

# **THE EFFECT OF NETWORK CENTRIC OPERATIONS IN TELEMETRY FOR AIR FORCE FLIGHT TEST AND EVALUATION**

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## **ABSTRACT**

We discuss how aspects of telemetry can be effectively incorporated and modeled as a component within network-centric operations and warfare paradigms. Telemetry is particularly vital in Air Force Flight Test and Evaluation. As such, this paper has a specific emphasis and provides discussion within this domain. We also present how an existing framework for network-centric operations and warfare can be particularly beneficial to telemetry modeling, and discuss the potential insights and utility within this context.

## **KEYWORDS**

Network-Centric Operations, Test and Evaluation, Telemetry, Performance, Modeling and Simulation

## **INTRODUCTION**

The collection and transmission of data is key in Air Force Test and Evaluation (AF T&E). The method of transmission of this data is in the process of transitioning to a network structure as envisioned by the integrated Network Enhanced Telemetry (iNET) project. This is consistent with the military's movement towards network-centric operations (NCO) [1] and it is appropriate to start considering how the telemetry network will interact with, and affect, the NCO environment. The flow and timing of data transmission and gathering within a networked and distributed system often create unexpected difficulties. During flight tests these difficulties are especially of concern for safety of flight and catastrophe analysis, which are primary reasons for

real-time telemetry. Corrupted or latent data may also affect other real-time decisions during test or training.

In order to focus in on the potential complexity, consider a large scale multi-Service test and training exercise. As written in [2], such an exercise “might include 100 aircraft of different types, aircraft carriers, tanks, troop carriers, tens of thousands of troops, etc. All of these have telemetry and recording requirements. An extreme case would include transmission of simulated vehicles, which could far exceed real vehicle telemetry requirements.” Meeting these requirements requires implementation of multiple subnetworks in multiple frequencies so that performance not only has to be tested within each subnetwork, but also within the systems that are fusing the data and transferring the data between subnetworks. Furthermore, the effects of the T&E environment affect the overall data collected and the time needed to transmit data.

An important question is thus how are the affects of the testing network on the operational network (and vice versa) identified? These affects must be extracted from the final analysis of the test or training exercise as well as from the analyses of the performance of the networks themselves.

To help mitigate these issues, a realistic NCO performance model must be incorporated in order to produce an overall telemetry T&E framework. Such a framework within the telemetry process can provide information regarding behaviour and performance of T&E environments both generically and specifically within Air Force test environments, especially as it relates to overall communication performance, and data gathering. Furthermore, an NCO performance model could also aid in performance prediction and bottlenecks that can degrade performance in telemetering. This capability will allow testers to be able to analyze, predict, and pinpoint potential stumbling blocks for a variety of test and evaluation scenarios, as well as serve as a first-indicator of platform and scenario viability. In [3], an introduction to these issues as well as the presentation of a rigorous and realistic framework for NCO/NCW that allows for assessment and performance was provided. Moreover, in [4], we discussed first steps towards a subframework for instrumentation within the overall NCO/NCW framework. This is particularly useful for effective T&E telemetry performance analysis.

The focus of this paper will be on the issues involved in how to effectively utilize the framework(s) discussed in [3,4] for T&E telemetry modeling. We will provide a discussion of initial issues and potential approaches as it relates to telemetry.

## **NCO FRAMEWORK AND RELEVANCY TO TELEMETRY**

NCO is a key component in modern-day military needs and applications and thus requires significant research investigation. Due to the inherent complexity of net-centric operations, modeling and analysis of NCO can be particularly difficult. Therefore, a framework that can provide descriptive and mathematical formulations of NCO infrastructure and its performance will be useful. Such a framework can aid in pinpointing bottlenecks, providing suggestions for modifications, and providing the means for effective analysis and prediction.

In [3], such a framework was presented. In a subsequent section, we will describe how this framework can be used in order to aid in analysis and prediction of performance in T&E telemetering. We will now provide a brief description of this framework. A more in-depth discussion along with formal specifications can be found in [3].

