

## IP CONVERGENCE FOR MILITARY NAVAL COMMUNICATIONS

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**Abstract.** The global technology trend in communications is towards richer digital services, greater bandwidth, higher capacity and increased resilience all contributing to greater efficiency for the user. Internet Protocol (IP) has become the undisputed pervasive world standard that is supporting and accelerating this trend. The advantages in using full IP based architecture are many and there is every reason to expect that the capability gap over other technologies will continue to widen thanks to the massive investment by industry and research institutions alike. The use of IP architecture is essential to ensure that our forces will be networked, interoperable and agile to meet the array of new and existing threats with confidence and prevail. The inadvertent selection of non-IP based architecture for communications may be an error in judgement that could ultimately limit Australia's military effectiveness.

### INTRODUCTION

This paper discusses the use of packet switched Internet Protocol technologies from the commercial world that can be effectively applied for tactical Voice Communications Systems (VCS) on board naval vessels. A key architectural decision is to use voice-over-IP (VoIP) at the core of the secure voice and tactical intercom solution. This is far more effective and future proof than the alternative approach whereby VoIP capability is added on to non-IP architecture systems using gateway functions.

The subject of this paper is relevant to a number of future naval projects in Australia including:

- SEA 4000 Air Warfare Destroyer, Communication and Information System (CIS)
- SEA 1439 Phase 5B2 Collins Class Submarine CIS and High Data Rate SATCOM (HDR) Upgrade
- SEA 1442 Phase 4, Maritime Communications Modernisation.

The content is also relevant for any future upgrade requirements for in-service naval platforms.

An overview is presented on the industry wide trends of convergence of service delivery technology to open systems Internet Protocol (IP), as summarised in the statement "Everything over IP" (EoIP). Adopting the same philosophy for the definition of the future Naval CIS requirements will not only deliver significant operational advantages but also improve the supportability of these systems through future proofing and a reduced Total Cost of Ownership.

Although the specific application discussed in this paper is centred on naval applications, the same arguments are applicable generally across the full spectrum of military communications.

### THE ADVANTAGES OF IP

#### *Fits the NCW Roadmap*

The ADF published a roadmap for its path to achieve network centric warfare capability in 2007 [1]. The use of IP technology is a key enabler for this capability, a view

reinforced with the development of ADF projects such as SEA 1442 Phases Three and Four.

An IP based VCS means that end to end user connectivity can be extended beyond the traditional fixed frequency simplex line of sight (LOS) links to wide area networks through bearers such as SATCOM or high speed line of sight (HS-LOS). Current LOS links are resource intensive yet under utilised. Extending secure VoIP over HS-LOS will not only free up resources but allow richer interaction between warfighters.

Traffic prioritisation through the WAN can be achieved if the traffic type is appropriately Type-of-Service (ToS) tagged within the on board network. Multi-channel voice services can be delivered according to command priority across a digital trunk LOS bearer as opposed to the current RAN scenario that requires multiple analog LOS bearers.

#### *Global Trend Towards EoIP*

There is an undeniable trend for convergence in the global communications community towards EoIP. As a result, there is a massive amount of investment in product development and new services that are being made available. Determining factors such as capability, capacity, bandwidth, processing power and functionality will continue to grow in the commercial market. Developments will be driven generally to reduce costs and increase user experience and efficiency.

Having an IP based VCS enables full leverage from these developments into the maritime domain.

#### *Future Proofing for Capability and Obsolescence*

##### General

A significant factor for a naval ship as a result of their extended life of type, is a future proof architecture. This is best achieved by selecting from the most promising and pervasive technology standards. For voice and data systems, the clear trend in commercial and military domains is IP based architecture.

With an IP based architecture, through life support philosophies can be optimised so that COTS equipment items are routinely replaced when they fail or at specific time horizons. A key foundation of a support system with this philosophy is a shore based test bed facility that can be used to prove any new upgrades prior to installation on board ship.

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This approach will effectively eliminate any obsolescence impact throughout the life of the ship.

