11th International Command and Control Research and Technology Symposium
Coalition Command and Control in a Networked Era

COALITION AIRSPACE MANAGEMENT AND DECONFLICTION

Topics

Coalition Interoperability
Lessons Learned
Cognitive Domain Issues

David A. Griffith
Geoffrey K. Wilson-Smith, Sqn Ldr, RAF
Marc Ohmer, Maj, USAF
Michael F. Seifert
Francis A. DiLego
John Hitchings
Joshua Sterling
Chad Salisbury
Henry Simmons

Air Force Research Laboratory (AFRL)
Information Directorate (IF)
Information Systems Division (IFS)
Command Control Engineering Branch (IFSA)

POC: David A. Griffith
+1 (315) 330-4361

David.griffith@rl.af.mil

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ABSTRACT

The risk of fratricide is a constant problem in all military engagements, a problem that is exacerbated in coalition operations where military forces from many allied nations operate in close proximity. Despite considerable efforts to mitigate this risk, friendly fire engagements between air and ground units resulted in 13 deaths during Operation Iraqi Freedom. These incidents resulted, in part, from poor situation awareness and failures in the air command and control process. The movement of ground forces was swift and, in many cases, exceeded the ability of airspace management capabilities to keep up with the evolving situation. Lessons learned indicate that collaborative airspace planning, dynamic replanning, operational deconfliction and information sharing all needed to be significantly improved. The emergence of unmanned aerial systems, stand-off weapons, loitering munitions and sensors platforms necessitate their incorporation into disciplined airspace management, while the coordination of operations in both combat and civil airspace further exacerbates the planning process. The US Air Force Research Laboratory (AFRL) is addressing cognitive domain issues associated with collaborative planning and the provision of airspace information to planners to support conflict identification and dynamic reassignment. In addition, development is being undertaken into network-centric information service provision and coalition information sharing to support enhanced situational awareness. As a result, AFRL is developing the Joint AirSpace Management and Deconfliction (JASMAD) automated planning system to address the current and future challenges facing airspace managers. This paper details the ongoing research and the progress of the JASMAD program.

COALITION AIRSPACE MANAGEMENT AND DECONFLICTION

COALITION AIRSPACE MANAGEMENT – AN HISTORICAL CONTEXT

Exploitation of the air has been a critical element of military operation for almost 100 years. Since the first military use of aircraft for reconnaissance during World War I, the ability to project military power into the third dimension gained ever increasing importance to the successful prosecution of military operations. The strategic objective of achieving supremacy in the air was quickly identified; however, by World War II (WWII), the sheer number of operational aircraft led military planners to consider the air as a resource which, like personnel and materiel, required careful management. Unfortunately, many of the valuable lessons learnt during this period were forgotten in the post-war demobilization. Each Service developed doctrine and tactics based on their independent view of the employment of airpower, views that were consolidated and entrenched during the standoff of the Cold War.

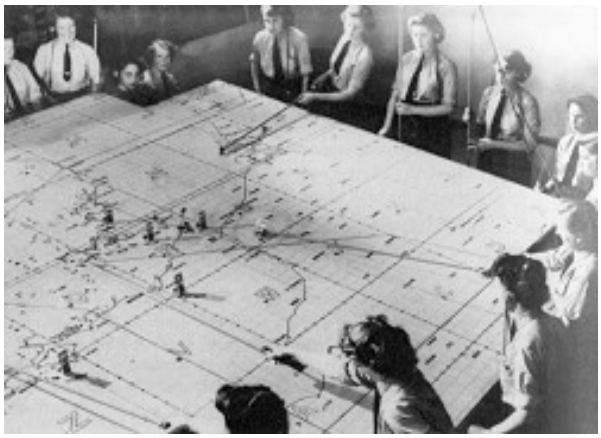

Figure 1 - Managing air assets in an RAF Sector Control Room during the Battle of Britain (RAF Photo)

The Cold War saw improvements in doctrinal approach to airspace management and operations at the international level. While the North Atlantic Treaty Organization (NATO) became the standing coalition of western nations, its doctrine envisaged declared forces with a fixed command structure enacting prepared battle plans over a known geographical area. Air operations were planned and coordinated by the Combined Air Operations Centers (CAOCs), but were undertaken by national elements operating in segregated areas over which they retained operational control. However, the US military's attempts to improve air operation coordination at a national level during both the Korean and Vietnam Wars resulted in little definitive progress, with each of the Services reverting to standing operating procedures at the cessation of both these conflicts.

The introduction of the Goldwater-Nichols Defense Reorganization Act of 1986 was the clarion call for change in US military operations. As *Dr Stephen Frought* indicates, the Act 'Gave the Joint Chiefs of Staff responsibility to develop joint doctrine' and 'gave [combatant] commanders authority to resolve issues involving unity of command'.[1] In response to the Act, the US military moved to a component-based operational structure to address unity of command and effort which saw the creation of Joint Force Air Component Commander (JFACC).

[1] *The Tale of the C/JFACC – A Long and Winding Road* by Dr Stephen O Fought (Air and Space Power Journal – 22 Dec 04 – Page 5).

