Could UAVs improve New Zealand’s Maritime Security?

149.800

Master of Philosophy Thesis

Massey University Centre for Defence Studies

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Due date: 28 Feb 2009

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Glossary

ACF	Air Combat Force
AP-3C	Lockheed Orion (maritime patrol aircraft - RAAF update)
APDC	Air Power Development Centre
ASW	Anti submarine warfare
ATC	Air Traffic Control
AV	Aerial Vehicle
BAMS	Broad Area Maritime Surveillance
BLOS	Beyond Line of Sight
BPC	Border Protection Command (Australia)
C^4	Command, Control, Communications, and Computers
C-130	Lockheed Hercules transport aircraft
CAA	Civil Aviation Authority (NZ or UK)
CAR	Civil Aviation Rule
CBP	Customs and Border Protection (United States)
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CDL	Common Data Link
CONOPS	Concept of Operations
COTS	Commercial off the Shelf
CPL	Commercial Pilot's Licence
Dash 8 (Q300)	Short range passenger aircraft converted for MARPAT
DB2K	Defence Beyond 2000 (report published 1999)
DoC	Department of Conservation
DoD	Department of Defense (United States)
DOP	Defence Output Plan
DPF	Defence Policy Framework (2000)
DSTO	Defence Science and Technology Agency (Australia)
DTA	Defence Technology Agency
EEZ	Exclusive Economic Zone
EO	Electro-optical
FAA	Federal Aviation Authority (United States)
FLIR	Forward Looking Infra-Red
GCS	Ground Control System
GDP	Gross Domestic Product
GDS	Government Defence Statement (2001)
HALE	High Altitude Long Endurance
HQJFNZ	Headquarters Joint Force New Zealand
ICAO	International Civil Aviation Organisation

IFR	Instrument Flight Rules
IPV	Inshore Patrol Vessel
IR	Infra Red
ISR	Intelligence, Surveillance and Reconnaissance
IUU	Illegal, unregulated, and unreported (fishing vessels)
JCCS	Joint Command and Control System
LCC	Life Cycle Costs
LOS	Line of Sight
LRE	Launch and Recovery
LRGCS	Launch and Recovery Ground Control Station
LTDP	Long Term Development Plan
MAF	Ministry of Agriculture and Forestry
MALE	Medium Altitude Long Endurance
MAOT	Multi-Agency Operations and Tasks
MARPAT	Maritime Patrol
MARSURV	Maritime surveillance
MAV	Micro (or miniature) Air Vehicle
MCC	Maritime Co-ordination Centre (now NMCC)
MDA	Maritime Domain Awareness
MFAT	Ministry of Foreign Affairs and Trade
MFish	Ministry of Fisheries
MFR	Maritime Forces Review (2002)
MMA	Multi-mission Maritime Aircraft
MNZ	Maritime New Zealand
MPA	Maritime Patrol Aircraft
MPR	Maritime Patrol Review (2001)
MRV	Multi-role Vessel
MSA	Maritime Safety Authority (now MNZ)
MTCR	Missile Technology Control Regime
NAS	National Airspace
NATO	North Atlantic Treaty Organisation
NMCC	National Maritime Co-ordination Centre
NORPAT	Northern Patrol
NPF	Naval Patrol Force
NWS	North West Shelf (Australia)
NZDF	New Zealand Defence Force
OEF	Operation Enduring Freedom
OEM	Original Equipment Manufacturer
OIF	Operation Iraqi Freedom
OPV	Offshore Patrol Vessel

P-3K	Lockheed Orion (maritime patrol aircraft – RNZAF update)
POC	Predator Operations Centre
PPL	Private Pilot's Licence
RAAF	Royal Australian Air Force
RHIB	Rigid hull inflatable boat
RMA	Revolution in Military Affairs
RNZAF	Royal New Zealand Air Force
RNZN	Royal New Zealand Navy
SAR	Synthetic Aperture Radar
SaR	Search and Rescue
SATCOM	Satellite Communications
shp	Shaft horse power
SLOC	Sea Lines of Communication
SMRPA	Short/medium Range Patrol Aircraft
SOI	Statement of Operating Intent
TCAS	Traffic alert and Collision Avoidance System
UA	Unmanned Aircraft
UAS	Unmanned aerial system
UAV	Unmanned aerial vehicle
UHF	Ultra High Frequency
UNCLOS	United Nations Convention on the Law of the Sea
UPT	Undergraduate Pilot Training
USAF	United States Air Force
USCG	United States Coast Guard
USN	United States Navy
USR	Unmanned Systems Roadmap 2007-2032
VFR	Visual Flight Rules
VHF	Very High Frequency
VUAV	Vertical take off and landing Unmanned Aerial Vehicle
WMD	Weapons of Mass Destruction

A b s t r a c t

In 2001 the *Maritime Patrol Review* (MPR) was published by the Department of the Prime Minister and Cabinet to determine the maritime patrol requirements of interested civilian government departments; such as Ministry of Fisheries, Customs, Foreign Affairs, Maritime Safety Authority, Police, Department of Conservation and others. The Review was driven by the planned $600m sensor system upgrade to the RNZAF's P-3 Orion maritime patrol aircraft, which the new Labour Government saw no real justification for. The Review highlighted the poor state of maritime domain awareness in New Zealand in general, and of maritime aerial surveillance in particular. The threats to maritime security are many and include illegal fishing, drug smuggling, illegal immigration, terrorist activity, energy security, and transnational crime generally. The review concluded that a 10 times increase in aerial maritime surveillance was needed to meet the minimum requirements of the various government departments.

Eight years have now passed since The Review and it is timely to revisit the state of maritime domain awareness in New Zealand to assess what, if any, progress has been made. This thesis has found that there has been no increase in aerial maritime surveillance during the intervening period and that the NZDF is either unwilling or unable to fulfil government defence policy in respect to protection of New Zealand's Exclusive Economic Zone. Research indicates that the aerial maritime surveillance requirements of civilian government departments may have increased and that considerable gaps continue to exist in maritime domain awareness and thus maritime security. This thesis contends that UAVs provide a credible option to manned aircraft and bring a number of unique advantages. The need to increase maritime surveillance exists now, and with a potentially less stable global strategic situation together with a potential increase in off-shore energy activity, the need to plan for increased aerial maritime surveillance is compelling.

Brian Oliver February 2009

INTRODUCTION

> …formal Defence Assessments and White Papers in the last decade have placed emphasis on the role of defence in dealing with non-military security challenges, it is the view of the committee that this has not been reflected in the actual tasking and use of NZDF resources. There has been and continues to be an imbalance in favour of military activities further afield that is considered to be inconsistent with the priorities set out in the Defence Policy Framework.
>
> *Maritime Patrol Review* - February 2001[1]

The *Maritime Patrol Review* (MPR) was commissioned to report to the government on New Zealand's civil and military requirements for patrolling its ocean areas.[2] The review concluded that there were significant gaps in the maritime surveillance of New Zealand's ocean areas,[3] and put forward a number of suggestions for closing the gaps. While the suggestions put forward for increasing maritime surface surveillance have largely been acted upon, aerial maritime surveillance remains deficient. One option not put forward was the possible use of unmanned aerial systems (UAS) for aerial maritime surveillance. The reason for this is apparent with the one and only mention of unmanned aerial vehicles (UAVs) in the whole report.[4] The review proposed the establishment of a Maritime Co-ordination Centre, whose function among others, was to diversify the range of source information by monitoring research into 'evolving technologies', one of which is listed as UAVs.[5] The implication being that at the time the technology was not developed sufficiently to be worthy of consideration. While this may have been true eight years ago, the evidence indicates this is no longer the case. UAVs are now mature technology and offer an option worthy of

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[1] *Maritime Patrol Review* February 2001, p.19.

[2] Ibid, p.1.

[3] The most important being New Zealand's Exclusive Economic Zone.

[4] A UAV is merely the aerial platform component of the complete UAS which includes ground support equipment.

[5] *MPR*, p.35.

serious consideration as a means of closing the gaps in New Zealand's maritime surveillance of its ocean areas of responsibility.

New Zealand as a small nation of around 4.3 million people is fortunate and privileged to have the world's fifth largest Exclusive Economic Zone (EEZ), courtesy of the United Nations Convention on the Law of the Sea (UNCLOS).[6] Of potentially equal importance is New Zealand's exclusive economic right to 1.7 million square kilometres of continental shelf which is believed to be rich in mineral deposits. New Zealand is already deriving significant wealth from its EEZ through fishing, and oil and gas extraction. It is believed that New Zealand's potential for offshore oil and gas production may eventually rival that of the North Sea.[7] With the inevitable rising cost of crude oil and advances in deep water extraction technology, once marginal fields are becoming more economically viable with each passing year. It appears to be a case of when, not if, oil production reaches its potential, New Zealand will become a significant player in the global energy market. While the fishing industry is under pressure and is exploiting an extremely sensitive resource that needs careful management, it nevertheless will continue to make a major contribution to the economy through direct and indirect employment and exports. Both energy production and fishing are potentially vulnerable to outside influences. Fishing is under pressure now from illegal activity, and energy production issues can have a major impact on the global economy. In the last year or so deficiencies in food and oil production and rapidly escalating costs have caused major problems internationally. Continued oil-fuelled growth of developing nations and a rapidly rising global population is likely to increase the competition for resources dramatically.[8] Given this scenario it appears that there is a strong possibility of major international tension or conflict before the middle of the century.

As well as the valuable resources the oceans bring to New Zealand, they also act as seaborne highways, or Sea Lines of Communication (SLOC), carrying virtually all of the country's trading goods by ship. SLOC can also bring drug trafficking, illegal immigration, smuggling generally, transnational crime and

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[6] Briefing for incoming Minister of Fisheries November 2008, http://www.fish.govt.nz/ennz/default.htm?wbc_purpose=basic, accessed 17 Feb 2009

[7] James Weir, 'The North Sea of the south', *Dominion Post*, 10 Mar 2008 p.C1.

[8] Boston Consulting Group and Wharton University, Pennsylvania, *Special Report: The New Competition for Global Resources*, September 2008, http://knowledge.wharton.upenn.edu/special_section.cfm?specialID=76, accessed 22 February 2009.

terrorists. New Zealand generates around 3300 international shipping movements a year,[9] and this activity requires safe and secure SLOC. New Zealand is a maritime nation that is not only dependent on the sea for a significant proportion of its wealth, but is absolutely dependent on maintaining clear SLOC for its continued well-being. The first proposition of the leading naval theorist of his day, Alfred Thayer Mahan,[10] was that maritime commerce was essential to the economic prosperity of a great power.[11] This being the case it is probably even more essential for a small island nation 1200 miles from its nearest trading partner.

Unfortunately New Zealand does not adequately protect its maritime assets and sea-lanes. *The Maritime Patrol Review* (*MPR*) of 2001 found that there was very little routine surface surveillance carried out around New Zealand,[12] and that aerial surveillance, particularly in support of MFish and Customs, was 'patchy … and occurring too infrequently to contribute effectively to either surveillance or deterrence'.[13] It has now been eight years since the *MPR* and considerable gaps continue to exist in New Zealand's Maritime Domain Awareness (MDA). The introduction of the Navy's new patrol vessels will address some of those gaps but there will still be insufficient aerial surveillance. This thesis will show that the gaps in maritime aerial surveillance may best be closed by the operation of UAVs dedicated to the task of supporting various civilian government agencies that operate in the maritime domain. UAVs bring a number of significant advantages to the surveillance role, including persistence and stealth, as well as potentially lower life-cycle costs. The Department of Defense definition of UAV is 'A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload'.[14] A UAV is not a weapon and therefore cruise-missiles, and various other rockets and projectiles, are not UAVs.

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[9] Raewyn Peart, *Looking Out to Sea: New Zealand as a model for ocean governance*, Environmental Defence Society Inc.: Auckland, 2005, p.66.

[10] USN Rear Admiral, 1840-1914.

[11] Jon Sumida, in Colin S. Gray and Geoffrey Sloan (eds.), *Geopolitics, Geography and Strategy*, Frank Cass Publishers: London, 1999, p.39.

[12] *MPR,* p.38.

[13] *MPR,* p.35.

[14] United States Department of Defense, Joint Publication, JP 1-02, p.579.