#### Integration of New Capability after Delivery

New services and functionality will always become available due to the ever increasing investment by the commercial sector. Some examples that are now available include:

- Extension of video, for example from a flight deck camera, gangway camera or damage control cameras to any voice user terminal in the ship.
- Web based browsing of call party lists.
- Text alerts that could include SMS, MMS, email or signal traffic.

IP based architecture allows the simple integration of these types of functions that will maximise the use of available infrastructure and decrease the decision cycle of the operator. Additionally, crew reduction could be achieved through enhanced efficiency. It would be impossible to insert this kind of capability into legacy circuit switched systems.

#### Simplified Expansion after Delivery

If additional user terminals or telephones are required to provide wider distribution of existing capability, they can be simply added into the system by connecting to the nearest available IP network outlet rather than by running cables back through the ship to a central switch.

As an alternative to installing new equipment, functionality, such as a "Soft Phone" application, can be added to any computer that is connected to the network allowing access to the shipboard VCS.

#### ***Common and Robust Infrastructure***

With IP architecture, a highly robust and reliable network can be deployed that automatically re-routes traffic in the case of switch failure or battle damage using the standard automatic features of the network.

A common infrastructure can be deployed for voice and data networks that will simplify new installations and make existing ones more resilient. In the event of serious failures or damage, equipment can be "hot-swapped" if necessary based on command priorities. For example, a router from an administration network could be used to replace a failed router in a core network in the extremely unlikely event that the primary, secondary and cold-spares routers failed in the core network.

Security enclaves can be effectively deployed through the use of multi level thin client architecture with client distribution operating across the common network infrastructure. This greatly reduces the distribution and desktop space that would otherwise be needed if separate clients are provided for each enclave.

The ability to integrate Red and Black voice functionality will mean that the user workspace can be simplified and unnecessary clutter removed greatly improving efficiency especially in stressful battle or damage control situations.

#### ***Common Management and Support***

There is a major saving in the cost of ownership with the option for reduced manpower and training overheads. The skills needed by personnel are portable, enabling selection by pre-existing qualifications.

Overall operator workload will be reduced and more efficient. Common centralised management will enable full network visibility and fault diagnosis from one environment. Day to day system administration tasks, including backup and user management, will be more efficient.

A greater level of commonality in equipment will be possible simplifying the number and type of spares that are needed both on-board and in the depot.

Because much of the equipment and management tools are COTS, training courses are commercially available.

#### ***Lower Overall Life Cycle Cost***

Overall life cycle costs are anticipated to be at least 50% less by using an IP based system compared to a legacy circuit switched system over the typical 30 year platform life cycle. Obsolescence can effectively managed with a COTS refresh support model.

There will be a reduced cost of installation on new platforms as only one set of infrastructure will need to be fitted. This is a major saving identified in the commercial world with IP convergence where only one cable is needed for each desktop position.

#### ***Integration of IP to a Legacy System***

It is possible to integrate IP capability to a legacy system that uses circuit switching at its core through the provision of an IP gateway interface. This is certainly a step in the right direction however fundamentally it will not be future proof. In general, the issues associated with this kind of approach are:

- The end-user remains locked into proprietary technology.
- There will always be an obsolete system at the core.
- On-going upgrades will be only accomplished with partial and limited functionality work-around solutions and may require significant changes to the gateway interface.
- Expansion is problematic, new cabling back to central switch will always be needed.
- In many cases it will be impossible to add new functionality constraining the possibilities of improved operator efficiency and safety.
- End-to-end service delivery will be limited to the legacy system interface rather than right through to an end-user.

#### **IP MISCONCEPTIONS ADDRESSED**

The use of VoIP for ships VCS could be considered as a risk in terms of the use of a new technology in this area. In fact the base technology is well and truly proven in the commercial world where many legacy circuit switched systems are being replaced by VoIP. This includes safety

critical systems such as Air Traffic Control. The fundamental controls, indicators and functions required for a full featured ship's VCS are well understood and have been reproduced in the new IP based solutions. These systems have been selected and are being delivered for major European naval communication programs for large and small surface ships and submarines. Therefore, the technology risk associated with this solution is no more than existing legacy circuit switched solutions and is significantly lower risk in terms of obsolescence.

