



FUTURE OF AIR-TO-AIR REFUELLING IN NATO



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Combat Support Branch,
Air-to-Air Coordination Cell
Joint Air Power Competence Centre
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Executive Summary



Scope: The JAPCC undertook this study to foresee and analyze future developments impacting NATO Air-to-Air Refuelling (AAR), inform NATO planners and commanders of potential impacts, and recommended appropriate alliance responses to support optimal alliance AAR capability and employment. The study considers the capabilities, doctrine and concepts of operations that member nations will provide, along with collective alliance capabilities, and the limited extant NATO doctrine for planning and employment. The report is presented at a level of detail useful to those generally familiar with air power concepts, while also relevant for AAR expert staff and commanders. The future time frame examined is from the immediate future (2007) projected forward for 15 years to 2022.

The study aims to answer the questions: “How is AAR transforming?”, and “How do we want AAR to transform?”

Classification: This report is not classified. Information presented is Non Sensitive Releasable to the Public, and information from classified sources and references is not cited or referenced in this report. Discussions, findings, and recommendations are not based on classified information. Reference to classified sources may be required to support more detailed analysis and recommendations that go beyond the unclassified information, discussion, and recommendations presented here.

The AAR Effect: The primary AAR effect is identified here as spatial or temporal extension of other air capabilities by providing additional fuel to airborne aircraft. Effectiveness can be expressed in results produced; including numbers of tanker sorties generated, tanker hours flown, time on station, amount of fuel offloaded, and number of receivers supported. Extension will remain the primary AAR effect, and focus on the associated statistics and measures of merit will continue to be appropriate.

Resources: Overall tanker numbers will decrease, but tanker numbers will generally be sufficient to meet national, if not alliance needs. Resources sufficient to meet national needs don’t guarantee sufficiency for alliance needs, and not all national tankers are necessarily made available to the alliance. Planning software and net-enabled C4I will provide incremental improvements in efficiency and effectiveness. New dual-capable (boom and drogue on same sortie) tankers will improve tactical interoperability and flexibility, and the two current refuelling methods: boom-receptacle, and probe-drogue will both continue to be used.

More flexible and capable aircraft will present greater opportunities and challenges for national and alliance operations. Interchangeable role, and receiver capable tankers will facilitate role flexibility, force extension, and fuel consolidation. Understanding and managing this increased flexibility will present conceptual and practical challenges. Development of NATO AAR doctrine could assist with these challenges.

Requirements: More, and more reliable receiver aircraft predict an increase in AAR requirements. The report however predicts little qualitative change in the requirement for AAR apart from potential development of specialized equipment for UAV rendezvous and AAR.

Interoperability: This report identifies procedural interoperability as important to NATO AAR, with much room for improvement in NATO exercises to practice interoperability. It also notes the significance of the newly revised ATP-56(B) universal refuelling manual, being implemented in 2007. This implementation is the most significant development to date in AAR interoperability for the alliance. Maintaining agreed and effective procedures will continue to be a challenge for the refuelling nations.

UAV AAR: Though there is currently no requirement for UAV AAR in the alliance, UAV AAR developments are discussed. UAV developments could drive new requirements in tanker characteristics (including potentially tanker UAVs) within the time horizon of this study, but there is not currently reason to predict UAVs will drive requirements for new tanker aircraft.

Employment Concepts and Logistics: AAR employment concepts and operating context including threats to AAR operations are also discussed with discussion on deployed operations and support to long-range strike.

Doctrine and Terminology: More interchangeable role, receiver capable, and dual-capable tankers will improve interoperability, flexibility, efficiency and effectiveness across fleets, and on individual sorties. NATO has no AAR doctrine to guide employment of current or future capabilities, or provide common conceptual references or vocabulary.

Findings and Recommendations: The report concludes with findings and recommendations in the areas of: Revitalization of the PCC Regarding AAR, Basing, UAV AAR, Efficient AAR Planning, Doctrine and Terminology, Interchangeable Role / AT Capability and Other Secondary Roles, and AAR in NATO exercises.



I. Introduction: Objective, Scope, Assumptions, and Structure

A. Objective

1. This study was undertaken to foresee and analyze developments impacting NATO Air-to-Air Refuelling (AAR) in the future, inform NATO and national staff and commanders of potential impacts, and recommended appropriate Alliance responses to support optimal Alliance AAR capability and employment. The study aims to answer the questions: “How is AAR transforming?” and “How do we want AAR to transform?”
2. The study examines a broad range of AAR issues expected to impact future alliance AAR planning and execution, and recommends NATO policy to ensure the AAR capability required for the future. Issues are examined and discussed under the categories of: effects, resources, requirements, technologies, additional roles, employment concepts, operating context, logistics, and doctrine, procedures and training. Findings are then presented and used to develop recommendations for NATO policy and planning. Requirements discussed here should not be confused with requirements derived from the Defence Requirements Review (DRR) process for formal defence planning, and the classified DRR figures will not be referenced here.

B. Scope

1. The study considers the capabilities, doctrine, and concepts of operations that member nations will provide, along with collective alliance capabilities, and the limited extant NATO doctrine for planning and employment. The future time frame examined is from today (2007) projected forward for 15 years to 2022. The equipment, resources and systems covered include all air refuelling tankers and systems that support them including mission planning, basing, and training. Air refuelling capabilities residing outside national air forces, including naval, SOF, and commercial resources are included. As forces operating in the air supporting military operations, all of these aviation assets will be discussed under air forces. The study includes issues identified by military and industry sources as those likely to impact NATO AAR in the next 15 years, with implications for NATO planning and operations. Findings and recommendations follow the discussion sections, and are based on study findings. Many issues identified in the original research for this study are not included in this report, as investigation of those issues determined a low impact on future AAR operations. Decisions on inclusion, and discussion, findings, and recommendations, are based on the researcher’s subjective judgments after considering available resources, expert opinions, and predictions.
2. This report foresees and discusses future AAR issues in the categories identified above in paragraph A. Objective, in broad unclassified terms. It may be used to provide a common vocabulary and basis for planning, coordination, and discussion among NATO and national air and joint staff. The report is presented at a level of detail intended to be useful to those generally familiar with air power concepts, while also relevant for AAR expert staff and commanders. Findings and recommendations do not define specific actions and programs.

C. Assumptions

The assumptions below were used to define the scope of the study. Assumptions 1 through 5 are from the draft Alliance Air-to-Air Refuelling Concept, written by the Joint Air Power Competence Centre AAR Coordination Cell.

1. Tanker Aircraft are national AAR assets, under national command and control. This includes civilian tankers contracted by a nation or nations.
2. NATO has no AAR assets of its own, but national assets can be provided for the benefit of NATO upon national approval. This report discusses the potential for NATO owned tankers, but none are planned or foreseen, and potentially NATO owned tankers are not discussed as future resources.
3. During crises and conflicts, Transfer of Authority (TOA) of AAR assets will follow the NATO generation of forces procedure.
4. Agreements between providers and receivers are driven by bilateral Memorandums of Understanding (MOUs), and, for European Airlift Centre (EAC) member nations, within the EAC processes. Legal, financial, and operational specifics must be coordinated between nations for each combination of tankers and receivers, even when operating as NATO TOA assets. Although NATO funding principles provide general guidance, detailed financial agreements will normally be outlined in a MOU.
6. NATO's capability to influence national policy and shape current and future air refuelling systems, procedures, tactics and doctrine, is limited. NATO influence is restricted to Defense and Force Planning where NATO through its mechanism for Defense Requirements Review (DRR), Force Proposals and subsequent Force Goals can influence (or encourage) nations to prioritize their investments. Alliance priorities and STANAGs are considerations, but nations acquire and operate weapon systems on the basis of national interests and priorities.
7. Maximizing effects from the resources available is a NATO objective. Planners and operators will want to air refuel aircraft that can be air refuelled to optimize their effects.

D. Structure and Organization

1. The study began with a survey of information and data to identify a broad range of AAR issues. These issues were then screened to identify those warranting further research and development. Selected issues were grouped into categories of effects, resources, requirements, technologies, employment concepts, additional roles, operating context, logistics, and doctrine and procedures for research, discussion, and findings.
2. Some issues fit in more than one category. In these cases, issues are discussed in their primary category, and cross referenced in related categories. This necessarily involves some

repetition, but ensure issues impacting more than one category are considered in all appropriate contexts.

