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Network-Centric Warfare in Operation Iraqi Freedom: The Western Theater

Topics:

Lessons Learned
C2 Concepts and Organizations
Cognitive Domain Issues
Social Domain Issues
C2 Analysis
Policy
Network-Centric Metrics

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Abstract

The Western Theater in Operation Iraqi Freedom was the most networked battlespace in history, creating combat power through network-centric systems, DOTMLPF, and organizational culture. During phase one, Coalition forces accomplished all of their assigned missions, including prevention of all Scud launches while operating at a 500:1 ground-force disadvantage. The integration of existing C2 systems allowed more rapid response to time-sensitive targets while avoiding any air-to-ground fratricide during hundreds of engagements.

At the request of the Office of Force Transformation a MITRE team conducted in-depth interviews with war fighters throughout the kill chain and C2. This led to further investigation of particular systems, associated TTPs, and organizations. The loose coupling of networks that provided situational awareness from ground-to-air and air-to-ground enabled the coordination necessary to support lightly equipped ground forces. Enhanced communications infrastructure and collaborative tools enabled robust C2 networking that expanded both reach and richness of the information. The MITRE case study illuminates the road ahead for the interoperability of C2 systems. The success of the Western Theater and future conflicts depends on the successful integration of technology across disparate systems combined with the willingness of organizations to gain experience and adapt both culturally and organizationally.

1. Introduction: Western Iraq Case Study

At the request of the Office of Force Transformation (OFT), The MITRE Corporation conducted a case study of network-centric warfare (NCW) in the Western Theater during Operation Iraqi Freedom (OIF). The study had four objectives.

1. Determine what combat operations in the Western Theater of OIF applied NCW tenets.
2. Investigate how and why these manifestations of NCW were developed.
3. Assess the impact of these NCW operations on combat effectiveness.
4. Recommend future opportunities for NCW development.

The study was based on the hypothesis that the application of the NCW tenets shown in Figure 1 had a measurable, statistically significant positive impact on combat effectiveness. The study approach entailed a literature review, interviews with people performing different combat roles, and subsequent analysis. The interviews produced over 2,000 pages of transcripts rich in qualitative and experiential evidence, representing the views of air and ground personnel as well as decision authorities, sensor specialists, force applicators, and network enablers. These were incorporated in the study to paint as complete and unbiased a picture as possible.

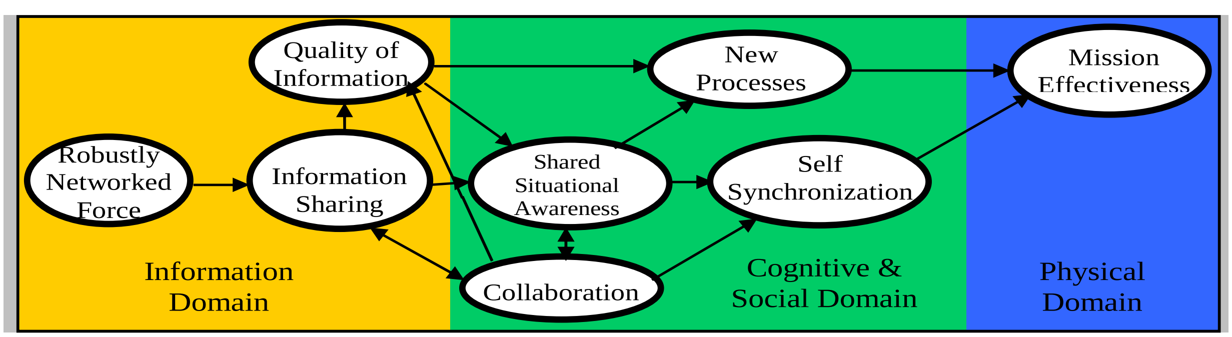

Figure 1 NCW Tenets

2. Western Iraq Theater

The Western Theater was one of three major theaters comprising OIF. It covered roughly 36,500 square miles and was divided into four areas of operation (AO). Like the Northern Theater, the battlefield involved both the Air Force and Special Operations Forces (SOF), unlike the Army- and Marine-heavy Southern Theater.

The Western Theater Coalition force was unique in several respects. First, ground troops consisted primarily of a relatively small SOF force, backed up by massive and impressively networked airpower, although there were a limited number of active Army personnel in the theater. The information flow between them was vital in coordinating efforts and effects from these units, particularly the missile artillery units. Second, the Combined Forces Air Component Command (CFACC) was the supported command rather than a support*ing* command – the first time this occurred in a major theater of war. For the Air Force the Western Theater was almost totally a Guard and Reserve operation. The 410 Air Expeditionary Wing (AEW) served as the main C2 headquarters in direct support of the SOF ground forces. Third, Western Iraq represented the first combat employment of a blended wing:[1] The 410 AEW supported over 250 aircrews flying 75 combat aircraft from nine different squadrons (6 different airframes) from two coalition countries at six different bases in three countries.

2.1.1. Time-Sensitive and Dynamic Targets

The engagement of fleeting targets requires an extraordinarily timely exchange of information and the establishment of TTPs that allow this exchange. A primary concern for the Coalition was to keep Israel out of the war by locating and neutralizing Scud missiles, and Scud missile launch facilities comprised a majority of the TSTs in the Western Theater, and Scud missile launch facilities comprised a majority of the time-sensitive targets (TSTs) in the Western Theater.

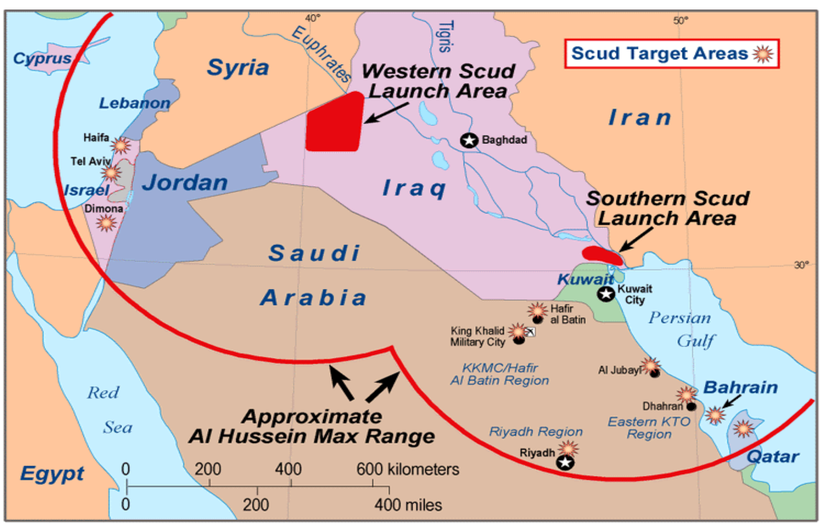

Figure 2 provides an overview of the theaters of war and the effective range of the Al Hussein missiles, and shows that the largest Scud launch area was in the Western Theater. The 410th AEW had the mission to use its F-16Cs and A-10s in direct support of SOF pursuing these and other mobile targets. Additional missions included destruction of enemy air defenses and search and rescue.

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[1] Air Wing composed of both Active and Reserve units

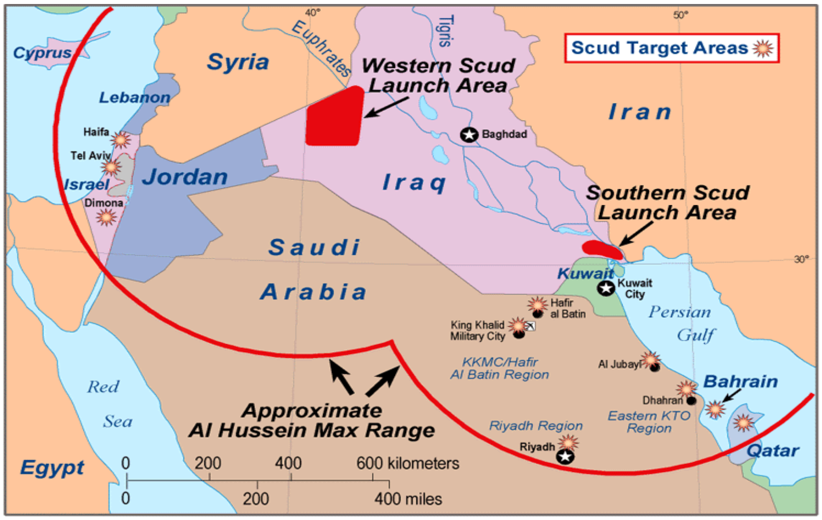

Figure 2 Scud Launch Areas [2]

The information gateways enabling NCW also aided CENTCOM to execute missions successfully on other TSTs) and dynamic targets (DTs), which are often mobile in nature. The Western Theater accounted for the largest number of dynamic targets, with the Southern Theater a close second. Beside Scuds, TSTs included high-value leadership, weapons of mass destruction (WMD), terrorist sites, and lines of communication. Extensive air and intelligence resources enabled the impressive TST performance in the Western Theater: Coalition forces flew over 2000 sorties and employed almost one million pounds of ordnance to accomplish 292 of the 842 TST and DT missions in OIF.

3. Innovative Systems: Information Age Opportunities

Many of the innovative systems used in OIF represent information age opportunities (IAOs). The value chain illustrated in Figure 4 reflects the key NCW principles that manifested themselves in Western Iraq. IAOs result from far more than networks and network connections. The people who make decisions, populate the network with information, and keep the network operating from the national to the tactical level all play vital parts in realizing the potential of NCW. The following sections describe some of the systems used in the Western Theater that presented important IAOs.

[2] MAJ White and MAJ McNulty. *410 AEW Intelligence Summary and Lessons Learned* (2003).