This definition covers most aspects, but generally speaking UAVs are meant to be reusable. Even the smallest tactical UAVs, which might be regarded as expendable, could still expect to be used a dozen or so times and just because something does not carry a human does not make it expendable. A UAV the size of a small aircraft, costing several millions of dollars such as a Predator, is meant to give many thousand hours of service. UAVs generally have some means of recovery, and this is perhaps the defining factor. [15] The difference between a UAV and a radio-controlled model aeroplane is that a model is always under direct control with no autonomy, never leaves sight of the operator, carries no payload, and is purely for leisure, not work. It is often stated that UAVs are best suited for the 'dull, dirty or dangerous' missions, which includes most military air operations. The 'dull' refers to the long duration sorties, such as is often the case on maritime surveillance duties, where crews scan the ocean for 12 hours or more. Another example are the long-range strike missions such as the B-2 that flew a 44 hour mission in support of Operation Enduring Freedom; this mission required careful crew-fatigue management.

The contrast is made with Predators that routinely fly day-long missions with crews operating from the USA on a four-hour rotation cycle. [16] While one cannot compare the capability of a B-2 with a Predator, the effects each can deliver are often similar. The term 'dirty' refers to the environment the aircraft operates in. Following the meltdown of the Chernobyl nuclear reactor, Finland sent up drones to take air samples, so that the level of radioactive contamination could be assessed.[17] The term 'dangerous' refers to any number of missions, but in particular covert reconnaissance, especially over hostile territory. Having an unmanned aircraft flying this mission lowers the political cost if the mission is lost, which prevents aircrew show trials such as the Gary Powers incident. UAVs appear to the public, and even to some defence people, as a new and a recent innovation, when in fact they have followed a similar path of development to manned aircraft over the last 100 years and have

[15] Laurence R Newcome, *Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles*, American Institute of Aeronautics and Astronautics, Inc.: Reston, Virginia, 2004, p.8.

[16] Office of the Secretary of Defence, *Unmanned Systems Roadmap 2007-2032*, Washington: 2007, p.19.

[17] Laurence R Newcombe, p.128.

reached a high level of technical maturity. The UAV scene in New Zealand is small but active with the Army and Navy both showing strong interest and making moves towards acquiring a tactical capability. Perhaps unusually the Air Force has shown little interest, but with their current involvement in several major projects the timing is perhaps wrong. However, the RNZAF did recently commission an independent report on UAVs and it is possible that more attention can be given to their employment once the current projects wind down.[18]

By far the largest producer and user of UAVs is the United States.[19] One study suggests that the US will account for 72 per cent of the worldwide Research and Development and Test and Evaluation spending on UAV technology over the next decade, and about 61 per cent of the procurement.[20] Because of this the great majority of literature available on UAVs emanates from the US, and consequently this thesis relies heavily on US sourced material, in the absence of literature from New Zealand and the Asia-Pacific region. Extensive use was also made of the internet, which provided up to date sources of information. This thesis will conclude that a layered approach using three types of UAVs of differing sizes and capabilities would produce maximum effect across the spectra of aerial maritime surveillance at a similar cost to manned aircraft but with the unique advantages that UAVs bring.

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[18] Tony Davies, Group Captain, RNZAF Capability Branch, personal communication, 30 Jan 2009.

[19] *Complete Guide to Drones*, Armada International, supplement to issue 3/2008, p.2.

[20] Military Aviation News, *Worldwide UAV Market Continues to Grow*, 20 Feb 2009, http://www.defencetalk.com/news/publish/airforce/Worldwide_UAV_Market_Continues_to_Grow100017172.php, accessed 27 Feb 2009.

Chapter 1

NEW ZEALAND'S MARITIME ENVIRONMENT

New Zealand lies at the pole of the water hemisphere and is surrounded by more ocean than any other country on earth.[1] It may well be claimed that the country is the most maritime nation on earth. The island nation straddles the warm northern sub-tropical waters where they meet the much cooler sub-Antarctic water to the south. Sea life is abundant in these frontal zones. New Zealand also lies at the boundary of the Pacific-Australia tectonic plates; this is a region of high seismic and volcanic activity which with its fault lines, sea-mountains, giant underwater landslides and sediment structures, all contribute to shaping coastal features and influencing offshore mineral and hydrocarbon deposits.[2] The land mass consists of an archipelago of over 330 islands larger than 5 hectares, surrounded by the world's largest ocean. The country has jurisdiction over 4.4 million square kilometres of ocean and the coastline is over 19,000 kilometres long.[3]

Almost 85 per cent of New Zealand exports by value, and over 99 per cent by volume, are carried by sea. In the case of imports, around 75 per cent by value is carried by sea and the volume is also over 99 per cent;[4] around 3300 international shipping movements occur each year. New Zealand also recently gained rights to an area of 1.7 million square kilometres of continental shelf extending beyond the EEZ.[5] Oil and gas have been discovered in several parts of the EEZ, and are likely to be present in the off-shore basins. New Zealand also has responsibility for surveillance of the Ross Dependency in Antarctica which is 2.3 million square kilometres in area, as well as constitutional obligations for the protection of the Tokelau, Niue and Cook Island EEZs.[6] The vast

[1] Raewyn Peart, p. xiii.

[2] Ibid.

[3] Ibid, p.51.

[4] Statistics New Zealand, Shipping, http://www2.stats.govt.nz/domino/external/web/nzstories.nsf/0/aa5cd290e1cd9810cc256b1f00040811?OpenDocument, accessed 01 Oct 2008.

[5] MFAT, Treaties and International Law, New Zealand's Continental Shelf and Maritime Boundaries, http://www.mfat.govt.nz/Treaties-and-International-Law/04-Law-of-the-Sea-and-Fisheries/NZ-Continental-Shelf-and-Maritime-Boundaries.php, accessed 28 Sep 2008.

[6] CCS, Maritime Surveillance Vol 4, Part 4, November 2000.

maritime surveillance area in which New Zealand routinely operates in, and in which the state also assumes responsibility for search and rescue, covers some 30 million square kilometres.[7] This area represents around 6 per cent of the earth's overall surface, and stretches from half way to Australia to half way to Chile. Under the 1978 United Nations Convention on the Law of the Sea (UNCLOS), New Zealand's waters were extended considerably.[8] Under this convention countries have the right to exercise differing jurisdictional powers over various maritime areas. These include:

- *Territorial waters* which extend 12 nautical miles [9] out from the low-water mark – full sovereign rights exist here, the same as on the land;
- *Archipelagic waters* which uncover exposed reefs at low water and are the same as dry land;
- A *contiguous zone* which extends out an additional 12 nautical miles from territorial waters and limited sovereignty applies, e.g. the retention of powers of arrest;
- *EEZ* which extends out 200 nautical miles from the territorial seas and in which the sovereign nation has rights of exploration, exploitation, and obligations of conservation. Due to the location of the Kermadec Islands, the EEZ extends out beyond 500 miles (800 km) from the mainland;
- *Continental shelf*, which is that area of the sea-bed that extends beyond the EEZ, as agreed upon with the United Nations, that is considered part of New Zealand and in which full rights to exploration and exploitation of the seabed and subsoil exist.[10]

The New Zealand maritime area of interest is impressive by world standards and the potential value of the EEZ and continental shelf cannot be overstated. New

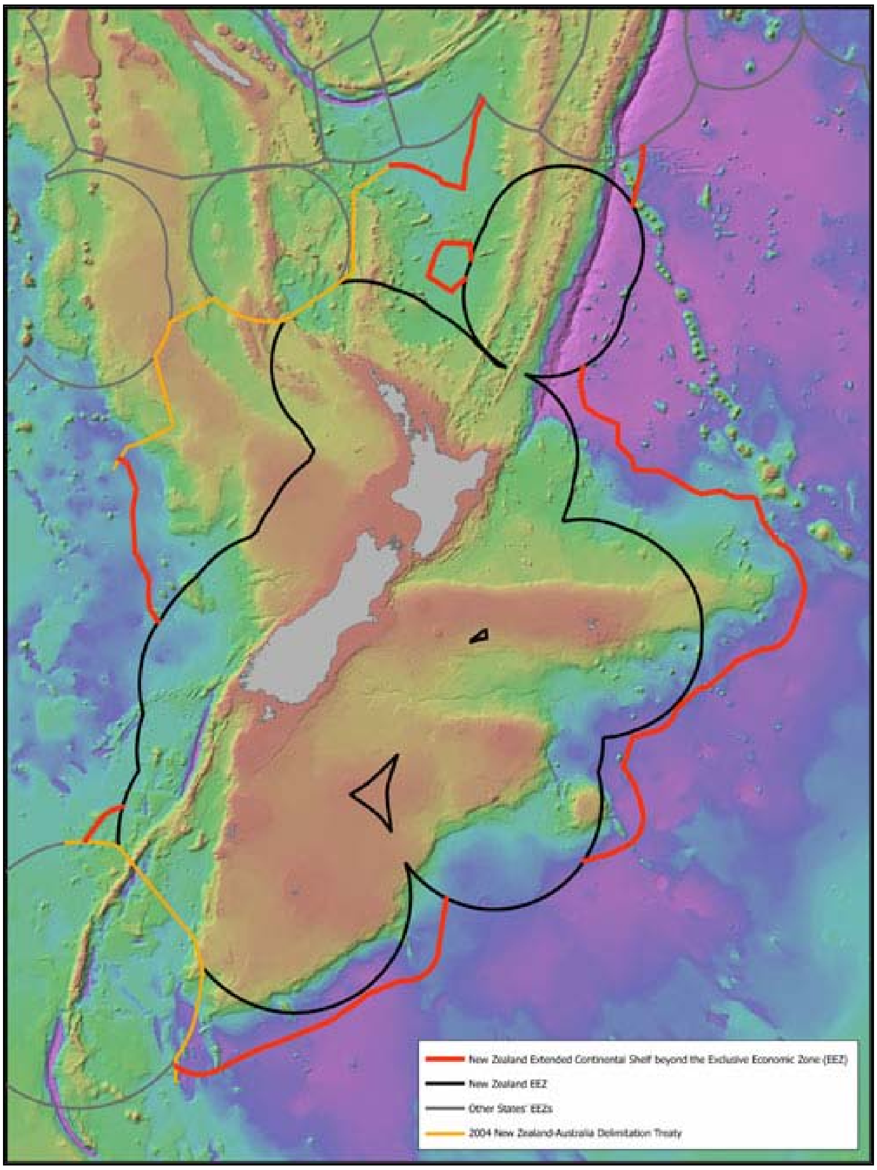
[7] MNZ, The New Zealand Search and Rescue Region, http://www.maritimenz.govt.nz/SAR/SARregion.asp, accessed 28 Sep 2008.

[8] J Floor Anthoni, *Why is New Zealand so Special*, viewed at http://www.seafriends.org.nz/oceano/special.htm, accessed 28 Sep 2008.

[9] All distances in UNCLOS that refer to a country's rights in respect to a body of water are referred to in nautical miles, http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm, accessed 22 Feb 2009. A nautical mile is a unit of distance equal to 1,852 metres (Section 2 of the TS, EEZ Act 1977). This value was adopted by the International Hydrographic Conference in 1929 and has subsequently been adopted by the International Bureau of Weights and Measures, http://www.linz.govt.nz/hydro/nautical-info/maritime-boundaries/definitions/index.aspx, accessed 22 Feb 2009. There is no standard abbreviation for a nautical mile though 'nm' is commonly used in aviation.

[10] Raewyn Peart, p.5.

Zealand must exercise authoritative control over its biggest natural asset, but before it can do this it needs to increase its knowledge of the maritime domain.



The black lines in this map shows New Zealand's Exclusive Economic Zone (EEZ), with the red indicating New Zealand's extended continental shelf beyond the EEZ. The grey lines indicate other states' EEZs, while the yellow lines mark the 2004 New Zealand-Australia maritime delimitation treaty.