3. The report concludes with Section XI, where findings support recommendations aimed at encouraging the greatest possible AAR capability available to the alliance, and optimal employment strategies.

E. Classification

This report is not classified. Information from classified sources and references is not cited or referenced in this report. Discussions, findings, and recommendations are not based on classified information. Reference to classified sources may be required to support more detailed analysis and recommendations that go beyond the unclassified information, discussion, and recommendations presented here.



II. AAR Effects

A. Purpose of AAR

Understanding the purpose and desired effect or “why”, of AAR is prerequisite to discussion and understanding of the resources, employment, and technology, or “how” of AAR for current and future NATO planning and operations. Considering this prerequisite, and current emphasis on Effects Based Operations, we first identify AAR effects as the objective answer to “why” AAR. These effects will apply to future AAR as well as current AAR.

B. AAR Effects

1. The primary AAR effect is spatial or temporal extension of other air capabilities like strike, transport, or ISR. This extension is accomplished by providing additional fuel to airborne aircraft. This extension also supports many second order effects like enhancing flexibility, reducing operating locations, and increasing payload capacity. How, when, and where extension is accomplished, are important variables that influence success and exploitation of the AAR effect. To ensure the effect is optimized, it is important that AAR does not substantially interfere with or hinder the receiver aircraft’s primary operations.
2. While there are many ways to accomplish and employ it, the irreducible effect of AAR is the extension effect caused by provision of fuel to airborne aircraft. Relevant measures of merit for this effect are right amount, right place, right time, and reliability.
3. AAR effectiveness can then be expressed in terms of results produced; including numbers of tanker sorties generated, tanker hours flown, time on station, amount of fuel offloaded, number of booms or hoses in the air, and number of receivers supported. Since AAR is an enabling or supporting effect instrumental to accomplishing ultimate air effects (e.g. cargo transported, or targets struck), relevant AAR results and statistics depend on desired ultimate air effects for a given operation. Acknowledging the importance of ultimate effects and situational variability, amounts of fuel offloaded and numbers of receiver aircraft supported are generally the most relevant results and expressions of the AAR effect.
4. NATO air missions and capabilities will continue to evolve. We may see new technologies and techniques for AAR along with new advantages exploited by receiver aircraft, but we can reasonably expect extension to remain the primary AAR effect. Focus on this effect and the associated statistics and measures of merit will continue to be appropriate for the future period covered in this study.

C. Maximizing AAR Effects

Basing, planning, and employment have potential for maximizing AAR effects, and means for maximizing AAR effects are discussed below in Section III, Future AAR Resources, paragraphs C and D.



III. Future AAR Resources

A. Tanker Aircraft Numbers

1. Several tanker numbers are of interest. They include 1) number possessed and or programmed by NATO nations, 2) number declared available for war planning, and 3) number available for NRF or rapid response use. Numbers of tankers made available for NATO training and exercises are also a concern; they are addressed below in Section X.

2. Available information suggests national tanker numbers will be sufficient to meet national needs. Several nations (Belgium, France, Germany, Italy, Netherlands, Spain, and UK) share AAR capacity to support each others requirements through the European Airlift Centre (EAC). This arrangement allows participating nations to pool resources when appropriate and optimize utilization. This has been an effective and efficient peacetime cooperation. However resources sufficient to meet national needs do not guarantee sufficiency to meet all alliance needs, and not all national tankers are necessarily made available to the alliance for planning or operations. National requirements may not include operations far from home MOB, but NATO requires expeditionary and deployed operations.

a. Overall tanker numbers will decrease slightly as US replaces its KC-135s with a smaller number of replacement tankers (numbers slowly decreasing, capacity uncertain), and Europe adds small numbers of tankers, and multi-role aircraft. The UK will have a greater number of older tankers retired than are replaced by new more capable tankers. The net number of tankers will likely decrease as the US and UK purchase fewer new tankers than will be retired, and other nations acquire tankers, but not on the same scale as the US and UK decrease. While newer tankers will provide more capacity per aircraft and higher utilization rates, the total number of tankers available to NATO will decrease. The numbers of US tankers retired and acquired over the period of this study.

b. It is not possible to forecast exact numbers, but current projections indicate fewer tankers, somewhat less offload capacity, and more permanently installed hose/drogue capability. USAF hopes to award a contract for a KC-135 replacement tanker in 2007. The replacement would occur over decades as the new “KC-X” enters service, and KC-135s retire. They may retire more KC-135s than they procure replacements for, but since the new KC-Xs will be more capable than the retiring KC-135s, replacements may yield nearly the same capability across the fleet. With the US KC-135s comprising the greatest numbers of NATO tankers, their uncertain replacement rate means total tankers could be as much as 300 fewer than today. The RAND Analysis of Alternatives (AoA) Executive Summary provides a useful discussion of requirements and recapitalization strategy.¹

¹ Analysis of Alternatives (AoA) for KC-135 Recapitalization, Executive Summary, RAND Project Air Force, 2006 RAND Corporation. Executive Summary available at <http://www.rand.org/pubs/monographs/MG495/#>

3. Tankers are declared by nations to NATO for defence planning. Resource requirements are identified in the Defense Requirements Review (DRR) process, and nations respond to the Defense Planning Questionnaire (DPQ) by declaring forces available for NATO planning. These forces may be some, all, or none of the forces possessed. Alliance plans rely on AAR as a critical enabling capability, and shortages in declared AAR capability would negatively impact alliance capability. AAR resources declared to NATO for war planning, and analysis of their sufficiency are classified, and will not be discussed in this study.

4. NATO Response Force (NRF) tanker requirements are identified and filled by nations under the Combined Joint Statement of Requirements (CJSOR) process for six month periods. Since NRF tanker requirements are relatively small, and each NRF series contains different receiver aircraft packages, tanker NRF packages must be tailored to ensure compatibility.

B. Tanker Aircrews

1. Crew ratios (number of crews available per aircraft) vary with air forces and aircraft. US crew ratios are likely to increase from 1.36 to 1.75 for KC-135s, and approximately 2.0 for KC-10. This will increase the number of available sorties per aircraft assuming aircraft utilization (maintenance reliability) rates and fuel availability rates permit flying crews at maximum monthly rates.

2. Crew ratios are only one entering argument in determining individual and collective tanker sorties available.² Increasing the number of crews can enable an increase in number of hours or sorties available, and can be done at a lower cost than increasing numbers of aircraft and crews. It should be noted however that increasing crew ratios entails significant costs beyond the personnel. Additional flying hours, fuel, maintenance, and airspace capacity may be required to maintain the additional crews' peacetime training and currency.

C. Potential Means for Increasing Number of Tankers Available to NATO

1. Along with traditional acquisitions, nations and NATO are exploring alternative means including leasing and collective acquisition to increase the number of tankers available.

2. Based on the Prague Capabilities Commitments (PCC) agreed by NATO Defense Chiefs, Spain led a group of nations, that examined potential for a program to collectively acquire and commonly operate a squadron size fleet of tankers to increase the number of tankers available to NATO. In the Prague Summit Declaration, the nations recognized AAR as a capability needing improvement and development, and pledged to implement the PCC.³ The PCC-AAR Working Group considered purchase, lease-to-buy, and leasing arrangements.

² Number of sorties available per aircraft depend on crew ratio, number of hours crews may fly per 30 day and 90 day periods, average duration of air refuelling sorties, and situational support constraints (fuel availability, air field operating hours, etc)

³ Summary of PCC commitments available on NATO website:
http://www.nato.int/issues/prague_capabilities_commitment/index.html

3. The resulting AAR capability, as agreed at Prague, would have been available for operations led by NATO and the European Union, and also for national purposes to be agreed. The group shared information with the European Capabilities Action Plan Project Group for AAR, also led by Spain.
4. Work on the Prague Capabilities Commitment AAR Initiative concluded in February 2005 with a report by the Chairman that the Working Group had reached an impasse, and could not forward proposals to provide further capabilities. Although the Working Group conducted valuable research and analysis of potential acquisition, management and implementation solutions for a collectively held and operated fleet, the final result was a conclusion that the financial commitment required was beyond that which the participating nations found to be feasible. A team from the European Defense Agency has begun a similar investigation into identifying ways to provide additional AAR capability.
5. The UK developed a scheme with the Future Strategic Tanker Aircraft Program that included a long-term lease program where some of the new tankers would be full time RAF military assets, and some would be on-call to be operated by RAF crews performing RAF military operations when needed. The on-call aircraft would otherwise be used by civil operators performing commercial operations. All of this capability could be declared and provided for NATO operations.
6. Contributions by commercial providers of AAR may grow, particularly for currency training and aircraft delivery purposes. Currently only one company, Omega Air Refueling Services Inc provides this service, but there is potential for growth in this area.
7. The non-traditional procurement and ownership strategies discussed above would require new arrangements for declaring the tankers to NATO, and defining their commitments to the nations involved, NATO and other European defense entities.