While the Goldwater-Nichols Act set the US Armed Services on the long and often difficult road to 'jointness' it did not address the wider implications of coalition operations. With the fall of the Berlin Wall in 1989 and the subsequent collapse of the USSR, many nations, specifically the members of NATO, were forced to reconsider the role their armed forces would play in the new world order. The new structures within the US military had little time to cement. The 1991 Gulf War, designated Operations Desert Shield (force build-up operations) and Desert Storm (combat operations), was an early trial of the evolving operational formations. The new air component concept operated well in the coalition context but a number of significant weaknesses were revealed. Collaborative planning and execution of air operations proved problematic and the situation was hampered by poor communications and extremely limited interoperability of coalition information systems. Failures in airspace management resulted in 11 of the US military's 35 'friendly fire' casualties, which equates to 7.5% of total combat deaths.[2]

Figure 2 - Two F15s and an AT-38 over the desert during Operation Desert Storm (USAF Photo)

The need to refocus military operations in the post-Cold War environment was also recognized by the UK. As a result of lessons learnt from the 1982 Falkland Conflict, the first Gulf War and from its experience of operations on the Balkans, the British Armed Services, and specifically the Royal Air Force (RAF), began to recognize that their Cold War structures of operating within the NATO were inadequate to support globally deployed operations and began to shift their operational focus to an expeditionary footing. This restructuring saw the formation of the Permanent Joint Headquarters and the adoption of the component command concept already in place within the US military. As part of this process, the RAF formed a standing cadre to provide the core staff of a deployable Joint Force Air Component Headquarters (JFACHQ). With its formation, the JFACHQ became responsible for the planning and execution of all UK air operations in both joint and coalition operations.

However, while the new military doctrine, tactics and procedures were given time to mature, many of the lessons learnt from Operation Desert Storm went largely unheeded. Air operations in Kosovo during Operation Allied Force once again revealed significant weaknesses in airspace management and operations. As *Wing Commander Redvers Thompson* indicates many of the lessons identified in Operation Allied Force '*were carry-overs from Desert Storm some nine years earlier*'. He goes on to suggest that '*while undertaken with the best military endeavor by all those personnel involved, the*

[2] *Gulf War's Friendly Fire Tally Triples* by Barton Gellman (Washington Post, 14 August 1991).

consequential expansion of the Vicenza CAOC into an operational-level JFACHQ was a case study in ad hoc crisis management'.[3]

Airspace management procedures were again tested during Operation Iraq Freedom in 2003. Despite efforts to address many of the outstanding problems and with the introduction of new technology, to support operational planning, weakness in the airspace management were still apparent. Problems in the dissemination of airspace information, compounded again by battle tempo, once again resulted in blue-on-blue incident that caused 13 of the 71 US deaths during combat operations.[4] While a huge numbers of missions passed without incident, Patriot missile defense systems engaged coalition aircraft on several occasions including the shooting down of a British GR-4 Tornado and an F/A-18C Hornet. Aircraft were also involved in fratricide incident including an F-15E Eagle whose pilot mistakenly bombed a convoy of US Special Operations Forces and Kurdish allies and a Marine AH-1 Cobra helicopter that shot and disabled an M1-A1 Abrams tank.[5]

Figure 3 - Patriot Missile Defense Battery in Iraq (US Army photo)

Communication between US and coalition units again proved to be a significant hindrance to effective military operations. In his testimony to the Senate Armed Services Committee on 9 July 2003 concerning the lesson learnt from Operation Iraq Freedom, General Tommy R. Franks, former Commander US Central Command, stated that "*coalition information sharing must be improved at all levels*".[6]

AIR COMMAND AND CONTROL

As has been shown, the lesson identified in the various conflicts of the last 20 years have all shown that significant weaknesses continue to exist in the processes for airspace management and deconfliction, especially when these processes are undertaken in a coalition environment. Before discussing the challenges that face airspace managers, it is important to understand the current process for air command and control (C^2).

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[3] *Post-Cold-War Development of the United Kingdom Joint Air-Command and Control Capability* by Wing Commander Redvers T N Thompson RAF (Air & Space Power Journal – 1 December 2004).
[4] *Gulf War II - The Road to Victory* by Adam J. Hebert (Air Force Magazine - May 2003 Vol. 86, No. 5).
[5] *Stopping Blue-on-Blue - How the U.S. military is trying to eliminate the age-old problem of friendly-fire deaths* by Christian Lowe (Weekly Standard – 8 September 2003).
[6] Statement of General Tommy R. Franks, former Commander US Central Command before the Senate Armed Services Committee 9 July 2003.

Air C^2, which incorporates airspace management and deconfliction, relies upon the creation and dissemination of the following three key documents:

- The Airspace Control Plan. The Airspace Control Plan (ACP) ACP is a document that provides specific planning guidance and procedures for the airspace control and management within the area of operation. The ACP is normally published prior to the commencement of operations and remains extant throughout the operational period.

- The Air Tasking Order. The Air Tasking Order (ATO) tasks subordinate units to undertake projected missions, sorties and tasks against specifies targets and, for the USAF, is the lawful order for an aircrew to commit a hostile act under the Law of Armed Conflict. Production of the ATO normally follows a 24-hr cycle.