Figure 1. New Zealand's Exclusive Economic Zone.[11]

The defence community, which shares responsibility for patrol of this area, tends to speak in terms of ISR, or Intelligence, Surveillance and Reconnaissance. Intelligence is the raw information or data that is collected and analysed and can be used to assist in planning and carrying out operations; reconnaissance is a

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[11] Retrieved from http://www.mfat.govt.nz/Features/0-continental-shelf-image.php, accessed 24 Sep 2008.

method used to collect the intelligence; and surveillance is reconnaissance of a specific target over a longer time. [12] Maritime Surveillance (MARSURV), then, is the systematic observation of areas of interest in the maritime domain. The desired outcome of surveillance is heightened awareness, and in the case of maritime surveillance, this is referred to as Maritime Domain Awareness (MDA). ISR used to be regarded as strictly a military capability, but that is no longer true as there are many civilian agencies around the world that have a maritime ISR function; for example, the Australian Border Protection Command, which operates under the Australian Customs Service, has guaranteed access to a dedicated fleet of aerial and surface platforms for the purposes of MARSURV activities. They are also able to draw upon the Australian Maritime Safety Authority's search and rescue aircraft (SaR), as well as limited access to Royal Australian Air Force (RAAF) AP-3C maritime patrol aircraft (MPA).[13] ISR is not

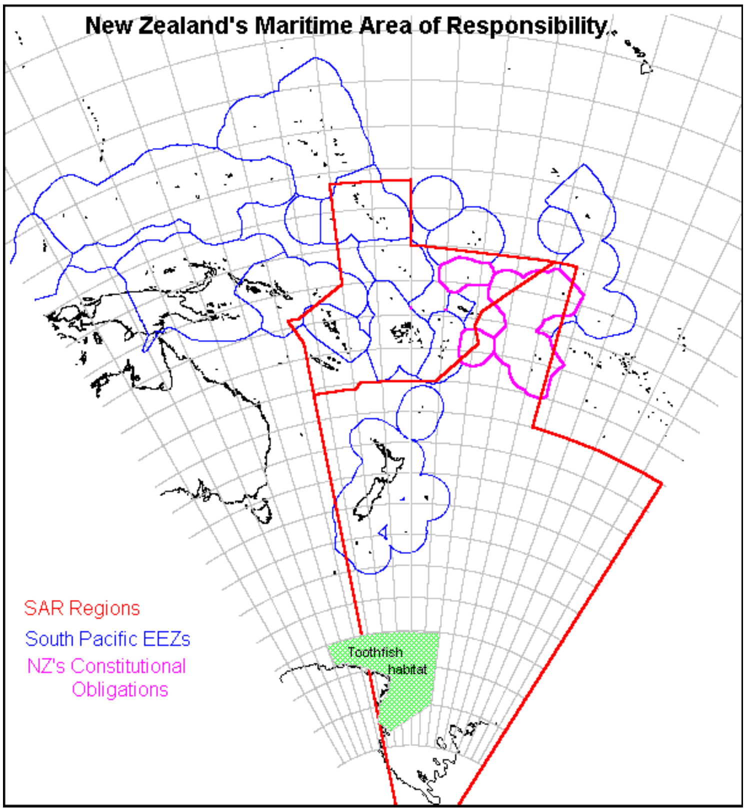

Figure 2. New Zealand's Maritime Area of Responsibility.

[12]DoD News Briefing Senior Defense Officials, Wednesday, October 31, 2001, *Background Briefing on Unmanned Aerial Vehicles*, http://www.fas.org/irp/program/collect/uav_103101.html, accessed 21 Nov 2007.

[13] Border Protection Command, Aircraft, http://www.customs.gov.au/SITE/page.cfm?u=5789, accessed 14 Jul 2008.

limited to expensive and sophisticated equipment and can be generated at many levels. At the lowest level it can consist of random eyewitness reports that might be phoned in, or at the next level, perhaps an MFish officer in a vehicle, armed with binoculars and a radio. At the strategic level it consists of a complex range of information from specialised platforms operating in the maritime, air or space environments.[14] All sources contribute to MDA.

The government has a fundamental need to assert and defend sovereignty, and this includes the waters and resources of the EEZ. MDA supports national assessments and decision-making on security issues, including military commitments and tasking, resource protection, border control, terrorist threats, and disaster relief.[15] Maritime patrol, both aerial and surface, is a major contributor to New Zealand's independent intelligence gathering process by both contributing and acting on intelligence. When available, assets can usually be deployed fairly quickly and they can provide information on specific targets to a degree of resolution and quality necessary for prosecution or diplomatic intervention.[16] Maritime patrol is basically concerned with the protection of sovereignty and as such is vital to the national interest.

The Political Backdrop

The previous Labour government came to power in November 1999 facing a number of defence issues. Prior to being elected, the Labour Party had been supportive of the *Defence Beyond 2000* (*DB2K*) report that had been published only two months prior by Parliament's Foreign Affairs, Defence and Trade Select Committee, and the party saw it as a solid basis for a defence policy if elected. The most pressing issues the new government faced in regard to maritime operations were pending decisions required on the purchase of a third frigate, and whether to go ahead with a proposed P-3 Orion anti-submarine warfare (ASW) systems upgrade (Project Sirius) that was projected to cost around NZ$600 million.[17] The government saw no need for a White Paper, instead choosing to be guided by and building on the *DB2K* report which had 'provided opportunity for wide public involvement and debate on defence issues' and

[14] House of Commons Defence Committee, *The contribution of Unmanned Aerial Vehicles to ISTAR capability*, Thirteenth Report of Session 2007-08, p.6.

[15] *MPR*, annex 7, p.6.

[16] Ibid, p.7.

[17] *Government Defence Statement 2001*, p.4 (all dollar figures quoted hereafter will be NZ unless otherwise stated).

‘gained considerable public and parliamentary support'.[18] The Government's *Defence Policy Framework* was released in June 2000, and one of the greatest needs was assessed as being: 'to maintain effective maritime surveillance capabilities of the Air Force and Navy within the New Zealand EEZ and the EEZs of Pacific Island States'.[19] The Framework also called for a review of options for surveillance of the maritime environment to be completed by November 2000, and somewhat ominously declared that the 'appropriateness of the proposal to replace the Orions' maritime surveillance and patrol capabilities', i.e. Project Sirius, was possibly to be considered before the review was complete.[20] Project Sirius was duly cancelled two months later due largely to the simple fact that no hostile submarines had ever been detected in New Zealand waters.[21] A new era of pragmatic defence policy based on empirical evidence had been launched in New Zealand.

The *Maritime Patrol Review* was released by the Department of the Prime Minister and Cabinet in February 2001. This document is central to this thesis and forms a basis for assessing maritime surveillance needs in New Zealand today. The *MPR* is the most thorough examination of New Zealand's maritime patrol requirements ever carried out, and is no less relevant for the passing of eight years since its publication. The objectives of the review are unambiguous and telling, and are worth stating in full. Specifically it:

1. examines New Zealand’s civilian requirements for maritime patrol, and makes recommendations on how they can best be met (Cabinet referred particularly to eight areas: fisheries, resource management, conservation, pollution, immigration, customs, maritime safety, and search and rescue);
2. examines, in the light of the Defence Policy Framework, whether a military maritime patrol capability should be maintained.[22]

The wording makes it explicit that Cabinet put support of non-military government organisation operations ahead of any military operations in the area of maritime patrol. The second issue also made it plain that the retention of the P-3 was open to question. With the then impending demise of the ACF, it seemed that

[18] *Defence Policy Framework* 2000, p.1.

[19] Ibid, p.8.

[20] Ibid.

[21] Helen Clark, *Misleading information on submarines*, http://www.beehive.govt.nz/release/misleading+information+submarines039, accessed 22 Dec 2008.

[22] *MPR,* p.1.

the entire future of the RNZAF as a military force was dependent on the outcome of this report. The producers of the *MPR* appear to have consulted thoroughly and widely and appear to have produced the fullest picture possible of New Zealand's needs for maritime surveillance. However, at times there appears to be only a marginal understanding in regard to the nature of air power.

Findings of the *Maritime Patrol Review*

The review was scathing of the state of Maritime Surveillance in New Zealand and especially so of aerial surveillance, remarking that operations in support of 'customs and fisheries are patchy, poorly co-ordinated, and occurring too infrequently', and that 'New Zealand … does not have the necessary air surveillance capabilities to meet … civilian needs'.[23] On the two specific review tasks stated previously it remarked in relation to aerial surveillance that: 'increasing needs could be met most cost-effectively using commercial aerial surveillance services at short/medium distances', while acknowledging that there was: 'an ongoing requirement for long-range maritime surveillance to meet civilian needs'.[24] On the second task it concluded that it was: 'hard to justify the retention of a comprehensive military maritime surveillance capability in New Zealand's sea areas'. However, the review panel then remarked that: 'If some of the Orions were to be retained they could perform the long distance civilian tasking with high quality commercial equipment matched to New Zealand's civilian needs'. It also noted there was no evidence that an ASW capability was required for national security.[25] These remarks set the tone for the remainder of the report, emphasising the need for a significant increase in patrol requirements in support of civilian agencies, while not finding any pressing military needs in the face of no military challenges to sovereignty.

The review concluded that a ten-fold increase in aerial patrol activity was required to meet the civilian surveillance and deterrence effort. The greatest need was identified as being in support of MFish and Customs where it was estimated that up to 3000 hours per year of aerial patrol were required.[26] The report states that each P-3 typically flew around 40 hours per year on civil patrol

[23] *MPR*, p.35.

[24] Ibid, p.1.

[25] Ibid.

[26] MPR, p.36.

tasks. It is not surprising then that there was awareness of a 'high level of dissatisfaction among civilian users over their inability to task the military assets for national civil purposes'.[27] A lack of national co-ordination and task prioritising was an obvious block to more efficient use of available assets, and the report called for the creation of a national Maritime Co-ordination Centre (MCC). The MCC was envisaged as being independent and providing centralised management of operational activities in respect of civil security of New Zealand's maritime areas. Of note is the emphasis given to the 'stand-alone' nature of such a unit. While the review acknowledged that there would be some benefits to being co-located with a Crown agency such as the NZDF, it quoted the Australian example, which 'firmly rejected the option because of the potential problems of capture'.[28] By using the word 'capture', it is explicit that the committee believed that if the proposed MCC was co-located with another crown agency, such as the NZDF, then that larger agency would be likely to exert hegemony, and thus effectively control, or at the very least exert a strong influence, on the MCC. This is an important point and will be expanded on in a later chapter.

The review also found that very little routine surface surveillance was undertaken and that the Royal New Zealand Navy (RNZN) had no vessels suitable for this kind of work. As in the case of aerial surveillance this was at odds with the objectives set out in the Defence Policy Framework (DPF), which states: 'The primary reason for maintaining a defence force is to secure New Zealand against external threat, to protect our sovereign interests, including in the Exclusive Economic Zone…'.[29] Similarly, the first item listed in the Government's Defence Policy Objectives is, 'to defend New Zealand and to protect its people, land, territorial waters, EEZ, natural resources and critical infrastructure'.[30] The DPF is quite clear in its intent; that the EEZ, natural resources and critical infrastructure are to be afforded priority in their protection. As the report established that New Zealand did not have the resources to do this, it suggested a force of three or four medium-sized vessels for off-shore patrol work, and a larger multi-role vessel for the limits of the EEZ and further afield. It was suggested that capital costs for such a patrol fleet would be in the region of

[27] *MPR*, p.9.

[28] Ibid, p.25.

[29] *DPF,* p3.

[30] Ibid, p.4.

$100-150 million.[31] This fleet was to be the core component of any future surveillance strategy, but as a stand-alone unit its utility was likely to be limited. The value of any surface surveillance fleet is inextricably linked to the enabling effect of the intelligence that it acts upon. While random patrolling has a place and does provide an unpredictable deterrent effect, sending boats to sea is too costly to base purely on the off-chance of actually catching someone engaged in illegal activity. The aim is to base tasking on intelligence that provides a target. And as previously mentioned, intelligence can take many forms, but in large ocean areas the most efficient way of identifying targets of interest is through aerial surveillance. In general, aircraft can sweep an area either visually or electronically much more effectively and a lot faster than a ship will ever be able to.[32] Effective assertion of sovereignty over large oceanic areas requires aircraft to identify targets of interest, and surface vessels to pursue and apprehend them.

The question of whether a long-range military maritime patrol capability should be retained seems to have engendered ambivalence. While the capabilities of the P-3 Orion were appreciated, it appears that it was obvious to the review panel that the Orions contributed little to the protection of New Zealand's EEZ. Their original role as an ASW aircraft was viewed as being virtually obsolete in the context of the prevailing strategic situation, and indeed the review stated that: 'in several decades of searching for them around New Zealand and in the South Pacific, neither the RNZAF or RNZN have had any confirmed sightings of hostile submarines'.[33] The review saw no need to retain an ASW capability, and that only a limited contingency capability against surface targets was required. To clarify any doubts over their future utility as military platforms it spelled out that: 'If some of the Orions were to be retained they could perform the long distance civilian tasking with high quality commercial equipment matched to New Zealand's civilian needs'.[34] Throughout the review it becomes clear that any case for the retention of the Orions in their military role was no more than secondary; and that if the Orions were to be retained, their primary role should be maritime surveillance in support of civilian organisations operating

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[31] *MPR*, p.39.

[32] M.A. Anderson and D.P. Galligan, *Exploring the Potential of UAV and Other Technologies to Support Naval Patrol Force Requirements in the Offshore Domain*, Defence Technology Agency, June 2007, p26, p36.

[33] *MPR,* p.23.

