Visualizing and Integrating AFSCN Utilization into a Common Operational Picture

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1. Introduction

The Department of Defense (DoD) and the 50th Space Communications Squadron Studies and Analysis branch (50th SCS/SCXI), located at Schriever AFB Colorado, face the unique challenge of forecasting the expected near term and future utilization of the Air Force Satellite Control Network (AFSCN). The forecasting timeframe covers the planned load from today to ten years out. Various satellite missions, satellite requirements, orbital regions, and ground architecture dynamics provide the model inputs and constraints that are used in generating the forecasted load. The forecasting challenge is to provide leadership with the insights necessary to manage the network today and tomorrow. For both today's needs and future needs, SCXI develops AFSCN utilization forecasts to optimize the ground system's coverage and capacity to meet user satellite requirements. SCXI also performs satellite program specific studies to determine network support feasibility. In a manner of perspective, SCXI builds a pseudo operating picture of the future to assist the leadership in making decisions. It is more of a view of how the 50 SW will execute planned missions versus how the Wing operates them right now.

The need to integrate and visualize a Common Operating Picture (COP) of the AFSCN was spawned from SCXI's experience in the AFSCN user set, data network, and modeling software tools, as well as needs of the 50 SW leadership. Even though there is no current official Air Force Space Command documented need for an AFSCN COP, it is still possible to provide the leadership both a day-to-day and a crisis management space situational awareness (SSA) tool when you consider the realization that both the data and the tools could be easily obtained and integrated. This point was also driven home by General Lance W. Lord who stated that "As we continue to mature technologies required to fully integrate space effects in the battlespace, we must also examine our existing organizational structures and processes."

This paper will provide a brief look at the history of the AFSCN, the basic components needed to build the COP, what an AFSCN COP would look like, other potential users of an AFSCN COP, and a suggested way ahead. Due to data restrictions, the COP and its data sources discussed here are kept strictly notional. In addition, the AFSCN COP is in the early foundational stages, so the visual and capability representations documented below are also notional and are part of the beginning groundwork.

2. Background

The AFSCN is the largest network the Air Force uses to control satellites worldwide. Each day, network personnel execute over 500 scheduled satellite contract events, e.g., satellite maneuvers and critical data downloads. The AFSCN is

- "A shared Government space- and ground-based network that provides
  - Launch, early orbit and anomaly resolution (LEO&A) support required by all satellite systems,
  - Assured access to space for time-sensitive satellite control functions,

- Continued support to users that require low data rates for satellite and mission operations…"

Providing command, control, and communications (C3) capabilities, the AFSCN, operated by Air Force Space Command (AFSPC), supports National, Department of Defense (DoD), Research, Development, Test, and Evaluation (RDT&E), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and other assigned missions. "Satellite- and mission-specific requirements are supported by Satellite Operations (SATOPS) functions. Network Operations (NetOps) functions, on the other hand, provide multi-user satellite control capabilities that are available to all United States (US) Government launch and space vehicles (SVs). These functions include: communications from SATOPS Command and Control Centers (CCCs) to/from the remote tracking stations (RTSs); launch vehicle and SV telemetry receipt at the RTSs; command uplink to SVs from the RTSs; radiometric tracking data collection; general orbital analysis; resource scheduling; and network management." [1]