D. Potential for Increasing Effects from Existing Tankers and Aircrews

1. Apart from increasing numbers of tankers, there are other approaches that could produce more effects from a given number of tankers. These approaches involve generating more sorties and or flying hours per aircraft, and using flying hours and sorties most efficiently.
2. Crew Ratios. See discussion in Paragraph III. B. above on effects of increasing crew ratios on producing effects.
3. Improve reliability rates. This involves engineering, modifying, or reengineering aircraft components, and or providing more robust maintenance capacity, including spare parts, at operating locations. The cost-benefit ratio of increased investment-improved reliability, and the optimum package of maintenance resources is dependent on the situation and the fleet. This study did not examine potential improvements to utility rates based on improving reliability.
4. Reduce time required between sorties (“Turn Time”). Turn time is impacted by quantity, location and characteristics of support resources like fuel, and maintenance. Air forces typically

use standardized planning factor turn times that assume typical support arrangements and average task times. Reduction of turn times also incurs costs in personnel and equipment, and this study considered turn times to be relatively inflexible though obviously dependent on local conditions. Therefore this study did not examine potential improvements to utility rates based on reducing turn times.

5. Emphasize basing close to operations. Number of sorties that can be flown and amount of offload fuel available per tanker and per tanker crew are inversely proportional to flying distance from base to operating area. Traditional planning that considered tankers a “High Value Airborne Asset” proscribed minimum distances from operating areas to minimize risk. This approach could unnecessarily eliminate potential tanker bases optimally located to maximize effects. To put it more simply, basing as close as practical to the AAR area(s) is almost always desirable unless proximity presents significant risk. Planning for future asymmetric operations without airborne threats to tanker bases may realize some efficiencies by basing closer to the area of operations. Availability of logistics and force protection resources must also be considered in basing decisions. See Section IX, Logistics, below.

6. Increased effects through advanced planning and assessment techniques.

a. Advances have been made in automating operational level mission planning that can improve efficiencies. The number of potential AAR pairings expands exponentially as receivers, tankers, aircrews, operating bases, airspace, and control times increase in moderate to large scale air operations. Even the most skilled and experienced planners working within a 72 hour ATO cycle, can not assure the most efficient and effective plan every day. Advances in automated mission planning and ATO building offer potential to more nearly approach maximal efficiency and effectiveness. The USAF Air Refueling Tool Kit (ARTK) and NATO’s Interim Command and Control (ICC) systems are being fielded, and provide improved interfaces, functionality and automated mission matching capabilities to improve efficiency. These improvements can be demonstrated in generic large scale operations and therefore used in warplanning and in crisis response operations. NATO also expects to replace ICCS with the Air Command and Control System (ACCS) system in the future which will incorporate ICC functionalities.

b. USAF unit level planners introduced “Effects Based AR Planning” techniques to allow tailoring of tanker force packages and adjustment of planning factors to maximize efficiency. This approach employs analysis of AAR operations performed to find opportunities to make incremental reductions in tanker requirements. It necessarily relies on experience within the current operation to predict and validate efficiencies, so is most valuable during steady state / sustainment operations when requirements are more easily predicted. Regular employment of assessment techniques could institutionalize analysis as a tool for optimizing AAR efficiency and effectiveness.

7. A “Fuel Consolidation” employment concept based on recent experience can provide similar efficiencies during mission planning and during execution. Under this concept, tankers provide AAR to other tankers to enable the most efficient combinations of tankers, take advantage of excess capacity, and avoid returning to base with unused fuel. Planners can maximize

efficiency when scheduling tankers, and operational level execution staff monitoring operations hour-by-hour can redirect tanker missions and redistribute fuel among tankers to consolidate savings realized when receivers take less fuel than programmed. Fuel Consolidation is also discussed as an Employment Concept in Sect VII, paragraph C. Fuel Consolidation requires tankers that can receive fuel airborne. The capability to consolidate fuel will be enhanced by the receiver capable tankers currently being acquired or programmed by Alliance nations.

8. In-flight replanning for individual tankers and formations offers similar potential for improvements to efficiency and effectiveness. In-flight replanning to manage individual tankers, refuelling tracks, and to redirect tankers and receivers in response to tactical developments has always been a requirement and capability in AAR operations. However thorough analysis of variables and potential courses of action is restricted by the time available for replanning. Introduction of net-enabled C4I connectivity and dynamic planning software into the tanker cockpit can improve information sharing, situation awareness, and comparison of alternatives within the cockpit and in collaboration with other aircraft and C2 nodes. These empowering technologies will be included in acquisitions and upgrades, and enable better decision-making for efficiency and effectiveness.

9. There are limitations to potential efficiency improvements. Some of the potential efficiencies from these techniques can be most effectively realized in sustainment operations after a rhythm and routine have been established that provides predictable and reliable opportunities for efficiencies. They are also most effective with large numbers of tankers where savings from individual sorties can be consolidated to reduce sortie, aircraft, and crew requirements. War planning and crisis response operations like NRF will still require conservative assumptions where assured effectiveness and flexibility are critical, but detailed requirements are unknown. Assured effectiveness may be assigned a higher priority than efficiency in planning and in early phases of an operation.

10. In summary, warplanners and commanders will enjoy small efficiency improvements in the immediate future, resulting from improved automation. Large scale operations may require up to 5% fewer tankers in best case scenarios. This estimate of savings is an educated estimate only; no data is available to demonstrate the cumulative effects of proposed efficiency techniques. Additional small efficiencies may be realized by improved analysis and management in sustainment operations. Even relatively small percentage savings can represent substantial savings in sorties, tankers, and fuel, making efficiency techniques worthy of consideration in planning and execution. Efficiencies are also important where there are sufficient resources for operations, as resources saved can be redirected toward other operational requirements or for reserve and reconstitution.

E. Aircraft Characteristics and Roles

1. Fuel Transfer Technology

a. The boom and probe/drogue hardware technology currently in use will remain the standard AAR equipment. Both systems have been in use by NATO for decades, and are

generally but not universally and formally standardized. Equipment specifications, tolerances, and STANAGs have been developed and proposed, but not yet agreed or implemented to formalize the standardization within NATO. New tanker aircraft could be equipped with new technologies in addition to current systems, but no alliance air forces have identified requirements that the current systems don't meet. See also Section V below for discussion on Interoperability.

b. Dual Capable tankers (able to refuel boom and drogue capable receivers on the same sortie) present a clear advantage to drogue-only tankers and to most KC-135s which can refuel both type receivers but not on the same sortie. They provide near universal interoperability and flexibility. All new tankers scheduled to enter the NATO inventory are dual capable. The number of drogue-only equipped tankers will decrease as they are replaced by dual capable tankers. Boom and drogue requirements are discussed below in Section IV.

2. Future aircraft acquired primarily as tankers will also have a transport capability, with differences in degree of capability in terms of capacity, and material handling equipment requirements. On one end of the spectrum could be a tanker that can carry cargo, but is restricted by cargo area dimensions and configuration of loading doors. And on the other end of the spectrum, the A400M optimized for tactical as well as strategic AT, and able to transition nearly seamlessly between AT and AAR roles. Interchangeable Role aircraft (termed Multi-Role by industry) being purchased by Canada, France, Germany, Great Britain, and Spain, were chosen based on their capability to perform air transport (AT) as well as AAR. These include the A-400M some of which are being acquired with AAR equipment to provide an interchangeable role capability. The US has also announced AT will be a required capability for the KC-135 replacement. Additional and secondary role employment is discussed further in Sect VI.

3. Future tankers will also be air-to-air refuellable to enhance flexibility, and take advantage of force extension and fuel consolidation employment concept discussed in Sect III, para C.7. (Fuel Consolidation) and Sect VII, paragraph A. (Force Extension and Fuel Consolidation)

4. Future tankers may also incorporate capabilities for missions other than AAR and AT. Capabilities like C2, or ISR on tankers will be discussed below in Sect VI.

