iNET DEPLOYMENT PROCESS: A CASE STUDY

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ABSTRACT

Sponsored by the Central Test and Evaluation Investment Program (CTEIP), the integrated Network Enhanced Telemetry (iNET) project has created a proposed architecture for network enhancing aeronautical telemetry. Given the static nature of the current aeronautical telemetry architecture (it has not significantly changed in over 50 years), it is recognized that iNET must be carefully deployed to avoid test disruptions and safety issues. In support of a smooth transition to this new architecture, the Naval Air Warfare Division Aircraft (NAWCAD) conducted an extensive continuous process improvement project. This paper will describe the process, defined and launched by this study, to assure the safe deployment of iNET.

KEYWORDS

iNET, Network Telemetry, Lean Six Sigma

BACKGROUND

Real-time telemetry is an integral component of flight test scenarios executed on Department of Defense (DoD) test ranges. For the last 50 years, virtually all real-time telemetry has been point-to-point one way transmission of data. Referred to as Serial Streaming Telemetry (SST), data are transmitted one way, from the test article to the remotely located test team. The test team evaluates the data in near real-time to ensure safe test execution and to monitor the performance of the test article. Data content and format of the SST data stream are fixed in advance of the test.

As complexity of weapon systems increased, the amount of data collected onboard test articles began to spiral upwards. However, the rigidity of point-to-point telemetry, coupled with limited spectral resources, severely limited the amount of data that could be transmitted. Increasingly, most of the data collected onboard a test article were recorded vice being transmitted. In some cases, less than three percent of the data being collected are transmitted. Test engineers have to wait until the test article returns to base to retrieve the data recorder so that the majority of the data can be downloaded and analyzed. Limited real-time access to all the data being collected has negatively affected the cost and schedule associated with flight test.

Considering the implications of this trend, it became clear that the traditional SST architecture needed to change. The million dollar question was; "Change to what?" The call for change was led by a rogue group of telemetry engineers who advocated scrapping SST and changing to a technology based on wireless networks. However, wholesale replacement of SST telemetry with wireless network technology was also problematic. While telemetry networks, via two way connectivity, could allow near real-time access to all the data recorded onboard the test article, they are ill suited for time critical delivery of data with no variance in latency (required for accurate near real-time time-history reconstruction). Despite its faults, SST excels at the delivery of time critical data with a fixed latency (supporting accurate near real-time time history reconstruction). Slowly the concept that telemetry networks and traditional SST were not mutually exclusive emerged. In fact, they compliment each other; each doing well, what the other does poorly. The use of wireless network technology to enhance traditional SST is the basis of the iNET Architecture.

The iNET Architecture describes how a collection of networks work in harmony with SST to meet emergent needs within the Major Range and Test Facility Base (MRTFB). This system can be thought of as a "network of networks" consisting of:

- A vehicular network (to be developed by iNET) on the test article that handles all onboard data acquisition functions
- A wireless network (to be developed by iNET) that provides for network communications between test articles and between the test articles and the range infrastructure
- The existing SST links
- The existing network infrastructure on DoD T&E ranges

iNET – A DISRUPTIVE TECHNOLOGY

"To boldly go where everyone else has gone before" Tomas Chavez circa 1999.

In the early days of the iNET project, Tomas Chaves uttered these prophetic words in describing the mission of iNET. As a project, iNET is bringing the ubiquitous world of network technology to the telemetry community. Similar to the introduction of network technology to the business world, the introduction of network technology to the telemetry world will alter telemetry in unforeseen ways.