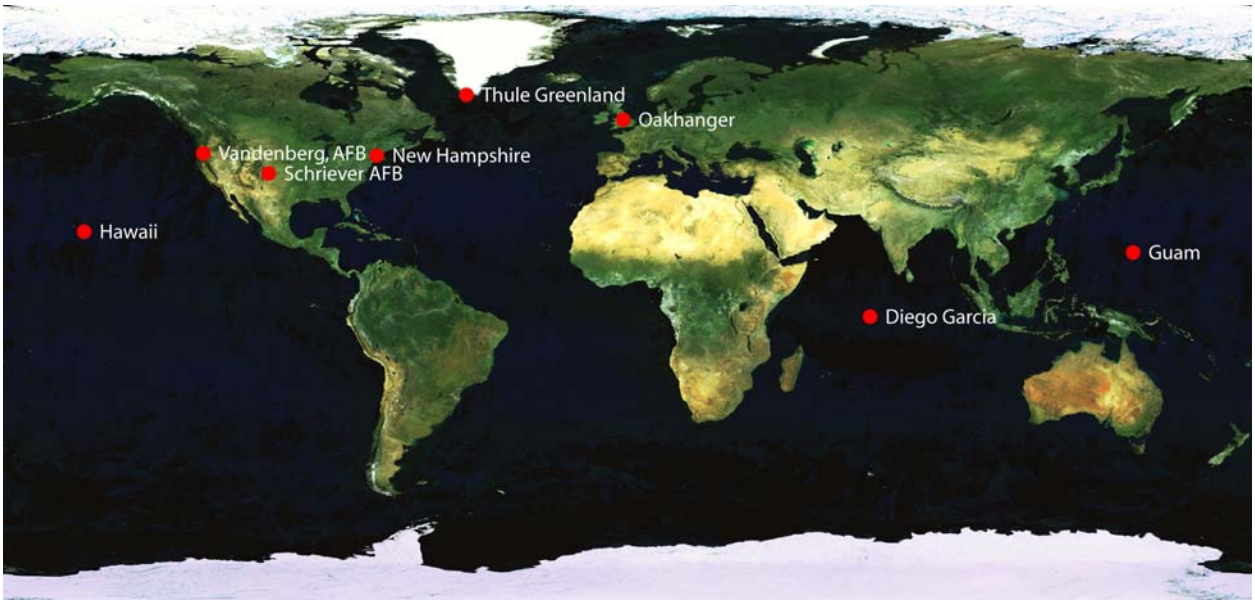

Figure 1 AFSCN RTS Ground Locations

The AFSCN (originally known as the satellite control facility, SCF) was established in the 1950s to support Weapon System (WS) 117L (i.e. MIDAS, which was later replaced by the Defense Support Program (DSP)). This network also launched the Westford Needles experiment, SAMOS & Discoverer (now known to be the Corona Program). There was also the TIROS/DMSP program, based on the (losing) RCA design for Corona. During its early years, the AFSCN supported mainly the National satellites, although that was kept a bit low key. The AFSCN locations were quite different than the ones we know today in New Hampshire, Colorado, California, Hawaii, Diego Garcia, Guam, Britain, and Greenland (ref Figure 1). Unique locations such as at Annette Island Alaska, Edwards AFB California, Ottumwa Iowa, Fort Stevens Oregon, Christmas Island, and Fort Dix New Jersey were used.

Currently, AFSCN space situational awareness is performed in more of an ad hoc manner than with a regularly updated, fused picture. As needs and/or situations arise, specific data focused on addressing the current problem is assembled to provide leadership the necessary decision aids. The Wing Operations Center (WOC) maintains status boards that provide operational conditions for some AFSCN users and most resources. Updates are provided via voice reports that are then upchanneled to higher headquarters. As the information comes in, a WOC operator updates the status, which changes the condition color. The condition color is textual based and not connected to any "live" information gathering system. However, the condition colors are effective in quickly communicating the status data. For the past 20 years, the 50th Operations Group (50 OG) has performed orbit analysis (OA) and constellation management within "mission stovepipes" that are separate and distinct within each satellite program. There is no current capability to integrate a COP across multiple AFSCN users within an orbital environment. Slides and graphs are typically used when an orbital decision needs to be made by the leadership on a specific satellite location or complete constellation management, including maneuvers, collision avoidance, or

defensive/offensive counterspace options. Satellite Tool Kit (STK) scenarios are sometimes created to support that decision instance, but the longevity of the supporting decision aides is still only applicable to that one point in time.

While this mode of operation might have been acceptable in the past due to the lack of capable tools to visualize and display accurate information, the space environment and the adversaries' space capabilities dictate a need for a rapid increase in situational awareness. The current process may not be "broken," but tomorrow will bring a completely different set of challenges the Wing has not yet faced. Future space combat will absolutely require new efficiency, speed, and agility. To increase senior leadership situational awareness and provide the "big picture", the Wing SSA will need to fuse data from multiple sources that provide services to the AFSCN. Whether in normal, day-to-day readiness posture or at higher states of readiness, a real-time, three-dimensional visual display will provide leaders greater insight into the Wing's operational capabilities and enhanced options in the space combat decision cycle.

3. COP Components

The basic components of an AFSCN COP/SSA tool would consist of the data sources relevant to operations of the network. The major pieces that drive AFSCN operations would be the deconflicted schedule, the status of the satellite and ground resources, and the orbital positions of the satellite users (see Figure 2).