5. Size / Capacity of Tankers.

a. The KC-135, currently the standard tanker for NATO planning, can be termed a medium size tanker with a max gross weight of just over 300,000 pounds. Most of the other tankers scheduled for acquisition including the KC-135 replacement will be in the medium to large category with max weights between 350,000 and 500,000 pounds. The A400M is a notable exception at 285,000 pounds. Some C-130 airframe based tankers will also continue in service, and air forces will continue to use buddy or fighter to fighter AAR in very limited circumstances. These exceptions notwithstanding, the clear trend is toward medium to large tankers, and they will comprise the preponderance of NATO's future tanker fleet.

b. These medium to large tankers optimize fuel availability per tanker and efficiency in most conditions. Within some condition sets, however, the larger tankers don't provide the optimum solution. In some situations the primary consideration may be how many aircraft can refuel simultaneously, and an amount of fuel distributed by two or more tankers simultaneously may be more effective than the same amount distributed by one tanker. The footprint or required pavement strength, parking, and runway dimensions may also favor smaller tankers in some conditions, and some of the smaller tankers are capable of refuelling helicopters along with fixed wing receivers. For tankers on the large end of the spectrum footprint requirements will restrict basing possibilities.

c. These considerations have led to discussion of heterogeneous tanker fleets with combinations of small, medium, and large tankers to mitigate restrictions and leverage relative advantages to optimize effects in a variety of condition sets. Such a fleet could operate effectively in operations where a mixture of forward austere basing and fixed Main Operating Bases are required. For example, an operation demanding forward but austere tanker basing, and support of small receiver packages separated in time and or space could be best supported by several small tankers, while a large operation with many receivers in compact airspace and time frames could be best supported by large tankers.

d. While there is supportable rationale for a heterogeneous fleet, and the A400M will provide good austere base capabilities, the future inventory of NATO tankers will consist mostly of medium to large tankers that require permanent well-supplied airfields, as nations invest the limited resources available in tankers optimized for large amounts of fuel available and for efficiency.

e. Some tankers dedicated to support Special Operations refueling may be significantly different from the medium to large tankers, as stealth, light footprint, and helicopter refueling capability influence tanker requirements. Some general purpose tankers will be able to support Special Operations, however Special Operations specific tankers may not be interoperable with heavy or fast moving receivers. An example is the C-130 based tanker aircraft supporting helicopter refueling.

6. There will be future condition sets where stealth tankers and or tankers with robust defense capabilities would be the optimal refuelling solution. One proposed concept is for a tanker capable of operating in the same speed and altitude envelopes as strike aircraft and penetrating defenses as required to accompany the strikers into other than permissive airspace. Apart from the current USAF MC-130 aircraft supporting special operations helicopter AAR, nations are not investing in tankers intended to refuel in hostile or defended airspace.

7. Tankers being acquired or considered by NATO nations will also be refuellable. This characteristic provides potential increased range and duration, and flexibility as tanker planners can plan operations extended in time and distance, and operators can respond to changing situations by redistributing fuel among tankers while airborne, as discussed in Paragraph III. D.

8. Many new tankers will also be equipped to refuel two or three small probe-equipped receivers at a time, increasing the number of drogue refuellings possible within a given time and space. This benefit however will remain limited to probe equipped fighter type receivers.

9. The final category of future tanker discussed here is the unmanned or UAV tanker, and here the discussion is limited to a hypothetical UAV tanker to meet a hypothetical requirement. Refuelling of UAVs is discussed later in this report in Section V, and discussion in this section will be limited to the UAV as a tanker. The JAPCC UAV Focus on Unmanned Aerial Vehicles and Unmanned Aircraft Systems in 2006 included examination of UAV AAR, and the JAPCC Future Capabilities Branch has undertaken a project to explore conceptual mission requirements for UAV AAR. Air forces and industry are exploring development of unmanned tankers using boom and drogue delivery systems, so far limited to very small tankers refuelling other UAVs. This is a logical first step because it minimizes the challenges with refueling a light UAV with a large tanker, and operating manned and unmanned aircraft in close proximity. A UAV tanker, as currently conceived, enjoys a compatibility with current UAVs based on shared characteristics of light weight and low cost while permitting operations without risk to human operators.

a. There is also the potential for larger unmanned tankers that operate similarly to current tankers, providing fuel to a variety of receivers. The current challenges to operating this type of UAV tanker, nearly interchangeable with manned medium to large aircraft, along with lack of research and development in this area, put such possibilities in a more distant future than the timeframe of this report. Therefore the most likely UAV tankers to become operational in the 2020 to 2025 timeframe will be small aircraft tailored to refuelling other UAVs, and operating under the same conditions as other UAVs.

b. Tanker force organization and structure for UAV tankers will become an issue when UAV tankers become operational. The most basic question will be whether to organize, and command and control UAV tankers as tankers or as specialized assets tied directly to the supported UAVs. Until the UAV tankers become interoperable and separable from a specific receiver unit and location, the likely solution will be to keep the UAV tanker under the authority and operation of the supported receiver unit.



IV. Future AAR Requirements

A. Determinants of Future Requirements

1. Numbers and characteristics of future receiver aircraft will be the primary drivers of future AAR requirements. The NATO Defense Requirements Review (DRR) process identifies operational requirement based on planning situations derived from the alliance's stated Level of Ambition. DRR driven requirement figures address minimum military requirements for war planning. These figures are classified, and will not be discussed in this report. The requirements discussion and findings here do not replace the DRR process and requirements, and should not be confused with minimum military requirements, the DRR process or any other aspect of the formalized force planning and defense planning processes.
2. Apart from potential development of specialized equipment for UAV rendezvous and AAR, the most likely changes for AAR requirement will be in numbers of aircraft and characteristics other than refuelling hardware.

B. Numbers of Receiver Aircraft

1. Three new refuellable NATO fighters will operate in the near and mid-term future: Eurofighter, F-22, and F-35/Joint Strike Fighter (JSF). Overall numbers of refuellable fighters in national inventories will remain near the number currently flying, as older fighters are retired with introduction of new models. The new fighters will be more efficient in amount of fuel used per mile flown, but planners expect to use more of them on long-range missions requiring more fuel and therefore a similar amount of AAR. In addition the number of nations providing fighters but not tankers will increase. Unless other nations provide more tankers than receiver aircraft (which is not the case), this situation suggests a net imbalance between numbers of fighters performing offensive and defensive missions, and numbers of tankers that enable the alliance to optimize fighter employment.
2. Refuellable transport and ISR aircraft numbers will increase slightly. Noteworthy here is the acquisition of the A400M by several countries and the NATO AGS manned platform. AAR of these aircraft can enhance their effects.
3. These future developments in numbers of receiver aircraft indicate a slight increase in refuelling requirements if all or nearly all NATO receiver aircraft were required in the case of a very large scale operation or more than one operation of significant size. Improved reliability and utilization of the newer aircraft imply a higher sortie rate per aircraft capability, which may further multiply the AAR requirement. Increased numbers of receiver aircraft, especially in Europe, will increase the requirement for AAR training provided by the limited numbers of tanker aircraft and crews.
4. DRR requirements are not necessarily required to analyze and predict the slightly increased AAR requirements. The increase in numbers of receiver aircraft in national and NATO fleets

should also drive an increase in AAR requirements. Additionally, the alliance's recognition of AAR as a capability to be improved within the scope of the PCC identifies it as a capability available in less than required numbers. Increases in numbers of receiver capable aircraft will also increase requirements for AAR training. Training requirements will be discussed further in Section X.

C. Receiver Characteristics

1. The boom and probe/drogue hardware technology currently in use will remain the standard AAR equipment. Both systems have been in use by NATO for decades, and are generally standardized. STANAGs incorporating generally accepted standards are being developed to formalize the standardization within NATO. Future receivers are necessarily being designed for operations with the current equipment, which in turn requires future tankers to use current equipment, perpetuating the current systems. New receiver and or new tanker aircraft could be equipped with new systems along with existing systems, but no alliance air forces have identified requirements that the current systems can't meet.

2. There is no alliance-defined requirement for Dual Capable tankers as discussed above in Section III. The ratio of boom capable receivers to drogue equipped receivers will remain near the current ratio. Therefore receiver characteristics will not drive a change in the required ratio of boom equipped and drogue equipped tankers. A minimum number of booms and drogues are required to support the correspondingly equipped receivers. Boom or hose only equipped tankers will continue to meet national and NATO requirements. The alliance objective of increased interoperability, and flexibility as an inherent principle, however, will make boom/drogue dual capable tankers more valuable and useful, and dual capable tankers present the optimum solution with flexibility to support either type of receiver. This dual capability has been and will be designed into future NATO tankers.