[34] Ibid, p.1.

around New Zealand and the South Pacific. To fulfil this role an upgrade of systems would be required. While no specialist investigation was carried out as to what this might entail, enquiries of a general nature came up with an overall picture of what might be desirable. The report remarked that high quality commercial off-the-shelf systems (COTS) were available that differed only in detail with specialised military systems, and at a reduced cost.[35] It was envisaged that the upgrade would include new synthetic aperture radar (SAR), an electro-optical (EO) system, and enhanced communications and navigational aids. While a detailed study of costs was not carried out, it was suggested that such an upgrade could be purchased and installed for a total of $10-12 million per aircraft.[36]

Despite uncertainty over the future of the Orions, the committee recognised that as capable as the Orion was, it was not an ideal surveillance platform for all circumstances. The areas to be patrolled ranged from coastline and territorial seas to the outer fringes of the EEZ, and beyond into the South Pacific and Southern Oceans. And while the P-3 is the aircraft of choice at the outer limits, it is a case of inefficient use of a resource in the short/medium range environment, where a small or medium-sized aircraft could operate for around 12-15 per cent of the cost.[37] Clearly, a layered approach is required and the committee accordingly recommended that provision be made for a short to medium range patrol aircraft (SMRPA) to be operated either by the RNZAF or by civilians contracted to the proposed MCC. In summary, the main findings of the *MPR* were that:

- a ten fold increase in aerial patrol hours was required to meet the minimum requirements of civilian organisations such as MFish, Customs, Maritime Safety Authority, Foreign Affairs, etc;

- the service provided by the RNZAF was insufficient and an independent body was required to co-ordinate efforts;

- the Navy required a new purpose-built patrol force for the EEZ;

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[35] *MPR*, p.26.

[36] Ibid.

[37] *MPR*, p.27.

- if the Air Force retained its Orions they should be upgraded to meet the needs of the civilian organisations that would henceforth provide most of their work; and

- a short to medium range patrol aircraft was required to complement the Orions.

While the cost of any new aircraft was not discussed, the report estimated that between $160 million to $222 million was required to build the naval patrol force and upgrade the Orions. Even with the benefit of hindsight these initial estimates seem very low, especially considering the cost of the original proposal just to upgrade the Orions' systems was in the region of $600 million.[38] It appears that initial costs were severely underestimated, which might have enabled the project to move to the next stage. The eventual cost of the above projects, which are ongoing, is likely to exceed the original estimate made in the *MPR* by a factor of five.[39]

The *Government Defence Statement* (*GDS*) of May 2001 was a follow up to the *Defence Policy Framework* and also acted upon the findings of the *MPR*, which had been released only three months previously; the government, appearing keen to maintain its momentum, was making decisions and taking action at a pace not usually seen in peacetime.[40] The Statement announced a number of decisions affecting maritime surveillance and ordered yet another review. The establishment of the Headquarters Joint Force New Zealand (HQJFNZ) at Trentham was announced, but potentially more significantly for New Zealand as a whole, the establishment of the new Maritime Co-ordination Centre was announced. The role of the MCC was to co-ordinate the maritime surveillance requirements of all interested government agencies and also to integrate the work of those agencies into a comprehensive national strategy for managing maritime risks. Unfortunately, and contrary to the advice of the *MPR*, the MCC was to be co-located within HQJFNZ at Trentham, thus lending itself to 'capture' by the NZDF, even though for administrative purposes it was a unit of

[38] *GDS*, p.4. The original upgrade included ASW systems which added considerable cost.

[39] The *MPR* estimated a total cost to upgrade the six Orions at $60-72 million (*MPR,* p.26). Currently a cost of NZ$373 million is projected and this does not take account of any costs associated with an up to two-year delay in its completion. A cost of $100-150 million was estimated for the naval patrol vessels (*MPR*, p.39); it was later budgeted at $500 million.

[40] This may have been driven by the high-profile NZDF deployment to East Timor alongside the ADF.

Customs.[41] The Navy's future was assured when it was announced that the two existing frigates would be retained and a study would be made into identifying a suitable multi-role vessel (MRV) to replace the soon to be retired frigate HMNZS *Canterbury*. This study would be part of a comprehensive review into the composition of the future maritime surface fleet, and in particular how it might meet the civilian requirements for coastal and mid-range offshore capabilities.[42]

The government decided to retain the Orions and provide a 'limited' upgrade using COTS where possible.[43] While the *MPR* emphasised the utility of the Orions to support civilian government agencies, it was also acknowledged that it was prudent to retain a military maritime surveillance capability, for among other things: 'the enforcement of sovereignty within the EEZ.'[44] Perhaps the saving grace was the fact that around $100 million had already been spent extending the airframe life of the Orions out to around 2025.[45] It is possible that had it not been for this previous investment and the potential of the Orions to contribute to the non-military goals of various civilian government agencies, they may well have followed the Air Combat Force and been disbanded.[46] Two of the reasons given for disbandment of the ACF were cost and the fact they had never been used operationally in their intended role. The Orions, similarly, had never engaged a submarine, as was pointed out by the *MPR*, and the maritime patrol force cost significantly more to own and operate at around $100 million a year,[47] compared to the ACF at around $85 million a year.[48] Apparently, having agreed to retain the Orions,[49] the need to supplement them was acknowledged and a study was ordered to determine the best options for short and medium range air patrol.[50] At this particular point in time (mid-2001) the government were clearly taking maritime surveillance seriously. The final piece of the puzzle would be provided by the study into the composition of the future maritime surface fleet.

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41 *MPR,* p.25.

42 *GDS*, p.3.

43 Ibid.

44 *GDS*, p.8.

45 Ibid.

46 Ibid, p.10.

47 *MPR*, p.9.

48 *GDS*, p.10.

49 Ibid, p.3.

50 Ibid, p.9.

The Maritime Forces Review

The *Maritime Forces Review: Key Findings* (*MFR*) released in January 2002 confirmed the dismal picture painted by the *MPR* in regard to the state of maritime surveillance in New Zealand. The review acknowledged the need for increased maritime surveillance, in conjunction with maritime air patrol assets, and that the Navy were not configured for this work. [51] The review remarked on the complementary air and sea requirements for effective maritime surveillance and policing. And while noting that aircraft are the most cost-effective method of providing surveillance over a large area, the review also affirmed that surface vessels are required for presence, pursuit, arrest and detention.[52] In other words, the surface patrol vessels are the maritime equivalent of 'boots on the ground'. The *MFR* surveyed the specific surface patrol requirements of the Ministry of Fisheries (MFish), the New Zealand Customs Service, the Maritime Safety Authority (MSA), the Police, the Ministry of Foreign Affairs and Trade (MFAT), the Department of Conservation (DoC), and the Ministry of Agriculture and Forestry (MAF).[53] The somewhat daunting conclusion was that 950 sea-days were required annually to perform inshore patrolling tasks (out to 24 nautical miles from shore),[54] and another 420 days were required for the offshore patrol tasks (out to the limits of the EEZ).[55] To meet these tasks, it was suggested that a force of five smaller inshore patrol vessels (IPV) and three larger offshore patrol vessels (OPV), plus the MRV, would be required. [56] The MRV would also be required to carry out the tactical sealift role throughout the South Pacific. The NZDF's draft *Long Term Development Plan* (*LTDP*) included provision of $500 million for capital acquisition to meet this requirement; a somewhat significant increase from the $100-150 million originally envisaged by the *MPR*.

In summary, what the *MFR* did, among other things, was to determine the nature and scope of surface maritime surveillance requirements. It determined the civilian requirements for coastal and mid-range offshore capabilities, which

[51] *MFR*, p.6.

[52] Ibid.

[53] The MSA are now known as Maritime New Zealand (MNZ).

[54] By UN convention the boundary of oceanic territory/EEZs is expressed in nautical miles.

[55] *MFR*, p.6.

[56] Ibid, p.7.

amounted to an annual 1371 sea-days of programmed and response activity.[57] It also reiterated New Zealand's responsibilities and obligations in respect to the Southern Ocean and Ross Dependency under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR aims to ensure that fisheries do not develop at a rate faster than data can be acquired to determine sustainable catch levels.[58] Further, the Review determined that a Naval Patrol Force (NPF) was necessary to conduct maritime surveillance, in conjunction with maritime patrol air assets, in the New Zealand EEZ and Southern Ocean, and also to assist South Pacific island states to patrol their EEZs. The review's terms of reference required examination of the surface fleet's capability to interact with maritime aircraft. However, apart from a brief mention of the planned upgrade of the Orions' systems, and the SMRPA study, there is nothing of substance that addresses this issue. Given the low levels of aerial surveillance (around 250-300 hours per year) and the acknowledged enabling role of aircraft, this is surprising. It would not have been unreasonable for the *MFR* to suggest the significant opportunities for improvement in this area. It did reiterate that surveillance tasks are primarily non-military in support of civilian agencies. These tasks were grouped as: inshore out to 24 nautical miles; offshore to the limits of the EEZ; and tasks in the South Pacific and Southern Ocean.[59] Having established fleet requirements, in mid-2004 a further study was undertaken in conjunction with the civilian agencies to decide the number of vessels and fleet mix necessary. On 29 July 2004 the Minister of Defence signed a contract with Australian firm Tenix Defence Pty Ltd to supply the RNZN with a Multi-Role Vessel, two Offshore Patrol Vessels and four Inshore Patrol Vessels, under Project Protector. Delivery was to be completed by October 2007.

The current state of Maritime Surveillance

While steps have been taken to fill the capability gaps highlighted in both the *MPR* and *MFR*, no more maritime surveillance is carried out now than in 2001.[60] The Protector fleet was originally planned to be commissioned by

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[57] *MFR*, p.20.

[58] NZMFAT, Convention on the Conservation of Antarctic Marine Living Resources, http://www.mfat.govt.nz/Foreign-Relations/1-Global-Issues/Antarctica/2-Antarctic-Treaty-System/conservation-of-resources.php , accessed 30 Sep 2008.

[59] *MFR*, p.4.

[60] At the time of writing it is not known exactly when the IPVs and OPVs will enter service, nor has there been any increase in RNZAF aerial surveillance hours as noted in subsequent annual reports, or appropriations documents (see p.22).

January 2008, though this has been delayed by contract and warranty issues with the shipbuilder, BAE Systems Australia (formerly Tenix). While the *Canterbury* MRV has been delivered there have been problems with the rigid hull inflatable boat (RHIB) design and launching mechanisms as well as issues raised over the ability of the ship to operate in rough seas. The latest forecast is that the *Canterbury* will not be released for unrestricted operations till April 2009.[61] The four IPVs and two OPVs similarly have issues with certification of the RHIBs and neither the Ministry of Defence nor BAE will state when the patrol craft will be available.[62] In June 2008 the manager of the now renamed National Maritime Co-ordination Centre (NMCC) commented that surface surveillance issues will be addressed by the time the NPF reaches full capability by the end of 2009, though this might now be in doubt. [63] The expectation is that each of the new NPF craft will eventually be tasked with 140 sea-days per annum.[64] This being the case, with the six patrol vessels and occasional operations from the MRV and a frigate, it is conceivable that around 900 sea-days will be available for support of government agencies in carrying out maritime surveillance.[65] While this falls short of the required 1371 sea-days as identified in the *MFR*, it is a huge step forward and it is likely that with some re-assessment and adjustment, most if not all of the high-priority tasks could be met. However, as previously discussed, to achieve maximum effectiveness requires significant enabling support from aerial maritime surveillance assets.

The *MPR* stated that the RNZAF fleet of six Orions typically flew around 40 hours per aircraft per annum in support of civilian agencies, but that to meet the minimum requirements they needed around 3000 hours in total.[66] Apart from the Orions, civilian agencies also occasionally hire commercial aircraft on an ad-hoc basis, usually for work in the littoral areas associated with specific operations, however the number of hours flown is few and effectively does little to mitigate the shortfall. A report based on information provided by the NMCC, and produced by the Defence Technology Agency (DTA) in 2003, determined that if

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[61] Attributed to Deputy Chief of Navy Commodore Bruce Pepperell reported in *Dominion Post* , 19 Sep 2008, p.A8.

[62] *Dominion Post*, 19 Sep 2008, p.A8.

[63] Mr Richard Davies, Manager NMCC, personal interview, 06 Jun 2008.

[64] Ibid.

[65] The MRV (HMNZS *Canterbury*), as part of the Project Protector fleet, and when available, was always meant to carry out EEZ patrols as part of Multi-Agency Operations/Tasks, though no specific allocation of time is given beyond a total of 120-140 sea days as stated in the *Performance Information for Appropriations: Vote Defence Force 2008-09* p.43.

