NEXT GENERATION FEATURE ROADMAP FOR IP-BASED RANGE ARCHITECTURES

Bob Kovach
Superior Access Solutions, Inc
bkovach@sa-solutions.com

ABSTRACT

The initial efforts that resulted in the migration of range application traffic to an IP infrastructure largely focused on the challenge of obtaining reliable transport for range application streams including telemetry and digital video via IP packet-based network technology [2] [9] [10]. With the emergence of architectural elements that support robust Quality of Service, multicast routing, and redundant operation, these problems have largely been resolved, and a large number of ranges are now successfully utilizing IP-based network topology to implement their backbone transport infrastructure.

The attention now turns to the need to provide supplemental features that provide enhanced functionality in addition to raw stream transport. These features include:

- Stream monitoring and native test capability, usually called Service Assurance
- Extended support for Ancillary Data / Metadata
- Archive and Media Asset Management integration into the workflow
- Temporal alignment of application streams

This paper will describe a number of methods to implement these features utilizing an approach that leverages the features offered by IP-based technology, emphasizes the use of standards-based COTS implementations, and supports interworking between features.

KEYWORDS

Telemetry Over IP (TMoIP), IP networking, Service Assurance, real-time monitoring, system integration, time-stamping, metadata, KLV, workflow

INTRODUCTION

To guide the following discussion two supporting models will be considered: the Range Architecture and Range Workflow. The Range Architecture identifies the functional elements that constitute the range information network, and includes stream sources, source encoding functions, stream transport and user applications. The Range Workflow describes the processes that are utilized by range personnel in the execution of missions.

The guidelines and procedures described in this paper are presented in the context of the current state of the art and workflows currently in place on test ranges. These techniques will draw upon experience in deployment of IP networks to carry time-sensitive traffic such as compressed digital video and telemetry streams, and are based on knowledge gained working with range personnel in the deployment of telemetry, video and associated metadata. Where possible, the recommended solutions will utilize standards-based, COTS (Commercial Off The Shelf) implementations which will enable the implementer to deploy multivendor solutions, decreasing product lifecycle and vendor risk.

RANGE ARCHITECTURE

The range architectural model has been discussed in previous work [1] and will be presented here as a reference to guide further discussion. The Range Architecture detailed in Figure 1 describes the functional blocks that support workflows frequently encountered in ranges that enable the acquisition, transport, management and dissemination of real-time information streams.

