



# SDN/NFV for flexible federation of SATOPS Networks

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# Overview

- **Background**
- **Software Defined Network(SDN) and Network Function Virtualization (NFV)**
- **Proposed changes**
- **Implications**
- **Future work**
- **Conclusions**
- **References**



# Background

- **General Hyten's Visions**
  - **The importance of the Joint Interagency Space Operations Center in building a resilient enterprise**
  - **Space Enterprise Vision (SEV)**
    - **Development of a Resilient Enterprise Ground (REG) architecture leveraging commonality and automation to reduce routine crew workloads and enable enterprise data sharing, robust backup functionality and cybersecurity**
    - **Development of an Infrastructure able to support development of SEV**

Need Resilient Enterprise Ground Architecture



## ***Background (contd)***

- **Currently every space system is highly stove-piped, and has limited interoperability with other mission ground systems**
  - **Separate mission specific SATOPS networks**
    - **Impacting Operational (OPEX) and Capital (CAPEX) Expenses**
- **Enterprise Ground System (EGS) is a step towards achieving the enterprise vision**
  - **Enables a common interface for multi-missions**
  - **Leads towards the open data standards**
  - **Provides foundational framework for Resilient Enterprise Ground architecture**
- **Transmit/receive network concepts under development for REG**
  - **Services, Networks and its Operations & Management**

**Integration & Consolidation of mission networks**



# *What is this about?*

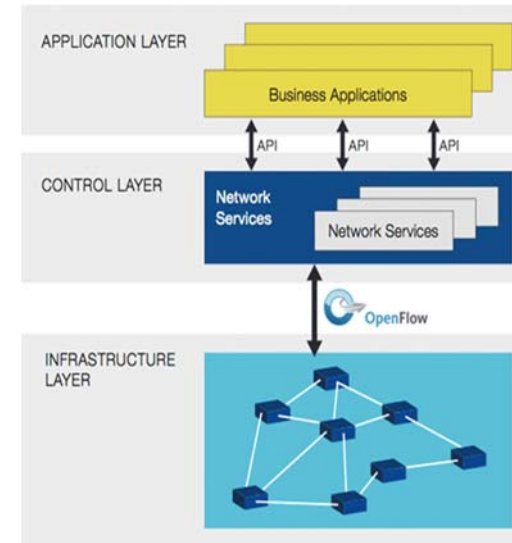
- **An approach to consolidate and integrate different SATOPS networks to meet the enterprise vision**
  - Consolidate and integrate different missions which have their unique networks, antennas, NCC, NOC, personnel,...
  - Complementary to EGS
- **Using SDN/NFV standards**
  - Centralized network control, management & operations
    - Agile and flexible
  - Virtualized network functions
    - Enables automation and easy deployment of updates and applications

Addresses Integration & Consolidation of SATOPS via SDN/NFV



# Software Defined Networking (SDN)

- Promoted by Open Networking Foundation
- Decoupled Control and Data planes
  - Moves the network from a distributed control plane based on OSPF and Spanning Tree protocols to a centralized controller
- Enables on-the-fly provisioning of the paths and allocate resources for the traffic from a central location
  - OpenFlow® Standard enables remote programming of the forwarding plane
  - Makes networking more dynamic and flexible by using logical overlay networks that can be configured without impacting the underlying physical network
- SDN-IP & SDN based MPLS can facilitate brownfield deployment of hybrid SDN networks