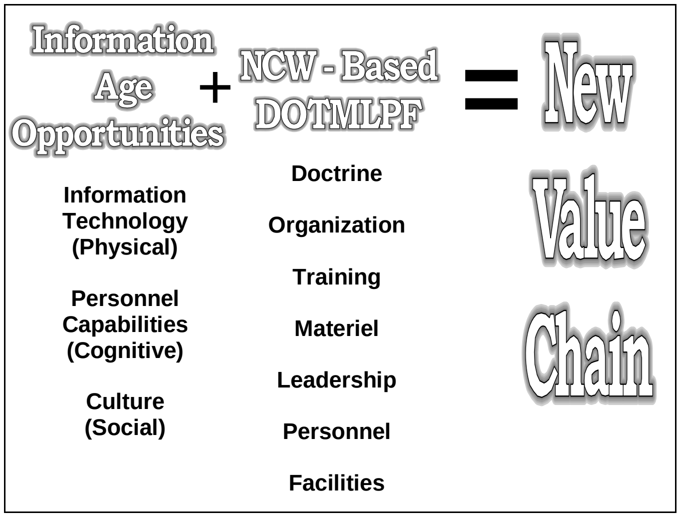

Figure 3 New Value Chain

3.1. Network Architecture

3.1.1. Architecture

As depicted in Figure 4, the Western Theater used several connectivity tools, of which the two airborne networks, Link-16 and the Situational Awareness Data Link (SADL), were especially important. They allowed airborne platforms to communicate digitally, thus enriching information exchange beyond the preexisting voice networks. The ground forces also had a mix of communications tools including tactical satellite radios (PSC 5, Inmarsat, PRC 117) and voice link (HF and FM radios).The Battlefield Universal Gateway Equipment (BUG-E) served as a crucial gateway ensuring interoperability between these systems.

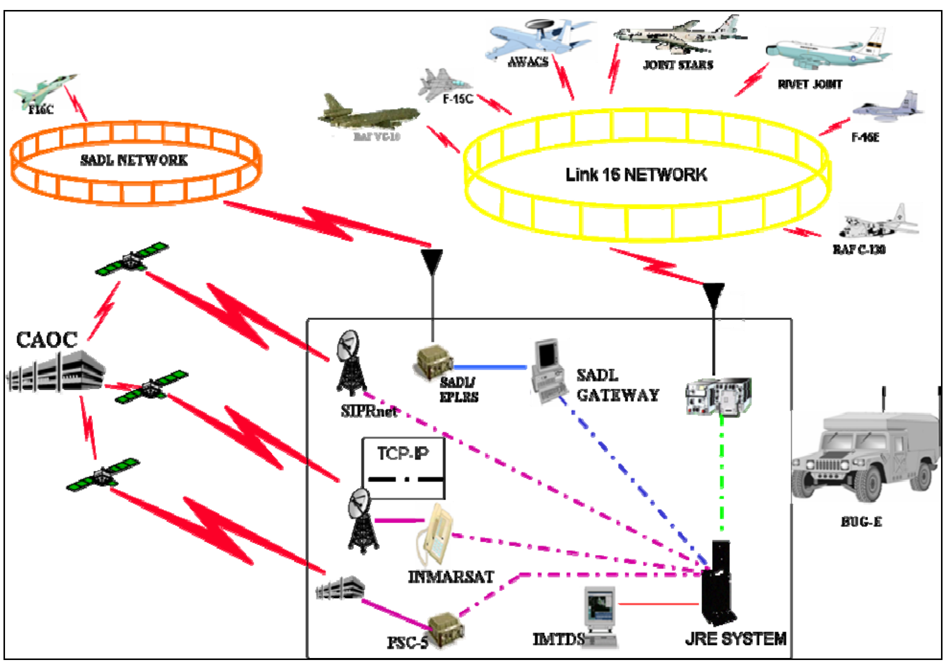

Figure 4 Connectivity Architecture

3.1.2. Communications Capacity

The U.S. Military had made significant investments in SATCOM infrastructure prior to OIF. These dedicated SATCOM resources made the fight possible by providing direct SATCOM links between joint fires elements (JFE), SOF teams, the Combat Air Operations Center (CAOC), and airborne C2. SATCOM provided a majority of over-the-horizon communication capability for OIF. Nevertheless, communications elements still encountered bandwidth problems resulting from allocation and priority of access. For example, no data SATCOM was available for the Joint Surveillance Target Attack Radar System for Combined Joint Special Operations Task Force-West (CJSOTF-W). **Table 1** depicts the change in network capacity for OIF and further details are given in Section 8.2.

Infrastructure	Pre-OIF	OIF	Change (%)
Commercial SATCOM Terminals	5	34	560
Avg Commercial Bandwidth (Mb)	7	10	47
Military SATCOM Terminals	20	44	120
Average Military Bandwidth (Mb)	2	3	68
Terrestrial Links	11	30	173
Avg Terrestrial Bandwidth (Mb)	2	10	44
Global Broadcasting System (Mb)	24	24	0
Total Terminals	36	107	167
Total Bandwidth (Mb)	113	783	596

Table 1 Communications Infrastructure[3]

3.1.3. Networking Systems

The communications infrastructure shown in Table 1 supported a wide range of information systems in Western Iraq. The Western Theater employed a combination of commercial systems (MS Office), government- designed C2 systems (Theater Battle Management Core System [TBMCS] and FBCB2), locally designed systems (Falcon View), and Defense Advanced Research Projects Agency systems (Automated Deep Operations Coordination System [ADOCS]). ADOCS, C2 Personal Computer (C2PC), Portable Flight Planning Software (PFPS), and Falcon View were primarily display systems fed by FBCB2, TBMCS, and the Air Defense System Integrator (ADSI). This display capability was crucial, as the study determined that the key measure of effectiveness for the resulting system of systems is how well they deliver and display information to the commanders and staff

3.1.4. SOF Connectivity

Army ground platforms primarily use Enhanced Position Location Reporting System (EPLRS)-based radio systems supplemented by other ground and satellite-based radios. The Air National Guard and Reserves therefore installed EPLRS in their aircraft to facilitate ground platform identification, but the SOF (U.S. and Allied) chose not to equip their forces with EPLRS because of the system’s excessive size, weight, and power requirements. Moreover, the SOF organic satellite and terrestrial radios were incompatible with the SADL systems in the F-16s, which created a significant disconnect. The Air Force Electronics Systems Command identified this issue and directed MITRE, their primary systems engineer,

[3] MAJ White and MAJ McNulty. *410 AEW Intelligence Summary and Lessons Learned* (2003).

to develop a set of IT tools to bridge this gap and enable integration of SOF data into larger networks. SOFs could then select what data to pass to the network via the BUG-E (see Section 3.2.3).

3.2. Key Systems

3.2.1. Link-16

Link-16 served as the primary C2 link for tactical platforms in OIF and presented an excellent IAO, as indicated in Figure 4. Link-16 provides situational awareness by passing data in TADIL-J message format.

3.2.2. SADL

SADL is a low-cost alternative to Link-16 for U.S. Air Force close air support (CAS) aircraft (primarily Air Force Guard and Reserve F-16 Block 30). Using the U.S. Army's preexisting EPLRS on selected ground platforms such as command tanks and armor personnel carriers, SADL performs simple digital exchange of location, identification, and information reporting and transmits this data through fighter-to-fighter, air-to-ground and ground-to-air data communications. Specifically, it enables pilots to share position, flight parameters, radar contacts, and system points of interest (SPIs). It supports four different types of message protocols: EPLRS, Joint Variable Message Format (JVMF), TADIL-J and SADL-specific messages. This IAO was fielded in 450 combat-coded F-16C+ (Block 30) aircraft for OIF. See Section 8.1.1 for more technical details of SADL.

Despite the valuable connectivity SADL provided, it was often viewed as a cheap data link designed by the Air National Guard (ANG) and therefore experienced pushback from some military elements during development and implementation. The active duty Air Force and the Office of Secretary of Defense C4ISR did study SADL, but chose Link-16 for its high performance characteristics, despite the extraordinary associated costs that confined Link-16 to providing airborne situation awareness (SA) as opposed to the air-ground SA needed for CAS missions. Budget priorities also excluded the Reserve and ANG aircraft from the Link-16 network. These issues are being addressed now in light of the importance of air-to-ground support in the OIF operational environment.

> *SADL is a four letter word to the air staff. And, instead, the radios sat on a shelf in Utah, instead of being used by more recipients..…For the war we were not permitted to put SADL radios on planes like the A-10 and the AC-130 -- which was a very simple thing that we proved already. - MAJ Blatt, USAF*

3.2.3. Battlefield Universal Gateway Equipment (BUG-E)

BUG-E is a mobile unit whose primary missions were to enhance network expansion though the use of IT equipment, assist in the TST kill chain, and provide JTIDS C2. BUG-E enabled data to pass from sensors, C2, and support aircraft to weapon platforms, staffs, and commanders via Link-16, SADL, or SIPRNET. The innovative linkage between SADL (EPLRS) and the radios deployed with SOF allowed SOF data to pass into the SIPRNET through conversion to TCP/IP. This data was then available to multiple C2 systems including TBMCS, GCCS, C2PC, and FBCB2 as well as Link-16. This IAO was a paradigm of loose coupling as an interim substitute for interoperability.

BUG-E proved key to TST mission success, because it permitted off-board sourced targets to be injected into cockpits equipped with either Link-16 or SADL and simultaneously accelerated the sensor-to-target timeline by supplying mensurated coordinates to fighter-bombers. It also supported combat operations that included tactical control (TACON) to TF Army Rangers for invasions, U.S. High Mobility Artillery Rocket Systems (HIMARS), post-HIMARS operations, post-hostilities, and data link coverage in "downtown" Iraq. Post-HIMARS and post-hostilities operations entailed continued support of data link gateway requirements for northern and central Iraq. The BUG-E was integrated into the Ranger battalion convoy element for the "D Day" border crossing; TF Hunter provided protection and logistics. Before the arrival of the permanent data link units the BUG-E filled gaps in Integrated Tasking Order link coverage. The BUG-E was eventually put in place at the Baghdad international airport.