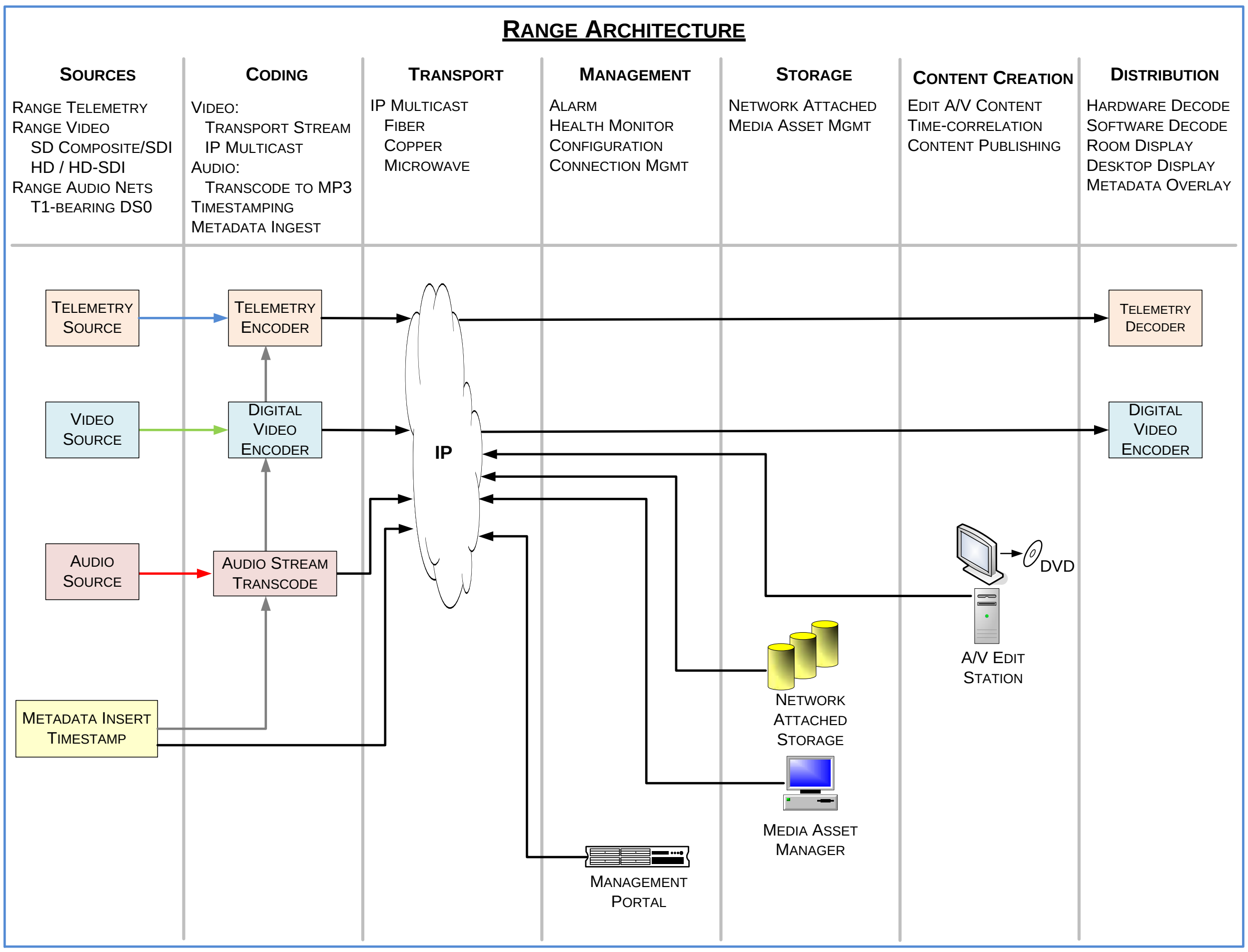

Figure 1 – Range Architecture

The major feature of the range architecture is that all sources are encoded to IP packets, and transported through the network as IP multicast streams. This method has the benefit of making all streams available anywhere in the network by utilizing the IGMP (Internet Group Management Protocol) to enable the reception of the stream at the desired endpoint.

In addition to the transport capabilities provided, additional utility can be obtained by exploiting standards-based features associated with IP networks to provide advanced monitoring, management and ancillary stream capabilities. The following sections detail proposed implementation schemes to support these goals.

RANGE WORKFLOW

The Range Workflow as detailed in Figure 2 below is divided into areas that define the three phases in mission operation: Pre-Mission, Mission and Post Mission.