This framework has four main subcomponents that serve to provide a foundation to represent, analyze, predict, and suggest modifications of performance. One strength of the framework is its rigorous plug-and-play nature, which allows for the capability to represent and model key characteristics of the underlying network. The framework also has the capability to provide measures and suggestions for potentially improved performance. The four subcomponents are (briefly):

- (1) Network representation component (NRC) is a model of the network that provides (i.e., represents) a static snapshot of the network. NRC is a graph model that provides the rigorous underpinnings needed for effective analysis, prediction, and modification.
- (2) Performance measures component (PMC) is the subcomponent that allows for the capability to map from one fixed NRC snapshot (graph) to another. PMC can be viewed as a collection of functions that provide the static values at different (future) times. The PMC can also provide a series of snapshots over time.
- (3) Performance tool suite component (PTSC) is another key subcomponent of the NCO/NCW framework. The combination of the first two components allow for predictive snapshots. In other words, it provides the representations of the important criteria and measurements of the NCO/NCW infrastructure. PTSC will provide the performance analysis across the specified snapshots. PTSC is also a collection of functions that take as input a set of graphs and outputs various types of analyses.
- (4) Submodel interaction component (SIC) provides modifications and suggestions based on analyses and representations provided from combinations of the other three components.

Effective telemetry performance modeling must rely on a number of key criteria dealing with communication. Although “telemetry” is often thought of as just the radio frequency signal, “distance measuring” involves different resources transmitting different information along different physical technologies (both wired and wireless) using a variety of protocols. Such heterogeneity needs to be realistically modeled within the infrastructure. One of the strengths of the NCO framework in [4] is the capability to represent such heterogeneity. Also, due to the plug-and-play nature of the framework, different telemetry characteristics that are relevant for different types of modeling, analysis, and prediction can be utilized or incorporated as needed. Therefore, depending on the significance of the analysis for items such as real-time re-routing, information flow, etc., these characteristics can be incorporated into the framework. As such there is the capability to theoretically model and test different characteristics in isolation as well as ripple effects in different contexts. Further information regarding the framework in general and in regards to some aspects of communication modeling can be found in [3].

## NCO AND AIR FORCE T&E TELEMETRY MODELING

As we discussed in the previous section, it is clear that an NCO framework that represents the communication methodologies and key criteria is critical in order to effectively model telemetry, its needs, and its effects. In regards to T&E telemetry, instrumentation should be modeled explicitly and incorporate key criteria relevant to telemetry. Although T&E instrumentation developers and engineers are striving towards commonality and interoperability, these goals generally mean allowing equipment from multiple vendors to work together in the same system. Thus, although there is a growing commonality of communication interfaces between instruments, individual implementations may still have significant timing and functionality differences. Further, T&E at different facilities is implemented using different instrumentation, procedures, and communication structures. Some of these differences may be due to local tradition (and will hopefully fade away), but many of the differences are due to differences in geography, organizational structure, and the fact that different facilities are focused on different types of test or different types of vehicles.

Thus, in order to effectively model T&E telemetry, an instrumentation model (i.e., framework) is vital. However, this is not a one-way street; T&E instrumentation without effective telemetry modeling would not produce adequate results or have high utility. Therefore an instrumentation NCO framework that incorporates telemetry and also serves as a subframework to an overall NCO framework would provide the means to analyze and predict performance in a T&E environment. Furthermore, our framework would provide for ease of isolating, or embedding, the instrumentation NCO framework within key parts of the NCO environment, allowing for even further analysis and prediction.

In [3,4], we provided issues and possible approaches in utilizing the broad-based NCO framework discussed above for use in T&E instrumentation. A number of issues regarding instrumentation and some discussion on telemetry was also provided. One particularly important point is the fact that instrumentation in and of itself affects the overall performance and the data and statistics gathered in T&E. As such, it is important to determine how to incorporate, yet simultaneously be able to decouple the T&E instrumentation from, the infrastructure in order to be able to represent, isolate, and explain the effects of the instrumentation on the overall environment. The overall NCO framework is able to incorporate a T&E instrumentation (sub)framework as a submodel or subgraph within the overall framework, as well as metrics spanning between the subgraph and other subgraphs in the framework, metrics that are meant to be computed based on a specific group of subgraphs, and other metrics. In fact this instrumentation submodel could have an instrumentation version of each of the framework components.

Clearly, T&E telemetry needs can be modeled within the instrumentation NCO subframework for resources that are explicitly part of the instrumentation. There needs to be a merger and mapping of telemetry between the instrumentation subframework and the NCO framework overall. However, telemetry is not the only characteristic that would require such mappings. Further information and discussion on instrumentation, its subframework, and mappings can be found in [3,4].

## CONCLUSION

Due to the distributed, heterogeneous nature of telemetry, many important issues need to be considered and modeled. In this paper, we discussed the importance of utilizing an NCO framework of the network infrastructure as a means to model, analyze, and predict telemetry within Air Force Test & Evaluation.

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