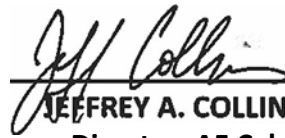# AIR FORCE CYBERWORX REPORT 17-003
Air Force Space Situational Awareness

Cynthia Brothers, Lt Col, USAF
Industry Liaison & Lead Facilitator

Douglas Howe, Lt Col,
USAF Sprint Project

JEFFREY A. COLLINS, Col, USAF
Director, AF CyberWorx

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Air Force CyberWorx™
2354 Fairchild Dr, Ste 2N300
USAF Academy, CO 80840
AFCyberWorx@usafa.edu - @AFCyberWorx - (719) 333–3399

Introduction to AF CyberWorx

CyberWorx is a dynamic organization partnering Airmen, industry, and academia to reimagine how technology might enrich and protect our nation, businesses, and lives. As a human-centric design center, we seek out unique ways to connect Air Force warfighters with current and future technology in meaningful ways. We look to transfer, license, and share promising prototypes, solutions, and knowledge with our partners to create value for both the warfighter and the economy as this is the best way toward operational advantage.

Design Thinking @AFCyberWorx

Design thinking is a common sense, human-centric problem solving method embraced by innovation leaders in industry, but often overlooked in the government sector. The CyberWorx design thinking process is a transdisciplinary method that breaks down silos of standard organizational structures. Organizations naturally form structures based on specializations to facilitate deep expertise, but these structures often impede creativity, collaboration, and knowledge sharing vital to innovation. CyberWorx deliberately reaches across specialties to bring diverse perspectives to a problem in a non-threatening environment. This evokes ideas that would otherwise be missed or stifled. The transdisciplinary design approach teases out meaningful solutions that are intuitive and desirable to Airmen.

Air Force CyberWorx offers facilitated design thinking sessions that bring stakeholders, industry and academic experts together to develop solutions to hard problems. These sessions are tailored to best meet AF needs with differing lengths based on time sensitivity and CyberWorx capacity. One method, which maximizes solution agility and the educational benefit to warfighters and industry partners, is to offer a design sprint where the week-long design project answers a challenge being worked for AF stakeholders. The goal of such a design sprint is to develop low fidelity prototypes that clearly convey the desired Airman experience and the technical and policy developments needed to bring that experience to fruition. These projects help refine the requirement by seeking the right problem to solve and finding meaningful, forward-looking solutions by exploring a wide range of possible answers to the design problem.

> The CyberWorx design thinking approach deliberately breaks through the military's hierarchical and mission silos to find hard-hitting answers.

For the Space Situational Awareness (SSA) Design Sprint, CyberWorx brought together 24 participants from numerous Air Force units, academia, and industry

partners to rethink how the Air Force might best exploit commercial, academic, and foreign SSA data to improve space outcomes.

Question Background & Participants

Modern space-capable innovations have become affordable and accessible to worldwide commercial, academic, and government sectors. As a result, Space Situational Awareness (SSA) – the ability to monitor, understand and predict natural and man-made objects in orbit around the earth – is more important and should be more easily solved than ever. Providing accurate SSA of the millions of objects orbiting the earth has been taken on largely by the US Government, but its process of tracking, analyzing and assessing data has grown so unwieldy that considering a new approach is essential to our future as a space-faring nation.

In February 2017, AFSPC/CC tasked AF CyberWorx to gather a team of government and industry partners to conduct a design sprint to lay out a fast, viable path forward for the AF to enable better experimentation and unity of efforts toward the future. Participants in the SSA Design Sprint included military and government civilians from AFSPC and AFTENCAP, academic representation from AFIT, AFRL, Georgia Tech Research Institute and USAFA, as well as industry representatives from nine different organizations (Aerospace, Applied Defense, Chandah Space Tech, Foresite, IBM, JHU/APL, KRATOS, MapR and ViaSat).