3. Optimal tanker size and capacity characteristics are somewhat driven by type of AAR support required. For example, smaller tankers may be optimal for operations from shorter runways, or more efficient in small discrete refuellings, while larger tankers may be more efficient in supporting strategic air transport flows, and provide flexibility as dual role tankers/transporters.

4. UAV developments could drive new requirements in tanker characteristics (including potentially tanker UAVs) within the time horizon of this study, but there is not currently reason to predict UAVs will drive new tanker requirements. See Section III. above for discussion of issues for potential UAV tankers. Primary considerations for refuelling UAVs involve Automated AAR to guide UAVs as receiver aircraft are discussed further in Section V below.

5. Air forces, including those from air and maritime components will operate increased numbers of air-refuellable helicopters, and potentially tilt-rotor aircraft. Capabilities and procedures exist, but this development will drive an increased requirement for suitable tanker aircraft, mostly in the area of "tactical" tankers optimized for AAR at low speeds and altitudes. As this capability grows among several nations, standardization and interoperability will become more important for this type AAR.



V. Technologies

A. Interoperability

1. Technical Interoperability. As discussed in Section III, the boom and probe/drogue hardware technology currently in use will remain the standard AAR equipment. Both systems are generally standardized, and equipment specifications, tolerances, and STANAGs have been developed and proposed, but not yet agreed or implemented. Dual Capable tankers provide near universal interoperability and flexibility. All new tankers scheduled to enter the NATO inventory are dual capable, and interoperability will correspondingly, if slowly incrementally, improve as the new tankers become operational.

a. Regarding hardware specifications and physical compatibility, almost all booms/receptacles and hoses/drogues enjoy interoperability across the alliance, and this will not present significant challenges in the future.

b. Challenges in certifying compatibility and arranging legal and financial preconditions for interoperability remain. Each mating of receiver type with tanker type requires certification of compatibility by specification comparison and or testing, along with agreements that establish requisite legal, risk and financial arrangements between aircraft operators (usually nations). Once obtained, the certification and agreements normally remain in effect permitting refuelling until revoked or superseded.

(1) This “Clearance” process is not standardized, and documentation is not always easily accessed, especially outside and across national systems. Since clearances must be obtained before refuelling, planners can not allocate alliance tanker to support an alliance receiver without an extant or new clearance. This has caused inefficiencies and delays in operations, but the requirement will remain.

(2) The Air Refueling Systems Advisory Group (ARSAG), an international organization of military operators and commercial systems providers, has examined the clearance process, and sought to standardize clearance and documentation processes to streamline clearances. NATO’s Air-to-Air Refuelling Coordination Cell (AARCC) cooperates with ARSAG in this effort and includes clearance formats in the ATP-56(B) AAR manual. Nations and industry have interests in obtaining specific clearances, but not in pooling resources for establishing and documenting common data to support clearances, and significant challenges remain. The US Navy has begun a pilot repository for selected aircraft as an ARSAG guided project. The program may be expanded if results are promising

2. Procedural Interoperability. Two NATO documents, MCM 217-98, Alliance Air-to-Air Refuelling Concept, and ATP-56(B), Air to Air Refueling Allied Joint Publication provide the foundation for AAR interoperability within the alliance. The Alliance Air-to-Air Refuelling Concept is under revision, and ATP-56(B) was promulgated in April 2007. ATP-56(B) establishes procedures for universal interoperability within NATO, and worldwide.

Implementation of this manual is the single most important development in AAR that will influence AAR operations in the near future. Variations in equipment and missions will continue to present arguments for differentiating procedures and terminology. Diffusion of procedures and terms as national procedures may undermine the interoperability achieved by adherence to ATP-56(B).

B. UAV Receivers and Tankers (See Section III above for additional discussion and findings on UAV AAR.)

UAV development, including weaponization of UAVs and experimental refuelling of UAVs is proceeding rapidly. Many nations, services, and commercial interests are pursuing development. UAVs are relatively small, inexpensive, and unrestricted by many of the regulatory controls on manned aircraft. This fosters proliferation of several viable programs, narrowly focused and uncoordinated with other aircraft and C2 systems. Uncoordinated programs which may meet national or service requirements may present interoperability, airspace, and C2 difficulties in integrating NATO forces for combined operations.

1. Refuellable UAVs

a. Several organizations are involved in research and development of refuelling for UAVs, with concentration on Automated AAR technology (to guide the receiver the final few meters to the tanker) as the critical capability that must be added to current AAR procedures and equipment. Most work focuses on this capability due to the time delay in transmitting and receiving remote guidance inputs for the fine adjustments that must be made instantaneously with two aircraft in close proximity. Laser, GPS, and infrared technologies have been considered for this purpose, and trials have proven Automated AAR feasible.

b. Two potential models for UAV AAR can be identified: refuelling current UAVs or UAVs similar to those currently operating (e.g. Predator or Global Hawk), and a future generation of UAVs more similar to today's manned aircraft (e.g. a UAV F-16 or F-35).

(1) Small size, light weight, and low cost contribute to the current UAVs' advantages over manned aircraft. Additional weight and cost from adding AAR capability would partially negate these advantages, and flight characteristics and aerodynamics would present challenges to interoperability with current generation tankers. These challenges would be especially significant with Predator and smaller class UAVs as current and near term future tankers typically refuel at relatively high speeds and altitudes, and or produce significant wake turbulence.

(2) A future UAV more similar in size and performance to current manned aircraft could be a more likely candidate for operational UAV AAR. Such UAVs have been proposed, and could be operated within the horizon of this study.

c. If a refuellable UAV enters operations, air forces and NATO would adapt to take advantage of the capability. Adaptations would be required in tanker equipment, and AAR procedures. The technologies adopted will determine the extent and type of required tanker

equipment and procedures. Some proposed technologies require more active tanker participation than others.

d. UAV AAR could drive requirements for specialized tankers, including UAV tankers (discussed below). Costs of developing, producing, and operating specialized tankers and or adapting non UAV-specific tankers could suppress UAV AAR. More commonality between UAV AAR and current AAR systems and procedures would provide opportunities for UAV – manned aircraft AAR, promoting flexibility and potentially limiting costs.

e. Segregation of airspace for UAV operations including AAR would limit utility of UAV AAR by restricting operations geographically, possibly distant from objective areas, and constraining available airspace for all operations.

f. There are currently no requirements for refuellable UAVs or for UAV refuelling.

2. UAV tankers

a. The potential for UAV tankers is closely tied to development of UAV receivers. As with refuellable UAVs, there are currently no requirements for UAV tankers. Development of refuellable UAVs may be the potential development that could most likely drive a UAV tanker requirement. If refuelling is required for missions requiring the endurance or exposure to risk that suit UAVs, it could be impractical to refuel the UAV with a manned tanker. This could drive a UAV tanker requirement.

b. Probe and drogue AAR may be the most practical system for UAV tankers. The probe and drogue system permits a more passive operation for tanker systems than boom AAR. With probe and drogue the receiver must be guided to the tanker drogue, and the tanker is not required to direct the drogue as precisely as the boom nozzle must be guided by the tanker with boom AAR.

C. Command, Control, Communications and Computers (C4)

1. Improvements to Communications and C2 technologies will provide future tankers a greater situational awareness in the tanker cockpit, and greater real time visibility of each tanker's capabilities at the operational level of command. Future tankers will therefore be more seamlessly integrated into net-centric operations. This capability is discussed in Sect II, paragraph D.8. Tanker crews will have situational awareness displays of friendly and other aircraft to facilitate the tanker's defenses and responsiveness to unplanned requirements. Simultaneously the operational executor in the Air Operations Center will be able to see tanker positions, and fuels capabilities in real time to support dynamic retasking and management.

2. The USAF has developed equipment and concepts for adding C4 functions as secondary capabilities to tankers. This is related to improved C4I for tankers and other aircraft, but is not a technology specific to AAR, and represents a capability that may be added to, but not included in the AAR mission. It will therefore be discussed in Sect VI as an additional role.

D. Night Vision Capability

Night vision operating capability and night vision compatible lighting will become more common among tanker fleets. Operations where visual detection of tankers and or receivers is a concern, and receiver crews operating with night vision goggles will drive these requirements.