BUG-E used the Joint Router Extension (JRE) to provide a translation point from Link-16 to SADL as well as an over-the-horizon extension for the SIPRNET. As depicted in Figure 6, the JRE served as a hub for Link-16, SADL, other tactical data links (TDLs), SIPRNET, and other systems, allowing information to flow to all users with access to the SIPRNET and leveraging multiple IAOs simultaneously. It also created linkages to network monitoring tools to allow real-time troubleshooting and enabled the BUG-E to monitor the track and data counts from these previously disparate systems.

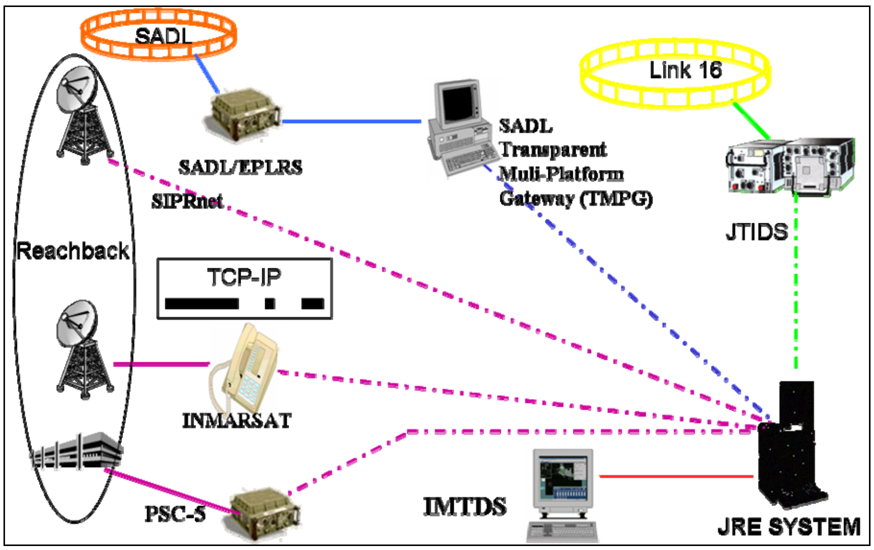

Figure 6 BUG-E Architecture

The BUG-E used the JRE gateway manager application (Figure 7), which fused information from multiple sources into an amalgamated coalition air and ground picture. This included TST transmission control, F-16C+ data link interface, Link-16 ground tracks, Link-16 free text from the CFACC TST cell and advisories to F-16s on "HOT" keypad/kill-boxes

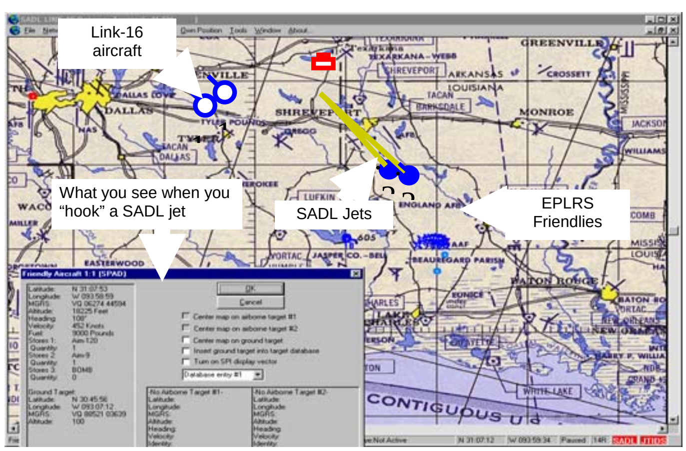

Figure 7 JRE Gateway Manager

The JRE gateway display was the key visual C2 tool used by the BUG-E crew to manage the splicing of various transmission systems. Data passed from the SADL radio or other connections through the JRE enabled the BUG-E gateway display to produce the map in Figure 7. BUG-E also excelled at eliminating time latency of blue force position data. Previously, unit locations would “trickle up” to headquarters over tens of minutes, providing decision makers delayed SA. Since BUG-E had immediate access to the platforms tracking data and applications that provided SA and common operating pictures (COPs) to decision makers and warfighters, it could selectively eliminate this latency. The more accurate position data allowed the air units to support widely dispersed SOF without risking fratricide.

To illustrate the effectiveness of the BUG-E as a component of the Western Iraq network the study tracked the flow of information from sensors to Western Theater F-16 attack elements. Feedback from interviews described the communications process prevalent in the Western Theater as follows:

1. Target detected by UAV and transmitted directly to the CAOC.
2. The CAOC determines whether target meets TST criteria as defined by the JTF commander
3. JFACC assumes responsibility to track target and enters information into C2 ISR data and tracking applications (ADSI, Rosetta, Multiple Subscriber Equipment (MSE), Improved Multi-Link Translator and Display System [IMTDS]). The TST cell determines that forces must be generated because a loitering platform on-call attack is not available. The TST cell considers various strategies and chooses rerole as the most feasible option.[4] The TST cell assesses possible threats to mission, including surface-to-air missiles and interdiction. JFACC creates IMTDS track in Link-16 and transmits J3.5 message.
4. BUG-E translates the Link-16 message to the SADL system through the JRE.
5. Reroled SADL-equipped platform follows digitally transmitted coordinates to target area.
6. Target is in a closed kill box due to SOF presence and therefore the platform cannot engage automatically. The JSOF and JFACC negotiate that the air asset will engage target.
7. With SOF permission, BUG-E pushes limited SOF position information to air platform via SADL.
8. Platform destroys target.

Figure 8 summarizes this process.

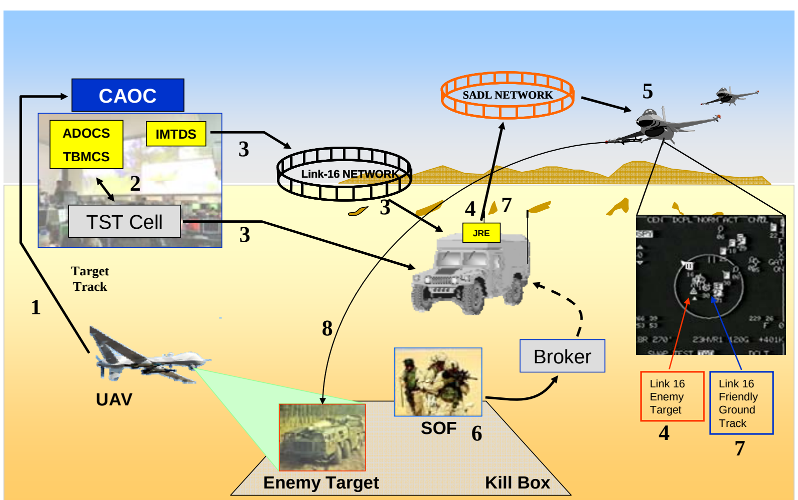

Figure 8 How F-16s Received Targeting Information

The information exchange described above enables the synchronization of SA for display in the cockpit. The two screen captures in 9 compare the heads-up displays (HUDs) in the F-16C and F-15E. Both

[4] “Reroling” is the reassignment of an attack platform to new and higher priority targets that arise en route.

represent excellent SA. The F-16 receives its information from its connection to the net through SADL, while the F-15 receives the SPIs from Link-16.

F – 16C + SADL Display **F 15 – E J3.5 Display**

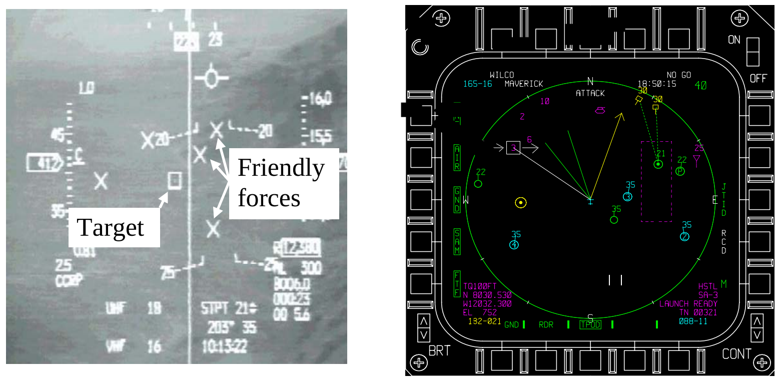

Figure 9 Cockpit Displays

The screen captures in Figure 10 show an F-16C engaging a set of enemy mortars. The information on the HUD and Horizontal Situation Display (HSD) is passed from Link-16 through the BUG-E, into the translator, and back out over the SADL system to the F-16 display. Permission from the ground FAC to engage is indicated in the "CLRHOT" text. This ability to engage only came about when the SOF command allowed the Air Force to know and display its units on the gateway. Thus, SADL adds significant value not only through the digital linkage with other Link-16 elements but also by providing data to the greater network.

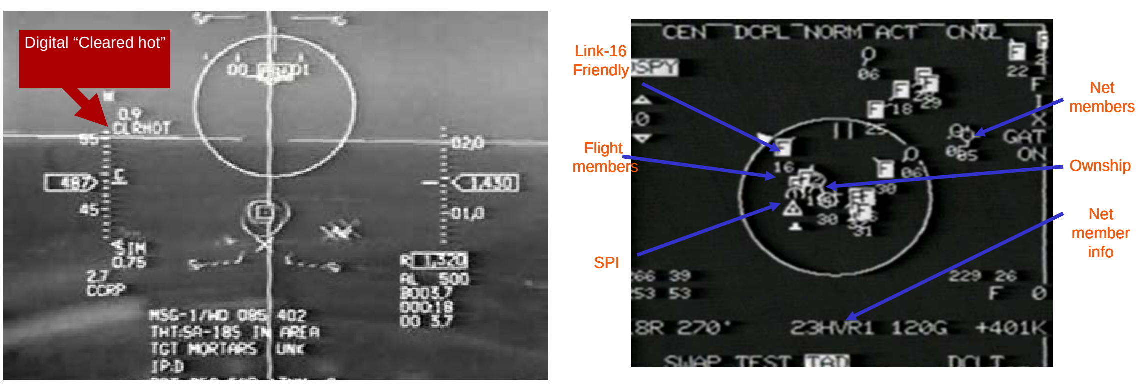

Figure 10 F-16 HUD and HSD

The BUG-E exemplifies how a vital set of IT tools can be developed and deployed, and the users trained in short order. However, proponents of BUG-E had occasional difficulty communicating their vision and ensuring buy-in from involved parties: Major Caine, USAF, recalled that "It was a bit of a non-stop battle to make sure that we had the priority that we needed."