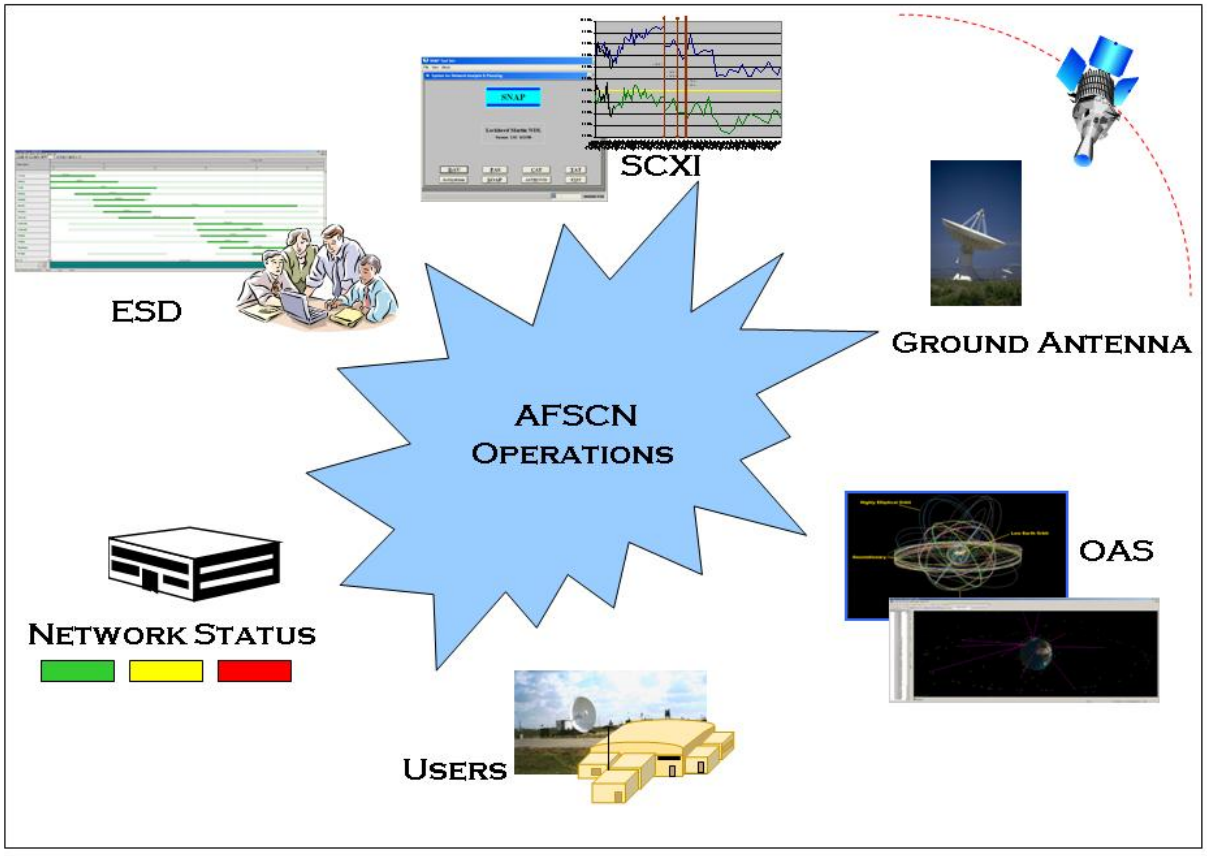

Figure 2 AFSCN Components

The current AFSCN components that provide these services and more are described below:

- The **AFSCN schedule** is the central repository of all requested and executing events on the network. Users submit their requested events to the schedulers who deconflict the requests against

other user requests and then assign the events to a specific time and resource. AFSCN schedulers use a scheduling system called the Electronic Scheduling and Dissemination System (ESD), which is currently a DOS based system undergoing a modernization to more current technology specifications. The new version of ESD will be a distributed web based system that will allow users to plan and request resources at a much more interactive level. The core scheduling engine is being updated from a proprietary engine to a COTS based STK/Scheduler solution.