- The Airspace Control Order. The Airspace Control Order (ACO) implements the ACP and provides details of approved Airspace Control Measures (ACMs) which detail the location, utilization and duration of airspace volumes. The ACO can be published for any duration but normally follows the same 24-hr cycle as the ATO.

Figure 4 - Air Operations Center for Operation Iraqi Freedom (RAF photo)

During normal operations, tasks are usually planned 72 hrs ahead of schedule.[7] These tasks are coordinated by the Strategy Division within the Air Operations Center (AOC) and incorporated into the long range (72 hrs+) ATO. This ATO is subsequently transferred to the Combat Plans Division which conducts detailed planning for missions occurring in the next 36 hrs. Once finalized, the ATO is published to components, agencies, subordinate units and coalition partners 12 hrs prior to its implementation. Finally, the Combat Operations Division is responsible for monitoring the execution of the ATO and for conducting any replanning to accommodate real-time operational requirements. Consequently, there are usually three ATOs in production at any time (the long range ATO, the ATO for the following battle 'day' hrs and the ATO in execution).

The ACO is published in support of the ATO and details the ACMs designated for use by air assets undertaking the planned missions. By coordinating ACMs with air tasks, airspace managers seek to

[7] This is normally the case for 'routine' missions. Short notice sorties, such as Combat Search and Rescue and missions against time sensitive targets can be planned, disseminated and accomplished within the execution day.

provide the safest and most efficient use of the airspace by mitigating risks of air-to-air collisions and blue-on-blue engagements. The ACO must accommodate all deconflicted airspaces being utilized by activities in the air. Also, it must be comprehensive and adaptable to real-time operational requirements. During Operation Iraq Freedom, a daily ACO could contain over 1200 ACMs and was amended on average 12 times a day.[8]

As has hopefully been demonstrated, Air C^2 is a hugely complex activity in which many different parties play critical roles. Only when the operation of all air forces, both national and coalition, are effectively planned, harmonized, disseminated and executed in a coordinated fashion can the aims of the air campaign be met.

THE CHALLENGE FOR AIRSPACE MANAGERS

As can be seen, the processes of Air C^2 are comprehensive and complex and must be adaptable to the dynamic nature of air warfare. Within this process, responsibility for the safety of air assets falls to the airspace managers. However, airspace management is becoming increasingly difficult with the proliferation of airborne assets and munitions. Air operations today and in the foreseeable future pose a number of challenges for airspace managers that must be effectively addressed if the risk to personnel and equipment, both in the air and on the ground, is not to be adversely increased and fratricide incidents are to be avoided. Studies by the US Air Force Research Laboratory (AFRL) have highlighted nine key areas that will need to be addressed:

- Lack of Situational Awareness. Currently airspace managers lack the facility to monitor the utilization of designated ACMs once the ACO has been published. This lack of situational awareness prevents effective policing of the airspace and significantly hampers efforts to redesignate ACMs to meet changes in operational priorities. Current operation support systems also lack the ability to simulate the execution of planned operations in faster-than-real-time that would allow planners to identify and address potential airspace utilization problems before the missions are actually flown.

- Airspace Reallocation to Support Mission Replanning. Closely associated with the requirement for enhanced situational awareness is the need to provide planners with the ability to rapidly conduct airspace reallocation to support mission replanning. Currently, ACMs specified in the ACO remain in effect until the next ACO is published (normally every 24 hrs). This leads to an inefficient utilization of the air environment as ACMs may only be required for short time period. Even when an ACM is in use, it may be possible, with the ability to track assets within airspaces through enhanced SA, to temporarily reallocate potions of active airspaces to higher priority tasks. For example, if situational awareness allowed airspace managers to know that an airborne tanker was in the north of its designated orbit, they could temporarily reassign part the southern portion of the orbit to facilitate the transit of Combat Search and Rescue package.

[8] *Operation Iraqi Freedom – by the Numbers* by the CENTAF Assessment and Analysis Division (2003).

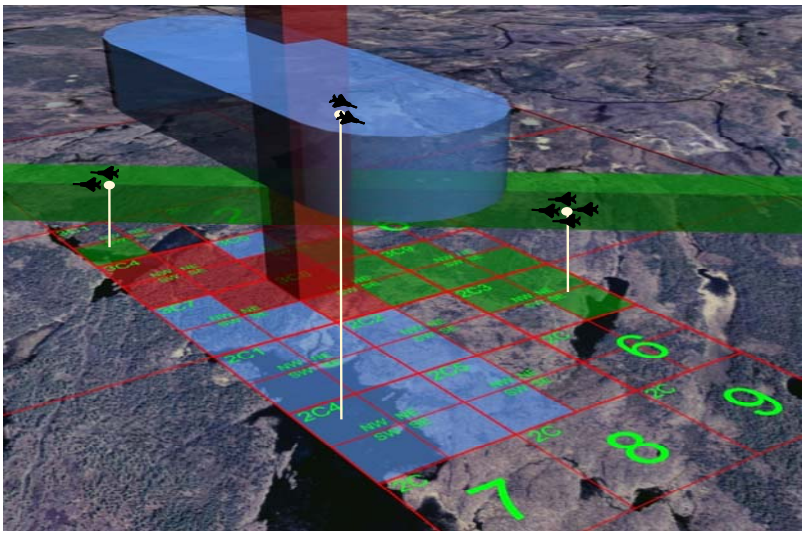

Figure 5 - 3D representation demonstrating how improved situational awareness could be used to support airspace reallocation and mission replanning