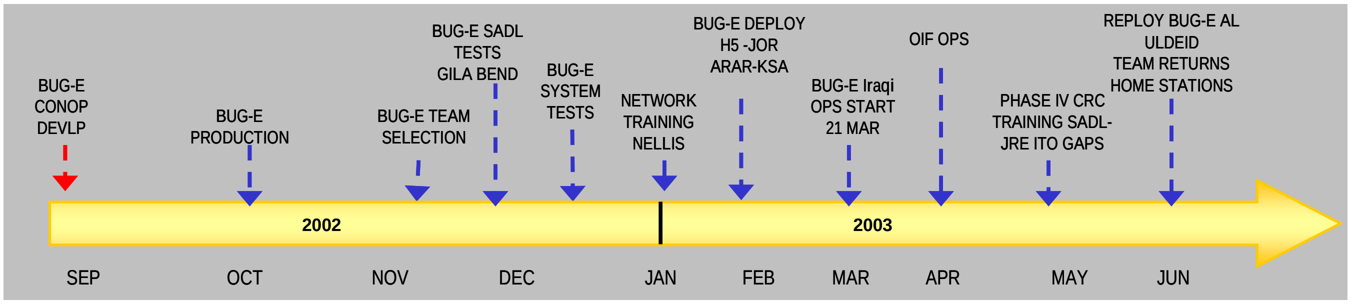

Figure 5 BUG-E Timeline

3.2.4. Collaborative Tools

In many cases a communication node needs the ability to connect to a new node in a seamless manner. This requires more flexible networks to support a constantly changing operational environment, One SOF leader explained the level of importance and effect that IT had on collaboration:

> *The mission was totally dependent on network collaboration and the attendant communications systems that went with that. The operations could not have been conducted without the technological tools and the mind set that said 'Let's see where these tools will take us.* ***Let's look outside the traditional lines of command and control and who works for who****…'.If somebody had told me 6 months before OIF that I personally would have tactical control of the ability of an entire air wing to employ fires in the western desert of Iraq … that fell within our JSOAs, I would have said 'You're crazy.'* (COL Bobby Green, SOF)

The Defense Collaborative Tool Set (DCTS) and other programs provided this agility and ease of instantaneous data or information transfer through applications that included chat and ADOCS. These collaborative tools increased speed of communication, directed communication more precisely to relevant decision makers, and enabled greater span and reach of communications.

The program my Internet Relay Chat (mIRC) was used prolifically within the Western Theater and served as its primary C2 administration capability. Chat also became a significant communications path for coordinating OIF operations; as one officer put it: "I could chat with ten or twelve people at the same time and get more done in... 30 minutes than I could on a radio." Chat enabled a synthesis of disparate sources to produce SA. Moreover, many interviews depict chat programs as transcending the formal communication barriers and flattening the communication hierarchy. Warfighters could talk more freely with decision makers and less information was lost or delayed in the bureaucracy. Chat therefore had the reach of the SIPRNET and a span across many levels of decision making, although, because chat does not have robust protocol or information channeling features, communicators had to select chat rooms and manually screen information.

Chat and email also served as conduits for maintaining morale and receiving daily news, supplementing other official sources. SIPRNET web mail capability was the primary means for used by C2 HQ to coordinate ADCON-OPCON, but the CAOC-PSAB (Prince Sultan Air Base) server host experienced reduced reliability during OIF.

Blue force tracking has greatly improved SA and has proven an excellent tool in preventing fratricide. However, due to its time latency, many warfighters hesitated to use its information to clear fires.[5] The OIF After-Action Report (AAR)[6] states: "ADOCS pulled information from other systems to provide one-

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[5] Authorize air strikes.

[6] 609 Air Operations Group. *Operation Iraqi Freedom After Action Report* (2004).

stop situational awareness for targeting, deconfliction and coordination internally in the CAOC and externally with components and CENTCOM. This transformational capability is a marked improvement to what was available during OEF." ADOCS provided data and graphical displays that resembled blue force tracking, and the bundled chat programs allowed decision makers to gain assurance from their colleagues about the accuracy of the blue force locations indicated in ADOCS. Without such confidence many air strikes in Western Iraq could not have been authorized.

3.3. ISR

OIF made extensive use of innovative ISR systems, including nontraditional ISR (NTISR), which involves the use of assets as sensors traditionally not tasked for ISR missions, and focused ISR, which supports a specific operation/mission *to achieve a specific operational effect.* The sheer volume of ISR data passed during major conflict operations in OIF was staggering, and the data came from a variety of sources. Images from targeting pods and other high-resolution radars were piped directly back to ISR units. The operation also included the first tactical-level comprehensive use of UAVs to obtain full-motion, real-time video across such a large potion of the theater. This accurate and real-time ISR was a significant positive contributor to the dynamic control of airborne weapons platforms. NTISR enabled responsive intelligence preparation of the battlespace (IPB). In particular, CENTCOM's TST cell used multiple IT tools to ensure unprecedented IPB. Hallmarks of the effort included the restriction of Iraqi theater ballistic missile (TBM) movements by downing bridges on lines of communication.

The success of focused ISR in OIF was transformational, particularly the use of Global Hawk.[7] Synchronizing ISR to support a specific operation succeeded only when there was very close coordination between Air Intelligence (A2) and Air Operations (A3). To assist with this coordination, ISR assets were assigned to work specific regions of the country. This customized ISR enabled greater contribution to TST missions, as well as to dynamic and emerging target operations. Additionally, the more specific ownership of ISR assets increased components' awareness of ISR support/operations and enhanced collection requirement planning. Finally, sensor downtime was reduced as platforms no longer flew from region to region. These and other ISR strategies dramatically improved satisfaction with collection. Six U-2 missions achieved 100% satisfaction rates, far surpassing previous performance in Operation Southern Watch.

In Western Iraq the ability to link to manned and unmanned air assets and have their information passed back to the CAOC and the supporting targeting cells allowed air resources to be maximized. Over 11,369 CFACC ISR objectives were met while F-16Cs were also allowed to strike dynamic targets. Often these dynamic targets were located by AWACS and other means and were passed to the aircraft though the combination of Link-16 and SADL, again demonstrating the power of the network and the effect on resources.

OIF represented the first time the ISR process and assets coordinated fully from the operational to the tactical level of war, which enabled dynamic control of warfighters' assets to align with the commander's tactics and strategy. The close coordination of the SOF headquarters team with the Air Force enabled the integration of air, SOF, and ISR assets. The links that allowed the information to pass directly through Link-16/SADL to both ISR and fighter aircraft (after permission by the SOF) allowed the rapid execution of CAS missions with a maximum response time of 10 minutes.[8]

This information sharing also facilitated the collection and dissemination of intelligence information outside the traditional organizational structure. Organizations married real-time and near-real-time

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[7] 410 AEW Intelligence AAR.

[8] COL Robert Green, SOF, interview.

information with traditional and nontraditional control measures such as fire and maneuver boundaries. For example, the ADOCS screens displayed kill boxes (KBs) along with traditional maneuver graphics, permitting more situational understanding and greater mission effectiveness. None of this could have taken place without a carefully crafted training process that allowed nontraditional units to share language and operational processes and thus break down the cultural barriers to collaboration.

4. Examples of NCW-Based DOTMLPF

As previously noted, the systems described above presented IAOs as well as technical solutions to persistent problems. However, IAOs would simply remain interesting “gadgets” if their potential were not tapped by NCW-based DOTMLPF. The DOTMLPF term of the value chain shown in Figure 4 covers a broad range of interconnected NCW instantiations; for example, viable doctrine cannot require a skill set not held by the personnel or developed through training. This interrelatedness is partially captured in the concept and importance of culture. The theme of culture as an IAO permeates the discussion of DOTMLPF, since a fertile cultural foundation is a prerequisite to new physical and cognitive thought processes integral to NCW.

In OIF the USAF and SOF were particularly well suited to leverage IAOs and develop new TTPs, since their cultures inculcate innovation at a base level. However, even they resisted some possibilities for NCW progress due to cultural factors.

> *I believe that there has been a cultural and mind shift. And we're talking about the collaboration to make the situational awareness happen. I think there's been a cultural shift driven by the technology and the organizational changes and the doctrinal changes that have made **people's attitudes towards getting that information exchange to occur a high focus**.* (MAJ Stoner, USAF)

> *It is important to highlight that USAF and SOF types are particularly culturally aware when it comes to technology. USAF and SOF folks tend to be ‘gadget people.’ They have cars with all the trimmings. They have great home entertainment systems, etc. So, the USAF and SOF communities are more eager to integrate new technology / approaches into warfighting than other groups might be.* (SOF Commander)

The sections below describe some examples of how NCW-based DOTMLPF transformed organizations and processes in the Western Theater of OIF.

4.1. Combat Air Operations Center (CAOC)

The Air Force considers the CAOC as a weapons system and therefore the technology, tasks, and training undergo constant evolution. The Air Force has been engaged in continuous combat operations since 1986, and the combination of combat experience and Joint Expeditionary Force Experiments (JEFXs) aided in CAOC development. The CAOC that commanded and controlled operations in Operation Desert Storm (ODS) and Bosnia only slightly resembled the one that controlled forces in OEF and later in OIF: for example, the OIF CAOC consisted of 1,966 personnel compared to only 672 in earlier operations. Operationally, CAOC communicators shifted from ensuring that directed *communications got through* to ensuring that qualified net *users accessed specific information* of interest in the tactically appropriate time.

