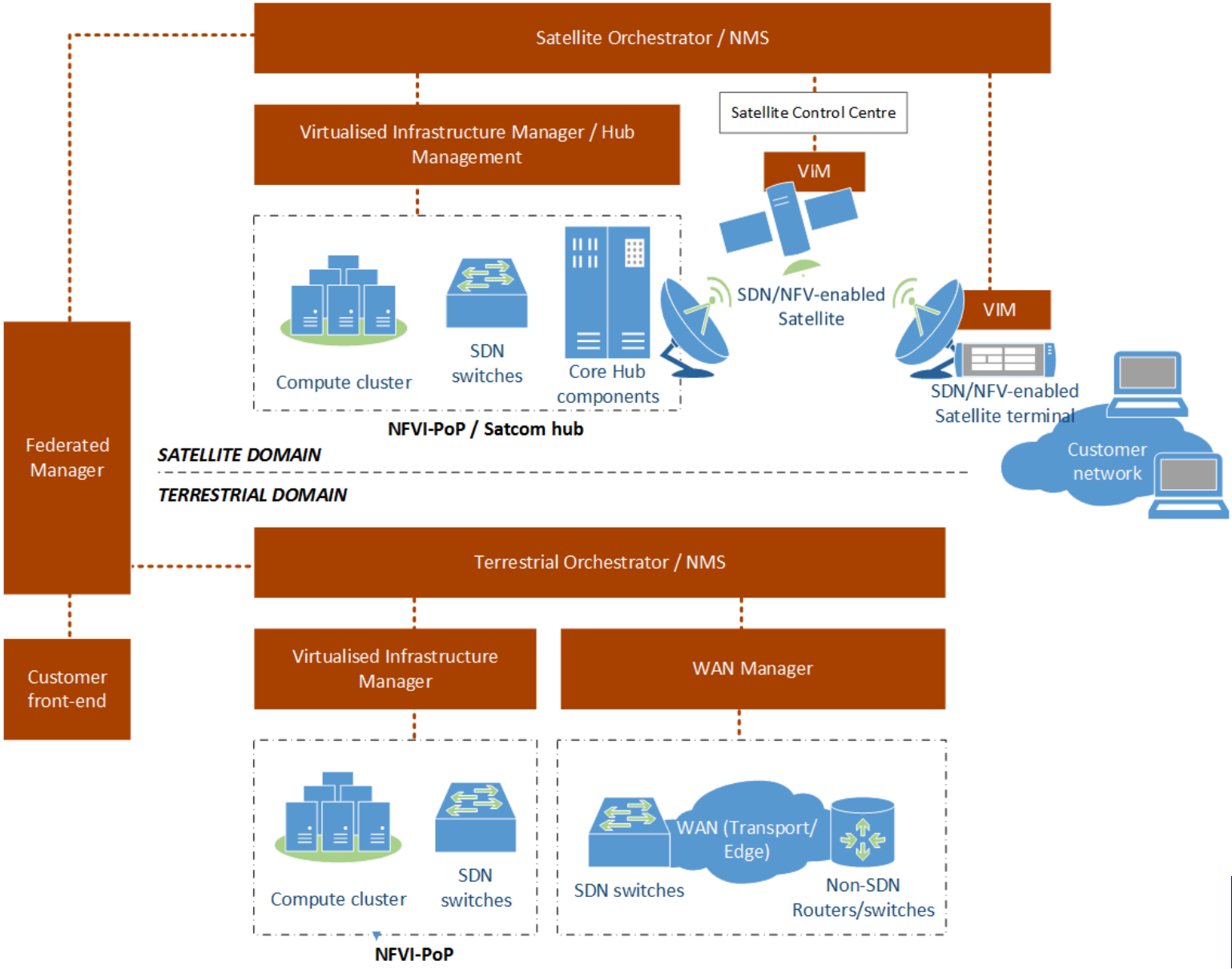
Federated management entity for joint management of satellite and terrestrial