- **Status of ground resources** within the AFSCN is managed by the Network Status office. As outages or other limiting factors arise within the AFSCN, these events are reported via telephone to the Network Status office. These events are assigned a tracking number to assist in getting the appropriate and necessary repairs accomplished. A condition code (green, yellow, or red) is assigned and then disseminated to the AFSCN users via ESD. This system is also going through a technology refresh. The new system, called the Network Management System (NMS), will allow more real-time statusing of the systems by both the resource operators and the users. Condition statusing will not have to wait for phone calls and manual data input. "Live" data will allow all interested parties to see the most up-to-date resource condition prior to their request or usage. This system does not report or status any AFSCN user satellite resource.
- **Orbital parameters** of the AFSCN users' satellites are maintained by each specific user, but these users send their parameters to both ESD and a central repository called the Orbital Analysis System (OAS). The format typically used is a two line element set (TLE). For scheduling purposes, this orbital data is used in visibility generation and radio frequency interference identification. OAS is also going through an upgrade, called the OAS Follow-on. Both the current and planned OAS component is STK based, which will allow more interaction within the NMS and ESD architectures.
- The **System for Network Analysis and Planning (SNAP) and the SCXI forecasting toolkit** provide a perspective on the past, current, and future awareness of the AFSCN. These components supply the awareness of what happened in the past for each user and each resource on the AFSCN and what is predicted to happen across the AFSCN in the future. The future AFSCN forecasting element is where SCXI's expertise lies. STK and STK Scheduler form the core of the tools used by SCXI. To establish this tool suite, SCXI evaluated, evolved, and validated the COTS products as well as internally developed data management and analysis code and processes. This process began with calibrating the network model to emulate the real life scheduling environment of the AFSCN. Multiple STK Scheduler optimizing (de-confliction) algorithms, including Multi-Pass, Sequential, Random, and Neural, were evaluated and adjusted to determine applicability to the model and the accuracy of the prediction. Additionally, the scheduling Figure of Merit (FOM), which permits custom weighting of various parameters, was analyzed and tested to verify performance and behavior versus current operational capabilities. SCXI's understanding and modeling of the AFSCN environment helped convey how important the correct visual and graphical representations of "stressed" nodes are to the key decision maker affecting the future architecture of the AFSCN.

These components are at the heart of understanding the AFSCN operating picture at any given moment. These data providers must be interconnected in a manner to bring the stored and processed information together in a central view that allows the leadership to understand and be aware of the AFSCN status situation 24/7.

4. COP – Our View

In the conception of an AFSCN COP/SSA tool, the core would be STK-centric due to its visual and analysis capabilities and the fact that it is used within most of the critical AFSCN data components. The central use of STK is the key point in understanding the ability to field an AFSCN COP today. Data formats and component integration is typically a major issue when attempting to fuse and share multiple data sources, but when the central engine is the same, complexity is reduced. The biggest advantage of STK is the graphic representation of most AFSCN events in the space environment. These events are often difficult to communicate or visualize, especially to personnel not deeply experienced in space operations concepts.

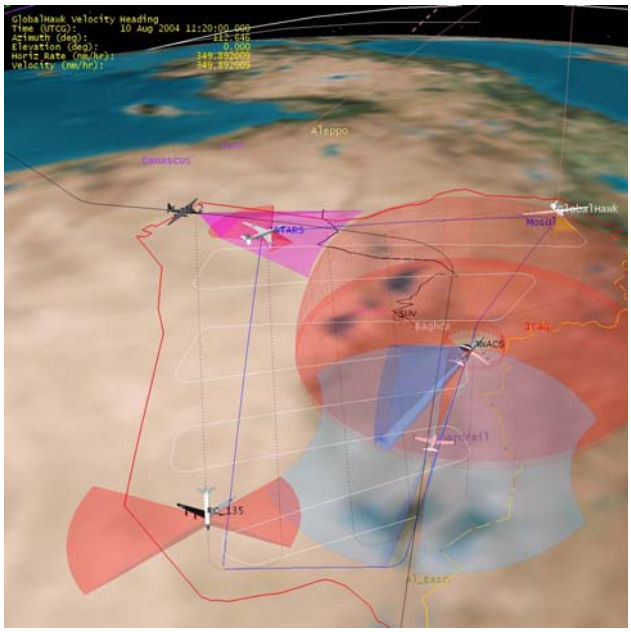

Figure 3 Typical Battlespace COP

The AFSCN is not a typical environment to consider for a COP implementation. The AFSCN is more of the middle man or a conduit for the information to travel between areas of responsibility (AORs). It is by no means on the pointy end of the spear, but is an enabler to provide critical services to the warfighter that allow the battlefield commanders to have the most up-to-date information and communication paths to win the fight everyday. A typical notion of SSA or COP is the fused picture of multiple sensors, combatants, and sources of data within a single battlespace (see Figure 3 and 4). So, what would apply to the AFSCN, and its need for an operational picture? As a service provider, the AFSCN users trust that the system will be there when needed and that the resources are protected to allow them to fully utilize the network for mission data gathering and delivery. When things go wrong, the AFSCN needs to respond quickly to determine impacts, alternate routes, and recovery actions that will allow the network to quickly be back on-line to service its users.