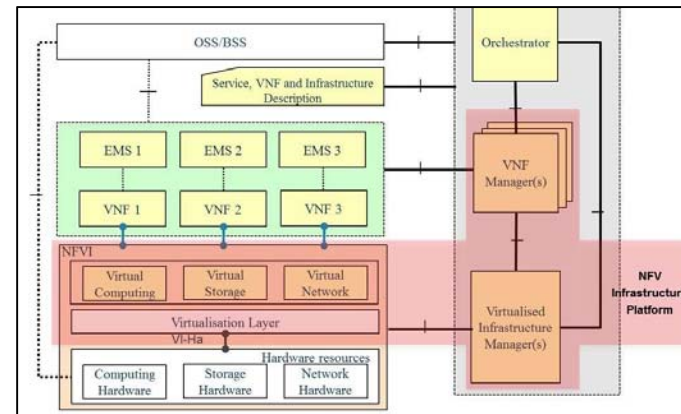


Decoupled Control Plane and Data Plane

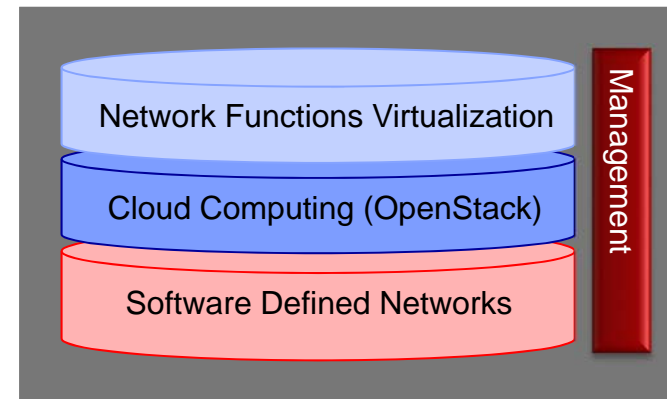


# Network Functions Virtualization (NFV)

- Complementary to SDN, can exist without SDN, and enabler of Virtual Network Functions (VNF)
- Global operators-initiated Industry Specification Group (ISG) under the auspices of **ETSI**
  - 290+ companies, including 38 Tier-1 carriers (and mobile operators) & service providers, cable industry
- Moves the network functions from dedicated hardware (HW) to virtualized Software (SW)
  - Same HW can now cater to multiple roles
  - Remote operation
  - From static to dynamic. Easy to scale
  - Scalable number of Virtual Machines (VM)
  - Enabler of Virtual Network Functions (VNF)
  - Reduces the CAPEX & OPEX



NFV Architectural Framework (ETSI)

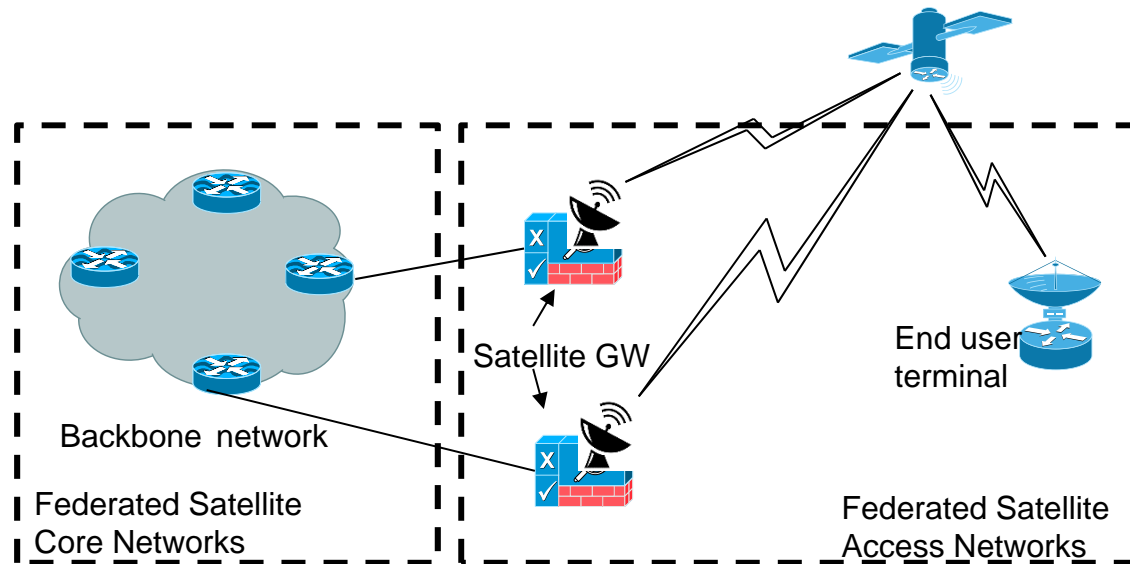


CloudNFV Stack [7]