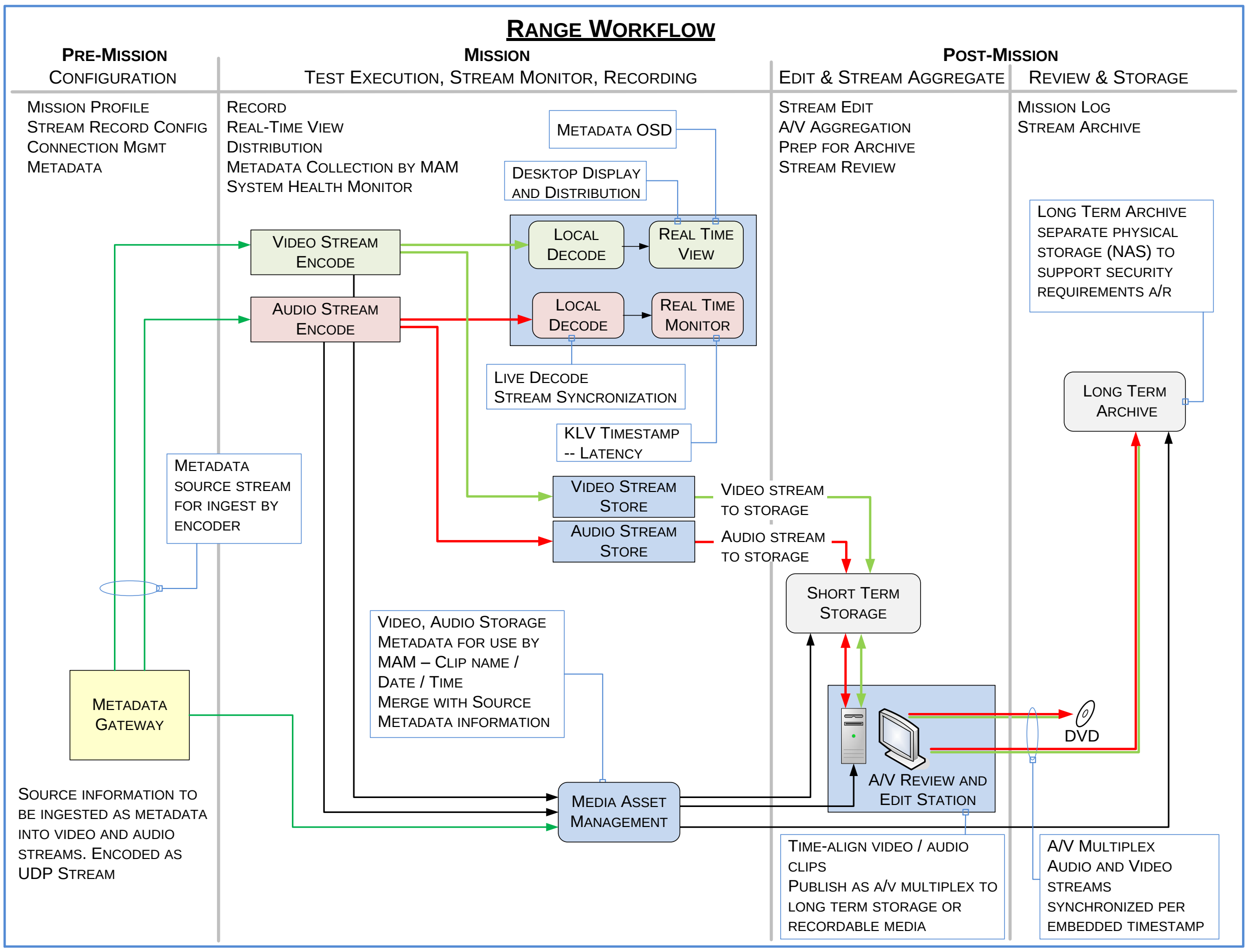

Figure 2 – Range Workflow

The Pre-Mission phase includes the tasks to prepare the range and end equipment for the mission and includes the following elements:

- Configuration – Profile generation and download. Decreasing the amount of time to configure range test equipment decreases configuration time, and automating this process reduces configuration errors, increasing efficiency.
- Test / Verification of range assets to ensure all test sources and transport are functional. This task imposes a requirement to quickly and accurately observe and verify operational readiness.

The Mission phase includes the actual activities that are executed during the mission and includes the following items:

- Real-time performance – The ability to monitor performance in real time enables rapid fault detection and resolution.