The AFSCN will need to employ common processes and tactics, techniques, and procedures (TTPs) and have common SSA/COP tools to maximize efficiency while minimizing information overload. These tools need to be faster/more responsive, with graphically intuitive interfaces and automated metrics to aid in the space combat decision process. SSA/COP tools can be better integrated and interoperable with other AFSPC units and associated weapon systems, providing a net-centric common data repository and the ability to use improved assessment capabilities based on best-industry practices. These tools should also help maximize efficiency associated with using various ground and space assets. Real-time decision support for the monitor-assess-plan-execute (MAPE) command and control (C2) cycle allows "faster than the adversary" space combat course of action (COA) development and execution. An AFSCN COP can be used in both peacetime and wartime crisis situations in order to operate our critical space assets and assure mission continuity.

With the inherent capabilities of STK and the ability to access databases, conduct analyses, and automate output, SCXI is now able to visually communicate AFSCN utilization in a three-dimensional, visual manner not previously available to AFSCN management meetings. Scenarios such as regional antenna load stress, satellite missed opportunities, and the overall network "big picture" can be visually displayed in 3D versus the textual and line graph methods used for many years. These capabilities are the first steps towards an integrated AFSCN COP with an operational focus. SCXI is working on advancing the visual forecast concept and fusing the multiple sources of data to build an AFSCN COP. The vision is to integrate more effective orbital determination processes, resource outages, current and forecasted satellite mission requirements, and future architectural changes into a real-time visual status to enable quick and responsive decisions.

This COP is targeted for use in the WOC for the Wing/CC or Battlestaff to provide up to the minute network status on where satellites are, which ground resources are in contact with them, and what resources are down. The ability to quickly absorb and process this data will enhance decision analysis and save valuable time in both day-to-day operations and for optimizing space support in wartime scenarios.

Figure 4 Typical Battlespace COP

An executive dashboard concept will be utilized that will allow the operator to see the AFSCN schedule visually executing in a 3D representation (see Figure 5). This method of presentation is typically used when a large quantity of complex information from multiple sources can be rolled up into easily understandable metrics that can effectively communicate system status to the executive layman. This "animated" schedule uses the current ESD schedule delivered in a STK/Scheduler format. Lines connecting resources will appear as satellite contacts happen in real-time. All satellite positions will be fed into the COP via OAS using the latest user TLE predictions. Ground resource status will be fed from NMS and visually displayed as color coding on the global resource location. Satellite status will be fed from the users (manually at first) to allow satellite models to be color coded to represent resource status. Filters will be used to turn on/off portions of data as to not overload the operator and obscure the message being communicated. The main focus will be to communicate the right amount of data at the right time for the necessary decision. The filters would allow graphical representations of AORs to be displayed, current ground and space threats to be represented, etc. With the WOC being a central data point for squadrons to report satellite events such as anomalies or unknown interferences, correlation to these events can quickly be cross referenced visually against threats such as lasers or jamming sources with the use of this filter. The data for these threat locations and capabilities would be maintained elsewhere, but the WOC would interface and maintain this data in the COP tool. Multiple views could be selected to alternate between the full AFSCN big picture or a specific location or resources. Additional features would integrate both the historical data and the predicted data. A rewind and fast forward button will allow the AFSCN to be watched from the past to the current to the planned to the predicted state, with the goal to provide an integrated, interoperable, responsive, and persistent situational awareness of space resources and events.