Quoting from www.businessdictionary.com, a disruptive technology is defined as "New ways of doing things that disrupt or overturn the traditional business methods and practices. For example, steam engine in the age of sail, and internet in the age of post office mail." ….*or iNET in the age of traditional telemetry!* For the first time in over 50 years, iNET will change the underlying architecture of telemetry resulting in the overturning of many existing "methods and practices." While many papers have been published on the promise of iNET to improve time, cost, and effectiveness of flight test, few have looked at the challenges of deploying this potentially disruptive technology.

iNET technology will first be deployed in the aeronautical telemetry environment. This is a particularly high risk environment where split second decisions (governed by methods and procedures) are required to preserve safety of flight and life. The introduction of iNET technology into the aeronautical domain has the potential to overturn, not just "*traditional business* methods and practices," but *critical safety* "methods and practices" as well. Many of these methods and practices are based on the SST architecture. As iNET technology revolutionizes aeronautical telemetry, the potential for iNET Technology to "disrupt or overturn" these critical flight test methods and practices is a significant concern. In preparation for the upcoming deployment of iNET technology at the Naval Air Warfare Center, Aircraft Division (NAWCAD), a process for identifying and mitigating potential disruptions to proven critical methods and practices was required.

THE iNET LEAN SIX SIGMA PROJECT

As the iNET Architecture was being developed, independently, the Department of the Navy was embracing a disciplined set of tools to improve productivity. In 1999, the Navy Depots adopted the use of a Lean Six Sigma (LSS) toolset in order to increase productivity through process improvement. The use of the LSS toolsets has proven to reduce lead times, remove waste (non-value added cost), and reduce variation. In 2004 the Navy, recognizing the positive impacts that the Depots were experiencing using the LSS toolsets, endorsed the utilization of the LSS toolsets across the Naval Air Warfare Centers.

When considering the challenge of deploying iNET, it was recognized that NAWCAD needed a defined process to mitigate the potential disruptions. While pondering how to establish this process, the concept that the LSS toolset could be used to design (as well as improve) a process was realized. Anderson [1] describes in detail the processes and results of this project. The goal of the project was to define a Process for the safe deployment of iNET. A focused team of subject matter experts employed the "Define, Measure, Explore, Develop, and Implement" (DMEDI) techniques to define this process. The team brought domain expertise in a variety of critical areas including: flight test, telemetry, data processing and display, airborne instrumentation, system safety, communications, range infrastructure, and operational risk management.

With weekly sessions and several all day off sites over nine months of project execution, the team methodically progressed through the DMEDI process. After each stage, the team leader reported a summary of findings / progress and plans for the next phase.

DEFINE

The initial step is intended to clearly define and frame the problem. A variety of tools, such as swim lane process mapping, voice of the customer / business evaluations were used to come to a common understanding of the problem. Available iNET data products (deployment schedule, capabilities, scenarios / use cases) were reviewed to gain insight into and scope the problem.

MEASURE

The iNET project has assembled a set of 53 scenarios that defined the capabilities the system needed to support. [2] Early in the systems engineering of iNET, each scenario was converted to a process map referred to an Operational Sequence Diagram (OSD) - similar to a DoDAF OV-2 diagram. These are diagrams depicting the connectivity and information flow between nodes necessary to fulfill the requirements of each use case.

The project goal was to define a process for the deployment of iNET, not necessarily to develop the solution for deployment. Scenarios likely to be executed first at NAWCAD were selected as candidates for the project. The predominate scenario identified to be among the first used, "Fetch Data from Test Article on Demand" describes the details needed to access previously recorded data from the test article in near real-time. Using the OSD shown in Figure 1, each connection and information flow was analyzed to uncover potential disruptions by posing questions such as; "If this step were deployed now, what would be the impacts and disruptions to existing processes, procedures, and infrastructure?"