NFVI-PoPs (in-network clouds) for accommodating VNFs

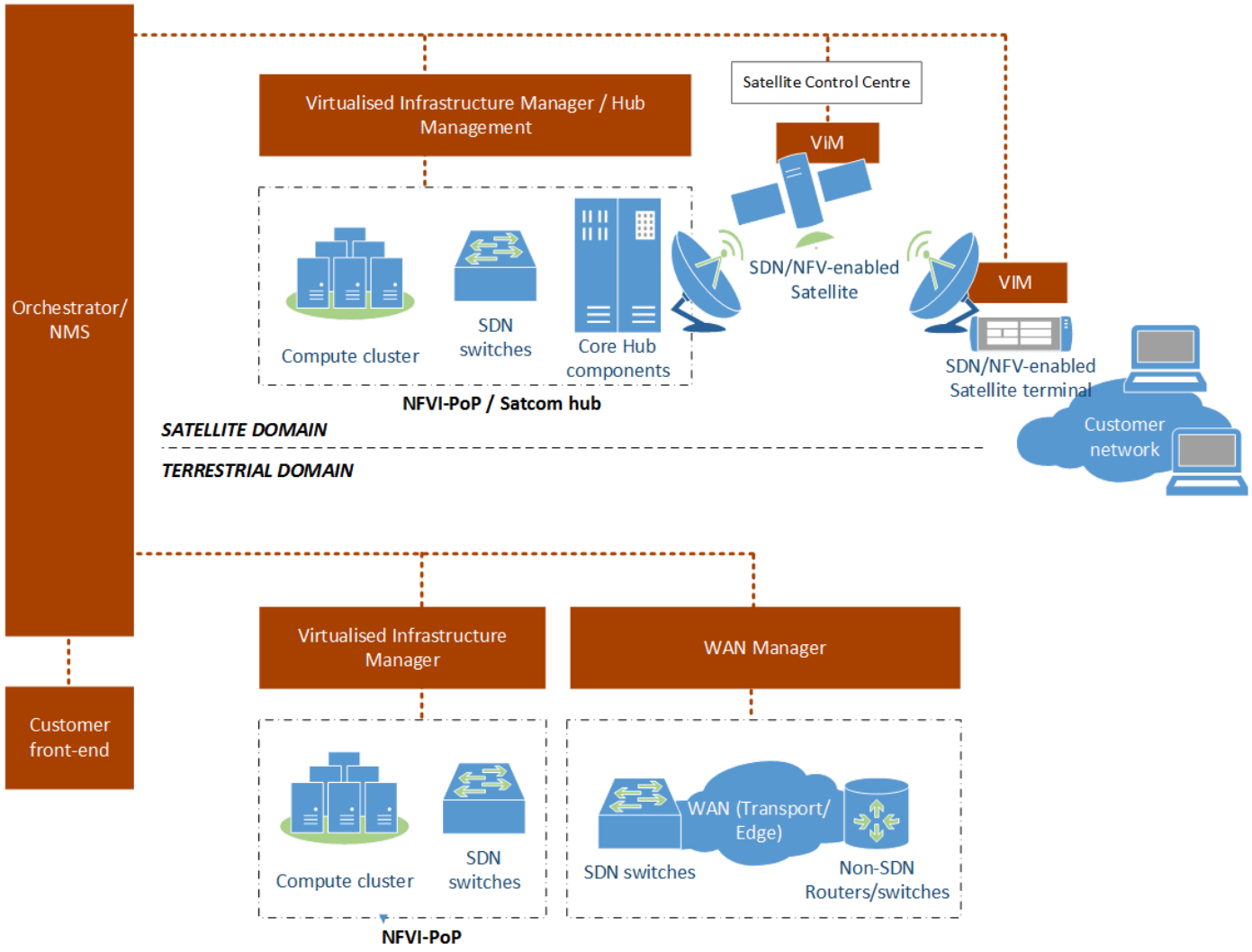
Two-tier hierarchical management structure to support heterogeneous infrastructure segments within the domain (e.g. cloud and transport networks, SDN and non-SDN networks etc.)

Service interface to customers (via front-end portal) for both GUI and programmatic access