[66] *MPR*, p.28, p.36.

the Orions were to provide all of the aerial maritime surveillance required by the various government departments, both coastal and offshore, excluding low and medium priority tasks, the total would amount to around 3700 hours annually.[67] The comment was also made that this is significantly greater than the '1000 hours' available for NMCC tasking from the current operating budget.[68] This figure of 1000 hours has not featured in any official documents and when the author of the DTA report was queried on this, he remarked that this figure: 'was originally "suggested" by ACAS DEV [Assistant Chief of Air Staff Development] at the time as the amount they [the RNZAF] could possibly run up to'.[69] However, as the correspondent also remarked: 'Subsequently, for reasons unknown, the hours were never increased from 400 to 1000 hours'.[70] This figure, upon which the report was largely based, appears to have had no basis in official policy, and appears not to be used again in any subsequent calculations or outputs. The figure may also be misleading because only in an extreme case, such as a national emergency, would 1000 hours be available for maritime surveillance in support of civilian agencies; the actual hours available for normal aerial MARSURV in support of civilian agencies, including incidental surveillance and training flights, remains nearer the 400 hour mark.[71]

Since 2003 the DTA has produced six reports that address issues relating to New Zealand's maritime surveillance requirements.[72] None of these reports suggest that the aerial surveillance requirements identified in the *MPR* have in any way diminished; and as noted in DTA's estimate of required hours, it appears that in some cases they have increased. The role of aerial assets in enabling

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67 D.P. Galligan, *Analysis of Air Force Rate of Effort Available for Maritime Surveillance*, Defence Technology Agency, May 2003, p.4.

68 Ibid.

69 Dr David Galligan, DTA, personal correspondence, 14Jul08.

70 Ibid.

71 *Performance Information for Appropriations: Vote Defence Force 2008-09,* p.17.

72 D.P. Galligan, *Analysis of Air Force Rate of Effort Available for Maritime Surveillance*, Defence Technology Agency, May 2003.

D.P. Galligan, *Considerations for the Efficient Use of NZDF and GONZ assets in the NZEEZ Maritime Patrol Role*, August 2006.

D.P. Galligan and M.A. Anderson, *Exploring the Potential of UAV and Other Technologies to Support Naval Patrol Force Requirements in the Inshore Domain*, Defence Technology Agency, August 2007.

D.P. Galligan, *Meeting the Whole of Government Short to Medium Range Maritime Aerial Surveillance Requirement*, Defence Technology Agency, December 2004.

M.A. Anderson and D.P. Galligan, *Exploring the Potential of UAV and Other Technologies to Support Naval Patrol Force Requirements in the Offshore Domain*, Defence Technology Agency, June 2007.

Mark Anderson and Phil Strong, *Considerations for the Maritime Employment of Unmanned Aerial Vehicles*, Defence Technology Agency, August 2006.

effective surface surveillance is emphasised throughout.[73] DTA modelling has shown the value of broad area surveillance in directing surface vessels, and further that surface vessels are shown to significantly under-perform in large offshore areas without external cueing.[74] There is no evidence to suggest that the NZDF has increased aerial surveillance of the EEZ since the release of the *MPR* in 2001. This appears to be at odds with the *Defence Policy Framework* and government intent following the *MPR*, and the findings of several reports that support the intent that the Orions should be primarily engaged in support of those civilian government agencies undertaking maritime security operations, such as Customs and MFish. The Vote Defence Force Estimates for 2008-09 allocates a nominal total of 2380 hours of flying time to the Orions for all tasks. It states that the Orions are to undertake Multi-Agency Operations/Tasks (MAOT) in support of other government departments 'when not committed to operations'.[75] As approximately only 400 hours are allocated to patrolling New Zealand's EEZ and the Southern Ocean, this is difficult to reconcile. Planned fleet hours are likely to increase slightly by 2012, to 2006-07 levels,[76] as the upgrade to the Orions is completed.[77] Any change in priorities by the new government will not be known until the release of the White Paper.

The forecast cost to own and operate the Maritime Patrol Force of six P-3 Orions for 2008-09 is $166.85 million.[78] At face value this does not appear to represent good value in the context of hours allocated to directly protecting New Zealand's EEZ.[79] The relatively small amount of time given in support of civilian agencies does appear at odds with numerous government documents which give high priority to the protection of New Zealand sovereignty, and specifically the EEZ. This anomaly is compounded by the fact that the *Defence Output Plan* (*DOP*), which specifies the number of hours allocated in support of civilian organisations, is derived following consultation between the Chief of Defence

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[73] MA Anderson and DP Galligan, June 2007, p.26, p.36. Galligan, August 2006, p.48, being typical.

[74] DP Galligan, August 2006 p.1.

[75] *Performance Information for Appropriations: Vote Defence Force 2008-09*, p.28. The 400 hours covers all civilian government departments.

[76] *NZDF Annual Report 2006-2007*, p100.

[77] *Performance Information for Appropriations: Vote Defence Force 2008-09*, p.28.

[78] Ibid, p.27.

[79] At the time of the *MPR*, Australian P-3s provided around 250 hours per year in support of civilian ocean surveillance, with contractors providing around 15,000 hours; Canadian CP-140s (CAF designation for P-3) provided up to 1000 hours, with contractors providing up to 5,000 hours, *MPR Annex IIIA*, p.21.

Force and the Minister of Defence. The *DOP* is essentially a level of service contract, with which the Minister is undoubtedly familiar. The reason for this having arisen is unknown. Approaches to the Ministry of Defence, and the Department of the Prime Minister and Cabinet, which produced the *MPR*, and the Chief of Air Force, did not elicit a response. A question on this issue was also put to the Director of the Air Power Development Centre, who suggested that perhaps the Orions are engaged on operations that are not discussed in the public domain.[80]

Another issue surrounding the Orions is that of crewing. Providing crews for the Orions has been a constant challenge. The intent is to have four operational crews, and one under training, at least on paper, at any one time.[81] It appears this has seldom been achieved in recent times and this is reflected in the Annual Reports, in which there are frequent remarks upon the insufficient levels of aircrew, ground crew and in some cases, equipment.[82] The most recent figures, given in the *NZDF Annual Report 2007-2008*, put figures at 77 per cent for aircrew.[83] Insufficient ground and aircrew numbers has had the effect of limiting operational tasking; for example, on five occasions search and rescue tasks were passed on to 40 Squadron.[84] While there is no short-term solution, the RNZAF is currently pursuing a vigorous recruitment campaign with some success, though it can take several years to train operationally proficient personnel in both air and ground crew disciplines.[85]

The National Maritime Co-ordination Centre

The NMCC shares a location with the NZDF at HQJFNZ in Trentham. The NMCC is a separate and independent unit with New Zealand Customs Service as a host agency. Customs were approached for an interview in regard to their maritime surveillance needs, but referred enquiries to the NMCC for all matters associated with this issue. This was not what might be expected as NMCC's

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[80] Timothy Walshe, Wing Commander, Director APDC, personal interview, RNZAF Base Ohakea, 16 Jun 2008.

[81] Ibid.

[82] *NZDF Annual Report 2006-2007*, pp.99-101.

[83] *NZDF Annual Report 2007-2008,* p.75.

[84] Ibid.

[85] An NZDF press release dated 29 Jan 2009 stated that RNZAF personnel numbers had increased 4.3% from the previous 12 months. Viewed at http://www.nzdf.mil.nz/news/media-releases/20090124-niasehdaakp.htm, accessed 24 Feb 2009.

function is to co-ordinate civilian maritime patrol tasking,[86] and has no operational role within Customs. NMCC is part of Customs mainly for legacy reasons, as the original 12-month pilot programme came under Customs oversight and it has remained there. The NMCC has three liaison officers: from Customs, Defence, and MFish, and it has three full-time staff.[87] The NMCC is 'independent', being funded cooperatively by eight agencies that use NMCC services and is overseen by the Officials Committee for Domestic and External Security Coordination (ODESC).[88] All maritime information (intelligence) is passed on to NMCC, though no analysis is carried out, for the purpose of dissemination to interested parties. NMCC is an initial response unit, and allocate ownership of an incident to the appropriate agency. For instance if there were an oil spill the Ministry of the Environment would be informed and expected to take the lead in organising a response. If aerial surveillance were then required to assess the incident, NMCC might pass on the request for aerial support to the defence liaison. NMCC assess needs and coordinate, but they have no authority to task.

Richard Davies, the NMCC Manager, suggested that the country is now better informed about the surrounding ocean areas than before NMCC was set up.[89] There is no compelling reason to accept this though, as research indicates that no more surveillance is carried out presently than there was before NMCC was established. The quantity of information is the same.[90] Planning, and thus development of strategy, is based on a three to five year cycle, and no consideration is given beyond this time span. Currently there is nothing forecast that may require an increase in surveillance.[91] Davies also suggested that the introduction of the new NPF and the upgrade to the Orions could cope with any foreseeable growth in surveillance tasking (though this is obviously subject to the previously stated limitations of the planning cycle). In support of this the suggestion was made that the Orions will produce a lot more information of a higher quality than was previously the case (implying the upgrade will have the

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[86] NMCC Working Group, *National Maritime Coordination Centre: Governance Framework*, NMCC: Wellington, 2006, p.4.

[87] Ibid.

[88] *The NMCC and Customs*, viewed at http://www.customs.govt.nz/library/Accountability+Documents/Statement+of+Intent+2006-2007/Part+A+-+Statement+of+Intent/Customs+Capability/Customs+Capability.htm, accessed 24 Feb 2009.

[89] Richard Davies.

[90] This is expanded upon later. The difference now is that the various agencies' knowledge now informs a collective body, as much as they choose to submit, rather than remaining in the fragmented and discrete form that it previously existed in.

[91] Richard Davies.

effect of a force multiplier in the context of one hour of surveillance with the upgraded systems might be the equivalent of two or three hours with the old systems). The NMCC state they are capable of handling a lot more information than they currently process.[92]

NMCC believe that gaps in surface surveillance will be addressed by the new patrol vessels, which are expected to be in service by the end of 2009, and that the Orion upgrade will address aerial surveillance issues by providing a better product despite there being no more platforms or additional hours. A patrol provides a ‘snapshot’ of activity for the duration of the patrol, and the enhanced systems will provide a better snapshot. This, however, does not mitigate the fact that on average there are two weeks between snapshots. NMCC did acknowledge that currently there is no clear picture of illegal activity within the EEZ and consequently it is not known what the level of risk is.[93] The reason for this appears straightforward: the country does not have the assets to find out; or as the military would put it, ‘we don't know what we don't know’. This appears to contradict any inference that current or projected surveillance levels are adequate. For instance, it was remarked in the *MPR* that nearly all of Customs surveillance needs could be met by air, and this was acknowledged by NMCC as not having changed.[94] However, the view of NMCC appears to be that there are no major issues with maritime surveillance, in contradiction of the *MPR*, and that what is currently available or planned in the near-term is adequate for future requirements (presumably, again, within the limits of the planning cycle).

Various representatives have approached the NMCC trying to 'sell' surveillance platforms, such as satellite time and UAVs, but in New Zealand's case NMCC believe these are a solution looking for a problem,[95] the implication being that there is no 'problem' in the area of maritime surveillance. While the NMCC is now in a position to provide improved coordination of maritime surveillance, it is constrained by limited assets and a limited role. Because of this it seems that the NMCC is forced into a disadvantaged relationship management role as they do not have primary and guaranteed control over any maritime

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[92] Richard Davies.

[93] Ibid.

[94] Ibid.

[95] Ibid.

surveillance assets as envisioned in the *MPR*. [96] For instance, the RNZAF may allocate extra time on occasion, but it is usually at a fixed time, and it is a case of 'take it or leave it'. The NMCC is still developing and increased investment is planned for the future, though how this will manifest itself is unclear. At this point in time the NMCC has probably reached around 50 per cent of the vision as stated in the *MPR*. [97]

To further explore NMCC's view that planned aerial maritime surveillance is adequate, it needs to be understood how information is used. In MFish's case the Manager Compliance Advice, Eidre Sharp, observed that:

> …our information needs are aimed at identifying normal behaviour and trends/triggers that could indicate change in behaviour (from compliant to non-compliant or undesirable behaviour). There are a number of ways we get this information and use it to influence behaviour. This information is important for our risk assessments to focus on monitoring efforts and educational programmes to promote compliance or deter offending. In addition to that there is the enforcement angle where our information indicates or shows offending … Patrolling supports us in providing information, identifying offending, providing supporting evidence of indicative offending, and promoting compliance (where fishers know, or have reason to know) that we are out and about.[98]

So there are a number of ways in which the information is used, perhaps the most important of which are gathering trend information and deterrence. The first requires frequent and regular information gathering in order to establish norms, and the second requires regular and sustained presence.

Given that only around 400 hours in total is allocated to the Orion fleet in support of Multi-Agency Operations and Tasks (MAOT), and that MFish specific allocation is perhaps only half this figure,[99] it would appear that suggesting aerial

[96] *MPR,* p.33.

[97] Richard Davies.

[98] Eidre Sharp, Manager Compliance Advice, MFish, personal correspondence.