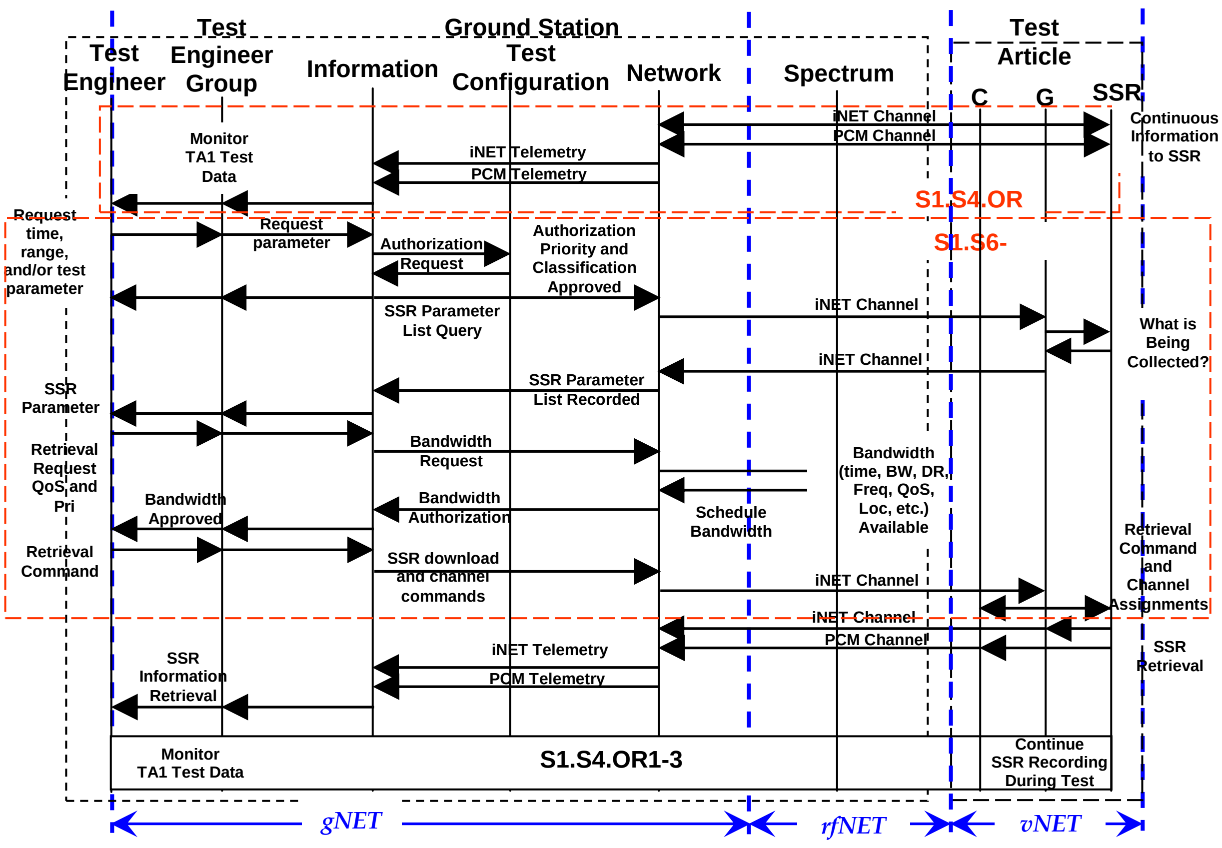

Figure 1. Operational Sequence Diagram: "Fetch Data from Test Article on Demand"

EXPLORE

The first pass through the OSD highlighted 144 disruptions which were documented in a Failure Modes and Effects Analyses (FMEA) spreadsheet. Among the artifacts of the project is a listing of over 250 potential disruptions. Some of the higher level issues will be discussed later.

This typical 'brainstorming" method for analysis proved successful; however, it was far too time and labor intensive to be advocated as the process used for the deployment of iNET. A straight forward standard process, defined by a guidebook, which would guide the finding and mitigating of the potential disruptions in the deployment of iNET, was needed. Although at this time vaguely defined, the concept of the Disruption Finder Guidebook was established.

DEVELOP

An efficient approach to identifying and categorizing potential disruptions was designed building on a concept used by Microsoft Corporation called "Threat Modeling." Threat Modeling uses data flow diagrams (Similar to the OSDs) and an acronym to focus brainstorming. The project created the unique acronym ***ITD3***. ITD3 stands for ***I***nformation Assurance, ***T***est Conduct, ***D***ata Quality, ***D***ata Delivery**,** and ***D***isplay & Human Interface. This acronym was derived from the use of Affinity Analysis to categorize the 144 FMEA disruptions discovered during the Measure process. Transitioning from an OSD to a data flow diagram (Figure 2) was straightforward. The acronym was used to focus the brainstorming in the analysis of the data flow diagram.