CloudSat reference architecture



Single-operator variant



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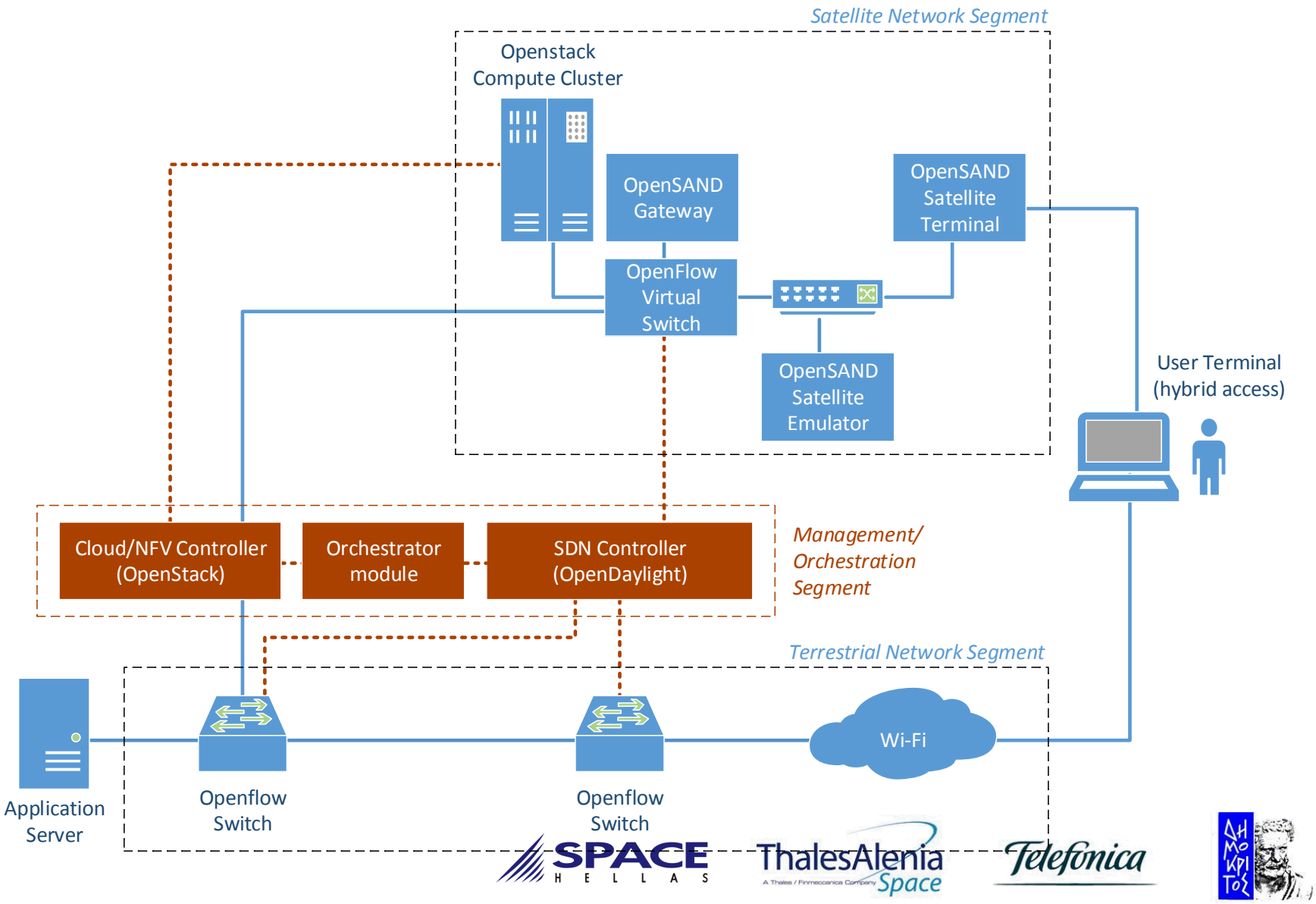
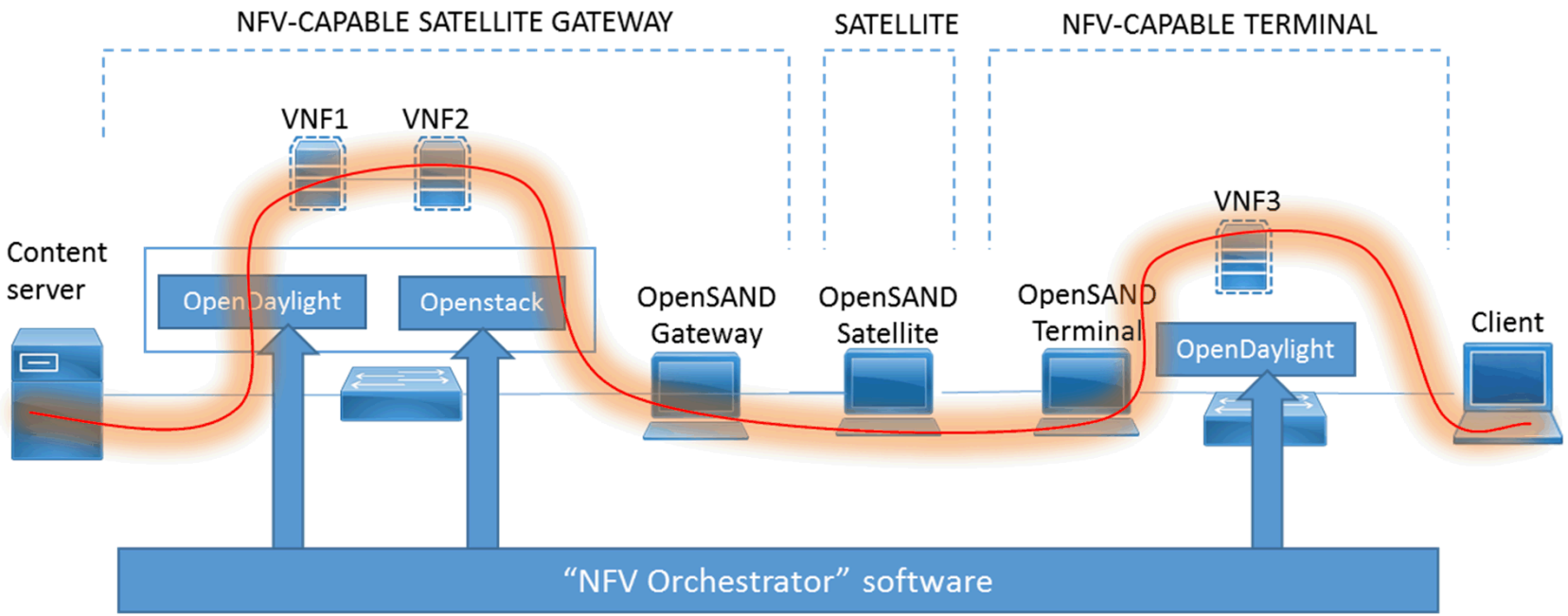
Proof-of-Concept implementation