Attendees brought a broad range of insight and experience to the Sprint and approached the problem set with enthusiasm and open-mindedness. The CyberWorx Design Thinking approach aided the solution-oriented process and allowed participants to run through a variety of scenarios to achieve the best possible "prototype" for the result.

Figure 1: Participants from nine different corporations made up approximately 50% of the #AFSpaceSA Design Sprint.

Problem Statement

How might the USAF best exploit commercial, academic, and foreign data to improve space situational awareness for operational advantage? Identify ways to better use available Space Situational Awareness (SSA) data in operations to improve situational awareness of satellite movements and threats to U.S. military satellites. (Short name: #AFSpaceSA)

For now, Airmen seem trapped in industrial age processes that lag far behind the technology integration and datasharing seen in industry and even in their personal lives. CyberWorx was asked to address the challenges of incorporating non-traditional (open source, academic, and foreign) SSA data sources for space

operations use. In order to properly enter the design thinking process, the teams must assess the original problem statement and address the realm of the possible in the problem area. Through phase one of the design thinking process the teams developed a user focused problem statement that more accurately addresses the problem space. The revised problem statement below frames the remaining phases of the design sprint.

> How might we overcome classification, communications and data compatibility, legal, and segregation issues in order to ingest and exploit "Non-traditional" (non-metric and low quality metric) data, such as open sources, from other mission areas as well as commercial and foreign sources?

The diversity of the team led to a broadening of the design question and discovery of three interconnected, overarching themes for exploration.

With the massive amounts of SSA data available, it becomes even more essential that the USAF pave a path to extract the usable data quickly and accurately assess risk in order to take decisive action toward a potential threat. The SSA sprint germinated a foundational statement that gets to the core of the solution, "**Individuals closest to the problem, armed with unprecedented levels of insight, offer the best ability to decide and act decisively.**"

The question then becomes, how can we arm the right people with such unprecedented levels of insight?

Theme Discovery

The early stages of a design sprint and the design thinking methodology call for analyses of the users' work environment, their desires, and their dislikes to inform and revise the initial problem statement. As part of the design process, the participants spent time looking into the various facets of the challenge to ensure they understood the challenge and were working on solving the right problem. This included interviews with functional managers and operators.

 Over the course of the Sprint, participants discussed, assessed, brainstormed, and refined user-focused ideas streamlining the AF's SSA challenges. The 20 participants were split into four teams, each encompassing diverse backgrounds across the AF and industry.

This phase also included interviews with industry and academic partners as well as guest speakers from a variety of non-cyber backgrounds to tease out interesting ideas and possibilities. These experiences and views from science and technology,

humanities, and business specialties provided an unparalleled view of the problem that could not be achieved with a homogeneous group.

Leveraging this unique group, we discovered a much broader problem set that not only captured the challenges currently associated with the IST pipeline, but also identified five overarching themes:

A key component to address a challenge from a user perspective is to identify the common themes that speak directly to how the user utilizes SSA data and tools. During day one, the teams identified the following themes that must be addressed in order to adequately rationalize the incorporation of non-traditional SSA data sources:

Figure 2: Designers ideate 100's if not 1000's of ways to improve the lives of Airmen and other partners involved in SSA.

- Transition to Commercial/NGO for Accessibility and Integrity

- Centralize SSA for Usability

- Authorize DevOps model for Flexibility

These themes formed the foundation of an ecosphere capable of providing greater data fidelity, standardized formats, and agile operations.

Design Themes and Personas

Progressing through the design process required teams to analyze and organize information in a manner that effectively communicated the message through the development of Personas - archetypal descriptions of user behavior patterns into representative profiles, to humanize the design focus and test scenarios. The following story illustrates the teams' design focus.

Sebastian, an amateur astronomer living somewhere in a foreign country will illustrate the problem.

One evening while scanning the night skies with his telescope and tracking the usual debris and satellites, Sebastian noted something unusual. A satellite with the appearance of a fuzzy blob, characteristic of uncontrolled satellites, suddenly became slightly less fuzzy. This satellite, floating in orbit around the earth, suddenly appeared to move with intentional exertion; it was being controlled by someone, somewhere.