- Coordination of Air and Ground Operations. A long-standing problem in air warfare is the need to coordinate air and ground operations with the aim of preventing potential blue-on-blue engagements, both from the ground and from the air. This is a particularly relevant issue for the coordination of aircraft with ground-based air defense (GBAD). Airspace managers require improved situational awareness of air and ground operations, along with the current weapons control status, to ensure that appropriate measures are put in place to prevent fratricide incidents. This is especially germane in high-tempo operations where both air and ground units are moving rapidly over wide geographical areas.

- Unmanned Aerial Systems. One of the greatest challenges facing airspace managers is their current inability to coordinate and deconflict the operation of Unmanned Aerial Systems (UASs). The unprecedented proliferation of UASs in recent years, specifically within tactical-level units and sub-units, has dramatically increased the risk to air operations. In Afghanistan, an Airbus 300B4 airliner with 100 personnel on board came within 170 feet of a German EMT Luna tactical UAS,[9] while in Iraq reports have indicated that helicopters have been struck by UASs.[10]

Figure 6 - The view from a German UAS in a near miss with an airliner over Kabul, Afghanistan – 30 Aug 04 (Bundeswehr photo)

[9] *Near misses between UAVs and airliners prompt NATO low-level rules review* (Flight International – 14 Match 2006).
[10] *Controlling Iraq's Crowded Airspace No Easy Task* by Sandra I. Erwin (National Defense Magazine – 17 November 2005).

While the operation of larger UAS may be reflected in the ATO, airspace managers have no way of controlling UAS operations at the tactical level where hand-launched systems are often employed for localized reconnaissance. As the potential uses of UASs continue to expand, their impact on airspace management will certainly increase. Plans to use UAS 'swarms' in an intelligence, surveillance and reconnaissance role will greatly increase the potential for air-to-air collisions with other aircraft. Indeed, Brig Gen Robert P. Lennox, Commander US Army Air Defense Artillery Center stated that "*You might have missiles flying, UAVs, communications relay systems, intelligence systems, all in the same airspace, staring at the same area on the ground*".[11]

Figure 7 - The proliferation of small UASs, such as this Army Raven, presents a considerable challenge to airspace managers (US Army Photo)

- Stand-off and Loitering Munitions. Traditionally, airspace managers have had to be cognizant of airborne munitions such as artillery, mortars and GBAD. However, the difficulty of deconflicting weapons profiles with other airspaces is becoming increasingly more complex with the introduction of stand-off and loitering munitions such as the Joint Air-to-Surface Standoff Missile (JASSM) and the Low-Cost Autonomous Attack System (LOCAAS). Current airspace management procedures are inadequate to deal with these types of weapons. As with UASs, the uncoordinated use of stand-off and loitering munitions introduces the threat of collision with other air assets.

- Coordination with Civil Aviation. It is inevitable in the modern age that air operations during conflict will need to be conducted in airspace simultaneously utilized by civil aviation. Current procedures only present a rudimentary facility for avoiding International Civil Aviation Organization (ICAO) airspace. Coordination with civil aviation is essential where civil aircraft continue to operate in a conflict zone. Interaction with civil aviation is also directly relevant to inter-theatre military flights, such as air transport and long-range strategic operations, where military aircraft may use a combination of civil and military airspace.

- Training and Experience. Airspace management is a highly specialized task that requires specific skills of the staff involved. To become an effective airspace manager requires considerable training and relies extensively on personal experience. However, personnel selected to augment permanent cadre staff often have minimal training or experience in the field.

[11] *Controlling Iraq's Crowded Airspace No Easy Task* by Sandra I. Erwin (National Defense Magazine – 17 November 2005).

- Lack of Automated Mission Support Systems. Currently, airspace management is disconnected from mission planning. The ability to correlate between the ATO and the availability of airspace is a highly labor-intensive process that lacks any significant automated systems. Also, the lack of similar automated assistance for operations execution places the burden on the airspace manager to anticipate airspace and aircraft conflicts and know how to best communicate with the forces to resolve both potential and actual conflicts. The ability to provide planners with a dedicated airspace management, integrated with the wider information support infrastructure, would significantly improve planning efficiency and would reduce the burden on training and experience.

- Communication and Dissemination. Given the current capability of dedicated planning tools, airspace management remains a largely manual process. Planners rely on unreliable communications infrastructure when attempting to coordinate requests for airspace. This situation is compounded significantly when communicating with coalition partners. Even when the ACO has been produced, difficulties are often experienced in effectively disseminating the information which must be provided to all components, subordinate units, agencies and coalition partners involved in or impacted by air operations. The need to ensure the information is delivered often requires a reliance on the communications 'lowest common denominator' such as formal messaging or telegraph. In almost all circumstances, interoperability between the US military information systems and those of their coalition partners is extremely limited.