- Satellite Emulator
  - OpenSAND
- NFV Infrastructure
  - Openstack Liberty
- SDN Programmable Network
  - OpenFlow 1.3 switch
  - OpenDaylight Lithium
- Federated Management
  - Programming Scripts
  - APIs of:
    - » OpenStack
    - » OpenDaylight

Testbed topology



Indicative UC: Customer Functions Virtualisation



- VNF1: Firewall
- VNF2: TCP accelerator
- VNF3: Web cache

Name / Path	Met...	Status / Text	Type	Initiator	Size / Conten	Time / Latency	Timeline
test.html	GET	200 OK	text/...	Other	502 B 206 B	577 ms 577 ms	

Name / Path	Met...	Status / Text	Type	Initiator	Size / Conten	Time / Latency	Timeline
test.html	GET	200 OK	text/...	Other	586 B 206 B	4 ms 3 ms	

Findings of Cost Benefit Analysis

- The introduction of NFV/SDN in SATCOM industry may bring
  - **CAPEX cost reduction**
    - » GEO 18.78%
    - » MEO 29.03%
    - » LEO 41.10%
  - **Increased Revenues due to the NFV-based value-added services**
    - » Use-case #1 Discounted Payback: 2 Years 5 Months
    - » Use-case #2 Discounted Payback: 3 Years 7 Months
    - » Use-case #3 Discounted Payback: 2 Years 10 Months