Both network managers and the supported commanders and staff were able to use the ground force positions reported by blue force tracking. This created significant management challenges, since not all of the networks had the same degree of latency or accuracy. Continual target/friendly coordination and de-conflicting in the Deep Battle Area was accomplished by using redundancy afforded by network applications (chat, ADOCS, email, transfer of briefing materials, J messages).

IAOs prompted the CAOC and other targeters to develop new targeting TTPs that capitalized on the enhanced connectivity to deliver staggering destructive capability. The results illustrated that once a commander identifies the desired effect of a military operation, the vulnerable enemy areas must be targeted with appropriate and available military means, and that a networked environment expands the range of targets possible to engage in near-real time.

4.1.1. Targeting

The CAOC directed operations against many different types of targets, including DTs, TSTs, and time-critical targets (TCTs).

- DTs emerge or gain higher priority *during* the execution of an air plan. The target list for DTs can change dynamically to adjust for changes in the battlespace, including rapidly moving ground forces and new opportunities for soft approach.
- TSTs are a subset of DTs that are generated on the basis of a priori IPB. TSTs are defined as targets of such high priority to friendly forces that the Joint Force Commander designates them as requiring immediate response because they pose (or will soon pose) a clear and present danger to a friendly force or are highly lucrative, fleeting targets of opportunity.[9]
- TCTs are an even more restrictive set of targets that typically must be serviced in less than ten minutes from the time they are detected. These emerging targets challenge achievement of theater objectives and require immediate exploitation or attack in accordance with Joint Force Commander Guidance.[10]

Many different platforms and organizations (UK and U.S. Navy, Marine, and Air Force assets) were involved in the Western TST effort. In fact, 52% of all theater-wide tasking from the TST cell was assigned to western assets. Additionally, DCA, SEAD, and alert assets were used for the bulk of all dynamic targets. The ability to task assets not already assigned targets in the ATO streamlined the targeting process.

With so many sensors, decision makers and shooters involved in TST execution it is easy to see how "training was key to successful TST execution."[11] TST TTPs and CONOPS were developed and exercised during Internal Looks. ADOCS became the primary tool for TST execution during this exercise, and a few evolutionary changes were made. The C-TBM live fly at Nellis AFB in January 2003 enabled additional refinement of TST processes.

The use of a loitering "combat reserve" of airpower proved a crucial strategy in pursuing DTs. Often the proximity of an attack platform with general-use ordnance enabled successful destruction of fleeting targets as well as excellent CAS. An on-call attack (XATK) occurred when a sensor discovered a target of interest and relayed the information through the system to the loitering shooter. XATK missions hit 52% of the targets identified by the TST cell, serviced 12% of CFACC-designated mean points of impact (DMPIs), and did so faster than traditional rerole while simultaneously accomplishing armed reconnaissance. XATK contributed to the excellent performance on DTs and enabled typical aircraft response within single digits of minutes.

Traditional partitions of the battlespace had been constructed from geographic and political boundaries. However, a "more precise, fluid and nontraditional construct would be needed for coordinating and

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[9] Joint Publication 3-60. *Targeting* (2002).

[10] Briefing, Director of Command and Control, Air Staff.

[11] (S) 609 Air Operations Group. *Operation Iraqi Freedom After Action Report* (2004).

deconflicting all joint fires in the AO and delineating the shifting boundaries of operational areas being used by SF units."[12] Thus, the entire Western Theater was divided into non-overlapping "kill boxes" (KBs) that were used to direct both maneuver and strike operations. The special operations area (SOA) was subdivided into several sectors. Then, a 30-minute square latitude-longitude grid further partitioned the SOAs. Each of these squares was in turn subdivided into a nine-square "keypad" of 10 minutes per side. Cardinal directions then referenced four more subdivisions of each "key" (see Figure 11).

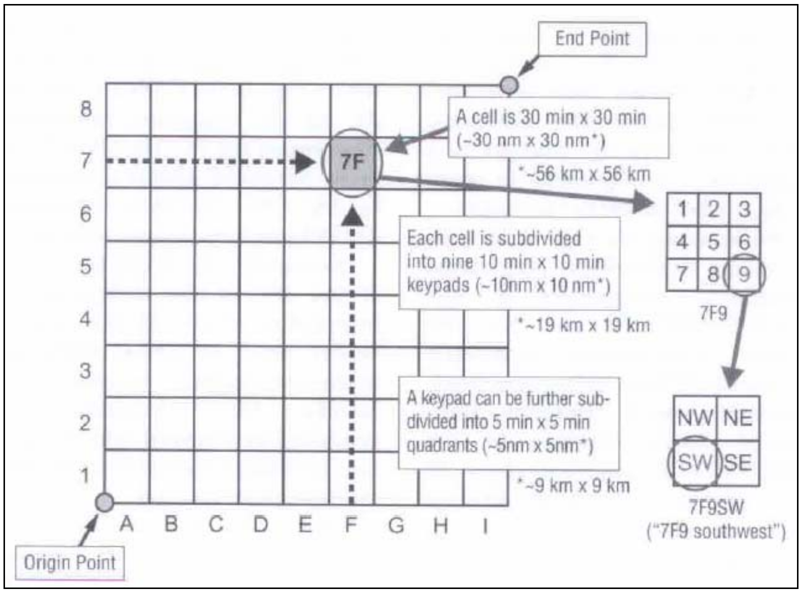

Figure 11 CGRS and Kill-boxes[13]

The procedure for updating and maintaining this Common Grid Reference System (CGRS) was relatively rapid and precise. Joint SOAs (JSOAs), comprising selected contiguous squares, could be changed several times within the ATO cycle, as often as every two hours. Changes to the JSOAs occurred through preplanned procedures and were typically executed by requests transmitted to CJSOTF JFE 36 hours prior to the Air Tasking Order (ATO). More immediate changes could be made by sending requests directly to the CAOC TST cell.

The CGRS system yielded significant benefits in depicting the location and movement of forces. While the location of KBs remained fixed for the duration of the conflict, managing the status of each KB was a dynamic process. SOF presence could be more accurately depicted by turning an assortment of keypads black. This CGRS system performed very well in tracking the movement of a unit through an area: SOF could simply close keypads ahead of them and open those through which they had passed. Therefore, the presence of a few SOF tactical units did not restrict aircraft from an unnecessarily large area.

The KBs were used to direct ISR assets as well as ordnance drops and acted as surrogates for traditional graphical control measures such as No Fire Areas, which were only used on three occasions in the Western Theater. Previously, CAS was performed visually, which made night operations precarious and susceptible to fratricide. Keypad methodology combined with voice and digital aircraft links not only enabled safer, 24-hour CAS, but also decreased the reaction time to under 7 minutes (compared to over 30 in ODS).

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[12] COL Green, Robert B. Joint Fires Support, the Joint Fires Element and the CGRS: Keys to Success for CJSOTF-West. Special Warfare.

[13] Id.

The new TTP of KBs translated into increased combat power by providing a common targeting language for all components of the kill chain. The innovators of this TTP understood which doctrine would be beneficial and took the initiative to make it a theater-wide practice.

4.2. Air Tasking Order (ATO)

As the CAOC evolved and new targeting TTPs emerged, the ATO – the CAOC's key doctrinal product – also progressed further into the Information Age. The essential processes for the ATO are:

1. **Collection of target information,**
2. **Decision making**, including the **allocation of air assets** to targets, and
3. **Transmission** of this plan to warfighters.

The Western Theater exhibited unprecedented integration of air, SOF, and ISR through streamlined C2, decentralized execution of operations, and newly developed TTPs. Many of the ATO TTP innovations came from Guard and Reserve personnel who collaborated with Active counterparts to ensure timely information flow. TBMCS, ADOCS, and extensive use of mIRC greatly enhanced the ATO process. These systems, operating over the high-bandwidth backbone that connected several layers of staff both in and out of country, allowed the ATO to become much more responsive. Additionally, the new TTP included the use of Combat Air Patrols (CAP), NTISR, and XATK. One of the most telling results of ATO modification was the reduced engagement time in support of TSTs: TSTs and TCTs were cleared for fire in "generally under ten minutes."[14]

Planners in Western Iraq used the connectivity enabled by the BUG-E to pass vital targeting information to both sets of fighter-bombers and thus had a larger set of airframes to consider for actions. Input from SADL and Link-16 aircraft could be entered into the planning process though the net and incorporated in air-strike planning. Collaborative tools such as ADOCS also provided target information to the staff for inclusion in the ATO as well as in support of TST and TCT.

These systems did not always *produce* new information, but they provided excellent access to previously disparate information sources; information that had been produced and used by stovepiped staff sections was now available to communities of interest (COIs) throughout command levels. Thus, information that was posted *in the faith* that it would benefit warfighters throughout the theater was found to do just that.

The TST West cell in the CAOC was specifically tasked with preventing Scud launches in Western Iraq. They were able to execute that mission successfully by using NTISR integrated with ground forces. After daily VTC briefings they specifically assigned search points for each NTISR asset that was part of a fragmentation order in the daily ATO. The targeting and operations cell used mIRC chat, C2PC (COP), JWICS systems, M-3 messaging, email and PFPS (Falcon View) to coordinate aircraft.

During the target analysis and assignment process, TBMs or other potentially significant items that had been captured on the targeting pod footage were assigned to imagery analysts (IAs). These analysts joined the pilot-squadron intelligence briefing and debriefing process to create a combination of expertise (pilot, 1N1, and IA) in resolving high-interest targets in the Western AO. Their analysis was then immediately passed via voice to the TST-W cell. This provides another example of how COIs collaborated over high-speed data links and were served by compatible but not identical information systems. The combination of the network and the willingness to share made the significant improvement in combat effectiveness.

[14] LTC Sidney Gray

SIPRNET enabled remote locations across the world to become active players in ATO planning. In the words of LTC Backes, USAF: “I don't want to use the word reach-back because reach-back gives you this idea that you would call them if you need them. They were **active players at nodes literally across the world**...”

Many tools were used to create this “virtual staff” environment. Some were the more traditional file sharing and VTC capabilities, but many of the interviewees, both commanders and staff, pinpointed chat as the system that provided access to the largest number of individuals involved in decision processes throughout the theater. A simple chat post could reach any number of people interested in the chat room, often up to 30 individuals.