THE USAF APPROACH TO THE PROBLEM

In response to the lessons learnt from Operation Iraqi Freedom and the challenges identified above, AFRL initiated an Advanced Technology Demonstration (ATD) program to develop a Joint AirSpace Management and Deconfliction (JASMAD) system. JASMAD will provide a single distributed joint theater airspace management and dynamic deconfliction capability to coordinate near-real-time air operations planning and execution in order to minimize conflicts and assist airspace managers to optimize the airspace utilization. The system is intended to provide an automated collaborative environment to create, import, modify, deconflict and disseminate the ACP, ACO and ACMs, in addition to providing airspace inputs into the ATO.

In addition, JASMAD will have enhanced visualization capabilities including the ability to utilize and display tactical data feeds and weather information. The planning capabilities of JASMAD include providing a 4D[12] visual picture for the purposes of airspace management. The airspace planner will be able to select and sort airspace volumes based on criteria such as time frames, geographical area, airspace types and usages, requestors and airspace status. Functional mission planners will have the capability to create and coordinate airspace usage to plan mission packages, launch times, time on target, target areas, altitude blocks and air refueling tracks. Airspace managers and functional mission planners will be able to create and import routes and operating areas to facilitate the automated creation of ACMs in order to concurrently show visually airspace conflicts.

JASMAD will improve the efficiency of the airspace management process by allowing airspaces to be defined more accurately and by specifying a variable activation period. Currently, planners allocate large volumes of airspace to specific tasks. The airspace allocated for a tanker refueling area can be 60 miles long, 20 miles wide and can occupy 15,000 feet of height. Also, such an airspace may be allocated for as long as the ACO is extant, whether there are tankers present or not. Also, the package is intended to be interoperable with the US Federal Aviation Agency (FAA) and the ICAO and will have

[12] 4D represents latitude, longitude, altitude and time.

the capability to import/export route changes within civil aviation and deconflict these with planned military airspaces.

During execution, JASMAD will allow 4D observation of ATO/ACO execution and will provide replanning and support re-tasking options. Mission planners will be able to change routes and preview the impact on airspace management. Conflict alerts will automatically identify negative aspects of those proposed route changes. Once complete, JASMAD will automatically prepare ACM information in near real time for dissemination to all pertinent nodes.

In addition to supporting operational level planning, consideration is being given for JASMAD to support combat units at the tactical level. This support could allow units to submit automated ACM request to obtain airspace allocations directly to the AOC. It is also intended to provide tactical situational awareness to allow deconfliction of assets within allocated airspaces. In this way, JASMAD could be used by a UAS commander to deconflict systems within a dedicated UAS operating area. Similarly, artillery batteries can coordinate fire missions automatically with the airspace managers in near real time to ensure friendly air assets are not endangered. The use of stand-off weapons and loitering munitions could also be coordinated using a similar process.

JASMAD's automated airspace deconfliction facility will be based on modern algorithmic techniques to minimize the time required for conflict detection between without jeopardizing accuracy. Conflict detection will start with rudimentary checks that can be performed very quickly, in essence, to determine if further work to detect a conflict is required.[13] Only when these checks fail would more elaborate means of detecting potential conflicts be required. In addition to air object deconfliction, JASMAD will also undertake weather and terrain deconfliction. Early prototyping of the conflict detection algorithms have already resulted in performance that far exceeds fielded systems with similar capabilities.

As part of the program, new methods of portraying airspace information to the airspace planner are under development. Some of this activity involves modeling airspaces in 3D on an elliptical model of the Earth. Historically, airspaces have been represented on a flat, paper map-style projection of the Earth's surface (sometimes known as XYLL). The use of flat projections inherently introduces distortion when trying to represent 3D airspace volumes.[14] Representing these spaces over a geocentric terrain removes both types of distortion and is inherently easier to understand, as shown in Figure 8.

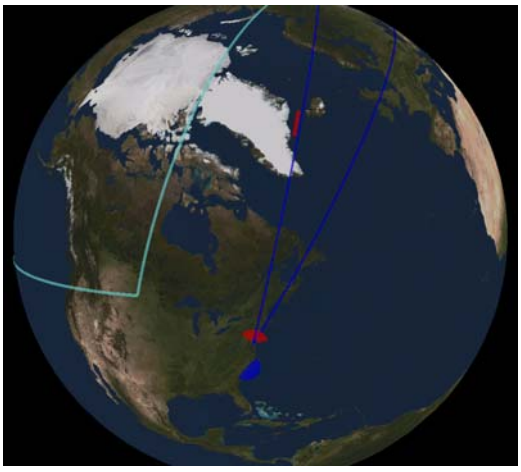

Figure 8 - **Airspaces on a Geocentric Projection** - The corridor airspaces in this picture span large distances, yet on this projection, suffer no distortion as would occur near the poles on a flat earth projection. Additionally, the airspaces bend intuitively around the globe along the great circle routes that are the shortest distances between two points on a globe

[13] For example, the times airspaces are active and the altitude ranges that they occupy can readily be checked via simple value comparisons. If the times the airspaces are active never coincide, or if the minimum altitude of one is higher than the maximum of the other, then no conflict could possibly exist.
[14] The inherent distortion when approaching the poles coupled with the fact that the shortest path on a sphere is a great circle arc requires (for accuracy) warped versions of airspaces when drawn to this projection.