[99] Incidental surveillance is however carried out on other missions whenever the opportunity arises.

maritime surveillance is adequate does not bear scrutiny.[100] This was reinforced when Sharp further remarked that:

> As a coordinating agency they [NMCC] are not aware of our operational needs and deficiencies as they relate to patrolling. The reality is that the gaps identified in the Maritime Patrol Review are gaps and they have not all been addressed … for example Customs has quite clearly identified they still have an inshore surface gap and all agencies, including MFish, have identified deficient capacity in aerial availability. The reality is that since the MPR and our own work to quantify aerial deficiency in asset availability, the needs of agencies have grown so the gap would now undoubtedly be larger particularly if we include over land needs rather than just maritime.[101]

In summary, no more maritime surveillance is carried out now than in 2001. The requirements of various civilian government agencies for maritime surveillance have not decreased, nor have they been addressed. The creation of the NMCC was a positive move though it could do more given the resources. Significant gaps still exist, though with the introduction of the new NPF these will be mitigated to a greater or lesser degree dependent on the level of support given by aerial surveillance. However, no evidence is available to indicate any increase in NZDF aerial maritime surveillance support to civilian government agencies in the foreseeable future.[102] While a study was ordered into a short/medium range patrol aircraft, and a report was produced by DTA in December 2004,[103] the whole issue was omitted from the 2006 update to the *LTDP* and has not officially featured since.[104] It is therefore concluded that in the eight years following the findings of the *MPR*, New Zealand is still not able to adequately monitor and control its EEZ, and that this is likely to continue in the foreseeable future, contrary to the direction of the Defence Policy Framework. This statement is made in the context of today's strategic and economic

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100 MAOT applies to all other government departments outside of the NZDF, MoD, and MFAT.

101 Eidre Sharp.

102 For instance, the RNZAF Annual Plan makes no specific mention of any increase.

103 D.P. Galligan, *Meeting the Whole of Government Short to Medium Range Maritime Aerial Surveillance Requirement*, Defence Technology Agency, December 2004.

104 *Defence Long-Term Development Plan: 2006 Update*, MoD, October 2006.

environment. The next chapter will take a more in-depth look at what that environment is, and what developments may lay ahead in the future.

Chapter 2

THE VALUE OF NEW ZEALAND'S MARITIME DOMAIN

New Zealand's EEZ and continental shelf will only grow in their importance to the New Zealand economy. Fishing and oil and gas extraction are already major contributors. And while fishing is now subject to necessary controls to assist sustainability, it will continue to make a major contribution both as a source of export dollars, and as a significant employer. Oil and gas production in New Zealand have always been modest and in 2007 oil production averaged around 40,000 barrels per day,[1] with ultimate proven reserves of around 500 million barrels. Gas production in 2007 was around 150 billion cubic feet with ultimate reserves of around 7 trillion cubic feet.[2] And while both of these commodities are of great value to New Zealand even at their present levels, some industry experts are predicting much greater things for the New Zealand energy sector.

Oil and Gas production in New Zealand

A story in the *Dominion Post* on 10 March 2008 observed that: 'New Zealand may be the southern hemisphere's answer to North Sea oil, according to a leading geophysicist, with the potential for finding billions more barrels of oil off the coast'.[3] This made the prospects for New Zealand oil exploration seem positive. The event being reported was the New Zealand Petroleum Conference, and while there is possibly an element of an industry talking itself up in the interests of investment, the evidence appears encouraging. The current daily average production from the offshore Taranaki Tui oilfield alone exceeds last year's average from all sources, and in June 2008 estimated reserves were lifted to over 50 million barrels.[4] But this apparently is merely the tip of the iceberg according to reports. The volatile price of oil is expected to have an overall

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[1] A barrel has a capacity of 159 litres.

[2] Ministry of Development (MED), Facts and Figures http://www.crownminerals.govt.nz/cms/petroleum/facts-and-figures, accessed 04 Oct 2008.

[3] James Weir, 'The North Sea of the south', *Dominion Post* ,10 Mar 2008 p.C1.

[4] 'Tui oil field reserves lifted - 50.1 million barrels down there', *New Zealand Herald,* 20 June 2008, viewed at http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=10517398, accessed 27 Oct 2008.

positive effect on oil exploration, as once economically marginal deposits of oil, and gas, become potentially profitable.

Early seismic work carried out off East Cape, Taranaki, Otago and Southland has been promising. According to Institute of Geological and Nuclear Sciences exploration geophysicist Chris Uruski, the Raukumara basin (East Cape) alone has a potential capacity of up to 50 billion barrels.[5] Other reports put the potential of Taranaki Deepwater at up to twenty billion barrels [6] and the offshore Canterbury Basin at 'many 100's of millions of barrels of oil'. [7] The ultimate potential of New Zealand's deep water basins is unknown but is 'likely to be tens of billions of barrels'.[8] The Great Southern Basin off the Southland coast perhaps has the greatest potential and is set to have $1.2 billion spent on exploration over the next five years.[9] Of course, these impressive figures contain an element of speculation and presumption, and there is considerable risk associated with forecasting oil deposits. Nevertheless, if 'only' a one billion barrel field was realised, and based on US$100 barrel in the future, the government would have a significant windfall. The government takes a five per cent share of any oil revenues or 20 per cent of profits as a royalty, whichever is greater, as well as corporate tax of 30 per cent.[10] This means the potential oilfield could yield a combined royalty and tax revenue of up to US$40 billion over its lifetime, which could take as long or short a time as the oil companies decide. It is reported that if everything went to plan in this particular area, oil could be flowing by 2013.[11] If only a quarter of the industry's forecasts prove correct, New Zealand might be producing up to 0.5 million barrels per day within the next 10

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[5] Chris Uruski, *Petroleum Potential of an enigma: the Raukumara Sub-basin, East Coast, North Island*, paper presented to the New Zealand Petroleum Conference 2008, p.10, viewed at http://www.crownminerals.govt.nz/cms/petroleum/ conferences /conference-proceedings-2008-results, accessed 26 Feb 2009.

[6] CI Uruski and P Baillie, *Petroleum systems of the deepwater Taranaki Basin,New Zealand,* paper presented to the New Zealand Petroleum Conference 2002, p.5, viewed at http://www.crownminerals.govt.nz/cms/petroleum/conferences/conference-proceedings-2002-1, accessed 26 Feb 2009.

[7] WG Mogg, Aurisch K and O'Leary R and Pass GP*, Offshore Canterbury Basin –beyond the shelf edge*, paper presented to the New Zealand Petroleum Conference 2008, p.7, viewed at http://www.crownminerals.govt.nz/cms/petroleum/ conferences /conference-proceedings-2008-results, accessed 26 Feb 2009.

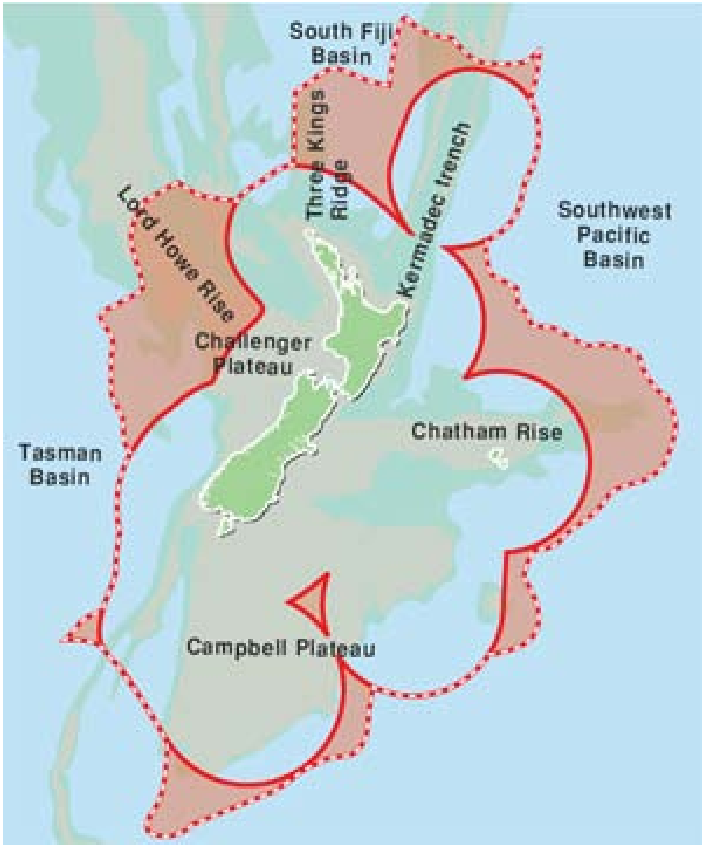
[8] Chris Uruski, *New Zealand Exploration – moving into frontier areas and what lies ahead for explorers*, presentation to the New Zealand Petroleum Conference 2008, viewed at http://www.crownminerals.govt.nz/cms/petroleum/ conferences /conference-proceedings-2008-results, accessed 26 Feb 2009.

[9] H Duynhoven, *Great South Basin oil and gas quest set to begin*, Beehive press release, 11 July 2007, viewed at http://beehive.govt.nz/release/great+south+basin+oil+and+gas+quest+set+begin+0, accessed 28 Aug 2008.

[10] James Weir, 'Search for the big one steps up', *Dominion Post*, 26 Aug 2008, p.C3.

[11] Ibid.

years, and perhaps up to 2 million barrels per day within 20 years. This is similar volume to what Nigeria and Norway have produced in recent years.[12]



The Dominion Post

Shaded red areas showing where New Zealand has control of 1.7m sq km of the sea floor – areas of continental shelf that extend beyond the country's 200 nautical mile exclusive economic zone.

Figure 3. New Zealand's Continental Shelf

The air of optimism in the oil sector is only equalled by that of the gas industry, which is at its most buoyant in years. Gas reserves have grown significantly in the last five years and more may be discovered. From a low in 2003 when it was estimated that only around six years worth of gas remained, that figure has now risen to 14-15 years and is steadily growing as estimates for current fields are revised.[13] There are also significant deposits of gas hydrates off the Fiordland coast and the east coast of the North Island. Gas hydrates are icy deposits containing mostly methane mixed with mineral deposits, lying just below the seabed. They are viewed as the probable next source of natural gas, and while the extraction process is still under development by government

[12] The CIA World Factbook, Nigeria, https://www.cia.gov/library/publications/the-world-factbook/print/ni.html, and Norway, https://www.cia.gov/library/publications/the-world-factbook/print/no.html, accessed 24 Dec 2008.

[13] James Weir, 'Industry buoyant as gas reserves grow', *Dominion Post*, 11 Mar 2008, p.C1.

scientists, it is possible that commercial extraction may be viable in 10-15 years time. It is estimated that the deposits off the east coast might contain 8.5 to 21 trillion cubic feet of potentially recoverable natural gas.[14] The energy sector is alive and well and exploration in New Zealand's EEZ is set to double in the next few years.[15] The recent granting by the United Nations of an area of 1.7 million km^2 of continental shelf to New Zealand comes with exclusive rights to the seabed resources.

There could be large oil deposits on the Lord Howe and Chatham rises, and gold and other valuable minerals on the Three Kings Ridge.[16] While it may be many years before any exploitation takes place it is all boding well for New Zealand's future prosperity. The levels of infrastructure required to support projected energy and mineral sector growth are huge and are likely to run to billions of dollars. Investment on such a scale would represent a strategic national asset and it would require protection from interference or interruption brought about by any number of possible events. The North West Shelf (NWS) of Australia is an area of similar importance and potential and is the subject of significant spending by the Australian government to assure its security. Additional Armidale patrol boats have been purchased,[17] a counter-terrorist unit will be based on the east coast and the UAVs of Project AIR 700 Phase 1 will be heavily utilised in this area.[18] The NWS was the area chosen to demonstrate the maritime surveillance potential of UAS, and in particular to see how such UAS could operate with patrol boats as a contribution to the protection of the NWS region and other maritime environments.[19] The trial, which was hosted by the Defence Science and Technology Organisation (DSTO) was expected to provide useful data to assist the Australian government in developing its requirements to acquire a long-endurance, multi-mission unmanned aerial system under Project AIR 7000 Phase 1, as well as assisting the Joint Offshore Protection Command,

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14 MED, *Gas hydrates off East Coast could be future gas resource*, viewed at http://www.crownminerals.govt.nz/cms/news/2008/gas-hydrates-off-east-coast-could-be-future-gas-resource, accessed 05 Oct 2008.

15 *Crown Mineral Annual Report 2006-2007*, p.7.

16 Attributed to GNS scientist Ray Wood as reported in the *Dominion Post* 23 Sep 2008, p.A4.

17 *Securing Australia's north west shelf*, http://www.uavworld.com/_disc4/00000103.htm, accessed 15 Jan 2009.