The span and reach of these IAOs enabled those involved in the ATO process to share SA and contact decision elements precisely and immediately. Especially important was that bypassing bureaucracy with less formalized communication did not degrade the ATO process. Such improvement did not come without operational considerations. Chat must be monitored at all times; moreover, it lacks capabilities for playback and alerting, and (unless a command implemented it) has no “net control” feature. Still, this study and others ongoing clearly demonstrate that it has become a major information conduit.

The primary means of ATO distribution was through TBMCS, which was carried on the SIPRNET throughout OIF. This enabled all connected elements to access the latest version of the ATO and respond to revisions. The simple improvement created by automated electronic distribution of the ATO increased convenience in comparison to previous operations and, as discussed before, permitted COIs to coalesce in ways not envisioned by the traditional organizational chart and relationships.

The value of training and team building cannot be overstated. During the interview process many warriors made it clear that that the exercises in Florida, previous JEFXs, and the OEF experience contributed greatly to the team’s ability to work together. However, in other cases a very rapid buildup of expertise was necessary. The IT systems that support difficult missions such as XATK, NTISR, CAS, and other operations must be easy to install and manage, and not complicate them further.

The scope of the ATO also meant that large-scale mission rehearsal and coalition planning proved highly beneficial. The close relationships between forces began with rehearsals at various JEFXs, including Millennium Challenge. Additional rigorous training took place both in CONUS and in theater. Crash course training immediately prior to operations proved valuable as well. For example, two weeks before the operation began the American AWACS had to go to another mission, but, as one SOF officer (COL Green) recalled, “The British AWACS came in and trained to the CONOPS that we had developed, and stepped right into the mission. Of course they were super professional.”

The previous ATO process had required that the DMPIs be planned 72 hours in advance. The missions became increasingly less flexible as the time neared for the aircraft launch and follow-on ATOs were less likely to benefit from incoming intelligence. This procedure is analogous to a football coach signaling a play and having time to adjust to a new defensive setup. The new ATO process was much more responsive. Aircraft routinely launched without targets and DMPIs were found and matched in near-real time. Continuing with the football analogy, the new ATO process is an audible: “I’ll hit the open man.” By the end of the first week of major combat operations more than 80% of the strike sorties were leaving their base of operations (both land and sea) without specific targets. Missions were established or refined while the aircraft were in the air; thus, both the ground and target staff viewed these missions as a form of “combat reserve.”

Western Theater targets were serviced in 9 minutes on average. While no direct numeric comparison is available, interviewees stated that these results were unprecedented, even in exercises. A SOF team leader who had fought in many previous engagements pointed out that the combat reserve (loitering weapons platforms) was a key success factor, noting “[T]here is a world of difference between calling in a weapon waiting to be used and waiting for something to be scrambled." To accomplish this, the CAOC provided a very flexible supporting infrastructure, including data buses that could handle a wide variety of precision-guided munitions, chat rooms that linked staff, graphic renditions of targets, and sharing of blue force locations.

While the benefits of net-centric creation of the ATO are clear, the system is inherently and inevitably complicated. Planners require more SA and flexibility, and the need for contingency planning increases drastically. For example, unknown targets require less specific tasking of armaments and fuel planning is uncertain. Meeting such challenges was requisite to achieving the tremendous success in Western Iraq, and will continue to define NCW.

5. Mission Effectiveness of NCW

5.1. Overall Results

Blue forces successfully seized the Western AO, roughly the size of South Carolina, despite a ground troop disadvantage that ranged from 1:10 to 1:500.[15] Although the traditional 3:1 troop advantage that forces generally prefer has dropped in recent years, the *dis*advantage in Western Iraq was unprecedented. The implementation of a robust network enabled our forces to maintain the element of surprise, exploit unity of effort between ground and air, and capitalize on the advantage of speed of maneuver to give U.S. forces the combat advantage.

No U.S. or Coalition force casualties resulted from friendly air actions in the approximately 100 engagements in the Western Theater. Many of these engagements incorporated "troops in contact" (TIC), and many of these TICs were supported at very close range (CAS). The use of information magnified the asymmetric airpower advantage of the U.S. forces to become an even greater enabler in overcoming the ground troop disadvantage.

5.2. TSTs

The U.S. forces in Western Iraq succeeded in their key mission of preventing missile launches. This mission was supported by the largest Coalition air and SOF team in history. SOF teams assisted by Air Force assets undertook numerous actions to engage missile locations. In comparison, there is still debate over whether the Air Force destroyed even a single Scud launch vehicle as a TST during ODS.[16]

Measuring the effectiveness of actions such as Scud suppression is difficult when the mission is so successful and the enemy's intentions cannot be clearly deduced. Responsibility for TST planning and execution resided in the TST cell of the CAOC, and this cell tracked missions through to completion. However, the study was not able to obtain compiled accounts of TST exercises for statistical comparison to other theaters, OEF, and ODS. The interviews indicate that TST missions were conducted successfully and particular anecdotes directly attribute these successes to the SA created through the discussed systems described above and TTPs. The bottom line is that no Iraqi launches occurred, although many believe that Iraq would have used Scud missiles had they had the opportunity.

5.3. Surveillance

Surveillance, as always, played a major role in operations. Actual data on improvements in surveillance and the direct effect on operations is hard to find, since no standard and comprehensive metrics exist for

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[15] MAJ White and MAJ McNulty. *410 AEW Intelligence Summary and Lessons Learned* (2003).

[16] Bokhari, Col (Retd) Eas. *The Scud Missile Syndrome* (Defence Journal: 7/1/05). http://www.defencejournal.com/may99/Scud-missile.htm.

ISR. In essence, any SA derived from surveillance is useful; in this theater it became even more valuable thanks to the interoperable digital connectivity that permitted sharing of surveillance information between units. Such "reach" and "richness" of surveillance data had never previously been available to the same numbers of staffs, commanders, and weapons platforms. Additionally, the ability to share national-level intelligence via the SIPRNET allowed surveillance intelligence to reach many more consumers then ever before.

5.4. Fratricide

The OIF rate of fratricide was low and there were no reported incidents in the Western Theater. In comparison to the 35 friendly fire deaths in ODS[17] only 13 such fatalities occurred in all of OIF as of 2004.[18] The absence of fratricide in the Western Theater resulted partly from the robust networking and the ability to pass blue force data electronically from the units in the field to the target planners and pilots. The new IAOs described previously, combined with legacy voice links, prevented at least three air-to-ground fratricide engagements.

> *The effectiveness of Joint Fires Command and Control in the western desert can best be summarized by the results: In the first 27 days of combat Ops the Joint Fires element at the JSOTF did 393 successful Joint Fires deconflictions while prosecuting the highest percentage of Dynamic Target strikes in IRAQ (40%) …. and had absolutely zero incidents of fratricide and injury due to friendly fire.* - COL Green, SOF

The case study did not address ground-to-ground fratricide, and the only other metrics are incidents of fratricide and recorded avoidance of fratricide. While no air-to-ground fratricide occurred in the Western Theater (in contrast to documented incidents in the Southern Theater), we recognize the Western Theater was less congested with both red and blue forces. The report does describe specific Western Theater incidents that were prevented through the available SA.

5.5. Statistical Evidence

The National Command Authority faces difficult challenges in determining the degree of NCW implemented and its effectiveness on warfighting. The three key areas – robustly networked force, information sharing, and shared SA – are all among the critical NCW tenets shown in Figure 1.

Figure 12 represents the findings from the surveys incorporated in the interviews. In each case the results were statistically significant to at least the 95% level using a Wilcoxon statistical measure. The most striking difference between the Western Theater and previous engagements was the degree of system and organizational networking. Nearly all the participants believed that shared SA was much better in the Western Theater than in previous conflicts, as evidenced by the correctness of the picture, the level of awareness of critical elements battlespace elements, and the completeness of battlespace awareness, as well as the perception of shared understanding. However, several areas should be of concern in future operations and as the community moves forward in NCW experimentation.

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[17] Doton, Larry. *Integrating Technology to Reduce Fratricide* (1996). http://www.dau.mil/pubs/arq/94arq/doto.pdf.

[18] Cahlink, George. *Better Blue Force Tracking* (Journal of the Air Force Association. Vol. 86, No. 6. June 2004). http://www.afa.org/magazine/june2004/0604blue.htm.

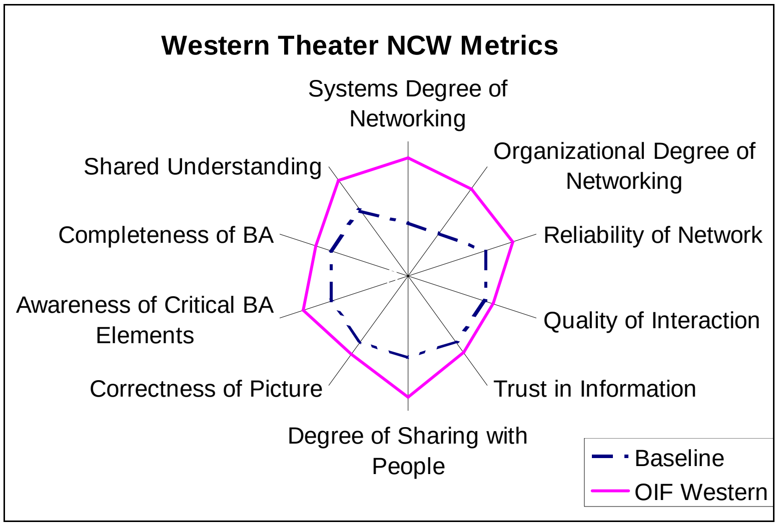

Figure 12 NCW Metrics

5.6. Trust in Information

Our findings showed that NCW practitioners have two views of trust in information. From a purely statistical standpoint, there is greater than a 95% confidence that personnel felt significantly more trust in the information provided to them via the network than they had felt in previous operations. The converse is that nearly all the respondents said that their organization devoted teams of individuals to verifying the accuracy of data in the network. There are several ways to reduce such an effort. First is training. The more personnel become used to the nuances of a system the more willing they will be to accept data as accurate. Second is adding inherent error checking. Some capability in the system should track both when the information was added and how many sources confirmed the validity of the information. Third is force structure. If having dedicated error checkers is a new part of the landscape, we should actually program them into the force structure and design education and training to maximize the utility of the personnel available.