Security may be seen as a risk with the use of IP technology. In fact, the use of IP supports the concept of built-in trusted security enforcing functions that improve security performance beyond that of circuit switched solutions.

There is the potential that the implementation of IP standards may not be uniform across all COTS suppliers. This has been proven to be less of a problem as time moves on due to the wide base of IP products and the general need across the board for interoperability. Experience in the Thales Network Enabled Warfare Laboratory in Sydney has shown that the integration of new products and features with existing IP based equipment is relatively straight forward. One example is the integration of a Cisco VoIP wireless system with a naval VCS VoIP system and an Asterix open source conferencing package that was completed in a matter of hours.

The underlying complexity of packet based systems may be seen as a barrier to its implementation on a warship. Due to the widespread use of IP technologies in the commercial world, the complexity has been made common place. More and more, operators and maintainers will be familiar with COTS technology. This common and widespread use effectively diminishes or tames the issue of complexity. The technology is becoming easier to use and concepts such as "plug and play" are now a reality. In fact, who would have thought ten years ago that it would be common place to have a wireless router in your own home?

The nature of packet based systems is that the values for key quality of service parameters such as jitter and delay are difficult to precisely determine. In reality, quite good performance for real time traffic such as voice and interactive data exchange is readily achieved on the public internet. For a closed network VCS, standard techniques such as multi-protocol label switching (MPLS), overprovision of bandwidth and quality of service management will deliver a level of performance more than adequate for voice services.

## THE DECISION FOR IP

### Selection Criteria

Selection criteria have been chosen for a comparison between circuit-switched and IP architecture solutions within the context of delivering the best value for money voice capability over the life of a typical naval platform that can extend up to and beyond 30 years.

The following criteria have been identified:

- Tactical intercom and secure voice functionality
- Security measures
- Scalability

- Availability
- Flexibility for functionality enhancements
- Open standards based
- Life cycle cost

### The Decision Analysis

Based on the selection criteria, and an analysis of each characteristic, the following table in Figure 1 has been developed. The score range and weighting figures are based on a range of one to five, with five as the highest.

The relative scores were developed based on the understanding of the performance of each system guided by factors such as life cycle costs.

Selection Criteria	Weighting	ANZAC Reference		IP System	
		Score	Weighted	Score	Weighted
Tactical intercom and secure voice functionality	4	3	12	4	16
Security measures	4	3	12	4	16
Scalability	3	2	6	4	12
Availability	5	3	15	5	25
Flexibility for functionality enhancements	3	2	6	4	12
Open standards based	3	2	6	5	15
Life cycle cost	2	2	4	4	8
<b>Total</b>			<b>61</b>		<b>104</b>

**Figure 1. Decision Analysis Result**

The Tactical intercom and secure voice functionality rating is based on the fact that the ANZAC circuit-switched reference system is well known and performs its task. The higher score for the IP system is based on the fact that the clutter at an operator position has been reduced as only a single interface is required to achieve both the functions of Intercom and Secure Voice.

The Security measures rating is based on the fact that there are now better and more trusted means to provide security functionality within an IP architecture.

The ratings for Scalability, Availability and Flexibility for functionality enhancements are reasonably self explanatory. The IP architecture scores highly on the Availability as the underlying network infrastructure has multiple levels of redundancy using the same methods for service delivery as used by the major telco carriers.

The decision result is clearly in favour of IP architecture.

## COMMERCIAL INDUSTRY TRENDS

### Telstra

In a press release [2], Telstra and Alcatel announced a works program for Telstra's fixed network transformation. It will see Telstra move to the next phase of its Internet Protocol (IP) network transformation that will deliver leading-edge services to 5.3 million Telstra customers over the next five years.

Telstra stated "These upgrades are important for future-proofing our network over the next five to ten years, where we will be able to provide customers with access to offerings such as high speed internet, telecommuting, video conferencing and video delivery of services in general."