Research is also being performed regarding the representation of a multitude of airspaces simultaneously without overcomplicating the display and obscuring data from the planners. In addition to traditional translucency (which distorts the airspace's color which have significance to the airspace planners), alternative visualization techniques have been investigated, including airspace outlines that are solid when visible and shown as dashed when obscured by other airspaces (indicating overlapping airspaces while preserving the color and its significance). Figure 9 depicts representations of airspaces using both visualization techniques.

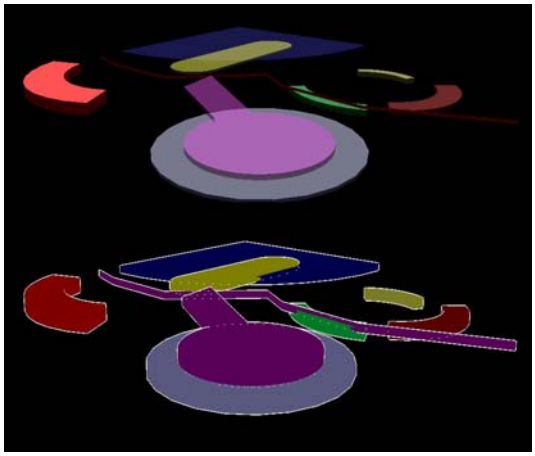

Figure 9 - **Translucency versus Airspace Outlines** - This figure demonstrates how traditional translucency will change the color of the airspaces while the outlining technique preserves the exact colors of the airspaces.

COLLABORATION AND INTEROPERABILITY

Coalition operations have consistently shown a lack of partner coordination in Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR). While JASMAD will meet the joint service airspace management requirements for the US military, the program is not currently considering these requirements in the wider context of coalition operations. To mitigate the problems that have plagued airspace planning during such operations, it is essential that multi-national collaboration and coordination of airspace planning, deconfliction and situation awareness information is addressed.

While this would be a worthy goal, it would be impractical, if not impossible, for JASMAD to support bilateral interfaces to the myriad of C^2 systems that could be fielded within a coalition operation. Indeed, US Joint Publication 1-02 defines coalition as "an ad hoc arrangement between two or more nations for common action" and multi-national action as "action outside the bounds of established alliances, usually for single occasions, or longer cooperation in a narrow sector of common interest".[15] Therefore, given the dynamic nature of global politics today, it is impractical to attempt to accurately predict the likely composition of coalitions that may be formed to address future conflicts. Past attempts at achieving interoperability through the use of fixed format messages, message parsers and static databases has had limited success and has resulted in problematic and costly maintenance efforts whenever inevitable changes have needed to be implemented.

Nonetheless, steps can be taken to alleviate information sharing issues and improve collaborative operations. The JASMAD program will facilitate interoperability through the publication of a standard Application Programmer Interface (API), the implementation of an Extensible Mark-up Language

[15] Joint Publication 1-02 - Department of Defense Dictionary of Military and Associated Terms (Department of Defense – 31 August 2005).

(XML) schema and the production of data objects as Tailored Information Products (TIPs). However, this approach relies upon coalition partners to implement the interface(s) in their own systems.

In addition to the core JASMAD program, AFRL has proposed three additional associated programs over the next three years that will consider the implications of system interoperability with coalition partners; these are the Coalition Airspace Management and Deconfliction (CASMAD) program, the Coalition Airspace Information Sharing (CAIS) program and the JASMAD for Coalitions program. These three programs are complimentary, with later programs building on the success and leveraging the products of earlier research and development.

The aim of the CASMAD program is to consider international interoperability within a very tight frame of reference. AFRL will work in conjunction with the British Ministry of Defence to develop a software capability that demonstrates interoperability between JASMAD and airspace planning tools within the UK Air Command and Control System (UK ACCS). This capability will enhance the functionality of JASMAD by developing a software package to provide a defined machine-to-machine (M2M) interface to create a network-centric interoperable suite of collaborative airspace management tools. It will facilitate automated data exchange mechanisms to support collaborative airspace planning and deconfliction within a bilateral US/UK coalition environment. CASMAD is designed as a proof of concept to consider the technical and ontological implications of multi-national collaborative planning. While the program is primarily focused on the development of a M2M interface, it will also consider wider implications for information sharing such as procedural differences, data standardization, data formats, communications connectivity and security (both procedural and technical).