Hardware to Software based Network functions



# Architecture for the multi-gateway satellite operations network



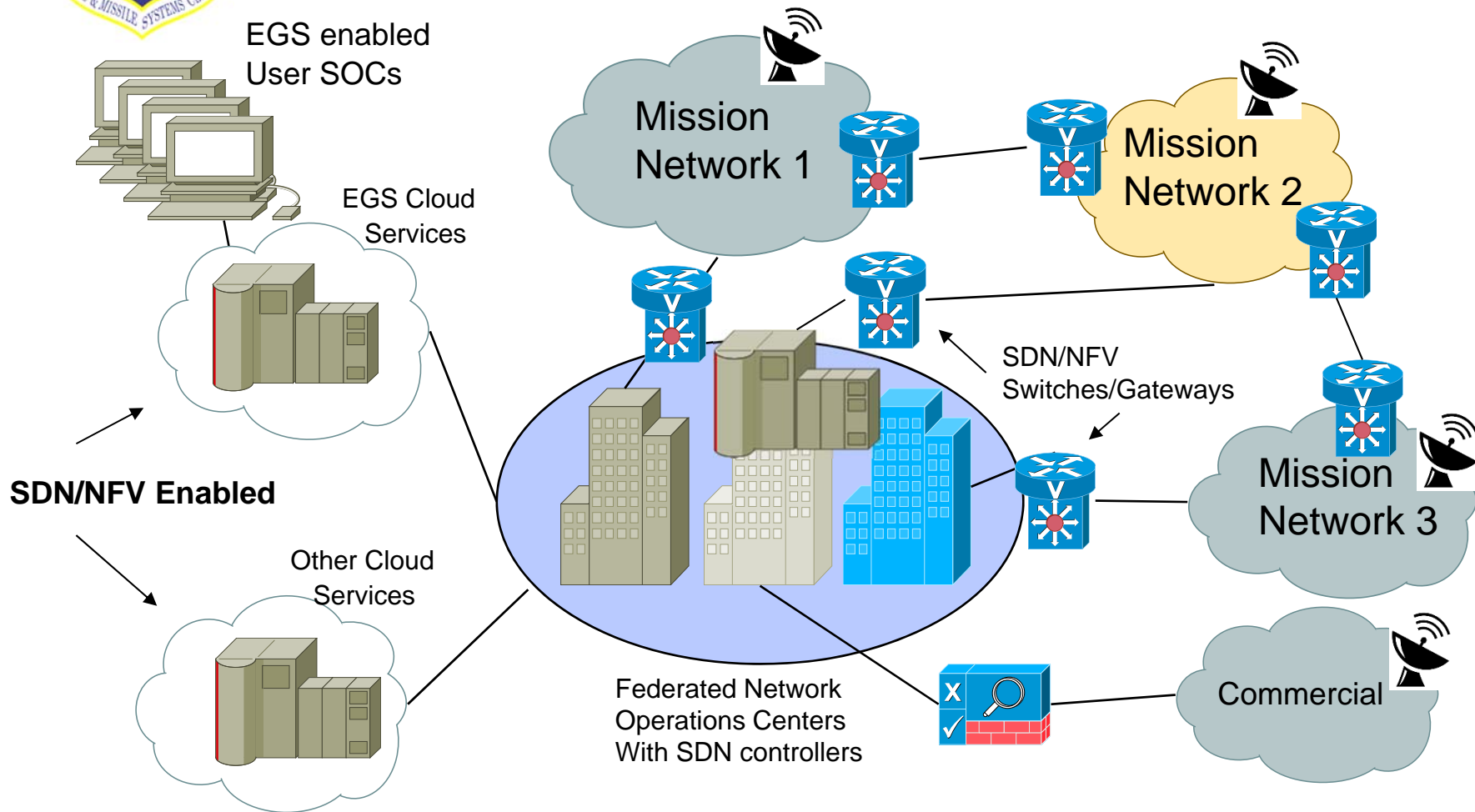
- Satellites can be accessed by multi-mission antennas of different missions
  - Increases resiliency of access
- Enables detection of a failure of a satellite and switchover to the redundant satellite

