**GSAW 2021 Tutorial F:**

Software Defined Networking Leveraging Cloud Processing for Ground Satellite Operations

**Overview:**
Software Defined Networks (SDN) allow networks to be run in a more flexible and cost efficient manner, e.g., by increasing network resource utilization and by decreasing operational costs. Network Function Virtualization (NFV) allows even further flexibility by migrating network functions from dedicated hardware to virtual machines running on commodity hardware, Virtual Network Functions (VNF). Network operators find VNFs appealing to ground system operators since they can be migrated and flexibly adapted to current demands. New satellites services can be added to an operation system in hours not weeks.

This technology is well known and extensively utilized by the telecommunications and IT industry; however, it is either not known or not well integrated into the satellite ground industry. Advances in virtualization capabilities specific to satellite ground operations and ongoing improvements in cloud processing technology, both in power and bandwidth capability have created the perfect storm allowing ground operations to adopt SDN technology in many key areas.

The newly achieved flexibility opens a set of key questions concerning i) reliability, ii) service orchestration iii) function placement, and iv) performance.

This workshop will cover the basics of SDN and how it can be effectively integrated into a satellite ground operation.

I. SDN/NFV architectures, applications, and use cases
II. Typical domains within the proposed SDN/NFV satellite ground architecture
III. Examples of how the architecture adapts to mission unique requirements of both commercial and military endeavors
IV. How to operate virtualized network functions in a reliable manner including redundancy and load balancing
V. How VNFs can provide performance figures required for satellite network operation
VI. How service chains can be virtualized and automated in a satellite ground operation
VII. Review of example service chains for use in operation systems today.
VIII. What VNFs are available for satellite ground networks and how they be utilized to optimize the satellite ground network subjected to different design criteria
IX. What is SDN/NFV-based service orchestration and how it can be incorporated into the satellite ground network
X. What is multi-domain service orchestration and how to take advantage of it in a ground satellite operation
XI. SDN/NFV-based network deployment and management for a ground satellite operation
XII. How to add a RF monitoring service to the flexible satellite ground network architecture presented.
XIII. How to add a network monitoring service to the flexible satellite ground network architecture presented.
XIV. Satellite Ground and the role of Operational Support Systems (OSS) and Mission Planning for service demands
XV. Other topics as time permits with an emphasis on virtualized networks and further discussion on industry standards and common methods to deploy network functions.

**Instructors:** Chris Badgett and Frank Sandoval, Kratos Space

**Biographies:**

**Chris Badgett** is Vice President of Technology for Kratos Space. He has been instrumental in designing the capability for the military to take advantage of virtual ground solutions and the ability to securely leverage the power of cloud computing and global antenna networks. Prior to Kratos, Mr. Badgett served in the Air Force Research Lab and Space and Missile System Center enabling technologies for UAVs, datalinks, small satellites and ground systems. Mr. Badgett holds a BS in Electrical Engineering from University of Tennessee and an MS in Space Systems from the Air Force Institute of Technology.

**Frank Sandoval** joined the communications industry in 2001 after stints in Silicon Valley as a software engineer and architect. He has contributed to many standards and open source efforts, most recently in the fields of Software Defined Networking (SDN) and Network Function Virtualization (NFV). His current focus is working with Kratos to develop NFV service and resource orchestration solutions..

**Description of Intended Students and Prerequisites:**

Attendees should have a general knowledge of satellite ground operations.

**What can Attendees Expect to Learn:**

Software Defined Networking as applied to the satellite ground networking. How to enable cloud processing to gain the most benefit.