## Optus

Optus has a plan to upgrade all its backhaul networks to IP. The Optus vision is to IP enable the network that will become known as the Next Generation Network (NGN). This will provide greater capacity and be future proof. This is necessary as the traffic loads grow and the use will be more towards data traffic than voice traffic.

An Optus document [3] describes an IP convergence package for enterprise IP telephony. It states that the benefits of running IP telephony can be many but choosing the right technology for your business can be a challenge.

According to Optus [3], the features and benefits include:

- Reduced complexity – Optus has already done the hard work and designed a range of pre-configured solutions with defined management and feature options providing the benefits of VoIP.
- Ease of transition – the handsets, hardware and network are all pre-configured to have a system up and running day one.
- Increased productivity – Because the solution is fully managed from day one, it is possible to take advantage of the enhanced features such as online management platform, IP Videoconferencing and hot desking as soon as the solution is deployed.

Notably, these benefits are available at no risk within IP based naval VCS solutions.

## Alcatel-Lucent

An Alcatel-Lucent Technologies circuit voice migration solution document [4] describes how Alcatel-Lucent has developed a comprehensive solution designed specifically for regional independent operating companies, rural telephone companies, and competitive local exchange companies. The solution helps to address business and competitive needs—and migrate seamlessly from a legacy TDM infrastructure to a lower-cost, next-generation infrastructure, which can deliver voice and multimedia services cost effectively.

This concept is designed to future proof the operator's investment. Today's network investments need to do more than support VoIP. The platform that meets current migration needs should also support the emerging world of IP and advanced communication services. The IP solution provides a service platform to handle both the present and future requirements. It provides a way to leverage legacy investments while introducing a comprehensive, scalable, forward looking network that supports existing services along with enterprise and consumer VoIP.

## Cisco Systems

A top level view of Cisco Systems thinking on converged IP networks is found within a white paper called "Building the Carrier Class IP Next Generation Network" (NGN) [5]. As depicted in Figure 2, central to an IP NGN are three fundamental areas of convergence already being enabled by service providers today:

- Application convergence – Carriers can integrate new IP data, voice, and video applications over a single broadband infrastructure. Application convergence opens

the doors to "all-media services" such as videoconferencing, which is effectively a new service that is not simply voice, video, or data, but an integration of all three. This and other innovative value-added services can be delivered over any broadband connection.

- Service convergence – The Cisco IP NGN makes a service available to end users across any access network. For example, a service available in the office can be available over a wireless LAN, a broadband connection, or a cellular network.
- Network convergence – Creating a converged network is a goal that many carriers are already pursuing through their efforts to eliminate multiple service-specific networks or to reduce multiple layers within a network. A "many services, one network" model in which a single network can support all existing and new services will dramatically reduce the total cost of ownership.



Figure 2. Cisco IP NGN Architectural Overview.

## MILITARY TRENDS

### US Navy and Marine Corps Implement NCW Concepts

A study written for the US Naval Networking Group [6] notes that the communications gear currently used by the Navy and Marine Corps was acquired haphazardly before the full potential of internet-style connectivity was grasped. In order to fashion an integrated warfighting posture that can respond flexibly and efficiently to diverse threats, the sea services need to migrate to a new networking environment that satisfies several demanding requirements:

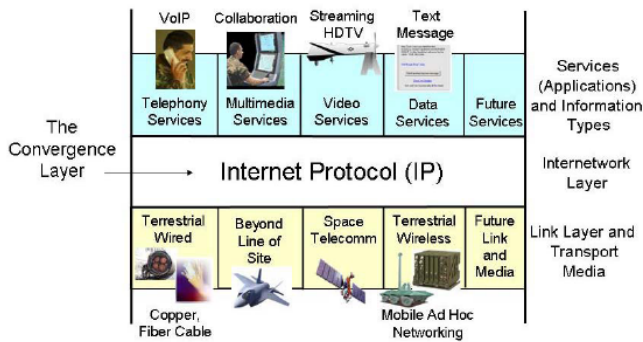
- It must provide robust carrying capacity and access to all friendly forces, while prioritizing service for tactical users who have the greatest immediate need of assistance.
- It must be interoperable across the full spectrum of forces and organizations likely to participate in missions, allowing any qualified user to "plug and play" as required.
- It must enable fusion of warfighting information from all relevant sources, including an ability to reach back to remote resources with unique insight into specific threats or situations.
- It must support agile command capabilities, especially the capacity to make precise and perceptive decisions that can be quickly conveyed to all members of a fighting force.