5.7. Quality of Interactions

As with trust in information, NCW practitioners hold two views of the quality of interactions. Statistically, the results showed a greater than a 95% confidence that personnel perceived a significant increase in the quality of interactions during major combat operations in the Western Theater. The converse is that it also seemed harder to reach operational and tactical decisions. Respondents identified three causes. First, personnel were not always sure of the quality of the data: in previous operations the personnel knew that what the observer-controller said was true, but during OIF a data element might or might not be accurate. Second, personnel found themselves waiting for more information, hoping and in fact expecting that more useful information might be forthcoming. Third, because time frames for decisions were dramatically decreased, personnel found themselves making decisions with less than the desired level of certainty. These areas should be explored in exercises, experimentation, and other training, and in educational settings.

6. Conclusions

The systems used in the Western Iraq theater represented significant evolution of the value chain depicted in Figure 4 compared with previous engagements. Specific IAOs and NCW-based DOTMLPF helped unleash potent combat power upon the enemy and accomplish staggering combat effectiveness. Certainly much room for improvement remains as NCW technology approaches interoperability and military culture continues to transform accordingly. Western Iraq provides both a benchmark of success and a guideline for future development.

7. Recommendations

7.1. SADL Target Information

The study discussed how the BUG-E conveyed Link-16 and other netted data to SADL equipped aircraft and how SADL aircraft were visible on Link-16. However, SADL aircraft did not push target tracks back through the network onto Link-16. Developing this full duplex data path would create valuable SA and enable platforms to perform NTISR with SADL.

7.2. Interfaces and Gateways

Gateways proved invaluable in the battlespace, but the case study identified a number of opportunities where networking could be improved. A-10s and C-130s would have benefited from and contributed to the network significantly. Also, data displayed on ADOCS was not automatically linked to TBMCS. These two systems contained such valuable SA that a linkage seems entirely beneficial. One possible improvement would be for ADOCS to “push data back into TBMCS, ITS and other systems in order to provide better visibility into what happened during ATO execution.”[19]

7.3. SIPRNET

This study found SIPRNET connectivity beneficial at increasingly lower tactical levels. To the extent that security is not compromised this trend should continue.

7.4. NCW Feedback

The U.S. military needs to evaluate and revise the lessons learned process, particularly the evaluation of information, SA, and information systems. Current lessons learned and debriefings focus on kinetic and combat effects, but not on information and cognitive effects.

7.5. Programs of Record

The study discovered two excellent technologies that do not benefit from the support inherent in being a program of record. ADOCS provides a critical capability that should be formalized. Likewise, the BUG-E is not an official program but proved indispensable in OIF. Both programs will probably lack training, maintenance and funding without formal recognition.

7.6. Commercial Technologies

Associated with, but not incorporated in, the program of record issue is the ability to integrate civilian applications such as chat. Chat and similar applications will continue to have a strongly positive – or negative – impact on C2 hierarchies and TTPs. The armed services must learn to modify such technologies and understand their use, including the development of protocol and standard operating procedures.

7.7. Doctrine

Doctrine may always play catch-up with IAOs, but it is imperative that the gap between doctrine and the missions and processes to which it pertains does not loom large. In OIF, deluges of information

[19] (S) 609 Air Operations Group. *Operation Iraqi Freedom After Action Report* (2004).

converged on talented individuals who fortunately were able to develop their own methods for handling the situation. In some cases the individuals at these crucial crossroads may need the guidance of doctrine to withstand the tremendous stresses and to succeed. Leadership must therefore develop NCW-based doctrine by explicitly rewarding individuals for actively seeking solutions and testing innovative methods. In particular, the excellent IAO of chat requires some attempt at channelizing information and protocols for chat networking.

7.8. ISR Persistence

The study made three fundamentals of ISR clear: ISR does not maintain itself; real-time updating of all ISR is currently infeasible; and forces using ISR SA should know when the last update was made to that SA so that they can assess its latency. Forces must also understand the uncertainty of the SA available and develop natural mechanisms to incorporate this uncertainty into their decision processes, or establish chat rooms to reconcile latency issues. For example, as SA data ages in the database its value would decline from green to yellow to red.

7.9. Cultural Changes

Cultural characteristics occasionally prevented realization of NCW tenets. For example, the semi-implementation of SADL is a prime example of cultural resistance that severely hamstrung the network potential of platforms such as the A-10. An NCW culture revolves around the *belief* that information one element produces may be useful to another element for unforeseen reasons. Thus, the information age solution is adopted in the *faith* that it will increase combat power in unspecified forces. Decision makers must turn from the "hunt" for combat power toward the "farming" of combat effects through IAOs. A change toward an Information Age-compatible culture requires its people to take risks in developing new solutions and an organization that tolerates individuals willing to take risks.[20]

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[20] Staats, LTC Richard and COL(R) Fred Stein. *Changing Army Culture to Leverage Information Age Opportunities* (2005).

8. Annex

8.1. Interview Subjects

Name	Rank	Service	Assigned Position in OIF
Anonymous			SOF Commander tactical level
Brett “Plink” Plentl	LTC	USAF	Dep. Chief of TST Cell, CAOC, PSAB
Chris Bush	MAJ	USAR	OPS Officer &Battle Captain, Theater C4ISR Control Cent
Christopher Stoner	MAJ	USAF	Joint Interface Control Officer, 965th AACS, CAOC
Dan “Razin” Caine	MAJ	USAF ANG	Chief of Wing Weapons and Tactics, Western AO
David Stephenson	LTC	USAF ANG	131st Expeditionary Fighter Squadron OPS Officer
David Ward		MITRE Corp	Systems Engineer and Integrator, BUG-E
Gary “Jethro” Backes	LTC	USAF	AOC Trainer for Tactical (TST) Smart Team
Greg White	LTC	USAF	Chief of Intel, 410th EOS, Intel Flight
JC Dominick		MITRE Corp	Chief Engineer, CAOC PSAB
Jerry Dillon	COL	USAF	Chief of Counter Scud Strategy, CAOC
Jerry Vaughan	MAJ	USAF	CAOC Systems Manager, AOC Weapons Systems 609th AOG
John McCann	LCDR	USN	O-in-C and Commander Bug-E Unit
Matt Eager	MAJ	USAF ANG	Chief of Targets and ISR, 410th AEW
Nicole Blatt	MAJ	USAF	Joint Warfighter Integration Team Chief
Norm Michaels		MITRE Corp	Tech Lead for Strategic Comms Eng, CENTCOM CCJ6-C
Robert Boston	LTC	USAF	Lead Engineer for C4ISR (ADOCS)
Robert Green	COL	USAR	SOF COS Operational and tactical level
Robert Shaffer		MITRE Corp	Chief Engineer, AOC/ESC/ACF Weapons System
Sidney Gray	LTC	USA	Dep. Director of Special Operations Liason, CAOC
Steve Mas	MAJ	USAF	Chief of ATO Production, 609th Combat Plans SQ

8.1.1. SADL

EPLRS resides on the 425–447 MHz UHF and utilizes TDMA architecture. The cost of an EPLRS is in the range of $25–30 thousand. The radio transmits data at a rate of 2.5 Kbps during good connectivity, and the range is determined by LOS and the 100 watt maximum transmission power.

8.1.2. BUG-E

8.1.2.1. Components and Connectivity

The BUG-E connects to the SADL and Link-16 systems as well as to a family of radios such as the PRC 117 and the PSC 5D. These provide links to the command networks in the mission areas such as ScudNET, selected Air Force networks and the AC-10 community. The system uses a CISCO 2621 switch/router that connects to the worldwide network via a secure telephone (STU III and the newer STE) and then over Inmarsat to other users world wide. Figure 6 displays the system design of the BUG-E components.

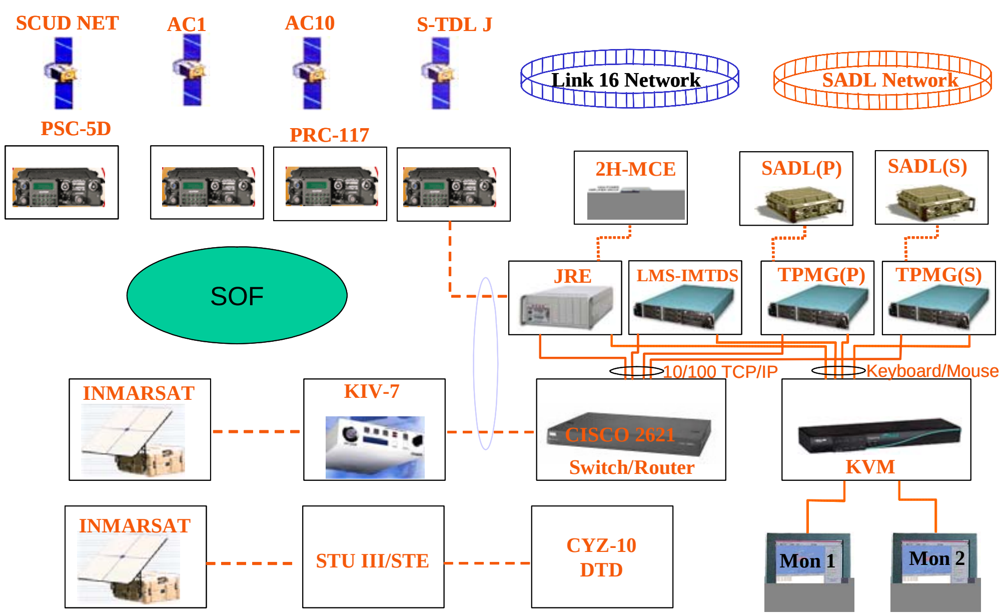

Figure 6 BUG-E Components

8.1.2.2. Testing

To ensure proper performance the following system checks were conducted on the BUG equipment:

System	Actions
JRE	Intensive tests on MCE 2H terminal, SADL, LMS MT, and IMTDS.
SADL	Live Fly Events during TDY and Garrison Operations (H5)
IMTDS	On site MITRE Support – Training and Operational testing TDY's and H5
LMS	TDY testing and Garrison (H5)
INMARSAT	Factory cables from KIV-7 to INMARSAT pinned-out incorrectly
KIV-7	Settings modified to suit the circuit
Router	Configuration enhanced to support TCP/IP traffic
BUG-E JRE to ACEP JRE	Tested circuit from BUG-E JRE to ACEP JRE successfully at Shaw AFB
Radios	Data fidelity checks accomplished using SAT-J link consisting of a PSC 5D, two KG-84As and a LANT-101 satellite communications antenna. Three PRC 117F's provided ground-to-ground and air-to-ground voice.