E. Simulation

1. Distributed Mission Operations (DMO) simulation of multiple aircraft supporting realistic training from more than one location is becoming possible. DMO is being used for fighter training and mission rehearsal. Technology is available that can link realistic 3D tanker cockpit and boom operator training with other participating simulated flying. Integration of tankers into existing DMO training can benefit receiver crews, tanker crews and mission commanders in routine currency training as well as mission rehearsal.
2. Simulation as a replacement for flight training can have negative consequences if flying training hours are reduced in favor of simulator training hours. The concern is that even the most realistic simulations can not replace training in flight, and an appropriate balance should be found between replacing flying training and complementing flying training.
3. Benefits of simulation include economic efficiency, ability to concentrate on activities that require intensive training, and safety for Emergency Procedures training. An additional benefit, especially valuable for Alliance AAR is the opportunity to train for interoperability among allied air forces who may have limited opportunity to train together before war or contingency operations.



VI. Additional Roles for Tankers

A. Interchangeable and Dual Role AAR/Air Transport (AT) and Aeromedical Evacuation (AE) Capability

1. Interchangeable⁴ AAR and AT roles will become an increasingly important consideration for NATO AAR. Tanker aircraft currently support aircraft delivery, delivering receiver aircraft to operating locations using AAR to minimize en route support while transporting and delivering the receiver aircraft support personnel and equipment on the same tankers. Until now this aircraft delivery mission has typified the “dual role” mission. Tanker aircraft have also been used in AT only missions. Aircraft delivery dual role missions will continue to be important, but future tanker aircraft will also be called on to perform a variety of additional roles.

2. With fleets of tankers specifically designed for interchangeable and dual role (AAR/AT) operations, future operations could include tanker aircraft and units transitioning from one role to another in accordance with operation phases and also transitioning dynamically in response to unexpected requirements and priorities. Commanders and planners may be faced with daily decisions on apportioning aircraft to one or both of the two roles.

3. While this increased flexibility is clearly an advantage, the consequences have not yet been addressed through thorough modeling, exercises or practical experience. CAOC planners scheduling a fleet of operational tankers currently assume aircraft turn times and crew rest times to project availability over sustained periods. Interrupting the AAR fly – turn/rest – fly sequence with AT onload and offload destinations introduces new planning factors. Planning becomes all the more difficult if the AAR to AT transition is injected in a dynamic, unexpected manner.

4. Dynamic role transitions could also introduce turbulence in unit operations as units must manage crew training to provide AAR and AT proficiency for aircrew members, and manage and position ground personnel associated with each role. Examples include the challenge of keeping aircrew members current in AAR during prolonged periods supporting AT missions, and positioning and depositing cargo handling support as the aircraft transition between AAR and AT roles.

5. Many tanker aircraft will be capable of and used in the AE role as a secondary role. The challenges identified above for interchangeability between AR and AT will also apply, with the additional considerations of specialized equipment and personnel required that may be attached permanently or as needed to the tanker mission and units.

⁴ Interchangeable Role is used in this study to describe aircraft that can be used interchangeably for AAR and AT roles. The term “dual role” is limited to describing missions wherein an aircraft performs AAR and AT simultaneously, usually in transporting components of the unit whose aircraft are being refuelled.

5. Interchangeable role aircraft expand the potential for national and NATO employment of precious resources, but realizing the potential presents new challenges. Policies, techniques, organizational structures, and training programs can address the challenges above to maximize flexibility and effects. NATO air forces and CAOC planners could begin now to assess the challenges and opportunities, develop responses and share lessons learned among the alliance.

6. The interchangeable role capability also presents opportunities and challenges in long term planning and programming. Aircraft acquired to meet AAR requirements may be used for AT and AE missions, but there is a danger of counting the aircraft against more than one role simultaneously for warplanning. AAR demand is likely to be very high for initial deployments and the high tempo combat operations at the beginning phases of war or contingency operations. We should also expect very high demand for AT during these phases. If sufficient aircraft are not available to meet both demands, one or both of the missions will be under supported.

B. Other Secondary Roles

1. The tanker's internal payload capacity, endurance, and range present a platform with potential to perform additional missions. The tanker also typically operates in or near the joint battlespace. These characteristics coupled with a growing requirement for net-centric communications connectivity, and technologies enabling autonomous, efficient, transportable line of sight and satellite communications have led to incorporation of C4ISR equipment and missions on tankers.

2. The US has begun utilizing Multi-Mission Platforms that can be loaded in tankers modified for electrical power and antenna fittings to enable the tanker to perform a C4ISR role simultaneous with or in addition to the AAR mission. This additional role can be as simple as automated radio relay which could require only minor aircraft modifications, but can include establishment of an "IP address in the air" network component. Surveillance and reconnaissance equipment and roles may also be incorporated with greater aircraft modifications and requirements for coordinating roles, missions, C2 and training.

3. As with the dual AAR/AT role function, planning, prioritizing, and managing the roles will be critical in maximizing the potential of this additional capability. CAOC current operations executors could be required to make real time decisions to change AAR plans to extend a tanker on orbit that is providing critical C4ISR service.

C. Managing Secondary Roles

1. As discussed above, the tanker offers great potential to support interchangeable, secondary, and additional roles, especially if planners and operators can develop tactics, techniques, and procedures for prioritizing tasks and roles to exploit the potential.

2. The challenges in managing roles should not come as a surprise during war or crisis operations. NATO exercises and national lessons learned can be used to prepare and train commanders, planners and CAOCs for employment.

3. Flying and ground support units will also have to be adequately trained and resourced to support additional roles, and to transition between roles.
4. Employment of tankers in additional roles also presents basing implications. This may be especially important for the AAR/AT transition. Optimal AAR basing with large quantities of fuel and parking enabling economies of scale may conflict with optimal AT basing near terminal nodes, and convenient to AT lines of communication. Basing is also discussed below in Section IX.

D. Doctrine for Interchangeable, Dual, and Secondary Role Employment

There is currently no NATO doctrinal guidance on terminology, definitions or employment of interchangeable, dual, and secondary role employment of AAR aircraft and units. NATO doctrine or other publication could encourage standardization in these areas and facilitate smooth coordination and planning.



VII. Employment Concepts

A. General Employment Concepts

Some existing concepts will be more fully exploited, but AAR employment concepts will remain similar to those currently in use. AAR will continue to be used in orbit areas and tracks to support tactical operations within theaters of operations and localized Areas of Operations, and on extended tracks to support national inter-theater fighter movements, global strike, and air transport operations. With the exception of paragraph D, Air Policing, the concept discussion here concerns wider employment of existing concepts driven by changing receiver support requirements and or enabled by new equipment.

B. Expanded Long-Range AAR Support and Deployed Operations

1. We can anticipate two requirements based developments in existing employment concepts that concern “where” AAR assets are employed and based: expanded en route AAR support for deployment and long-range strike missions, and more expeditionary deployment of tankers to Deployed Operating Bases (DOBs). These two concepts involve placement and basing of AAR assets, and may also be employed together when tankers are required to deploy to DOBs to support long-range AAR.

2. Long-range AAR.

a. Long-range strike or weapons delivery. Future fighters, notably the F-22, are intended to fulfill a global strike role previously limited to heavy bombers, and US and possibly NATO AAR will be tasked to support more US global strike fighter missions. AAR support for these missions would be conducted along extended routing of thousands of miles from fighter operating base to areas of operations. If these global missions replace missions that would have been supported from within theater, the additional AAR requirements would be partially offset by reduced in-theater requirements, but only partially since global strike would require more AAR per fighter than local missions. Supporting tankers would be based along or near the fighter’s route. This employment concept is valid today as a national concept, and may well be employed in support of future NATO missions if not necessarily within NATO tasking and C2. This support will be provided by tankers from NATO nations as national or NATO support missions.

b. Long-range deployment. NRF planning includes use of AT to move fighters and materiel over long distances, but does not include tankers for this purpose. If NATO follows the US concept of “air bridge” operations for strategic deployment, AAR will support deployment and sustainment AT, and this will certainly be the case if NATO relies heavily on US AT assets. Introduction of the A400M to alliance air forces may also encourage broader use of the air bridge model. To date AAR support for deployment has been a national task associated with the national task of deployment. Deployment responsibility and execution as a national responsibility is a long-standing NATO principle, but does not interface well with the NRF aim

of sourcing and operating forces in a joint and combined manner. The Allied Movement Coordination Centre (AMCC) has addressed coordination of multi-national air transport, but NATO has not taken joint combined deployment on as an alliance task. As NATO out of area deployment plans become more concrete, nations acquire more systems for strategic AT, and NRF evolution combines resources from nations, the impetus for NATO “air bridge” operations may become stronger. This is a potential new AAR concept of operations for the alliance.