18 *Securing Australia's North West Shelf, Government Policy Statement*, available at http://www.dsto.defence.gov.au/research/4601/, accessed 15 Jan 2009.

19 Duncan Craig, *North West Shelf UAS Trial*, executive summary, DSTO, February 2007.

Immigration, Fisheries and Quarantine services to assess the value of using UAVs for coastal surveillance and border protection.[20]

An Australian government policy statement on the NWS makes it plain that terrorist attacks pose a major threat to the region and steps are being taken to counter the threat. According to the statement; providing dedicated military assets to protect the NWS will:

- enhance Australia's capacity to successfully engage potential threats to the NWS, specifically terrorist attacks;
- provide a deterrent to those who may be motivated to attack the NWS, specifically terrorists;
- demonstrate to major customers of the NWS – including major trading partners such as China and Japan – that the Australian Government is willing to dedicate significant resources to secure the supply of natural resources from the NWS;
- enhance the attraction of the NWS reserves relative to competing sites, thereby enhancing the prospect of further commercial development of the NWS; and
- strengthen the security of Australia's borders and the defence of Australia's national interests.[21]

Relative isolation does not offer sufficient protection and all the above points would be similarly applicable to any future offshore New Zealand energy infrastructure. If production in New Zealand reaches the scales being discussed, then it could become a target for those who see energy as a lever and a point of vulnerability to the developed and developing world. Competition for energy resources will only increase. Japan entered the Second World War to secure the resources needed for continued growth; there is no reason to suppose something similar will not happen again in the foreseeable future. The future security of New Zealand's energy sector is something planners need to be considering now.

[20] *Aims of the North West Shelf UAS Trial*, viewed at http://www.dsto.defence.gov.au/research/4601/page/4602/, accessed 26 Feb 2009.

[21] *Securing Australia's North West Shelf, Government Policy Statement*, p.3, http://www.dsto.defence.gov.au/research/4601/, accessed 15 Jan 2009.

New Zealand's Fisheries

It is estimated there are between 55,000 and 75,000 species of marine life within New Zealand's EEZ. Around 16,000 species have been described so far and this continues at the rate of an additional 100 species a year.[22] Only 130 species are fished commercially and the total quota value is $3.8 billion, of which around $1.5 billion is exported. The fishery productivity is classed as medium. As a sustainability measure, 15 per cent of territorial waters and 32 per cent of the EEZ are closed to bottom trawling. The latest figures available states there are 1644 persons with a quota holding and there are 1277 commercial fishing vessels operating.[23] The industry directly employs 7155 people (and probably contributes indirectly to a similar number through retail outlets, fertiliser processing, boat builders and maintenance, MFish etc). In New Zealand, fishing is a $4.5 billion industry. New Zealand's fisheries are under constant threat from illegal fishing, and much of MFish's modest $96.5 million budget and the 443 employees' time is spent trying to protect this valuable resource.[24]

As the largest consumer of available aerial surveillance, and potentially the biggest beneficiary of any increase in aerial surveillance, it was considered worthwhile researching the fisheries situation in a little more depth. Mr Gary Orr, the Operations Manager of MFish, was contacted and was the subject of a personal interview.[25] New Zealand does not act purely out of self-interest in regard to protecting its fisheries. As a signatory of several agreements it has certain international obligations and responsibilities with respect to management of stocks generally and also controlling and monitoring access to specific species, such as bluefin tuna and toothfish. MFish is pro-active in controlling vessels and individuals and legislation is extra-territorial in that jurisdiction is over New Zealanders wherever they are. Two New Zealanders were prosecuted early in 2008 while in charge of a Cook Islands flagged vessel fishing illegally in the Australian EEZ.[26] Flags of convenience are a vexatious issue to fishing authorities. The flagged state usually exerts little control with minimal reporting

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[22] Raewyn Peart, p.54.

[23] MFish, *New Zealand Fisheries at a Glance*, http://www.fish.govt.nz/en-nz/Fisheries+at+a+glance/default.htm, accessed 05 Oct 2008.

[24] Ibid.

[25] Gary Orr, Operations Manger, Mfish, personal interview, RNZAF Base Ohakea, 28 May 2008.

[26] Gary Orr.

and monitoring. There appears to be plenty prepared to take the risk of fishing illegally, so the rewards are obviously worth it, especially if they believe the chances of discovery are low. The illegal fishermen appear to be well informed. Northern Patrols (NORPAT) are pre-scheduled and patrols are carried out incidental to the transit.[27] The illegal fishers seem aware that a 5 Squadron NORPAT leaves on Monday flying by the Kermadecs and then returns on Friday. The illegal, unregulated and unreported (IUU) fishing vessels[28] know to keep away from the EEZ in the northern areas on Monday morning and Friday afternoon, though apparently the routine is now varied.[29]

MFish table a three-monthly surveillance request at a monthly NMCC meeting and it will then be matched against available assets. MFish take an effects-based approach to their surveillance. The amount of time given over to fisheries surveillance by the Orions can be supplemented by way of part-tasking; such as flying a dual training/surveillance mission. There is a hope that the Orions' new equipment will lead to night missions (fishing is, of course, a 24-hour operation). Orions typically fly around 24 fisheries patrols a year, which are usually intelligence-driven rather than random patrols. And whereas MFish would be happy to have more hours, the organisation is limited by its own resources to support it, as well as aircraft availability (an example of how any increase in surveillance hours would impact further down the line). MFish are aware[30] of the Australian Border Protection Command where civilian operated aircraft fly around 5000 hours per annum of maritime aerial surveillance, and can call on the RAAF as required.[31] There is also a contracted Southern Area EEZ Search and Rescue (SaR) team that frequently flies maritime surveillance operations as part of their continuation training.[32] The view was expressed by Orr that such an organisation in New Zealand would merely result in duplication of an NZDF capability, and is unlikely to materialise. However, this is debatable if, for instance, NMCC had its own resources and it provided a service that cannot

27 Northern Patrol – a routine RNZAF patrol in support of South Pacific Island nations.

28 Referred to as IUUs by Mfish; Illegal, unregulated, and unreported fishing boats.

29 Gary Orr.

30 Ibid.

31 Border Protection Command, Aircraft, http://www.bpc.gov.au/site/page.cfm?u=5789, accessed 17 Aug 2008.

32 Gary Orr.

currently be provided by anyone else, such as guaranteed and exclusive access to aerial surveillance platforms.[33]

There is evidence to suggest that there is regular illegal activity in New Zealand's fisheries, but there are not the resources to prove or disprove it one way or the other.[34] MFish take a pragmatic approach to maritime surveillance and do not request resources beyond what they can realistically expect. MFish have adjusted their operations to fit in with what is available. The problem with only asking for what is available is that deficiencies never get highlighted, as the requests are usually met. This might explain why NMCC believe there are no deficiencies in maritime surveillance in New Zealand.[35] However, MFish reiterated that nothing has really changed since the *MPR*, and that current and projected assets will still not meet their needs for aerial maritime surveillance.[36] RNZAF tasking is still around 200 hours for fisheries surveillance, though the Air Component Commander [37] is looking at this and hopes to make more hours available.[38] While the NZDF-provided surveillance is not a cost to the civilian organisations that use it, it being part of the NZDF output plan, there may soon be a new type of cost to be borne. It is estimated that the Orions, even with the modest amount of time they contribute on MFish's behalf, generate most of the carbon emissions MFish produce.[39] While the current bureaucratic process does not attribute this directly to MFish, that may change. It is now accepted practice that everything in government service is attributed with a carbon footprint, with the ultimate aim of a carbon neutral public service.[40] While the necessity of aerial maritime surveillance is not negotiable, steps can nevertheless be taken to reduce the footprint. The Orions are powered by 1950's technology engines that are likely to carry a significant carbon footprint.[41] And while the RNZAF's

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33 Current support for government organisations is pre-planned several months ahead and it is unlikely an urgent request for RNZAF aerial surveillance could be met in a timely manner, dependent on serviceability and other tasking.

34 Gary Orr.

35 Richard Davies.

36 Gary Orr.

37 Air Component Commander, JFHQ Trentham.

38 Gary Orr.

39 Ibid.

40 Ministry for the Environment, POL (07) 131: Towards a Sustainable New Zealand: Carbon Neutral Public Service http://www.mfe.govt.nz/issues/sustainability/cabinet-papers/pol-07-131.html, accessed 25 Aug 2008.

41 No carbon emissions appear to be available for specific aircraft, though one guide uses a figure of 0.6 lb (0.272 kg) of CO^2 produced per passenger mile on an 'average' commercial aircraft, though figures vary considerably from site to site. One estimate for a flight from Auckland to Honolulu (7071km) produces 513kg of carbon emissions per economy class passenger, http://www2.icao.int/public/cfmapps/carbonoffset/carbon_calculator.cfm, accessed 26 Feb 2009. This would

Capability Branch will be exploring the use of bio-fuels in the future, there are platforms available now that can carry out many of the Orions tasks while only producing a small fraction of its carbon emissions.

While the introduction of the 'Protector' fleet will enhance surveillance, MFish acknowledge that surface surveillance is less effective than air as it cannot cover large areas quickly.[42] That said, routine patrols act as a deterrent, and if no patrols take place, it enhances infringement opportunities. However, it is believed that more aerial maritime surveillance is required, to give informed tasking to any surface patrols, and that ideally 'Protector' would be used more as a response asset.[43] There are around 1500 commercial fishing vessels registered in New Zealand and only a small number are electronically monitored through the Automatic Location Communicator system. Only those vessels over 26m length or fishing specific species are monitored. All the rest are out there somewhere and MFish have to rely on manual catch returns to see where they have been.[44] To adequately monitor smaller vessels would require significant amounts of additional aerial surveillance. MFish have identified year-round fishing patterns throughout the EEZ, and they look for activity outside these patterns to inform and task. Even if they went out and found nothing untoward, then at least they know that. But allocated time is too limited to act speculatively, though just being out there does achieve a deterrent effect.[45]

MFish is reliant on aerial surveillance for gaining the big picture of what is happening in the EEZ. Satellite imagery is used to gauge water temperature and chlorophyll levels, which itself is useful as an indicator of whether conditions are suited to fishing, but the images are not suitable as an intelligence tool. Fishing vessels are aware of what capabilities New Zealand has, and they act accordingly. An Orion can typically loiter for around six hours in some of the more distant offshore fisheries, and trawlers only bring in their nets twice a day.

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translate to roughly 136 tonnes for a 266 passenger Boeing 767 burning around 40 tonnes of fuel. Various sites give different formulae for calculating the carbon emission from burning one kg of fuel; though depending on the type of fuel it appears to lie somewhere between 2.5-3.1kg (the means of burning the fuel making no difference); the additional mass is attributed to the amount of air 'consumed' during the burning process. Using this figure a P-3 might produce around 75 tonnes of carbon emissions on a 12-hour patrol. An MQ-9 Reaper which would cover a similar distance would produce around 5.4 tonnes of carbon emissions over approximately 24-hours.

[42] Gary Orr.

[43] D.P. Galligan and M.A. Anderson, August 2007.

[44] Gary Orr.

[45] Ibid..

There is an approximate half-hour time-frame in which to get evidence.[46] It is not unknown for vessels to delay hauling in their nets until an aircraft moves on. As capable as the Orion is, it was never designed with stealth in mind, and it is not capable of acting covertly, as a small UAV can.[47] Some UAVs are also capable of loitering up to 24 hours or beyond, which would provide a significant advantage. For MFish, the 'holy grail' of surveillance would be near real-time video of evidential quality. It is not clear that even if everything in the *LTDP* comes to pass, that the Orions will be able to provide this. Regardless, this capability is several years away from being routine. Near real-time video would of course be an integral part for any New Zealand UAS. A surveillance asset covertly tracking vessels engaged in illegal activity, for 24 hours or beyond, while streaming video to analysts at MFish, or Customs officers aboard a patrol vessel, while also being monitored by NMCC. When officials decide that they have the evidence needed, NMCC could task a patrol vessel to intercept the IUU and take appropriate action, while the UAV continues to monitor. That brief vignette requires a level of integration currently not available, but it should be being planned for now, as MFish for one clearly need it now, not in 15 years time, by which time irreparable damage may be done to New Zealand's fisheries.

Fisheries are a fragile resource and something that is easily unbalanced; overfishing would be disastrous. Illegal activity can likewise upset the balance very quickly. Stock collapse can come about in a short time as projections are based on filed returns, not physical monitoring.[48] It seems somewhat naïve, though there is no current alternative, to base a $4.5 billion industry around an honesty system. New Zealand has better fish stocks than Australia,[49] due to better conditions mainly associated with prevailing currents and cooler temperatures, and vessels are known to range far and wide for good fishing.[50] The Hoki fishery is currently under tremendous pressure, and one only has to

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[46] Gary Orr.