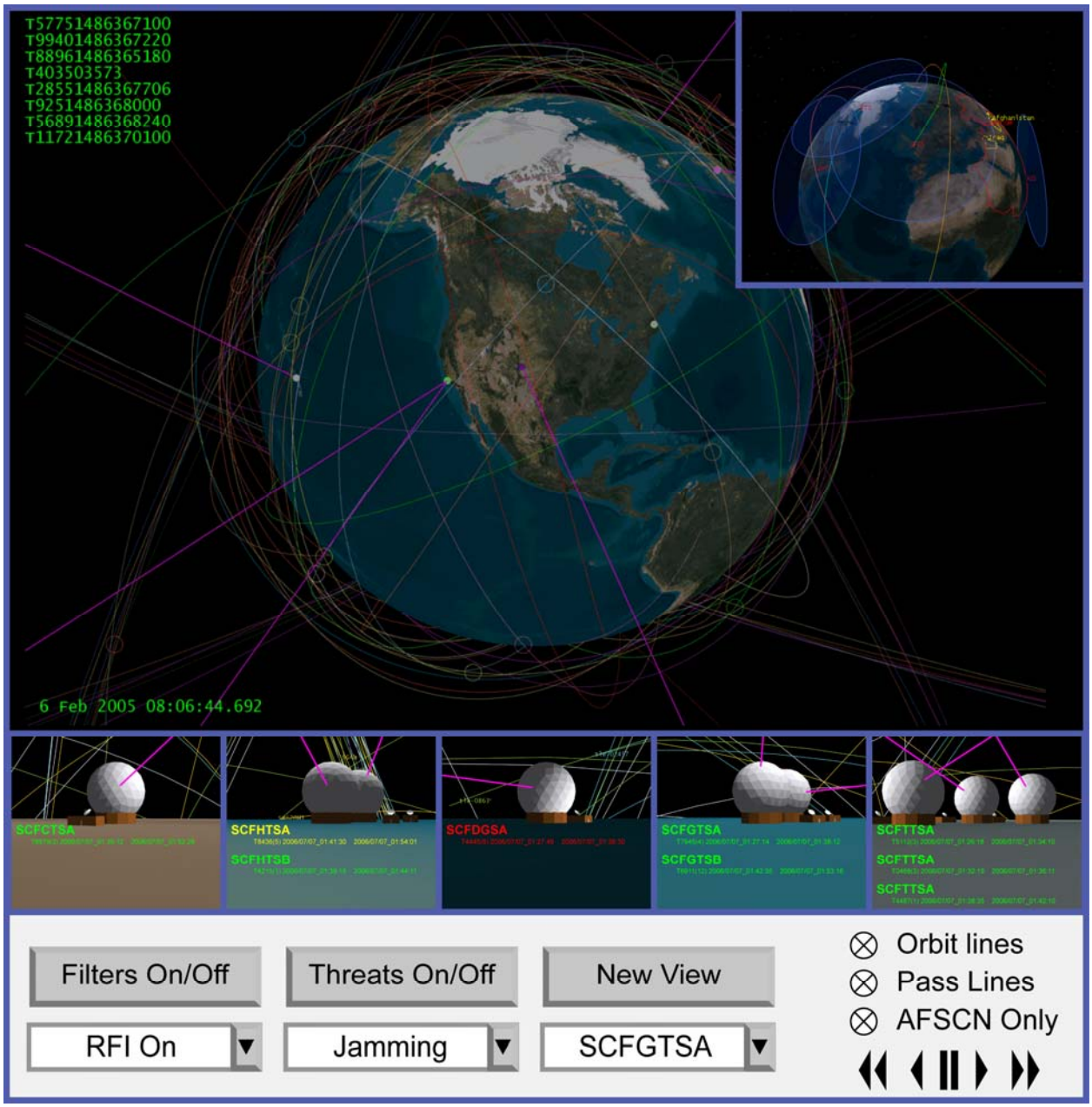

Figure 5 Notional AFSCN COP Tool

In addition, this AFSCN COP can provide time responsive SSA information into the space combat decision cycle. Horizontal integration of AFSCN data to the Wing/CC would allow more timely responsiveness to the vertical 14th AF mission taskings and better integration of the Joint Space Operations Center (JSpOC) and Cheyenne Mountain Operations Center (CMOC) indications and warnings (of natural environment or malicious threats).

5. Other Uses

An AFSCN COP tool can be utilized outside the Wing as well. It could be the template for a much larger but similar tool at higher level command centers. For instance, the JSpOC could build a large STK system with multiple space "views", importing data from and demonstrating the capabilities/readiness of the missile warning

network, space surveillance network, the AFSCN, etc. The goal is to improve COA development/planning/assessment/execution procedures faster than our adversary's decision making process.

At the 14th AF, major changes continue to occur in the operational execution of the DoD space mission. Recently USSTRATCOM announced the splitting of the Space and Global Strike missions. The 14 AF/CC now wears two hats: AFSTRAT-SP (a presenter of USAF space forces thru the JFCC-Space to USSTRATCOM), and Joint Forces Component Commander-Space (operational commander of multi-service space forces reporting directly to USSTRATCOM). The COP tool would be especially applicable in providing AFSCN SSA information to COA development in the space combat decision cycle.