This new process was applied to the Fetch Data scenario and resulted in identifying an additional 61 potential disruptions (major disruptions discussed later in this paper). Not only was this process more thorough, it was much quicker – days vice weeks of team effort.

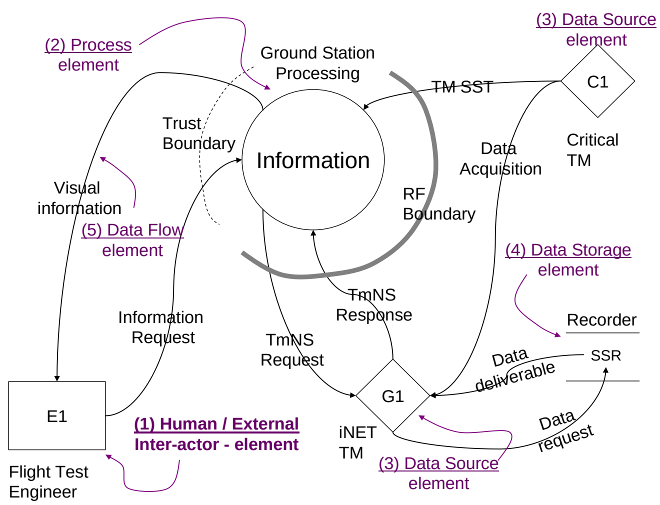

Figure 2. Data Flow Diagram: Fetch Data from Test Article on Demand

IMPLEMENT

An updated iNET Disruption Finder Guidebook was created to define a process that incorporated the threat modeling concepts, and lessons learned. This process was tested using three additional scenarios and yielded 51 more potential disruptions that require mitigation prior to deploying iNET.

As part of the transition from the LSS project to the process owner, a process map detailing the iNET Deployment Process was developed. While it is beyond the scope of this paper to describe the details of this process map, the iNET Deployment Process Map is presented in Figure 3 for reference.