- Fault Isolation to enable the rapid identification of fault location. This is an important requirement to decrease mission downtime during fault events.
- Profile capture to enable the archiving and downloading to range equipment in subsequent missions
- Storage of mission streams for archival, review and editing

The Post Mission phase includes follow-up tasks that support the capture, evaluation, and distribution of mission data and includes the following efforts:

- Review – The review activities require the generation of detailed information of the Mission, including equipment logs, Alarms and Events and logs of operator activities.
- Editing and content preparation of mission data to create review packages. This creates a requirement to assemble multiple streams that are time-correlated to provide a synchronized stream set.
- Archive generation and generation of asset data to allow rapid retrieval of mission data. This drives a requirement to quickly search the stored data to access the required stream data, via a well-organized media asset management (MAM) system.

From the Range Architecture discussion it is apparent that range operational efficiencies can be increased by continuous adoption of a set of standard tools, processes and protocols that enable the interworking of the application streams. The Range Workflow discussion has identified a number of requirements to enhance the operational efficiency of mission performance. The following sections provide proposed solutions to these requirements.

SERVICE ASSURANCE

Service Assurance (SA) uses tools and mechanisms to ensure the successful transport of application traffic over a network. The desired result of SA is to provide visibility of performance at all points in the network.

The benefits of the SA activities are:

- Provide enhanced monitoring and test capabilities at the system level.
- Decrease time to verify equipment readiness pre-mission.
- Simplify fault isolation, decreasing downtime.
- Provide visibility of correct functionality for each application stream type.
- Flag errors as soon as possible to accelerate troubleshooting.

In adapting SA strategies to the Range models, the user requires access to parameters and metrics that characterize the health of each information stream. In the optimal situation, the stream provides native parameters that can be used to monitor the health of the stream. For example, telecom streams such as DS3 provide embedded error detection bits (C bits, P bits) that enable the user to detect stream errors. In these cases, the SA implementation is straightforward, and consists of the deployment of test equipment that can detect this information and provide the performance monitoring capabilities that will enable the user to monitor the state of the information stream.

Unfortunately, Range Architecture application streams such as Telemetry and digital video do not natively support error detection at the stream level. However, this capability is available at the Transport level, via a set of applications supported by IP switch vendors that support the monitoring of network equipment. The two dominant implementations are:

- S-Flow – or "Sampled Flow" is an industry standard [11] for monitoring packets and provides packet statistics that indicate the health of the network.
- NetFlow – is a Cisco and IETF [12] standard that supports packet sampling and supports monitoring of IP traffic flows.

Flow monitoring support differs from vendor to vendor, so the range operator must identify which scheme is supported by the Transport equipment when deploying this function.

The implementation of the SA strategy for the IP/Transport consists of:

- Identify the supported flow monitoring scheme.
- Match flow monitoring scheme with the Management entity, (Management Portal) to enable the acquisition of flow statistics to monitor the state of the Transport Infrastructure.
- Implementation of feature set in Management Portal to present relevant performance metrics to operator.

As was noted earlier, there are cases where the application stream does not natively support error detection and the health of the stream cannot be measured. In the Range Architecture, the Telemetry stream is one example. In this case an alternative method must be devised to implement the SA strategy. The proposed approach is to deploy a test stream that is co-located at the Telemetry source, is verified at the Telemetry destination point, and that travels the same path through the transport infrastructure as the Telemetry stream. The test stream serves as a reference stream that represents the health of the Telemetry stream.

The implementation of the SA strategy for Telemetry streams consists of:

- Test stream source. This can be implemented as a separate test set, or it can be implemented as a feature integrated into the vendor Telemetry Interface Unit. Selection of a Telemetry Interface Unit with built-in BERT capability simplifies this task.
- Test stream test set, for verification which can be built-I to the Telemetry Interface Unit, as supported by the vendor.
- Provision test stream path to be co-incident with the Telemetry stream path.

This approach allows the detection and isolation of faults in the network path, but also provides a methodology to characterize the network transport system to provide advanced metrics such as latency and delay variation, as supported by the test stream equipment. Finally, this approach can be utilized to provide a real-time indication of the state of the Transport element, allowing the range operator to quickly identify a failure and isolate the error location.