As was the custom, Sebastian quickly went to the state-sponsored, USAF SSA Twitter account to share what he observed in the open environment. The NSDC

(National Space Defense Center) quickly responds since it openly shares and is actively engaged with the public on SSA.

Others amateur astronomers note the Twitter feed and look at the change in the satellite's status as well. They know the AFSPC has asked for a chain of custody so they organize themselves by saying, "I'll look at this object and track it. You watch that one and track it too." Their own intrinsic motivation compels them to participate and assist in this capacity and maintain the chain of custody.

An operator/analyst at a non-secret squirrel organization is actively observing the situation on Twitter. She relays the information to her commander who determines that an inspection satellite should be moved onto the scene to assess the situation. The inspection satellite takes pictures of the satellite in question and it is discovered that there is, in fact, a hostile payload. These pictures are then posted publicly for all to see. Individuals like Sebastian feel they've contributed to the fidelity and transparency of the field's greater knowledge base. The enemy has witnessed the collaborative effort of this exercise and recognizes the difficulty in trying to win over it.

From this persona, the teams were able to extrapolate the meaningful themes providing critical insight into best answering the design question from the user perspective.

Recommendations

1. Big Innovative Non-Governmental Organizations (BINGOs)

The most significant effort the USAF can make to move forward from this point is to encourage the creation of a BINGO to take the lead in performing conjunction assessments (CA) / safety of flight management as a normal operation for all resident space objects (RSO) and focus exclusively on DoD/USG assets. The BINGO should establish a blanket IDIQ-like contract with SSA competitors to allow industry to provide SSA data into BINGO. BINGO's architecture is comprised of a high performance cloud computing environment that allows them to ingest data from many providers. BINGO is able to use this data to take over commercial, civil, and scientific needs to manage space debris and missions, ensuring safe access to space. SSA competitors are incentivized to grow and maintain their networks.

Figure 3: The formation of BINGOs will change the paradigm and allow faster, innovative and unparalleled capabilities for the nation.

By relinquishing this responsibility, this paradigm busting

recommendation will allow the AF to dedicate focus on DoD/USG assets. Transitioning these services away from the AF allows the NGOs to deliver innovative and potentially unparalleled capability to the nation.

2. Relinquish Conjunction Assessments and Safety of Flight

The critical, first step is establishing a date when the US government will relinquish responsibility and get out of the business of providing this CA/safety of flight information. This will ignite the transition process and spark interest by BINGOs to perform the tasks for a fee. By no means should this decision be taken lightly. Transition will require risk tolerance outside of what has become the norm in the AF. A robust transition plan will be an absolute necessity in order to set the initial relinquishment date and execute the steps necessary to insure safety of flight and assess the paradigm shift.

3. Cost Model

No good idea can be addressed without the consideration of cost. During the earliest stages, the AF must initiate a process to determine a potential cost model for data acquisition and how the government might compensate a BINGO for data access. This model might take into account uniqueness of data, accuracy and timeliness. Non-metric data might also provide some valuation to incentivize BINGO's to obtain and provide value-added observational assessments.

4. Opening the Aperture through Policy Review

In order to enhance SSA operations a complete review of policy governing observing and reporting of RSOs must be conducted. Current policy precludes the aerospace industry, and even some DoD organizations, from observing and tracking specific space objects/vehicles that are not acknowledged by government policy. In contrast, the existing policy does not eliminate RSO reporting by amateurs and other nations.

In fact, other on-line databases and organizations provide updates and reports on newly discovered objects, especially non-US organizations. The following steps identify opportunities to open the aperture for available data sets while minimizing the potential impact related to the release of this information:

Figure 4: Innovative policy changes are essential for breaking down stovepipes and creating a new model for SSA.

