The Combined Aerospace Operations Center (CAOC) of the Future

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Abstract

The "art of commanding aerospace power lies in integrating systems to produce the exact effects the nation needs."[1] Currently, information overload prevents C2 warriors from making operational decisions with precision and effect. The objective is to correct this and dominate the battlespace by making smarter decisions faster. Intelligent decision-making will be enabled by awareness when and where it is needed, via an operationally superior information enterprise. This paper discusses a new Air Force Research Laboratory's Information Directorate initiative that combines prior work in areas such as Effects Based Operations, information fusion, decision support, mission training and enterprise defense. These efforts lay the groundwork so a Commander will receive the right information at the right time. This information will be displayed in a way to allow the Commander to do the right things, at the right time and in the right way. This paper discusses five applications built on JBI services that will fuse collected information to drive an "effects based" operational solution along with the research and development efforts required to transform today's AOC into tomorrow's CAOC. Ultimately, the objective being to develop and field a capability using the Command and Control (C2) framework of Monitor, Assess, Plan and Execute.

[1] *Global Vigilance, Reach & Power America's Air Force Vision 2020.*

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Introduction

Today's Aerospace Operations Center (AOC) is the nerve center in which Command and Control (C2) for the air war is accomplished. The product of the AOC is what's known as the Air Tasking Order (ATO): a detailed prioritized target list, which matches a particular weapons platform and munition package to a particular target or set of targets. Figure 1 illustrates the current ATO cycle and Table 1 lists some of the major milestones in creating an ATO. The current AOC has a very large footprint and consists of multiple heterogeneous systems providing information and planning tools on multiple workstations. Combining the manpower requirements (over 800 warfighters) with the current level of computer and information systems causes a full-up AOC too not only is an easy target, but to be a location of information overload contributing to the "fog of war".

However, for this to be effective, a new paradigm needs to be considered to bring the AOC into the 21st Century. At the heart of this new AOC is controlling the Joint Battlespace Infosphere (conceptualized in Figure 2). This is where the prototype of the new Combined Aerospace Operations Center (CAOC) comes into play, currently called the CAOC-X. The Combined AOC (CAOC) is that bridge that will transition to the future AOC. The CAOC takes into account that the Air Force of today does not fight the battles alone, but fights the battles with a strong bond with our coalition partners. The CAOC takes into account the coalition aspect of conducting an air war and merges together all aspects of warfare (e.g., air, space, and cyberspace) in order for the Air Force to achieve full spectrum dominance of any engagement.

The Joint Battlespace Infosphere (JBI) is a globally interoperable information "space," responsible for aggregating, integrating, fusing, and intelligently disseminating all relevant battlespace knowledge to support effective decision-making at all echelons of command. The JBI is a seamlessly accessible combat information infrastructure linking all sensors, systems, and users in a Joint Task Force to achieve an informational unity of effort. It is intended to provide a means to integrate legacy and emerging C2ISR resources as well as serve as a platform for rapid and cost-effective insertion of new tools. The end product of the JBI is information that is of "Decision-Quality"; that is, the right information, within the proper time constraints, in the appropriate formats, to make the most operationally effective decisions. The JBI is distinguished by four key concepts: (1) information exchange incorporating the latest advances in e-business technology in the area of **publish/subscribe** mechanisms; (2) **transforming** data into information and knowledge via "fuselets," (small/lightweight programs that refine or fuse information in a relatively simple way); (3) **distributed collaboration** enabled by information objects that are shared and easily updated; and (4) the ability to rapidly incorporate new/diverse units into a JTF's infosphere via a mechanism the USAF Scientific Advisory Board (SAB) termed **Force Templates**. The JBI allows the combined forces to dominate the battlespace by making smarter decisions, faster. Decision-making will be enabled by awareness when and where it is needed, via an operationally superior information enterprise. Dealing with situations and applying knowledge to make

decisions in near real-time will be demanding, as information overload increases and information warfare (e.g. cyberwarfare) becomes more common.

The future points to distributed staffs performing the C2 function in a less hierarchical organization, with greater execution autonomy enabled by horizontal levels of knowledge. This will require a new conceptualization of command relationships and new, dynamic rules of engagement. The objective will be to perform the entire C2 function more efficiently than the hostile force (getting inside their C2 planning function or Observe/Orient/Decide/Act -- OODA loop) while integrating information and systems to produce the exact effects required by the battlespace commander.