Federation of networks increases resiliency, capacity & redundancy





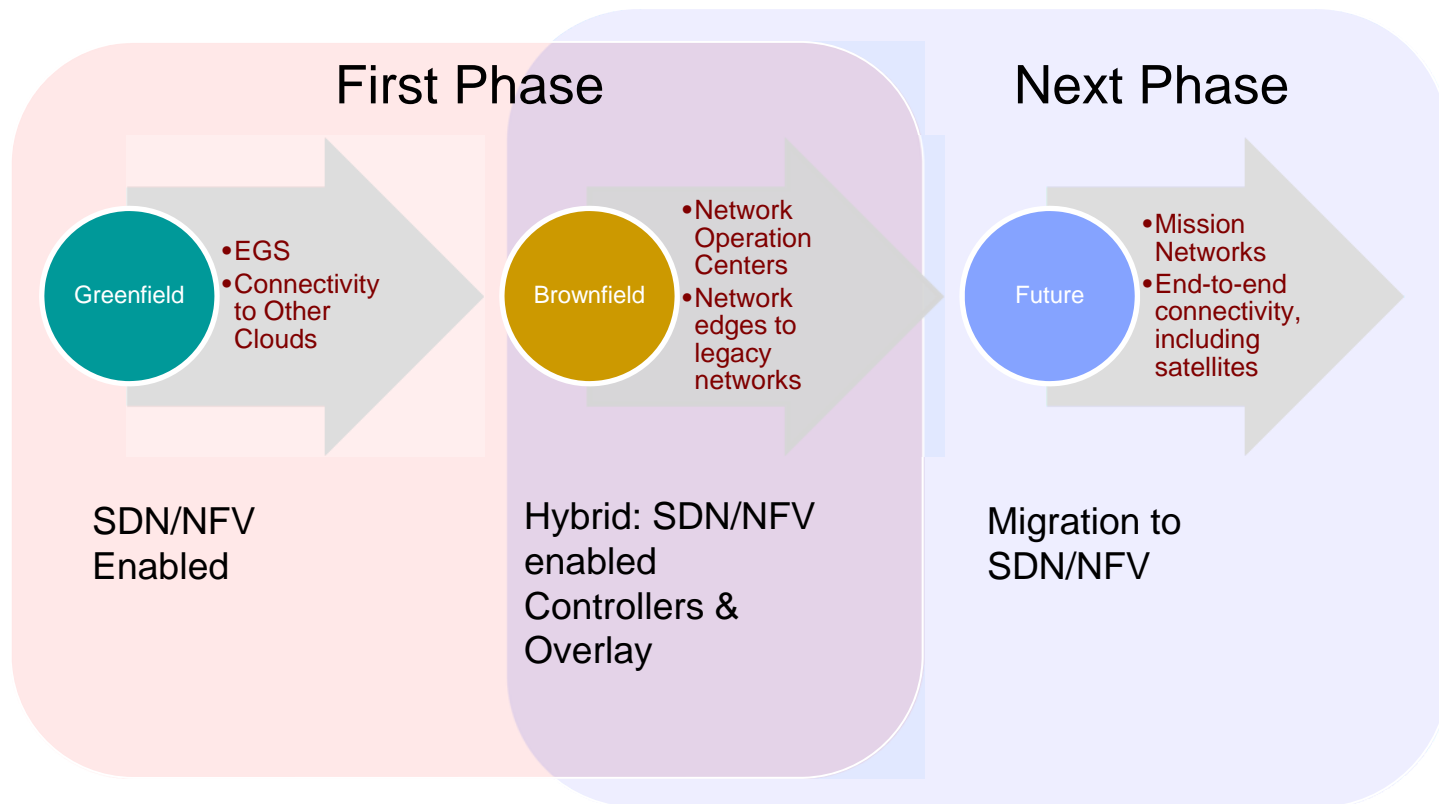
# SDN/NFV for the flexible federation of SATOPS (OV-1)