- Remove meta-data from the space-track.org web site that currently defines nation of origin, order of object deployment, date of launch, object size (gross), etc.
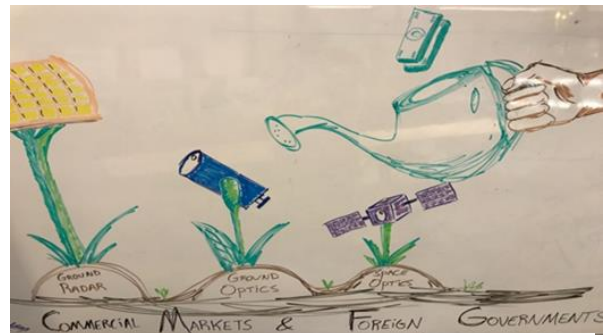
- Establish generalized identification numbers that do not correspond to specific events or other actions.

- Utilize the new detections originating from the operation of the initial space fence as a means to obfuscate the information further.

Taking these steps improves transparency and works to the US' advantage. If everyone knows where everything is located – regardless of whether they actually know the mission of the object – then changes in behavior (maneuver detection, orientation (via light curves), etc.) are more likely to be detected by the observing diverse group (qualified, non-qualified, and foreign partners). This increase in awareness has the potential to restrict aggressive behavior by non-compliant nation-states.

5. Data Access and Agility

Once the BINGO/s are established and fully capable of providing CA/safety of flight, they will be the collector of data from any and all potential providers, whether academic, commercial, government, or hobbyist. In order to facilitate the data integration the AF should define initial interfaces for the acceptable transfer of information from BINGO's. This step eliminates the need for the government to sustain and modify, on a continuing basis, systems such as the non-traditional data pre-processor (NDPP). These interfaces enable the BINGOs to develop software and systems based upon commercial best practices that tend to deliver new capabilities on a more frequent cycle and will be unconstrained by existing DoD program development guidelines and standards. This defined interface coupled

Figure 5: USAF facilitates the growth and success of the BINGO, nurturing rather than owning the processes, to enable better, mature public-private partnership.

with agile access to multiple BINGOs protects the government from stove-piped solutions in the event that a particular organization's product is deemed defective. Under this scenario the government has flexible access to another BINGO to obtain the required data to meet mission timelines.

By establishing the BINGOs, DoD will no longer need to define, develop, and execute an acquisition plan (Request For Proposal (RFP) process) to obtain innovative data processing technologies. Instead, the government can negate the rigors of the acquisition process through the established relationships where data is purchased with the expectation of accuracy. By doing so, the AF is able to meet mission requirements by decreasing acquisition complexity and execution time, while increasing the potential for success. Through this construct the USG would not task

the BINGO's sensors but would incentivize the BINGO to generate new and unique information, providing the impetus to deploy a diverse set of sensing systems in a geographically distributed fashion.

6. Data Lake

Additionally, USG should establish a government "data lake", supporting the collection and consolidation of all source data, at all classification levels. This can be reposed in a fashion that facilitates the exploitation of the information by the DoD to address USG asset flight safety and the ability to conduct space control operations. They must allow for data transfers to move through one-way guards to eliminate the potential for classified data leaks.

7. DevOps Model

Finally, the AF should move to a DevOps approach to managing C2 / analysis systems with the use of 3400 funds. DevOps combines multiple skill sets and Subject Matter Experts into a cohesive team (including operators, analysts, developers, testers, business, legal, etc.). The unified team operates under a construct where the team builds it, maintains it, upgrades it, operates it, etc. This will facilitate the movement of ideas into testable tools. Tools that aren't yet deployable are rolled back from the operational floor, as required. Executing a DevOps model expedites the adoption of desperately needed technology advancement to the operations floor.

Figure 6: DevOps quickly moves ideas and concepts to tangible, testable capabilities.

Summary of Benefits

The proposal presented in this report corrects many underlying issues the AF faces when ingesting space situational awareness data. These issues were raised by participants in the design spring and by key stakeholders. It is important to note many of these recommendations carry forward the idea of the AF focusing on the warfighting mission rather than traditional support roles and may provide further support for other activities taking place throughout the AF.