CAIS will build on the research undertaken during the CASMAD program but will focus on multi-national data standardization to support M2M data transfer between US systems and a wider set of coalition partners without necessitating the incorporation of US technology into their systems. In an attempt to mitigate interoperability problems, many potential coalition partners, including NATO nations, have agreed to participate in the Multilateral Interoperability Programme (MIP). The MIP consists of 11 core nations[16] and 14 associate nations,[17] along with Regional Headquarters Allied Forces North Europe (RHQ AFNORTH) and Supreme Headquarters Allied Powers Europe (SHAPE), now Allied Command for Transformation (ACT). A key product of the MIP is the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM). However, to date, development of the data model has centered on land operations. The objective of the CAIS program is to drive the development of data standardization and M2M communication and to define and coordinate airspace extensions to the JC3IEDM. CAIS will address, as a minimum, data definitions, attributes, relationships, domains, business rules, and logical/physical views. The definition of and migration to such a net-centric information service oriented architectures, complemented by M2M interfaces, would significantly enhance the effectiveness of collaborative coalition operations. In undertaking this program, AFRL intends to liaise closely with the MIP, NATO Data Administration Group (NDAG), NATO Air Command Control Management Agency (NACMA) and NATO Consultation Command Control Agency (NC3A).

The JASMAD for Coalitions is the third supplementary effort to the JASMAD program and is designed to leverage the outputs from both CASMAD and CAIS. This program will use the interfaces developed by CAIS to implement coalition interoperability between JASMAD and the airspace management information systems of selected coalition partners, initially from within NATO but with the future

[16] The 11 core nations of the MIP are Canada, Denmark, France, Germany, Italy, Netherlands, Norway, Turkey, Spain, United Kingdom, and the United States.
[17] The 14 associate nations of the MIP are Australia, Austria, Belgium, Bulgaria, Czech Republic, Finland, Greece, Hungary, Lithuania, Poland, Portugal, Romania, Slovenia and Sweden.

potential for wider application. JASMAD for Coalitions aims to extend US capability to partner nations to provide new tools to support multi-national collaborative planning and facilitate new ways of conducting combined/joint air operations. It will extend JASMAD's airspace information services and develop and test features which would allow it to be interoperable and integrated with MIP member nations' air C^2 systems. The long-term objectives of the JASMAD for Coalitions program is to directly assist CFACC and the Airspace Control Authority (ACA) to conduct combined air operations, at both the strategic and operational levels, in a more coordinated and controlled fashion and will seek to maximize the efficiency of airspace utilization within the air campaign. At the tactical level, shared information among airborne units, and ground/surface based air defense units, will improve situation awareness, and will help reduce the risk of fratricide incidents. Near-real-time collaborative dissemination and deconfliction of airspace information will greatly accelerate decision making in all areas, greatly enhancing the ability of coalition forces to prosecute time sensitive target, Special Operations Forces (SOF) operations and Combat Search And Rescue (CSAR) missions that will all require dynamic airspace reassignment.

The diagram below shows a conceptual view of the relationship between JASMAD, CASMAD, CAIS and JASMAD for Coalitions. Within the concept, JASMAD provides the network-centric information service to support airspace management and deconfliction. The JASMAD interface layer produces TIPs to provide disparate information systems with airspace management data. CASMAD resides within the interface layer and provides TIPs directly to the UK airspace management database. JASMAD for Coalitions fulfills a similar function of transferring information to NATO and other coalition databases. The process of developing CASMAD and JASMAD for Coalition interfaces is made significantly less complicated if the Air Operations Data Base (AODB), UK ACCS and coalition databases all adhere to the same data model (JC3IEDM) and support the same M2M communications. This standardization will be initiated by CAIS.