SDN/NFV enabled federated networks



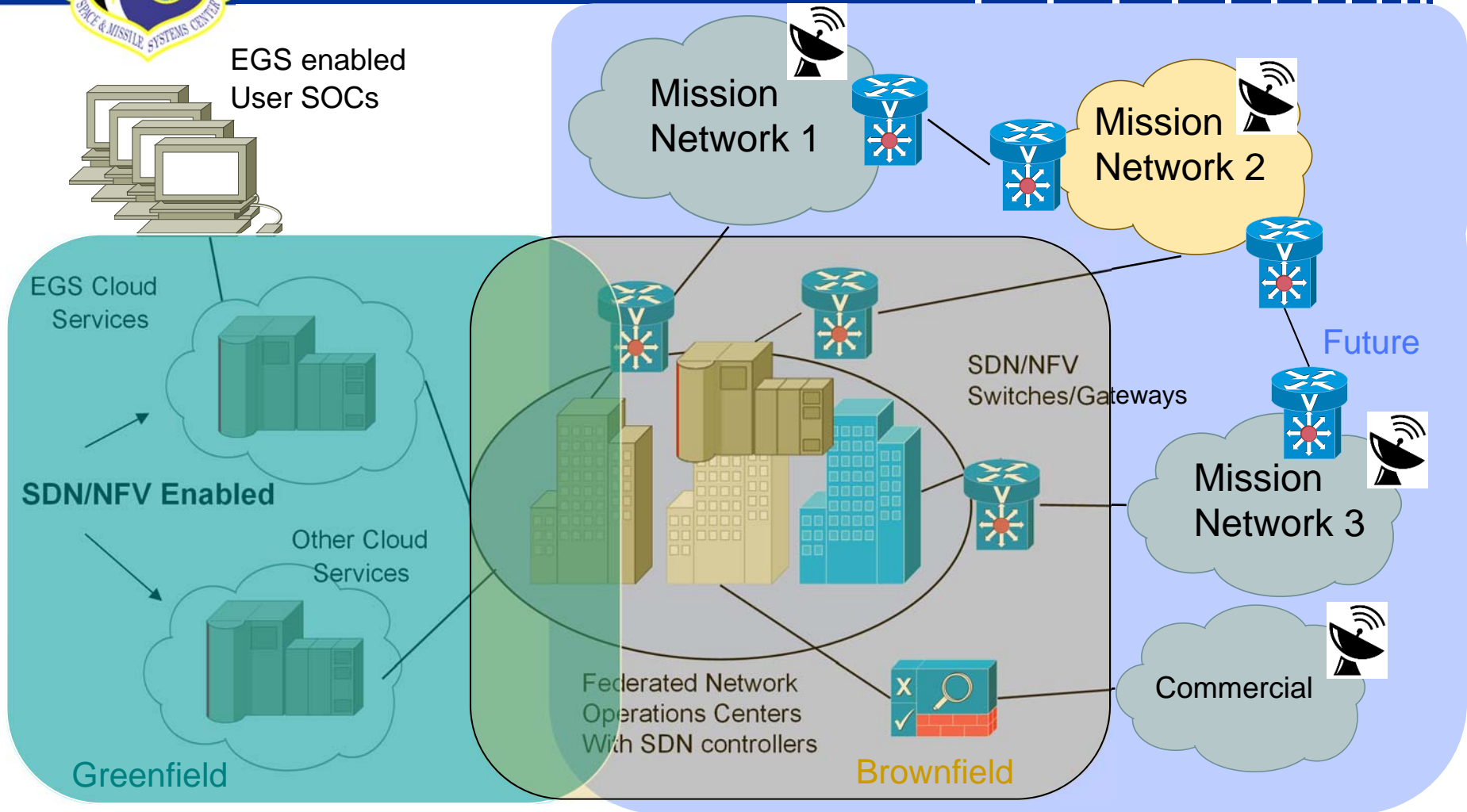
# Deployment Strategy



SDN/NFV Deployment in Phases



# Deployment Stages (OV-1)



Deployment of SDN/NFV enabled federated networks



# ***Network Functions Virtualized***

- **Centralized resource allocation for the end-to-end path**
- **Network & Element Management Systems**
- **Router Gateway Functions: Access control and policy functions, NAT, BGP, QoS, MPLS, DDoS detection, Proxy functions, IPSec Tunnel terminal services, Intrusion Detection, ...**
- **Cloud architecture: VMs, vSwitches, Load Balancers, AAA servers, ...**
- **Cyber Security: Firewalls, Gateway Functions, DS attack identification, Intrusion Detection, User Authentication, Host Based Security, Virus Software, ...**