The final case to consider in the implementation of an SA strategy is compressed video streams. One approach to monitor the video is to simply decode the video and view the video for observable artifacts. This is not the optimal approach for a number of reasons:

- Video encoding schemes implement error concealment that masks streams errors, making them difficult to detect.
- Errors in the stream not visually apparent, such as metadata will not be detected.
- Visual observation induces viewer fatigue, making detection difficult over extended periods of time.

Compressed video streams do not have native error detection built into the stream itself, but there is information contained in the protocol layers of the video stream that can be obtained, given the choice of coding methodology. If the video is encoded as a Transport Stream (TS), the stream contains a direct indicator and a number of indirect indicators that can be utilized in the Video SA strategy.

The Video TS is a packetized stream that is built as a multiplex of a number of separate information streams, called programs. A program can be a video stream, an audio stream, or an ancillary data stream that carries program information, metadata, or timing information. The presence and bandwidth of each of the separate programs can be monitored to determine the health of the stream. Additionally, each of the TS packets is numbered; this counter (Continuity Counter) can be observed to detect dropped TS packets.

The implementation of the SA strategy for Video streams consists of:

- Encode video streams as Transport Streams
- Deploy Video Test Set with capability to monitor Transport Stream
- Monitor Video steam for dropped packets via Continuity Counter in TS
- Monitor Bandwidth of individual programs to detect loss of program and changes in bandwidth

Figure 3 below details the various methods by which the SA strategy can be executed.