Space is a contested and congested environment where more and more US and foreign government entities are in need of high fidelity, agile data. In a domain that continues to grow in importance it is critical for the AF to accept the unconstrained capabilities commercial industry adds as a data curator and provider. Current AF policies and the acquisition process inhibit the ability to ingest the highest fidelity data and acquire agile SSA tools.

The stand-up of BINGOs will bust the current SSA paradigms allowing the AF unprecedented access to SSA data. These non-governmental entities provide CA and status of health data to the AF as well as commercial entities. By doing so, non-traditional data acquisition is freed from stringent AF SSA policy. Most importantly, this concept requires the AF to stop providing data for free and allows the AF to provide greater focus on DoD/USG mission assets. The relinquishing of these duties will not be easy as it will require the AF to adjust risk tolerances and overall hands on control.

Facilitating this paradigm change is the need to reassess the policy governing the acknowledgement of certain space assets. In order to insure the best SSA data possible the AF must adjust policy to allow greater disclosure of government assets to ensure traditional and non-traditional SSA data sources have a complete picture RSOs. Failure to open the aperture inhibits the ability of non-traditional data sources to provide the most accurate data to BINGOs.

Data access and agility play an integral role in enhancing SSA data sets. Standardization is the key. The AF needs to define initial interfaces allowing the integration of data sets from the BINGOs. In addition, this allows the BINGOs to use commercial best practices to deliver new capabilities on a more frequent cycle. In doing so, the AF will no longer spend critical resources maintaining SSA systems like the NDPP.

To reach full agility, the AF must move to a DevOps model with the use of 3400 funds. Today's cyber domain is far more agile than current government funding cycles. The AF must adopt ways to mirror commercial sectors where development and operations occur in a seamless environment providing critical agile enhancements to mission systems.

Summary: Ops Advantages + Fast Track

The CyberWorx "three slide summary" section is designed to help you consider the recommendations in this report by weighing the operational improvements proposed against the current cyber challenges and opportunities we face as an Air Force.

#AFSpaceSA:
Advancement Impacts on Operational Advantages

AF | CYBERWORX

Proposed Advancement: Cyber Challenge / Opportunity	#1	#2	#3
Acceleration of cyber industry (blue) and adversary (red) capabilities	High	High	High
Acceleration of algorithmic warfare from automation & human-machine teaming	Med	Med	High
Increasing cyber integration into AF operations at all levels of war	Low	High	High
Increasing cyber risks to Air Force and adversary core mission threads	High	High	High
Increasing mobility and sophistication of cyber workforce	Med	Med	High

Advance
1. Commercial/NGO Transition
2. Centralized SSA
3. Dev/Ops Authority

Impact
- High
- Med
- Low

In deciding what to do, the decision to do nothing is a decision and brings its own risks. Thus, the "fast track" slide spells out an easy set of actions to take at minimum to start trying to improve and to put the Air Force on a path of discovery in overcoming the challenges that drove this design project.

AF | CYBERWORX — **A fast track ahead**

- **Market research identifying entities for BINGOs* (#1)**
- **Relinquish conjunction assessments (CA) and safety of flight (SoF) management to Industry (#1)**
  - **Establish end date for current service structure**
  - **Establish transition plan/roadmap**
  - **Stop providing the "free" service from the AF**
- **Clarify policy regarding ops & reporting of Resident Space Objects (RSOs) by civilian/non-government entities (#2)**
- **Move to DevOps approach to allow Operators to ID and develop rapid operational solutions using 3400 funds (#3)**

*BINGO = Big Innovative Non-Governmental Org

Integrity - Service - Excellence   11

We recognize we live in a resource-constrained world. Each advance proposed in this report is graphed below: The graph compares the advance's relative impact on the ability of the Air Force to maintain information and decision dominance (x-axis) against the difficulty (e.g., expenditure of time/treasure, cultural evolution, policy

change) needed to implement that advance (y-axis). Cultural changes, like some of those proposed in this report, are not easy, but they are possible and needed for success in our digital, cyber-contested world.