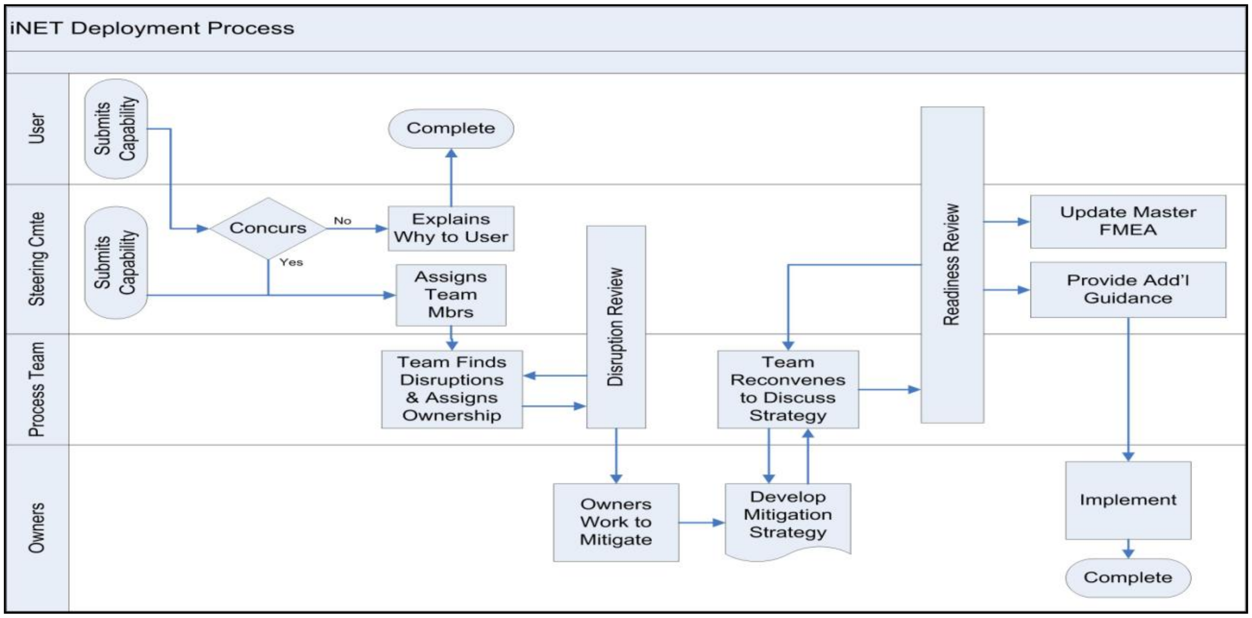

Figure 3. iNET Deployment Process Map

MAJOR DISRUPTIONS IDENTIFIED

Recall, the goal of the LSS project was to define a process for the safe deployment of iNET at NAWCAD. The DMEDI process led the team to focus on disruptions to the day-to-day normal operations. Throughout the project, a variety of issues were raised and more often than not, some variation of, or impediment to the standard range practice resulted when deploying the capabilities afforded by iNET. The charter of the team was not to identify and mitigate the disruptions, but to define the process to identify and mitigate these potential disruptions. However, in creating and testing the process, 256 potential iNET related disruptions were cataloged in a FMEA.

Some of the major disruptions identified for mitigation by a deployment team(s) include:

- Is displayed data near real-time or delayed (telemetry drop-out recovery or data retrieval).
  - Confusion with real time data reduction could lead to decision quality data issues
  - Potential for mishap if wrong data is monitored or analyzed.
- Latency of data in the network queue
  - Slow response for retrieval commands
  - Critical decision based on stale or latent data
  - Derived parameters (mixing real time and network data) are stale or have errors
- Delay and time associated with a data retrieval (or dropout reconstruction)
  - File size could be large and require an unacceptable amount of time for download
  - Test engineer monitoring flight needs the capability to stop a retrieval
  - Test engineer monitoring flight needs the ability to turn on/off dropout reconstruction
- Spectrum allocation
  - Real time change of frequency assignments may be missed by some participants
  - Aircraft preflight checks performed at a different frequency than that assigned real time
- iNET housekeeping workload (bandwidth requests/approvals, access authorizations, retrieval requests, IA issues) distracts from monitoring real-time safety of flight measurands
- Configuration Management
  - iNET settings were not saved from mission / can not reproduce mission settings
  - Test article configuration changed during the test mission; how is metadata changed

The disruptions cited above are just a sample of the potential disruptions uncovered during the development of the NAWCAD iNET Deployment Process. It is important to note that some of the potential disruptions identified have safety of flight implications. These potential disruptions must be mitigated by NAWCAD prior to the fielding of the iNET capability.

EMPOWERING THE PROCESS

With a process defined and documented, a process owner was needed. An iNET Steering Committee was created and empowered by a Memorandum of Understanding between the Senior Executive Service (SES) leadership of the NAVAIR Ranges, Flight Test, and Laboratories. This committee meets regularly and has the responsibility to:

- Prepare NAWCAD for the deployment of iNET Technology
- Provide guidance to users of the iNET Disruption Finder Guidebook
- Create ad-hoc teams to identify additional potential disruptions
- Assign ownership and responsibility for mitigation of disruptions
- Track the mitigation status of all potential disruptions

LSS PROJECT DELIVERABLES

At the conclusion of the project, the LSS team delivered the following solution package to the project sponsor:

1. iNET Disruption Finder Guidebook - *(A detailed guide for creating and using threat models)*
2. iNET Concept of Operations (CONOPS) document - *(How the guidebook and committee work)*
3. iNET Master Disruption List (FMEA) - *(containing disruptions with failure modes and effects).*
4. Memorandum of Understanding (MOU) – *(An MOU to establish a process owner and empower the iNET Steering Committee)*
5. iNET Steering Committee Charter
6. Recommendation for: iNET Steering Committee 1st agenda & schedule
7. Recommendation for: Subject Matter Experts by name for Committee participation

ACKNOWLEDGEMENTS

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