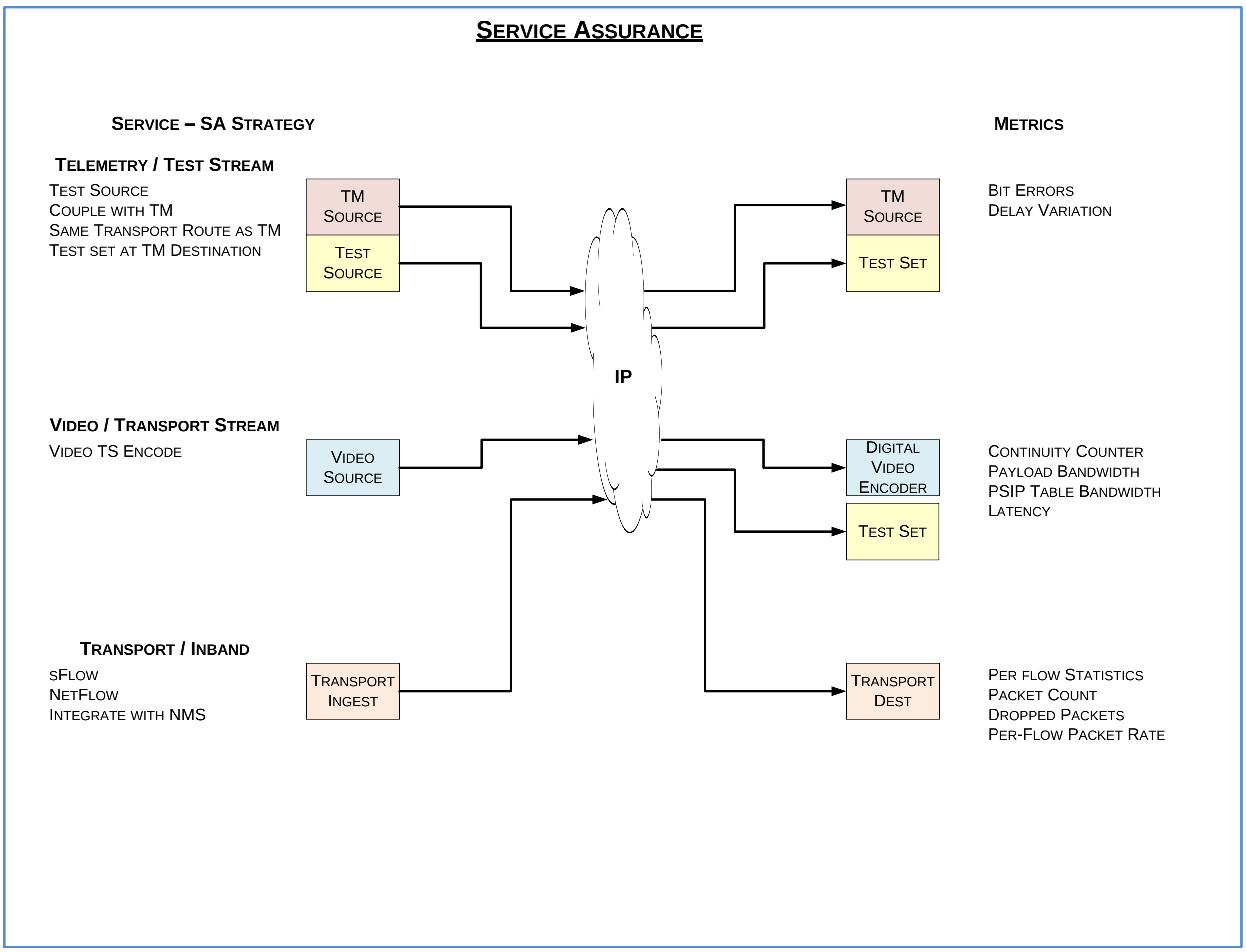

Figure 3 – Service Assurance

The SA strategy can be enhanced by the use of additional metrics that are more subtle than normal metrics, but are often more indicative of the health of the information streams.

Latency provides information about the state of the transport, and in normal operation should remain relatively static. Changes in latency are typically indicative in changes in the transport infrastructure, such as alternate routes.

Delay variation also indicates the state of the transport, but has important impact on streams that use adaptive clock recovery mechanism, as delay variation will cause wander in the recovered clock.

The use of the SA strategies supports the Range Workflow by providing the following functions:

- Enables the operator to characterize the state of the network and attached end equipment during Pre-Mission to verify operational readiness.
- Enables the operator to monitor the health of the range equipment in real-time during the Mission to quickly identify faults.
- Assists the operator to quickly isolate faults during the Mission to recover and resume the mission in a timely fashion.
- Facilitates the gathering of operational statistics to optimize network performance in future missions.

CONVERGENCE

Convergence refers to the methods where multiple services are combined over a common communications, management and operational infrastructure. As more services are integrated into a common infrastructure, operations and maintenance functions are made more efficient. Going forward, the aim is to continue the convergence activities to add additional stream types, eliminate overlay networks, and take advantage of operational improvements offered via integration of ancillary streams such as KLV and metadata.

This paper will focus on a single topic for convergence: the integration of KLV and associated metadata into the range workflow. KLV is a particularly important component in range workflow for the following reasons:

- Inherent timestamp enables real time stream display and alignment of streams.
- Enables real time overlay of information onto video assets.
- Facilitates real time latency calculation via embedded timestamp information.
- Can be accessed by third party applications such as Media Asset Manager.
- Allows real-time validation of live mission sources (avoid frozen video).
- Insert information into range assets to enable cataloging via media asset management functions.
- Ingest of dynamic information such as coordinates, azimuth and elevation for annotation.

A number of standards are currently in place that define the methods to ingest metadata and timestamp information [3] [4] [5] [6]. The enabling technologies for the KLV/ metadata functions are:

- Standards-capable ingest and timestamp [3] [4] [5] [6]
- End equipment that supports the ingest of metadata.
- Equipment that generates metadata streams for ingest.

- Media Asset Management applications that support the acquisition of metadata in application streams for the generation of stream catalog information.
- Video decode implementations to overlay KLM / Metadata onto live video.