The 614 OG at VAFB executes its daily operational mission through the JSpOC. Currently, two geographically separated squadrons of the 614 OG provide situational awareness to the JFCC-Space. 614 SOPS provides situation awareness for all space assets, ground-based or on-orbit. This includes sensor management of missile warning units and fused awareness of 21st, 30th, 45th, and 50th Space Wings' assets. 1 SPCS continues to operate the Space Control Center within Cheyenne Mountain. This mission is a holdover from the US Space Command days focused on space defense. The 1 SPCS mission has matured and is focused on space control and primarily space surveillance. This squadron will eventually move to Vandenberg and become a main unit of the JSpOC. The AFSCN COP could feed 50th SW SSA information directly into the JSpOC. 1 SPCS currently uses SCOPES but are transitioning to STK which would aide in the familiar look and feel and data integration.

For W13SXX, Whiskey Space Operators, these operators attend the USAF Weapons School at Nellis AFB and are the most visible space warfighters that serve in deployed locations, air operation center (AOCs) and warfighting headquarters throughout the world. The COP tool would be another training device to help visually explain the nuances of space events to non-space experienced personnel. The 3D visual display of ground traces, antenna coverage, and sensor field of view could enhance the quality of space combat COAs. The AFSCN COP tool should be a prominent aid in the deployed space operator tool kit. This is extremely important for the future when more time-responsive SSA information will be critical to feeding the space combat decision cycle.

The COP tool could be used in various NSSI training courses. In the area of Space Education and Training: Space 100 (381st Training Group) and Space 200/300 (National Security Space Institute), a space training aid could improve understanding. The AFSCN COP tool will greatly help visualization of various space events. This would be available in the classroom or in wargame scenarios. In addition to Space 100/200/300, the NSSI could use the tool in other courses, such as Space Fundamentals Course, Space Operations Course (Resident, Executive, and Mobile versions), Director of Space Forces (DIRSPACEFOR), and Space in the AOC.

At the USAF Weapons School, Space Division, the division teaches space operations officers to become W13SXX, space tactics specialists. A two fold approach could be employed at Weapons School: use the AFSCN COP tool for space event visualization in the classroom, and more importantly, teach the W13S officers how to use the AFSCN COP tool so that when they deploy, they will be able to more effectively educate senior decision makers.

6. Conclusions – Way Ahead

An AFSCN COP is initially a decision tool and not an analysis tool. Its main purpose is to visually communicate daily information so that leadership can rapidly assess the state of the network. After time, the COP will evolve as the AFSCN evolves. AFSCN users and roles will move towards a more joint based focus, and with more of the emerging counterspace mission areas, decision timelines would be streamlined to allow action and reaction cycles to be integrated. This evolution is also evident with the changes in the 50 Space Wing's new vision that is planning to move from the current WOC to an effects-based Wing Integrated Operations Center (WIOC). This WIOC will improve space capabilities integration, resource protection, and mission support via specific operation cells that avoid stovepiped single satellite operation centers. An integral part of the WIOC would be the AFSCN COP. The COP could be enhanced to incorporate real-time satellite resource status, orbital determination to allow rapid position assessment, and additional sources of data such as Cheyenne Mountain. The COP could allow drill down into specific satellite or ground resource status, but this could move the tool into the realm of an analyst vice the attended decision aid tool. To fight and win in space combat, the AFSCN must realize that it is also a component to an overall space COP that provides insight to how and what resources are used to provide space support to the Joint warfighter. An AFSCN COP is the first step in providing the essential data into the larger decision process.

There is no current documented requirement for a 50th Space Wing COP/SSA tool, but this does not mean there is not a need. With several of the main AFSCN core ground system elements going through upgrades that will

make them more net-centric and STK-centric, it seems logical to take an additional step to fuse the compatible data graphically into a COP. When minutes count in the decision cycle of a defensive or offensive counterspace engagement, critical data being communicated correctly and quickly will enable the 50 SW to win the fight every time. The data exists today, and the tools to effectively represent the data exist today. So, SXCI plans to move forward, take the initial steps, and lay the ground work for the AFSCN Common Operating Picture.

7. References

1. *Operational Requirements Document For Satellite Control System AFSPC 002-94-I/II (Revision 1)* dated 28 Feb 02