- It must be secure against enemy intrusion and disruption, assuring that vital information reaches users without being compromised by interception, corruption or jamming.

**USA Global Information Grid (GIG)**

The Global Information Grid Architecture Vision [7] states that like the Internet, the target GIG’s scalable, robust, and highly available communication infrastructure is based on packet switching to interconnect anyone, anywhere, at any time with any type of information such as voice, video, images, or text. With this common Internet Protocol (IP)-based packet communications layer, an information transfer through an EHF MilSatCom terminal to an UHF terminal or to a wired device is transparent to users. Also transparent is an information transfer from an Army brigade to a nearby Marine unit.

As depicted Figure 3, an IP-based network infrastructure is the foundation of end-to-end interoperability in the target GIG. All types of information such as telephony, multimedia services, video, and data are converged over this universal network.



**Figure 3. GIG Internetworking Convergence Layer.**

**USA Consolidated Afloat Networks and Enterprise Services (CANES)**

CANES is a program to modernise the IT networks fitted on US warships, clearly converging and consolidating the networks based on modern IP infrastructure in order to capitalise on the development of Service Oriented Architecture (SOA).

CANES will consolidate and improve the networks on tactical platforms. There are four primary shipboard infrastructure networks today in the USN: NIPRNET, SIPRNET, Sensitive Compartmented Information (SCI) and the Combined Enterprise Regional Information Exchange System (CENTRIXS), each operating at different security levels.

Additionally, many C4ISR applications bring their own unique networks and hardware. The average force-level USN ship has more than 50 separate networks deployed, all with significant installation, training and supportability issues. More importantly, these networks are typically not interoperable as they were each designed to support a single warfighting function, which is the origin of stove-piped systems.

CANES will accelerate the movement of DISA’s NCES core services to the tactical edge. Moving GIG core enterprise services forward to the warfighter will be accomplished by developing a set of federated services to support tactical C4ISR applications in the disconnected, intermittent or limited-communications scenarios often experienced by naval warfighters.

**USA Gigabit Ethernet Data Multiplexing System (GEDMS)**

A Data Multiplex System (DMS) network, AN/USQ-82(V) was first installed in the DDG 51 Arleigh Burke class destroyers DDGs 51-78 [8]. It is a multi-protocol ship wide area network specifically intended for real-time control system communications. GEDMS upgrades the backbone network to a 1 Gb/s redundant Ethernet mesh, bringing enhanced multimedia capability to the ships.

For several years now, audio and video data streams have been available over the Internet, providing stored or real time audio and video programming. These same services can be made available over GEDMS. The primary application in ships is to provide remote monitoring of unmanned spaces and to build interactive audio/video applications using these techniques. It is possible even to provide voice telephone services over IP and the US Navy is showing interest in this as well.

A core IP based Tactical Intercom system will be an important part of the ship's infrastructure to enable this kind of capability.

In August 2008 The Boeing Company was awarded a \$5.4 million firm, fixed-price contract by the U.S. Navy to produce an updated shipboard network communications system for the USS Arleigh Burke guided-missile destroyer (DDG).

**US Army Network Modernisation**

The US Army Infrastructure Modernisation Program (I3MP), part of the Army's \$4 billion Infrastructure Modernisation (IMOD) initiative, aims to rewire U.S. bases around the globe [9]. From Fort Hood in Texas to Camp Arifjan in Kuwait, technicians are ripping out old copper phone lines, analog switches and legacy network equipment, and replacing them with bandwidth-rich fibre connections and converged Internet Protocol networks.

“Much of the Army's legacy infrastructure consisted of separate stove piped communications paths requiring extensive oversight and intervention to ensure connectivity”, says Lt. Col. Charles Wells. I3MP moves the Army's architecture towards conducting "Everything over IP" (EoIP) - converging voice, data and video traffic into a unified, Army wide IP architecture.