The features provided by the Convergence activities support the Range Workflow by providing the following functions:

- Measure latency between range endpoints to support Pre-Mission operational readiness assessment.
- Metadata overlay capability enables monitoring during the Mission to verify correct video sources are in place
- Ability to ingest metadata information in real-time to Media Asset Management system allows efficient access to stored streams immediately upon the conclusion of the mission to support Post-Mission activities

WORKFLOW SUPPORT

The final item to be discussed is the integration of features that enhance the workflow for the range operator. With the migration of range assets to an IP infrastructure comes the potential to increase efficiency of range operations by providing the tools and processes to enhance the workflow. While some of this features require further development on the part of vendors to be fully realized, the concepts will be presented with the intention to elicit further conversation between the vendor and user community to accelerate their availability.

The capability to insert timestamp information into range streams adds the potential to synchronize streams from different sources and produce synchronized streams with the following benefits:

- Merge Video and Audio content, based upon timestamp contained in metadata
- Synchronous play-out of stored streams
- Merge metadata and source encoded streams on a common infrastructure

The enabling technology for stream synchronization is the capability to insert timestamps into information streams [7] [8] and the products that can access the timestamps and align the streams according to the embedded timestamps. Products are currently coming onto the market that enable this function, and it is anticipated that these products will become readily available in the near future. A key undertaking is to continue the dissemination of key standards and work with vendors to produce standards-compliant implementations.

The need for increased operational efficiency is driven by the requirement to support as many missions as possible. A key capability added by the migration to an IP infrastructure is the management capabilities provided by the SNMP (Simple Network Management Protocol) to provide a common platform for the configuration and management of range assets. One method to increase efficiency is to enable the rapid configuration of range assets to support mission preparation. The recommended method is the capability to build, maintain and retrieve mission profiles. A mission profile contains the configuration information for all of the required assets. Utilization of mission profiles provides the following benefits:

- Decrease Pre-mission configuration time.
- Reduce configuration errors

Additional efficiencies can be gained with mission logging. Mission Logging provides the methodology to obtain and archive the events and alarms in the range equipment. Additionally, configuration changes can be tracked in real-time during the mission for post-mission review.

The key enabler for mission profile and mission logging is the presence of equipment that supports the SNMP protocol for common configuration and monitoring.

The features provided by the Range Workflow activities support the Range Workflow by providing the following functions:

- Provide time-aligned streams during the Mission and Post-Mission phases.
- Enable merging of streams to support Post-Mission preparation of take-away packages.
- Provide mechanism to efficiently configure equipment prior to the mission.
- Provide information in the form of mission logs for review during Post-Mission activities.

CONCLUSION

The processes outlined in this paper are intended to take advantage of features that have been made available by the transition of range networks to an IP-infrastructure. These features are enabled by the extensive work done by the vendor community in the implementation of management and service assurance methods and policies for IP networks. The strategies detailed in the paper are intended to improve the workflow on the ranges to make mission execution more efficient, and minimize the occurrence and impact of network faults on range operation.

REFERENCES

[1] Bob Kovach, “Considerations for IP-Based Range Architectures, “ ITC Proceedings, 2013

[2] MISP 5.1, Motion Imagery Standards Profile Version 5.1, 11 December 2008

[3] SMPTE 336M-2007, Data Encoding Protocol Using Key-Length-Value

[4] MISB Standard 601.2, UAS Datalink Local Metadata Set

[5] MISB Standard 0102.5, Security Metadata Universal and Local Sets for Digital Motion Imagery

[6] MISB Standard 0902.1, Motion Imagery Sensor Minimum Metadata Set

[7] MISB Standard 605.3, “Inserting Time Stamps and Metadata in High Definition Uncompressed Video”

[8] MISB Standard 604.2, Time Stamping and Transport of Compressed Motion Imagery and Metadata

[9] ISO/IEC 13818-1:1996 Information technology -- Generic coding of moving pictures and associated audio information: Systems

[10] Telemetry Standard RCC Document 218-10, “Telemetry Transmission Over Internet Protocol (TMoIP) Standard”

[11] sFlow.org, “sFlow Version 5”.

[12] IETF, RFC 3954, “Cisco Systems NetFlow Services Export Version 9"