3. Deployed Operations.

a. NRF and other out of area operations will require tanker operations at Deployed Operating Bases (DOBs) to support forward deployed operations. Tankers may operate with bare-base kits at locations with minimal in-place infrastructure and support. Even deployments to bases with robust infrastructure will require deployable maintenance and support packages.

b. Long-range AAR and air bridge operations would include en route and forward based tankers to minimize en route stops for AT missions. This may require rapid establishment of en route tanker bases to support immediate deployment. They may be in place for a short time, then redeployed to home base or a Forward Operating Base to support operational AAR. This rapid deployment concept for tankers requires tanker units that are sufficiently resourced and prepared for operations away from home Main Operating Base.

c. Regardless of the mission or type of AAR support provided, deployment of tankers to DOBs requires prior preparation training, and equipment to assure this capability for the alliance. Relatively few tanker units are prepared today for rapidly deploying and operating for sustained periods at distant DOBs.

d. The employment concepts discussed above do not present changes to tactics techniques or procedures. They are new concepts only in the sense that NATO has not traditionally commanded or controlled AAR for long-range AAR or out of area operations, and alliance planning has been non-existent for long-range AAR, and limited for deployed operations. Whether accomplished as national or alliance tasks, they should be anticipated as requirements on the future AAR forces of the alliance.

C. Wider Employment of Existing Concepts to Enhance Flexibility and Efficiency

1. As NATO nations acquire more receiver-capable tankers, employment concepts that take advantage of tanker receiver capability will be used more to improve efficiency and effectiveness across fleets and on individual sorties. The discussion below delineates the differences between two related concepts of “Force Extension “and “Fuel Consolidation”, while explaining their advantages and how receiver-capable tankers will make these concept more widely available. While the concepts are closely related it is helpful to discriminate between the relatively narrow purpose of Force Extension as a planned fighter deployment AAR, and Fuel Consolidation as a broader concept applicable to any AAR mission, and subject to dynamic real-time flexibility in execution.

a. “Force Extension” has been used for tanker-to-tanker AAR, usually in the context of long-range fighter deployment (“Trail” missions in ATP-56(B)) where tankers refuel primary receiver-capable tankers associated with the Trail from fighter departure base to fighter destination. Opportunities to employ this concept have been limited by the relatively few receiver-capable tankers available, but opportunities will multiply as the number of receiver-capable tankers that can act as the primary departure to destination tankers grow. Therefore we may see more frequent and creative use of the Force Extension concept of employment.

b. Tanker-to-tanker AAR can be employed in support of almost any AAR mission, and the term “Fuel Consolidation” is being used to describe tankers refuelling other tankers to enable the most efficient combinations of tankers, take advantage of excess capacity, and avoid returning to base with unused fuel. Planners can maximize efficiency when scheduling and operational level execution staff and crews monitoring operations hour-by-hour can redirect tanker missions in real-time to redistribute fuel among tankers for tactical advantage and to consolidate savings realized when receivers take less fuel than programmed. Fuel Consolidation differs from Force Extension in that it can be used for any AAR mission, and can be planned and employed in a dynamic reaction to changing operational and tactical situations.

D. Air Policing

The NATO Air Policing mission has evolved as an AAR requirement for Current Operations planning (for basing and operations), and execution, but is not addressed in Force Planning or NRF CJSOR processes. This mission should also be included as a future requirement, and a baseline Policing AAR CONOPS could include orbit coverage, and ground alert tankers, executed by CAOCs with case-by-case tailored C2 requirements. Policing operations may also demand deployed tanker operations.



VIII. Operating Context and Environment

A. Threats

Threats to AAR operations will continue to evolve and drive requirements to counter them, including aircraft defensive systems, training, employment concepts and operational and tactical planning.

1. Increasing ranges of surface-to-air and air-to-air missiles could potentially push AAR operating areas back, or require AAR operations with greater risk.

- a. This possibility supports requirements for greater situational awareness, defensive capabilities and training. This possibility could also influence the mix of UAV to manned systems used, and support a UAV tanker concept of operations.

- b. Not all potential conflicts or enemies will have advanced weapons capable of influencing AAR operations, and these threats should not be assumed as given for all future AAR operations.

2. Local threats to air bases, even those within relatively secure or friendly areas must also be considered in planning and employment of tankers, both for base support (force protection) and aircraft defenses. Man Portable Air Defense system proliferation will require greater attention to defense during departure and approach phases.

B. Defensive Capabilities

1. Real-time threat warning can enable AA closer to actual or potential threats, and better support to receiver missions.

2. New tankers will be equipped with more defensive measures such as warning equipment, generally improved situational awareness capability and countermeasures. Some retrofitting of current fleets for defensive capabilities will also be accomplished. Crew training and tactics will have to supplement the new equipment. Some training and tactics will be common to all missions, and some will be tailored to the systems flown.

3. Differentiation of tanker defensive capabilities may require selective ATO tasking to keep less defensively capable tankers away from areas with increased threats. These differential defenses could restrict interoperability in execution.



IX. Logistics

A. Basing and Deployment

1. The greatest differences in future logistics requirements and concepts will be basing concepts and deployment requirements driven by deployed operations.

2. NATO planning includes provisions for forward basing within NATO borders. Numbers of beddown spots are calculated based on planning scenarios, and operations concepts. Primary bases, and less capable contingency bases are identified to accommodate the required numbers. The identification process includes analysis and verification of capabilities and agreements with host and user nations to ensure access. This process will continue to in effect for the foreseeable future.

a. Primary considerations for tanker basing, are adequate runway and taxiway dimensions to permit heavy tanker operations, adequate parking, and sufficient fuel storage and delivery capacity. Fewer bases with greater capacities are generally preferable to more bases with smaller capacities to permit economies of scale, optimize the logistics footprint and reduce risk associated with more locations. Proximity to operating areas and security are also important basing criteria. Base Operating Support common to all air operations is also a consideration. For example, ATC, security, fire protection, billeting, etc.

b. Out of area operations may also require tanker operating locations well outside NATO territory, however there is currently no formal planning effort to identify potential locations and their support capability. This eventuality is left for crisis action planning, so real capabilities and prospects for host nation permission are unknown, and alliance planning does not identify this possibility to the nations (outside the limited scope of NRF planning).

c. NATO anticipates and addresses the need for adequate AAR basing with the Capability Package process that identifies airfields within NATO territory that can support AAR operations, and funds airfield infrastructure improvements where appropriate to ensure airfields are capable if required. Decisions on inclusion of airfields in a Capability Package are based on operational utility and location, however the packages are financially constrained, agreed by alliance consensus, and exclude bases outside NATO territory.

3. Operations from austere deployment sites will require deployable support packages of equipment and personnel, from the tanker units and or from a bare base support capability. Tanker and support units will also require preparation in the form of training, and exercises to ensure a rapid deployment capability, and capability to sustain operations in forward locations.



X. NATO Doctrine, Procedures, and Training

A. Doctrine

1. There is currently no alliance promulgated AAR doctrine. There has been discussion within NATO air working groups and panels on potential development of AAR doctrine and whether there is a requirement or benefit. It's not possible to predict whether there will be NATO AAR doctrine in the future, or what impact it could have on AAR operations.

2. NATO doctrine could facilitate smoother coordination and planning as new aircraft provide AAR operators and planners more opportunities to employ AAR assets in additional and secondary roles, and under employment concepts that exploit more flexible and capable assets. Section III, paragraph D.7., and Section VII, paragraph C. discuss the what the capabilities of new tanker aircraft mean for increasing effects and employment concepts.

B. Procedures

1. The revision of Allied Tactical Publication (ATP-56(B)) should be fully implemented by all NATO air refueling nations by the end of 2007. ATP-56(B) is a thorough procedural manual, and includes critical information on allied tanker and receiver aircraft. ATP-56 has been in existence since 1991, but was not universally implemented by all NATO nations. Complete implementation will improve interoperability as all nations will now follow agreed and documented procedures.