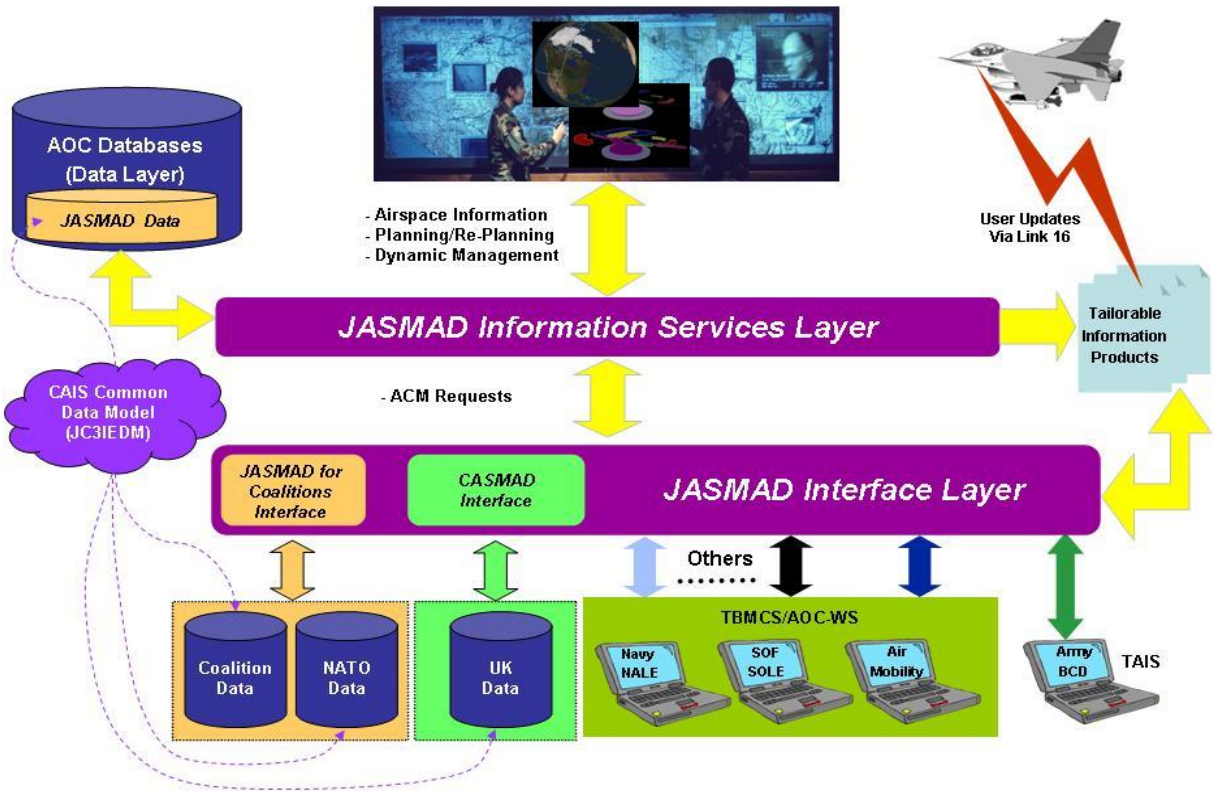

Figure 10 - Conceptual View of JASMAD, CASMAD, CAIS and JASMAD for Coalitions

SUMMARY

The overarching JASMAD program (supported by CASMAD, CAIS and JASMAD for Coalitions) intends to address all of the airspace management challenges previously identified. The automated airspace planning support services enabled by JASMAD will provide commanders at all levels with a significantly improved situational awareness. Enhancements to coalition information sharing will not only allow airspace manager to plan efficiently but will allow much greater coordination between air and ground operations. Also, the improved situational awareness provided by JASMAD will, for the first time, allow planners to modify airspaces during execution in near real time and provide the facility to replan missions or reallocate airspaces to meet urgent operational requirements. By introducing JASMAD's capabilities at the tactical level, the fidelity of airspace management can be improved to incorporate air assets such as UASs and standoff and loitering munitions that currently operate autonomously from the airspace management process. The effectiveness of the planning process will be further improved by the ability to integrate civil aviation requirements into the system. Finally, by taking a holistic approach to the problem and by providing automated planning support where possible, it is hoped that the training burden on airspace planners can be reduced considerably, allowing the AOC to be augmented more readily by inexperienced personnel.

JASMAD will provide a considerable uplift in capability and will improve both the effectiveness and efficiency of the airspace management process. However, it is already envisaged that the system may provide planners with the ability to adapt their processes to take full advantage of the benefits provided by the new technology. The introduction of JASMAD will facilitate much greater integration of air mission planning, and airspace management. This integration would break down the existing planning cycle where missions are coordinated in 24 hr blocks and would facilitate a move to a dynamic planning continuum where plans are fed continuously into execution and where replanning during execution can be rapidly fed back into the development of future missions. The constant feedback provided by such a process would allow a significant increase in planning tempo and in the ability of airspace managers and mission planner to react rapidly to changes in the operational situation. This increase in planning tempo would be supported by more efficient use of the airspace achieved through the accurately definition of airspaces in terms of location, volume and time. Future migration towards this goal will certainly provide considerable additional benefits for the effectiveness of Air C^2.

ANNEX

ACRONYMS:

ACA	Airspace Control Authority
ACM	Airspace Control Measures
ACO	Air Control Order
ACP	Air Control Plan
ACT	Allied Command for Transformation
AFRL	Air Force Research Laboratory
AODB	Air Operations Data Base
API	Application Programmer Interface
ATD	Advanced Technology Demonstration
ATO	Air Tasking Order
C^2	Command and Control
C4ISR	Consultation, Command, Control, Communications, Intelligence, Surveillance, and Reconnaissance
CAIS	Coalition Airspace Information Sharing
CAOC	Combined Air Operations Center
CASMAD	Coalition Airspace Management and Deconfliction
CFACC	Coalition Force Air Component Commander
CONOPs	Concept of Operations
CSAR	Combat Search And Rescue
FAA	Federal Aviation Agency
GBAD	Ground-Based Air Defense
ICAO	International Civil Aviation Organization
JASMAD	Joint AirSpace Management and Deconfliction
JASSM	Joint Air-to-Surface Standoff Missile
JC3IEDM	Joint Consultation, Command and Control Information Exchange Data Model
JFACC	Joint Force Air Component Commander
JUG	Joint Users Group
LOCAAS	Low-Cost Autonomous Attack System
MIP	Multilateral Interoperability Programme
NACMA	NATO Air Command Control Management Agency
NATO	North Atlantic Treaty Organization
NC3A	NATO Consultation Command Control Agency
NDAG	NATO Data Administration Group
RAF	Royal Air Force
RHQ AFNORTH	Regional Headquarters Allied Forces North Europe
SHAPE	Supreme Headquarters Allied Powers Europe
SOF	Special Operations Forces
TIPs	Tailored Information Products
TTPs	Tactics, Techniques and Procedures
UAS	Unmanned Aerial System
UK ACCS	UK Air Command and Control System
XML	Extensible Mark-up Language

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