Figure 1: Air Operations Planning Cycle

Figure 2: Joint Battlespace Infosphere

Table 1 : ATO "X" Generation Cycle

Time	Duration	Event
DAY-1: 48 Hours Prior to ATO "X" Execution		
0800	120mins	Day GAT Covers near-term guidance, apportionment, and targeting
		- Weather forecast, threat outlook, and ground picture for ATO "X"
		- Review JFC targeting guidance provided by previous day's JTCB
		- JFACC targeting objectives/prioritized tasks for ATO "X"
		- Review progress toward achieving current phase objectives
		- In operational terms, review JFACC air strategy for ATO "X"
		-- Key objectives by mission and geographic area (CA, AI, CAS, SA)
		-- Sorties available to JFACC (by component)
		-- Sortie allocation recommendation for ATO "X"
		-- JFACC signs Apportionment Recommendation letter
		- Proposed JFACC Guidance Letter presented for JFACC approval
		-- ATO "X" planning guidance (2-days out)
		-- Targeting guidance (3-days and beyond)
		- Strategy Division covers long-range air strategy and targeting priorities
		-- Recommended JFACC inputs to JTCB (3-days out)
1000	60mins	Strategy Team Meeting
		- Discuss/refine air strategy (3-4 days out)
		- Refine proposed JFACC Targeting Priorities (3-4 days out)
1100	120mins	- Component fixed target nominations due to JTWG
41-Hours Prior to ATO "X" Execution **Produce Proposed Target Nominations List (TNL) to Present to the JGAT**		
1300	120mins	JTWG - Chaired by Chief, Targets Team, and composed of component targeting representatives - Prioritize component target nominations based on JFC targeting guidance and JFACC prioritized tasks
1500	120mins	JGAT Meeting - Chaired by Deputy Director, Combat Plans -- Composed of O-4/O-5 level component planners/targeteers -- JTWG presents proposed TNL and Strategy Team presents long-range air strategy for discussion/refinement prior to presenting to JFACC for approval
1700	120mins	JFACC Afternoon Update - Combat Operations and Intelligence provide: -- An update on today's air war -- Weather forecast, threat outlook, and ground picture fir next 2-3 days -- JGAT presents ATO "X" TNL for JFACC approval -- Strategy Division presents "draft" air strategy/targeting priorities for 3-4 days out
1900	60mins	Component mobile target nominations due - 33 hrs prior to ATO "X"
2000	240mins	Night GAT develops ATO "X" Master Air Attack Plan (MAAP)
2200	720mins	ATO Development begins MAAP inputs into Automated Computer Systems
Day – 2: 24-hrours prior to ATO "X" Execution		
0600	60mins	All MAAP inputs into Automated Computer Systems
0700	480mins	JFACC Morning Update - 21 hours prior to ATO "X" - Combat Operations and Intelligence cover yesterday's results and today's plan - Night GAT briefs tomorrow's Master Attack Plan for JFACC approval
1400	240mins	All support asset inputs into Automated Computer Systems for final QC
1800		Transmit ATO "X" - Minimum of 10-hrs prior to ATO "X" Execution

CAOC of the Future

The resultant Combined Air Operations Center (CAOC) is envisioned to be comprised of five primary components resting on the JBI:

- **Joint Battlespace Infosphere.** Information sharing to enable the above capabilities will be provided by the JBI. One of the principles of the JBI is that of an "enabling architecture", that is, one that can grow in a disciplined way to accommodate changes of operational requirements and fully exploit evolving technology and have a low "cost of entry" for both developers and users. This effort will refine and test the JBI constructs (e.g., publish, subscribe, transform, query and control) being developed today in a mature warfighting enterprise (see Figure 3). For example, it will develop the fusion architecture for a consistent battlespace picture.