2. Initial implementation has been successful, but as the procedures are tested in practice, change proposals will be made as is common and desirable with flight manuals. Changes and adaptations for flight manuals must be done in a timely sometimes urgent manner to respond to the operators' requirements. For an alliance flight manual, consideration and approval of changes is complicated by the requirement for agreement and acceptance by using air forces. This acceptance, however difficult to achieve, is the critical factor in reaching true interoperability. NATO publications usually accommodate national caveats and exceptions to make the publication acceptable to all. For ATP-56(B) the balance between true interoperability and national caveats and exceptions is critical. Too many national exceptions may detract from the interoperability the manual seeks to provide, yet requirement for 100% consensus on all procedures may preclude timely changes that are important to most users. Other means, such as ATO SPINS, may be used to adapt procedures when required, however reliance on external or extraordinary means or publications to update procedures will undermine the effectiveness of ATP-56(B) as a single source reference.

C. Alliance AAR Concept

1. The NATO Alliance AAR Concept is under revision. The revision may be published in 2007. Assumptions in the draft revision were also used in producing this report. The revision prescribes a NATO AAR organizational structure with changes to NATO staff responsibilities

for coordinating AAR policy and planning. The new Concept may establish a better understanding of responsibilities for planning and strategic direction of the AAR mission among NATO headquarters and commands, but will not significantly affect operational or tactical level execution of the AAR mission.

2. With the exception of the implementation of the new ATP 56-B, which will improve procedural interoperability, NATO publications and guidance will not significantly impact future AAR planning and operations.

D. Training

1. AAR training will remain a national responsibility and activity. As an alliance, NATO's greatest interest in training is ensuring familiarity and interoperability during peacetime to prepare for crisis or war operations.

2. As more nations acquire more receiver capable aircraft, requirements for AAR training will increase. For nations with receiver aircraft but few or no tankers, this will require cooperation with other nations to ensure sufficient training.

3. Realistic exercises that include AAR between receivers and tankers that don't otherwise train or operate together will become critical as several new tankers and receives enter service. The current level of AAR accomplished during NATO exercises is not nearly sufficient to ensure the required interoperability. This low exercise level is due primarily to nation's failing to contribute sufficient numbers of tankers to NATO exercises. Nations habitually limit AAR involvement in NATO exercises, and AAR deployment to forward operating bases, C2, surge operations, and interoperability are not exercised realistically. NATO AAR exercise AAR operations tend to be pre-scripted and constrained by basing, limited tankers and airspace, and interoperability considerations including financial agreements.

Findings and Recommendations



A. Review and Revitalization of the PCC regarding AAR

Finding: The nations recognized AAR as a capability to be improved and developed in 2002, and a group of nations began studying alternatives. This study however led to a decision not to develop any improved capability. Examination uninformed by the classified war planning process suggests a shortfall. Although the operational need was identified, financial considerations discouraged development of the capability, and the PCC remains unfulfilled, and ignored in this area. See discussion in paragraphs III.C. and IV.B. of this report.

Recommendation: NATO headquarters and the nations should re-introduce the requirement for discussion at the ministerial level, and press for solutions to develop more AAR capability.

B. Emphasize basing close to operations

Finding: In the past war and contingency planning highlighted AAR aircraft as a high value asset, and recommended minimum distances from the area of operations for basing AAR aircraft. The high value asset concept has limited utility in planning and operations. Many to most military aircraft can be considered highly valuable in terms of financial cost, difficulty in replacing lost aircraft, and of course in the lives of the aircrew at risk. Acknowledging this value, prudent decisions on basing, require consideration of several operational factors, and risk management based on specific operations and objectives.

Maximum distance guidelines have also been used for basing. These distances are predicated on the inverse relationship between offload available and distance from the air refueling area(s). Closer is naturally better than farther for this purpose, but acceptable distances are situational, and it's not practical to identify an all-purpose maximum distance.

It is not possible to establish a distance range (between XXX and YYY miles) for tanker basing and accommodate the several considerations necessary for the variety of potential operations.

Recommendation: Arbitrary basing distance guidelines should not be used for defense planning and capability package purposes. Locations and distances from operations and threats should be based on planning situations.

C. Basing outside NATO

Finding: Information is compiled on potential Forward Operating Bases (FOBs) in NATO for use in crisis, but none is compiled for out of area Deployed Operating Bases (DOBs). It is easier politically to survey and compile data for bases on alliance territory than outside the NATO area.

Recommendation: Even a low profile method of compiling data from potential out of area bases would reduce time required for crisis basing and deployment decisions. Many nations on NATO's periphery have PfP or Mediterranean Dialogue relationships with NATO and member nations that could provide entrée for discussions on basing capabilities.

D. UAV AAR

Finding: UAV AAR is realistic as a future capability. It may be done UAV to UAV or between manned and UAV aircraft. It remains to be seen what technologies and systems will be adopted, but operational utility, safety, cost, and interoperability will be considerations with UAV AAR as they are with manned systems. Reference paragraph V.B. and sub-paragraphs.

Recommendation: To the extent NATO can influence national UAV AAR development, the alliance should emphasize the practical benefits of interoperability with other AAR and C2 systems to avoid developing and requiring specialized resources, procedures, and airspace.

E. Efficient AAR Planning

Finding: Planners and commanders will enjoy small efficiency improvements in the immediate future, resulting from improved automation in planning and dynamic replanning. Additional small efficiencies may be realized by improved analysis and management in sustainment operations. Small scale efficiencies can not offset significant shortfalls in numbers of aircraft or aircrews, but the resources saved can be redirected toward other operational requirements or for reserve and reconstitution

Recommendation: Technologies and techniques including efficiency as a basing consideration, current operations analysis and assessment, and fuel consolidation should be institutionalized and incorporated into all alliance AAR planning and execution. See Paragraph III. D. of this report. These methods can improve efficiency even where operations are not constrained by AAR resources, identify reserve capacity, and facilitate or accelerate reallocation.

F. Doctrine and Terminology

Finding: There is no alliance promulgated AAR doctrine. The only NATO approved terminology, from the ATP-56(B) AAR Manual, address techniques and procedures, not employment concepts, roles or doctrine. Nor does the draft Alliance Concept for AAR include doctrine or terminology. Alliance doctrine development could build a consensus of alliance thinking on a capability and its employment, define concepts, and provide a common foundation for alliance planners, operators, and commanders. Development of related terminology provides common language and understanding of concepts necessary to describe and discuss employment of the capability. As interchangeable roles, receiver capable tankers, and network-enabled AAR provide more options for efficient, effective execution across tanker fleets and on individual sorties, alliance doctrine development can identify and develop optimal employment concepts.

Recommendation: NATO should develop and document AAR doctrine. A basic and very general doctrine would be helpful in establishing common reference concepts and terminology. Examples of concepts where definition and documentation would be helpful include: tactical refuelling, interchangeable/dual/secondary roles, and fuel consolidation/force extension. The concepts are widely known, but not clearly defined and delineated.

G. Interchangeable and Secondary Roles for Planning

Finding: Additional capabilities like AT and C4I offer great benefits in flexibility to air operations at a relatively low development and acquisition cost. Individual aircraft however, can serve simultaneously as air refuellers and air transporters only in very limited circumstances.

Recommendation: Force planners, Defence planners, and Current Operations planners should recognize that aircraft can generally only be used in one role at a time, and avoid “double counting” aircraft.

H. Procedural Interoperability

Finding: Ratification and Implementation of ATP-56(B) as the single AAR Manual for NATO has been an unqualified success. Continued interoperability and effectiveness require balance between attaining widest possible acceptance of changes, and timely implementation of changes to meet operational requirements. Excessive reliance on national exceptions and special instructions external to ATP-56(B) would undermine the document as a single source reference for procedures that provides universal alliance interoperability.

Recommendation: Maintaining an agreed and effective manual will require careful attention, good staff coordination, and efforts to achieve workable compromises. Refuelling nations should pay careful attention and initiate change proposals as soon as a requirement is identified. National AAR Panel representatives must work diligently with other nations and within their national forces to achieve agreeable solutions so changes can be implemented quickly.

I. Training and Exercises

Finding: National training programs meet AAR procedural training requirements, but there is no realistic, challenging AAR exercise activity. Wartime deployment, interoperability, and C2 challenges are not addressed in these exercises.

Recommendation: Joint Force commanders emphasize realistic and challenging AAR activity in NATO exercises to address the same challenges that would be encountered with war or crisis operations: operations from forward operating bases, AAR between aircraft without a habitual tanker-receiver relationship, and dynamic tasking and retasking.