NFV enables Virtual Network Functions of SATOPS



# Network Management System

- **Centralized network management at the NOCs**
  - **Need new interfaces for interacting with cloud orchestration systems and SDN controllers**
  - **Provides network management for federated networks**
    - **Manages hybrid network: legacy, SDN/NFV**
    - **Increases the capacity and resiliency**
- **End-to-End visibility of the network**
- **Provides centralized administrative control for FCAPS**
- **Virtualized EMS**
- ***May need a new paradigm for NMS***

Centralized NMS needs new interfaces for SDN/NFV networks



# *Architectural implications*

## **Implementation**

- **Flexibility in interface implementation**
  - In existing systems
  - In new systems
- **Flexibility in deployment of applications and network functions**
- **Allows vendor choice for user C2 systems**
- **Eliminates reliance on proprietary multiplexers**
- **Reduced CAPEX**

## **Operations**

- **Agile, flexible, reconfigurable**
- **Multi-tenancy for multi-missions**
- **End-to-End network visibility**
- **Centralized and efficient resource allocation**
- **Automated**
- **Flexibility in updating applications, deploying new applications and network functions**
- **Reduced OPEX for training & sustainment**

Open networking standards increase Interoperability, Flexibility and Savings



# ***Benefits***

- **Unified capabilities as dictated in DoD I 8100.04**
- **Enables federation with other ground systems**
  - **Flexible, fast, and agile traffic steering and switching for the EGS**
  - **Centralized and granular control over the federated networking infrastructure**
  - **Facilitates prioritized per-flow traffic management & resource allocation**
- **Virtualized network functions on commodity hardware**
  - **Reduced stand-alone devices/hardware**
  - **Increased interoperability**
  - **Easy updates/upgrades**
  - **Reduced CapEx and OpEx**
  - **Automation**

New way of operating



# Where the Standards stand?

- **SDN**
  - Open Networking: OpenFlow protocol standard available for forwarding
    - OpenFlow applications may play key roles in NMS
  - IETF: IRTF SDN Research Group and other workgroups investigating
  - IETF: I2RS for hybrid SDN solutions for the near future
- **NFV**
  - European Telecommunications Standards Institute (ETSI)
  - IETF: The Network Virtualization Overlays (NVO3) WG is active in discussing Data Center Virtual Private Networks—VPNs across a number of virtual machines (VMs).
- **Service Providers, Vendors, and Others**
  - Google was the first one to build SDN enabled data centers
  - AT&T, Verizon, ..., have already implemented SDN/NFV in the production network, especially in the cloud
  - Vendors already have products

Service Providers and Vendors active, Standards are evolving





# *Future Work*

- **Keep track of the Standards which are evolving**
  - Open Networking, ETSI, IETF, ITU, IEEE, ...
- **Need to define and refine the architecture**
- **Consider deploying SDN/NFV enabled EGS**
- **Need to optimize the migration strategies for the legacy networks**
  - **Need to identify the mission networks for migration such that the migration would**
    - result in savings
    - increase in resiliency, redundancy, capacity, & automation
    - reduce manpower
    - other factors

Lot of work ahead!



# Conclusions

- **Proposed**
  - **SDN/NFV approach for the federation of SATOPS ground systems**
    - that will overcome the current limitations
    - while meeting the SEV visions
- **Discussed**
  - **Deployment strategies**
  - **Implications of the architecture & changes to business logic**
- **Addressed future work**

SDN/NFV for the federation of SATOPS networks





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# Acronyms

AAA	Authentication, Authorization, and Accounting
BGP	Border gateway Protocol
CAPEX	Capital Expenses
DDoS	Distributed Denial of Service
EGS	Enterprise Ground System
EMS	Element Management System
ETSI	European Telecommunications Standards Institute
FCAPS	Fault, Configuration, Accounting, Performance, and Security
HW	Hardware
IETF	Internet Engineering Task force
ISG	Industry Specification Group
MPLS	Multi Protocol Label Switching
NAT	Network Address Translation
NCC	Network Control Center
NFV	Network Function Virtualization
NMS	Network Management System
NOC	Network Operation Center
OPEX	Operational Expences
OSPF	Open Shortest Path First (Protocol)
QoS	Quality of Service
REG	Resilient Enterprise Ground
SATOPS	Sateliite Operations
SDN	Software Defined Networking
SEV	Space Enterprise Vision
SW	Software
VM	Virtual Machines
VNF	Virtual Network Function