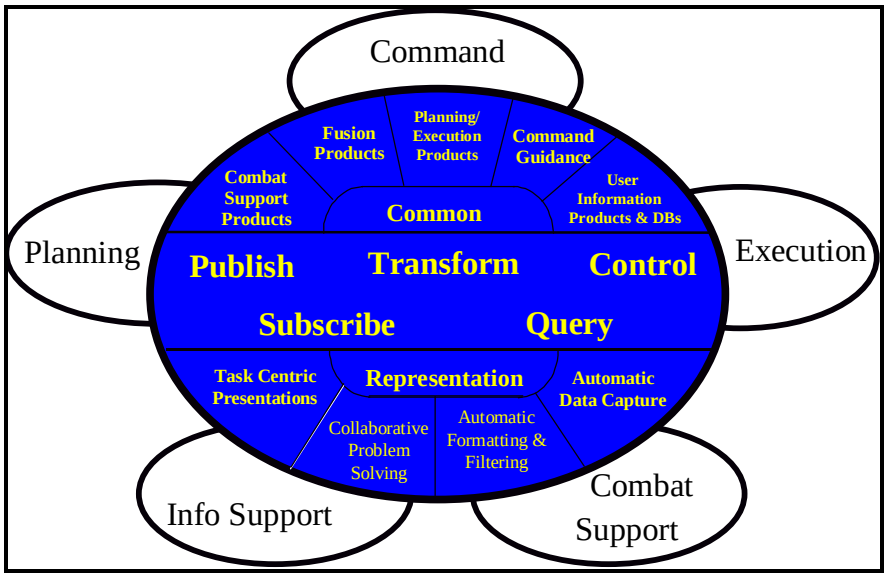

Figure 3: Elements of the Joint Battlespace Infosphere

- **Dynamic Information Fusion.** This component will develop the smart fusion manager and the tailored multi-INT fusion processes to generate an overall, consistent operational picture (see Figure 4). This fusion engine combine data from multiple sources to provide in time, tailored, relevant and actionable/decision quality information. Information fusion will provide multi-level understanding of the operational environment: from unit position in hours at the kilometer level to time-sensitive targets (TSTs) in minutes/seconds at the meter level). This all-source information is comprised of Intelligence, Surveillance and Reconnaissance (ISR) platform *data*, logistics, operations, socio-economic factors and coalition/neutral forces status for an operational area. The first step is the development of a consistent battlespace picture (CBP). The CBP will result from combining data from multiple intelligence sources to produce tailored, relevant, and consistent information. This information fusion will provide a multi-level understanding of the battlespace from

smart contextual fusing and understanding of information by providing access to complete battlespace information.

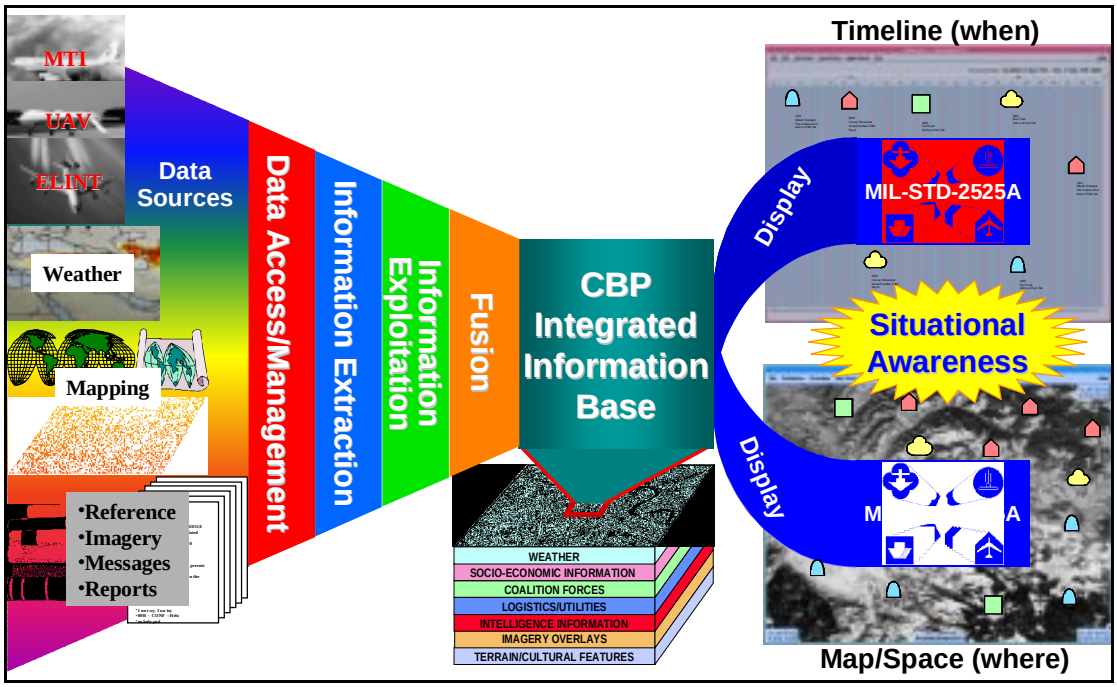

Figure 4: ISR Information

- **Decision Support and Mission Training.** This component will improve command and control (C2) and provide knowledge-enabled decision-making through innovative combat effectiveness visualizations and decision support and will provide mission rehearsal training for C2 warriors, working as individual and in intra/inter teams (concept depicted in Figure 5). A complete systems approach, which explicitly addresses the factors that (1) facilitate human capabilities in perception, cognition, and decision-making; (2) recognize human limitations in performance in complex, information intensive environments; and (3) improve human learning, cognition, and performance in these areas, will be applied. AOC decision-makers will be provided with an integrated suite of hardware and software tools to improve their ability to collaborate, plan, decide, and assess the effectiveness of global and theater operations with respect to the CINC's objectives and intent in the overall conduct of the campaign.