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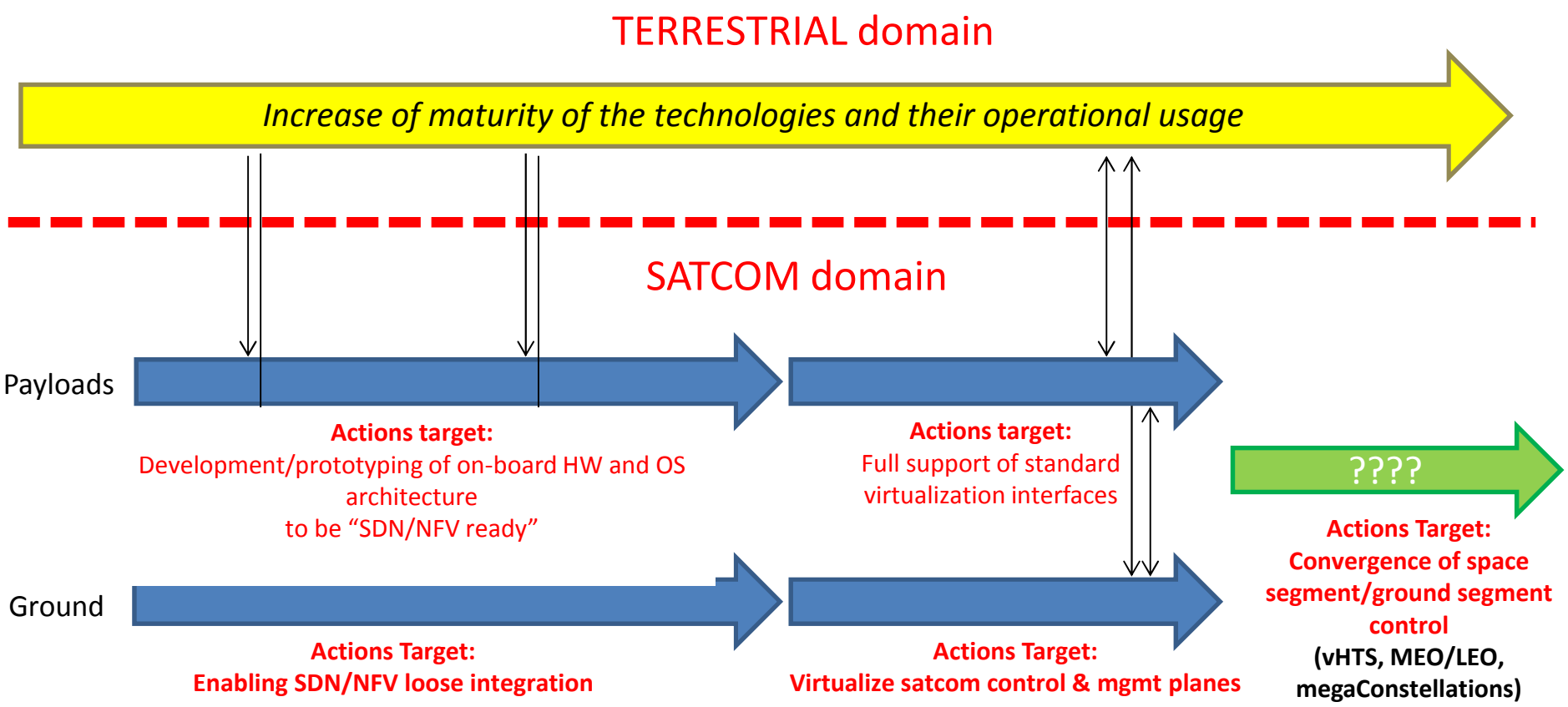
Future works recommendation/roadmaps



- **Technical developments**
  - Identify key services/functions
  - Identify/develop the new APIs
  - NMS + BSS/OSS evolution
  - Get technical feedback from service providers
- **Confirm/develop satcom business cases**
  - Dynamic/virtual provisionning of services
  - Virtual satcom operators and providers

- **Extension towards PHY/MAC layer virtualization ?**
- **Terrestrial/satellite integration (e.g. 5G)**
- **Standards evolution**

SDN/NFV extensions for better integration with satcom

- SDN support for **satcom-specific fields** (e.g. MPEG-2TS / ATM / ULE / GSE fields in DVB architectures)
- **Limitation of controller<>fabric communication overhead** (to allow remote SDN control over satellite)
- SDN extensions for **PHY and MAC control** (resource management)
- Extension of the Cloud-RAN concept for **multi-GW configurations**
- Adaptation of NFV management and execution platforms to accommodate **resource constrains** (payload, terminal)
- Integration with **satcom OSS/BSS**

Candidate targets for tracking & contribution

SDOs

OPEN NETWORKING FOUNDATION

ETSI World Class Standards

ITU International Telecommunication Union

Open-source initiatives

openstack CLOUD SOFTWARE

OPNFV

OPEN DAYLIGHT

SPACE HELLAS ThalesAlenia Space Telefónica ΔΗΜΟΚΡΙΤΟΣ

Follow-up activities

- **Close observation of virtualization technologies** and developments by the different parties.
- **Engagement of stakeholders;** Feedback from satcom Service Providers and Customers is of utter importance
- **Prototyping and testing** of different kinds of SDN / NFV-enabled solutions and platforms.
- TRL elevation via **H2020 (&5G) and ESA projects**

esa

CloudSat

Thank you for your attention!

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