8.2. Communications Transport Layer: Making NCW Possible

8.2.1. Planning and Organization

The JCSE and CENTCOM J-6 were service providers for the level I (CENTAF, ARCENT, NAVCENT, MARCENT), level II (Comm Units [Signal Brigades, etc.]), and Level III (military communications acquisition personnel [NOCAD, Army MILSATCOM, etc.]) military service components. The Strategic

Engineering Branch (SEB) of JCSE was responsible for planning all aspects of the communications, including SATCOM terminal systems, data networks, and circuit provisioning.

DISA had significant interest in the backbone infrastructure. General Moran, the J-6, integrated the JCSE and DISA efforts and thereafter all the service components reported to the one control center on the status of all systems. The DISA Regional Operations Center in Bahrain (DISA ROC, now called the Theater Network Ops Center [TNC]) performed centralized monitoring of the infrastructure. For instance, all the Promina multiplexers were actually configuration controlled, whether they were located at an Army division headquarters or back at a rear base headquarters.

Remote control and configuration of technologies, including the Promina multiplexers and Redcom switches, reduced the need to train personnel in theater. The users of these new deployed systems did receive training, but it was done at the service component level.

8.2.2. SATCOM

Once the military satellites had been tapped out CENTCOM went to the commercial sector to satisfy requirements (following a MITRE recommendation). Eighteen commercial satellites provided 3.5 gigahertz bandwidth and supported a wide variety of communications including DSN, NIPRNET, all the DISA services, Predator links, GUARDRAIL links and Global Hawk links. CENTCOM/J-6/JCSE SEB managed all of the previous. Intelsat and Utilsat both moved commercial satellites to support OIF operations. The total SATCOM bandwidth (C, KU, and X bands) amounted to 2,266,744 Mbps, of which 1,867,184 Mbps was C and KU band (commercial) and 399,560 Mbps was limited X band (military satellite). Thus, only about 18% of the satellite space used for OEF and OIF was military. The JCSE coordinated the use of SATCOM radio frequencies for each country. Countries with a preexisting U.S. military presence posed no problems, but others required extensive negotiations. For example, it took months for CENTCOM to coordinate rent payments for frequencies in Qatar.

8.2.3. Equipment Configurations

JCSE provided secure, reliable services through deployable KU earth terminals (DKETs). The configuration of these terminals consisted of the elements in Table 1. The DKET terminals offered multiple capabilities. Naturally, JCSE could not deliver every possible capability to each DKET terminal and in such cases prioritized the capabilities the descending order of Table 2.

KU band commercial satellite terminal antennas and transmitters/receivers
Promina baseband multiplexer system with crypto capability
Redcom switches
X band military satellite terminal with transmitters/receivers
Windows-based email server CPU
Windows-based Web server CPU
Data Packages for NIPRNET and SIPRNET
CISCO routers

Fiber connectivity
Microwave connectivity (some sites)
Special project systems (some sites)

Table 1 DKET Components

SATCOM
Multiplexer systems
SIPRNET
Link-11 and Link-16
JWICS
UAV dissemination
NIPRNET
DSN phones
DRSN phones
CENTRIXS Coalition Network

Table 2 JCSE Function Priorities

8.2.4. Locations

The ten sites in were initially served with the above capabilities. Eventually 57 sites had similar configurations.

Prince Sultan Air Base (PSAB), Saudi Arabia
CAOC at ES Kan Village
Al Dhafra, United Arab Emirates
Al Jaber, Kuwait
Al Salem, Kuwait
Kharshi-Khanabad, Uzbekistan (K2)
Jacobabad, Pakistan
Manas, Kyrgyzstan
Thumrait, Oman
Seeb, Oman

Table 3 Initial DKET Locations

8.2.5. UAV Demand for SATCOM/Bandwidth/Reachback

Leading up to OIF the United States added several Predators and a Global Hawk as a collection capability, and always had U-2s flying. CENTCOM had a communications and information collection and/or distribution system up and operating prior to troop deployment for OEF (Afghanistan). It supported one Predator UAV out of Al Salim Air Base in Kuwait. Leading up to OIF the system was expanded to handle a total of six Predators flying: two over Afghanistan; three over Iraq; and one over the Horn of Africa.

8.2.6. Fiber-optic Connectivity

Shortly before OIF commenced, JCSE acquired fiber-optic cable for key nodes in theater. JCSE leased 155 megabyte OC3 connections from Europe and CONUS to Bahrain. The Bahrain hub then connected Kuwait and Qatar with fiber optics. Eventually, Kuwait and Qatar had their own individual fiber-optic linkages to Europe.

8.3. Acronyms and Terms

Acronym	Complete Name
AAR	After Action Report
ABCCC	Airborne Battlefield Command and Control Center
ACEP	Air Operations Center Communications Enhancement Package
ADCON	Administrative Control
ADOC	Air Defense Operations Center
ADOCS	Air Defense Operations Center System
ADSI	Air Defense Systems Integrator
AEW	Air Expeditionary Wing
AFFOR	Air Force Forces
AFRC	Air Force Reserve Component
ANG	Air National Guard
ATO	Air Tasking Order
AWAC	Airborne Warning and Control
BFT	Blue Force Tracker
BUG-E	Battlefield Universal Gateway Equipment
C2	Command and Control
C2PC	Command and Control Personal Computer
CAOC	Combat Air Operations Center
CASEVAC	Casualty Evacuation
CDMA	Code Division Multiple Access
CFACC	Combined Forces Air Component Command
CGRS	Common Grid Reference System
COP	Common Operating Picture
CRC	Communications Relay Center
CSAR	Combat Search and Rescue
C-TBM	Counter Tactical Ballistic Missile
DCGS	Distributed Common Ground System
DCTS	Defense Collaborative Tool Set

DKET	Deployable KU Earth Terminals
DMPI	Desired Mean Point of Impact
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities
EFS	Expeditionary Fighter Squadron
EOSS	Expeditionary Operations Support Squadron
EPLRS	Enhanced Position Location Reporting System
FBCB2	Force 21 Battle Command, Brigade and Below
FDMA	Frequency Division Multiple Access
FLOT	Forward Line of Own Troops
GCCS	Global Command and Control System
HIMARS	High Mobility Artillery Rocket System
HUD	Heads Up Display
HSD	Horizontal Situation Display
HVT	High Value Target
IMTDS	Improved Multilink Translator and Display System
INO	Intelligent Network Operations
IPB	Intelligence Preparations of the Battle-space
ISARC	Intelligence, Surveillance and Reconnaissance Cell
ISR	Intelligence, Surveillance, Reconnaissance
ITM	Intra-AOC Target Manager
IWS	Info Work Space
JFACC	Joint Forces Air Component Commander
JEFX	Joint Expeditionary Force Experiment
JICO	Joint Interface Control Officer
JRE	Joint Router Extension
JTF	Joint Task Force
JTIDS	Joint Tactical Information Distribution System
JTSTM	Joint TST Manager
JVMF	Joint Variable Message Format
KB	Kill Box
LOC	Lines of Communication
MCE	Modular Control Element
MDS	Mission Design Series
MIDS	Multifunctional Information Distribution System
Mirc	My Internet Relay Chat
MTW	Major Theater War
NAI	Named Areas of Interest

NCA	National Command Authority
NCA	Network Centric Analysis
NCO	Network Centric Operations
NCW	Network Centric Warfare
NIPR	Non-Secure Internet Protocol Router
NTISR	Non-Traditional Intelligence Surveillance and Reconnaissance
NVG	Night Vision Goggles
OEF	Operation Enduring Freedom
OFT	Office of Force Transformation
OGA	Other Governmental Agencies
OIF	Operation Iraqi Freedom
OPCON	Operational Control
OPR	Office of Primary Responsibility
OTAR	Over the Air Receive
OTAT	Over The Air Transmit
PED	Processing, Exploitation and Dissemination
PFPS	Portable Flight Planning System
PSAB	Prince Sultan Air Base
PSC	Portable Satellite Communications
ROE	Rules of Engagement
SA	Situational Awareness
SADL	Situational Awareness Data Link
SBS	Special Boat Service
SIPR	Secure Internet Protocol Router
SOF	Special Operations Forces
SPI	System Point of Interest
STANAG	Standard NATO Agreement
STE	Secure Transmission Equipment
STU	Secure Telecommunication Unit
TACON	Tactical Control
TADIL	Tactical Digital Information Link
TBM	Tactical Ballistic Missile
TBMCS	Theater Battle Management Core Systems
TCN	Tactical Control Network
TCT	Time Critical Targeting
TD&E	Test Design and Evaluation
TDL	Tactical Data Link

TDMA	Time Division Multiple Access
TF	Task Force
TST	Time Sensitive Targeting
TTP	Tactics, Techniques and Procedures
UAV	Unmanned Aerial Vehicle
UCC	Unit Control Center
UTM	Universal Transverse Mercator
WMD	Weapons of Mass Destruction
XATK	On Call Attack