Figure 5: Advanced Visualization

- **Enterprise Defense**. Information integrity will be more difficult to maintain as time goes on. This initiative will incorporate and test Enterprise Defense capabilities to protect against corruption, exploitation, and destruction of friendly information systems, and ensure confidentiality, integrity, and availability of systems, as well as authentication of users and transactions (see Figure 6). It integrates actions (offensive, defensive, and mitigation) to ensure friendly awareness and the uninterrupted flow of information for weapons employment and sustainment; and integrates actions (offensive and defensive) to deny the adversary knowledge of friendly information, signatures and intent.

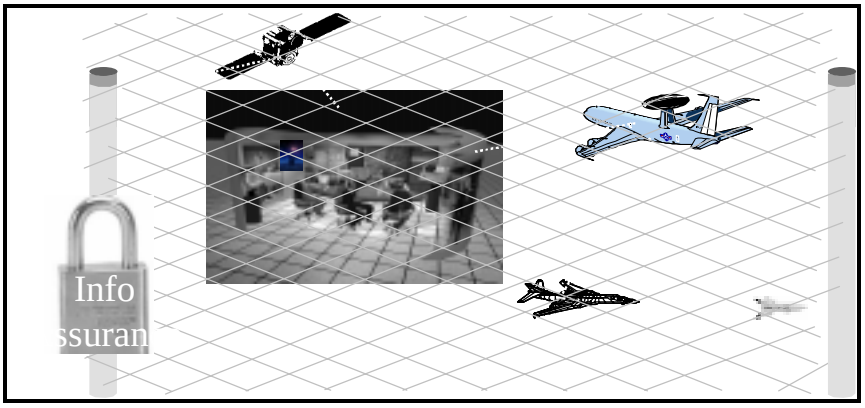

Figure 6: Enterprise Defense

- **Effects Based Operations.** The consistent battlespace picture will drive an end-to-end capability for effects-based planning, execution and assessment. By effects based we mean that we will provide the capability for the commander to build missions based on desired *effect* rather than simply planning missions against a target list. EBO is essentially a "smarter" application of the OODA Loop (see Figure 7) to Monitor/Assess/Plan/Execute military operations. For example, bombing a power grid to a facility may produce the desired effect of putting a manufacturing facility out of commission, rather than bombing the manufacturing facility which could result in long term undesirable political and economic repercussions. Operational planners

develop and assess, in real time, various courses of actions (COAs) that are based upon the Commander's intent and the Aerospace Component Picture. This program will provide the temporal reasoning capabilities provided by a Campaign Assessment Tool (CAT) and provide an apriori assessment regarding the likelihood that COAs match user-selected success criteria, including the effects to be caused and to be sensed for appraising campaign success.

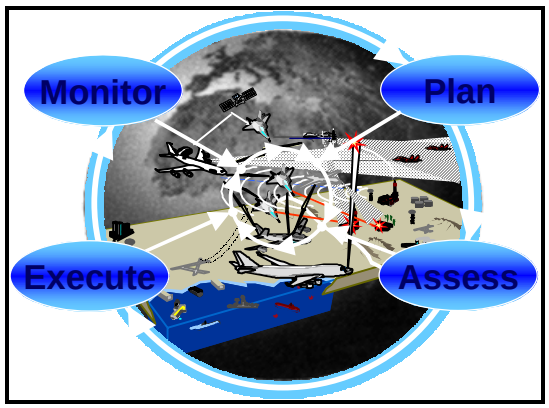

Figure 7: OODA Loop

CAOC-X

In the near-term, the ACC Commander, General John P. Jumper, has initiated action to build an experimental CAOC (CAOC-X) that will provide a place for rapid integration and baselining of software and systems. It focuses on "web enabling" all C2 applications and developing user friendly force and unit level C2 systems, as well as producing a "cockpit " to provide decision quality information to the Joint Forces Air Component Commander (JFACC). Information overload prevents scores of operational personnel from making decisions with precision and effect. The CAOC-X is just the first step towards the end-state, namely the CAOC of the future. The CAOC-X will the place where the AF can investigate operational applications of technology, focusing on the critical need to accelerate decision-makers' understanding of events and to improve their ability to collaborate, plan, and decide with all essential distributed parties regarding appropriate courses of action during multiple, concurrent theater operations, and assess the effectiveness of those operations with respect to the objectives and intent in the overall conduct of the campaign.