Members of the US joint community are moving forward on proving that voice over Internet protocol can be a force multiplier [10]. Although voice over Internet protocol is still in relative infancy, the Joint Communications Support Element, U.S. Joint Forces Command, has demonstrated through a series of exercises that this approach can increase both technological advances and bandwidth efficiency provided to the joint warfighter. It also decreases airlift requirements, reduces the number of needed personnel and

cuts the cost of communications systems by moving from circuit based to Internet-based networks.

According to a briefing on emerging IP network-centric requirements conducted by the Joint Chiefs of Staff/Command, Control, Communications and Computer Systems Support Division (J-6C), TDMA satellite modems create a 2-to-1 ratio increase in the efficiency of communications service allocations. As a result, a properly configured EoIP network results in a pool of available bandwidth, ensuring better use of satellite resources.

#### USA Defense Information Systems Agency (DISA)

DISA officials have completed a study that recommends shifting a large portion of Defense Department communications, including phone calls, to a converged network based on IP [11]. Depending on how DISA officials structure and contract for this converged network, it could siphon voice traffic off existing and planned federal government wide contracts as DOD military and civilian employees move from switched voice networks to voice-over-IP calling. DISA's goal is to "get to a single integrated network with voice just becoming another application on a large data network." This is similar to the Sea 1442 Phase 4 vision for the Digital Ship.

#### Australia

The 2007 NCW Roadmap [1] indicates one of the target states of the ADF's NCW Capability is to ensure deployment agility is achieved through self-synchronising networks at the service level throughout a significant part of the joint force.

An introduction to a report series by DSTO on IP convergence in Global Telecommunications [12] states "Service providers have been anticipating the rise of new services other than voice for some time. Architectures based on narrowband Integrated Services Digital Network (ISDN) and Broadband ISDN using Asynchronous Transfer Mode (ATM) technology have emerged for this purpose. However, user demand for data services based on Internet Protocol (IP), being much cheaper to implement end-to-end, has exceeded expectations. To satisfy this increasing demand, network service providers are now considering the development of carrier grade IP networks to support their data and voice services in a single network. With emerging IP switching technology capable of carrier grade switching loads and the promise of guaranteed high quality voice communications over IP, service providers see IP as the best business solution for converging their voice and data services."

A DSTO report on new approaches to network management and service provision [13] discusses the provision of voice services based on IP networks in contrast to traditional circuit switched technologies.

#### Europe

A presentation from the 5th European Defence Conference in 2006 [14] makes a point that network enabled capability (NEC) needs IP based communications. It states that "IP as convergence technology for voice and data is the only way to reduce complexity." The presentation is in the context of tactical land communications but also contains a connection to the "Naval Taskforce Intranet."

A presentation from the European Commission addressing IPv6 [15] discusses IP convergence. It states "The convergence of Voice/Data/video creates disruption in the market and IP plays a key role in this convergence." This is making the point that IP provides a good mechanism to achieve the desired convergence.

The following is from an internal Thales study paper on the voice solutions for the UK CVF program. "The primary operational advantage is that both voice and data share a common infrastructure, leading to cost savings in equipment, spares, management and maintenance. Functionally, the concept of convergence between voice and data simplifies the introduction of services such as video-conferencing, voice messaging and many other features. The IP backbone network is fitted with multiple links and robust network algorithms compliant with the latest commercial IP standards to provide a highly resilient backbone which can in the event of battle damage or component failure automatically and transparently re-route traffic across the backbone without any disruption to the end user voice communications."

### CONCLUSIONS AND RECOMMENDATIONS

Internet protocol convergence is clearly pervasive across all areas of the defence and commercial markets. The use of IP architecture solutions for naval SVS makes common sense and in reality, presents the lowest risk option for the future guarding against obsolescence. Non-IP based architecture solutions should be actively avoided as these will be quickly rendered obsolete by rapidly advancing technology and will ultimately limit defence effectiveness. The use of IP architecture based systems should be strongly promoted if not mandated for all future Australian defence communications projects.

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