Currently, within the Aerospace Command and Control (C2) Intelligence Surveillance and Reconnaissance (ISR) Center (AC2ISRC), they are utilizing the spiral development model to develop the AOC as an integrated weapon system. They have formed various spiral development integrated product teams (SDIPTs), namely C2 Ops, Agile Combat Support (ACS), ISR and Communications & Infrastructure (C&I). These spiral development IPTs support the AOC SDIPT which falls under the Spiral Development Task Force (SDTF). The CAOC-X is the testbed where new technologies can be demonstrated and is directed by the AOC SDIPT.

Next Generation CAOC

Given the fast pace of technologies today, especially in the wireless and cognitive engineering, it is envisioned that the CAOC of the future will evolve into a self-forming "entity" that can be tailored in real-time to allow the battlespace commander to "sense and smell" the entire battlespace.

Imagine that once the Air Expositional Force (AEF) has orders to deploy to a "hot spot" the members of the CAOC take their laptops and palm pilots to the waiting aircraft. Once airborne, they access the global AOC database and start downloading information and data. They start planning for the air campaign (refer to Table 1 for the individual functions that have to be performed). They can "beam" information to/from individual members sitting on the airplane simply by pointing their palm pilots at each other. Once on the ground, they enter the CAOC, which at this time is just a series of workspaces. As they turn-on their laptops, the AOC starts to "form" by using JINI technologies to connect to the network via the wireless LAN. Once connected to the network, the CAOC members upload the information they worked on during their trip over to the area. At this point there is a draft ATO ready for execution. If any member of the CAOC has to go to a remote area, they just take their palm pilot that has all the necessary software packages and continues the CAOC functions. Once back to the CAOC, the member uploads the information simply by "beaming" it into the wireless LAN. Additionally, whenever something has to be printer, all the member has to do is "beam" the info directly to the nearest printer.

This scenario illustrates what can be accomplished in the near term (next 3 years) to create a CAOC that has no wires connecting the various computers, terminals, keyboards and printers. This alone would save over six months of setup time by the logistics personnel that have to set up a CAOC. The self-forming part of the CAOC utilizes JINI technology that is commercially available today.

Technologies Required for the CAOC of the Future

The CAOC of the future must be an intelligent "entity" that is highly flexible, rapidly scalable and incorporate the smallest footprint possible. The goal is to provide the Battlespace Commander with the capability to superbly win all future wars. To accomplish this goal the following enabling technologies are pertinent:

a. **Decision Tools:** Battle Management Decision Aids, Dynamic Effects Based Operations (EBO), Autonomous Intelligent Controls, Deployment Planning Tools, Secure/Collaborative/Distributed Logistics Management Tools, speech recognition

b. **Cognitive Engineering:** Artificial Intelligence, Advanced Human Systems and Cognitive Skills Integration, Cognitive Performance Modeling, Human-Machine Interaction, Modeling and Simulations Technologies

c. **Computing:** Advanced Biometrics, Advanced Sensors, High Density Retrieval, High Density Storage, High Performance Computing (HPC), Human Interaction in Complex Automated Systems, Intelligent Agents, Target Recognition, Intelligent Collaborative Environment (ICE), Signal Processing, Power Generation, Power Storage, Micro-miniaturization and Nanotechnology, Reductions in Physical, Perceptual and Cognitive Workload

d. **Visualization:** Advanced 3-D and 4-D displays, total integration of sound with visualization, virtual reality technologies

e. **Modeling and Simulations:** Advanced model abstractions, distributed collaboration tools

Summary

This paper discusses the evolution of the existing AOC into the CAOC. In the near-term there is the prototype (CAOC-X) where new systems can be introduced and evaluated against the entire C2 process. The CAOC is the weapon system that combined aerospace forces will perform aerospace C2 well into the 21st Century. The Information Directorate of the AF Research Laboratory has provided a bundled set of R&D initiatives that support the AC2ISRC's CONOPS and operational architecture for 2010 and beyond. These initiatives are the joint battlespace infosphere, dynamic information fusion, decision support and training, enterprise defense and effects based operations. These initiatives will guide the systems and technical development of the transition from the AOC to the CAOC using the spiral development model approach. Technologies from DARPA's Command Post of the Future (CPoF) program and the Navy's Commander-in-Chief 21st Century (CINC-21) Advanced Concept Technology Demonstration (ACTD) will also be leveraged to the fullest extent as well as other DoD and service programs relevant to command and control.

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