[47] The reasons for this are expanded upon in Ch. 5.

[48] Gary Orr.

[49] In 2006-07 Australian fisheries, which at almost 9 million sq km (http://www.afma.gov.au/fisheries/industry/default.htm) are approximately two times larger than New Zealand fisheries, produced 240,000 tonnes, which is around half of New Zealand production (http://www.abareconomics.com/interactive/08afs_june/).

[50] Gary Orr. An example of this was reported recently when the *Dominion Post* ran a story covering the presence of a Spanish owned fishing vessel operating illegally in a controlled area of the Southern Ocean. *Dominion Post*, 20 Dec 2008, p..2.

look at the state of Orange Roughy as an example of how not to do it.[51] Coastal fisheries are under similar pressure. The Abalone fisheries of South Africa have collapsed and the Australian fisheries have been devastated by a virus,[52] thus leaving New Zealand with the last remaining healthy stocks. Abalone are located in shallow water in isolated parts of the country's coastline, most being harvested around the South Island, and Stewart and Chatham Islands,[53] and these areas are difficult to monitor; aerial surveillance perhaps offering the best option.

A small UAV would be well suited in these circumstances sending real-time video to officials on the ground using hand-held monitors. This kind of operation could be carried out in the short-term with only moderate development and cost. The New Zealand Army has been carrying out trials with small UAS for a number of years and in association with DTA has built up considerable experience, and could possibly assist with any trial. MFish and Customs' need for aerial surveillance has not changed since the *MPR*, and it appears that MFish's needs have grown in the succeeding period.[54] These two organisations' needs alone would justify obtaining an additional surveillance capability. But when the possible massive expansion of the offshore energy industry and associated infrastructure is taken into account, the case for a significant increase in aerial surveillance is compelling. The value to New Zealand of its maritime environment is significant as it is, and the signs are there that it may well provide the means of providing unprecedented levels of wealth to the country.

[51] The annual Orange Roughy take has now been reduced to around 20% of what it was 20 years ago due to overfishing of a species whose biology was not understood at the time, http://www.forestandbird.org.nz/what-we-do/publications/-best-fish-guide-/orange-roughy, accessed 19 Jan 2009.

[52] *New Zealand Herald* (online), $402m abalone fishery at risk, viewed at http://www.nzherald.co.nz/marine/news/article.cfm?c_id=61&objectid=10531748, accessed 07 Oct 2008.

[53] Paua Industry Council, The commercial paua fishery, http://www.paua.org.nz/industry.htm, accessed 03 Jan 2009.

[54] Gary Orr.

Chapter 3

THE NEW ZEALAND STRATEGIC ENVIRONMENT – CURRENT AND FUTURE DIRECTIONS

For the last twenty years or so, New Zealand has been adrift in a dynamic strategic environment that is less predictable in the long term than during the Cold War. The general apathy of New Zealand in the new millennium, strategically viewed, is reminiscent of, as Colin S Gray notes of Europe, the peaceable era of the mid 1920s. But as is often the case, reference to history to frame an opinion is often dismissed as irrelevant, or worse, goes unrecognised.[1] The outcome is that there is a lack of support in New Zealand to sustain a perceived costly defence establishment and thus the economic aspects of security are paramount.[2] New Zealand is not particularly security minded, and probably less so militarily minded. The apathy of the general public of New Zealand may be evoked by a false sense of security in that it is their belief that the NZDF is on the job 24 hours a day, so everything must be being taken care of. This is nurtured through the NZDF having a high media profile. Current deployments, which have now become a repetitive routine, receive regular attention on prime-time news nonetheless.[3] The NZDF also have strategies to heighten their profile and thus build up the public's perception of constant activity, such as sending a P-3 on a coastal patrol around New Zealand on public holidays in summer, and overflying popular beaches.[4] The public see this and seem to gain the impression that military assets are providing comprehensive cover of the country's coastal and ocean assets.[5]

New Zealand trades with over 150 countries [6] and maintains strong bilateral ties equally mixed with multilateral diplomacy seeking engagement wherever outcomes are fair.[7] Within dynamic strategic interests there are permanent

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1 Colin S Gray, *Explorations in Strategy*. Westport, Connecticut: Praeger Pub., 1996, p.16.

2 William M Carpenter & David G Wiencek (Eds.) *Asian Security Handbook – Terrorism and the New Security Environment*. NY: M E Sharpe, 2005, p..205.

3 TV One News had three features during Nov-Dec 2008 (http://tvnz.co.nz/search/?q=NZ%20troops&start=30) and there was also a recent series on NZSAS selection and a documentary on Willie Apiata VC.

4 RNZAF source.

5 *MPR*, p.9.

6 Ralph Pettman, (ed.), *New Zealand in a Globalising World*. Wellington: Victoria UP, 2005, p.53.

7 Terence O'Brien, 'Facing the world the New Zealand way', *New Zealand International Review*. 30 (1), 25-27, Jan-Feb 2005, p.1.

features to the strategic environment. New Zealand is anchored in the seas and oceans that surround it – New Zealand is a maritime nation. Similarly the nation is inextricably linked to Australia, and though it has divergent views in some key security areas, Australia remains New Zealand's closest ally and the key to the country's strategic environment.[8]

A permanent, though intangible, feature of any strategic environment is change. The 'foreseeable future' is often spoken of by those who create policy and strategy. However, it is that which is unforeseen that generally causes problems, and future direction should consider a range of possibilities, and not be lulled by that which may be perceived as 'benign'. There are many potential variables that may affect New Zealand; while the possibility of an external threat in New Zealand's region is low, the risk of internal disturbance is high. Pacific Island nations have not adjusted well to globalisation, and this has had a destabilising effect in a number of countries.[9]

New Zealand's Maritime Interests and Defence Policy

New Zealand's geography, size, and economic potential shape its strategic perceptions and sense of security.[10] To the west, continental Australia shelters, and to the east, the South Pacific exposes. Australia and New Zealand constitute a strategic entity. Security and trade considerations have always been the main drivers of foreign policy, and will continue to be so. The *Defence Policy Framework* of June 2000 states the primary outcome as: 'A secure New Zealand including its people, land, territorial waters, exclusive economic zone, natural resources and critical infrastructure' – in other words, 'home security', the primary function of government. Influenced as the country is by the ocean and the economic advantages of sea transport, New Zealand's insular geostrategic limitations demand the necessity of a maritime focus to its security strategy.[11] At its next level, the ultimate goal is unfettered access to the world's common transportation routes, as well as access to markets and materials. Ninety per cent of world trade by volume and weight travels by water,[12] and in New

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[8] *DPF*, pp.2-7.

[9] Terence O'Brien, 'God defend New Zealand—from what and how?' *New Zealand International Review*. 30 (2), 25-28, Mar-Apr 2005, p.3.

[10] Ralph Pettman, (ed.), *New Zealand in a Globalising World*. Wellington: Victoria UP, 2005, p.145.

[11] Colin S Gray, *Explorations in Strategy*. Westport, Connecticut: Praeger Pub., 1996, p..25.

[12] Colin S Gray, Eliot Cohen, James Wirtz & John Bayliss; &, (Eds.). *Strategy in the Contemporary World*. Oxford: UP, 2002, p.132.

Zealand's case it is ninety-nine per cent by volume.[13] It should also be noted that of the approximately 230 million container movements around the globe each year, only around 1 per cent are screened for illegal/hazardous goods[14] – shipping is therefore the vehicle of choice for the illegal movement of people and goods, by transnational criminals. Despite not being made explicit in the *Defence Policy Framework*, sea lines of communication are crucial to trade and to New Zealand's economic wellbeing – they therefore should be a primary focus of New Zealand's strategic interest and thus defence policy.

Recent defence policy has been focused on the here and now, and has not been forward looking to any significant degree. There has been no External Assessment Bureau strategic assessment since 2000 and that only looked ahead five years. In 2006, and perhaps because of this, the NZDF released its own well considered Strategic Trends Assessment out to 2026,[15] but the assessment was intended as nothing more than a Capability Branch discussion paper and it goes to great pains to emphasise it is not policy.[16] The Ministry of Defence have not produced anything significant recently beyond an internal 'Geopolitical Scan' in May 2008, though work is currently underway on some kind of assessment.[17] It is strongly implied in the *MPR* that as a long-term goal the NMCC would produce the constituents of a maritime strategy,[18] including monitoring of evolving technologies such as UAVs. And while work is underway towards a maritime surveillance and patrol strategy; with only a staff of three, it is likely to be a long process. In the platforms department, the Programme Management Office (PMO) of the RNZAF Capability Branch are looking at a number of options for short/medium range surveillance in the future, despite being dropped from the *LTDP*, but nothing is likely to materialise before 2020 at the earliest.[19] It is understood that the PMO intend 'developing a UAV knowledge base' over the next few years.

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[13] David Dickens, Inquiry into Defence Beyond 2000: An Independent Review of the Foreign Affairs, Defence & Trade Parliamentary Select Committee's Interim Report, Working Paper 13/99, CSS: Wellington, 1999, p.2.

[14] Michael Richardson, *A Time Bomb for Global Trade – Maritime-related Terrorism in an Age of Weapons of Mass Destruction*. Singapore: Institute of South East Asian Studies, 2004, p.6.

[15] NZDF, Strategic Trends Assessment 2006-2026: An Estimate of the Future Strategic and Defence Operating Environments and the Consequences for the NZDF, Wellington: 2006.

[16] Every page apart from the cover has a header and footer stating 'Development Branch Discussion Paper—Not NZDF Policy'.

[17] Dr James Rolfe, Ministry of Defence, personal correspondence, 5 Aug 2008.

[18] *MPR*, p.35.

Regardless, there appears to be nothing on the RNZAF's horizon to mitigate immediate shortfalls in aerial maritime surveillance. However, everything, or nothing, may change in the future with the change of government, as the National Party defence spokesman Wayne Mapp stated before the election that National will: 'Publish a White Paper in its first year in Government to provide a fresh look at the capability requirements that shape our Defence Force'.[20] A defence White Paper will be both welcome and timely. Currently there appears to be a proliferation of projects either underway or planned as noted in the *LTDP*. Most of them are behind schedule and some of the communications projects appear to have scoping problems deciding what they actually need or want and sticking to it. For instance, the Joint Command and Control System (JCCS) which is mentioned in the original 2002 *LTDP* is not now expected to be complete till 2014, and the Land Command and Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (Land C4ISR) system which was to be in place by 2004 will not now be complete until 2013. Walton talks of the 'Fog of Technology'.[21] By this he means that the proliferation of technology makes it difficult for small powers to decide what is really needed. This seems to particularly afflict New Zealand at the moment.

Features of the Strategic Environment and What Lies Ahead

The invariables of New Zealand's strategic position can be broadly considered under two contexts. Firstly there is the geostrategic context, which while relatively isolated, is overshadowed by Australia to the west, and the inescapable fact that New Zealand is a maritime nation. Secondly there is the geopolitical context, which encompasses the limits of size, population and resources and the effect these have on policy. While geographical location is often perceived as an asset, New Zealand is intrinsically vulnerable, as a small distant island nation, of being marginalized on the international stage.[22] Even New Zealand's relationships with its Pacific Island 'friends' have been strained of late, but despite this New Zealand remains obligated both formally and informally in many areas of the Pacific for defence and security issues, including maritime

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19 RNZAF source, PMO.

20 Hon Dr Wayne Mapp, *Defence White Paper will review capability requirements*, 07 Oct 2008, viewed at http://www.national.org.nz/Article.aspx?ArticleId=28673, accessed 09 Oct 2008.

21 C. Dale Walton, *Geopolitics and the Great Powers in the Twenty-first Century: Multipolarity and the revolution in strategic perspective*, Routledge: Oxon, 2007, p.96.

22 Terence O'Brien, 'Facing the world the New Zealand way', *New Zealand International Review*. 30 (1), 25-27, Jan-Feb 2005, p.2.

surveillance of EEZs and fisheries protection. As regards paying for these services, in real terms the defence budget has declined approximately 50 per cent since 1988, during a period, at least during 2000-07, of increasing GDP, low unemployment, a relatively strong dollar and share market,[23] and treasury surpluses. While there has been recent capital expenditure on various projects, the government really had little choice but to do something, and the NPF is the one shining light. Regardless, the recent downturn in the economy will likely impact on Defence and it is unlikely there will be any new projects in the short-term, and some planned ones may be shelved for the time being, though all is speculation until the Defence White Paper is released later this year. The ability to act independently in the South Pacific and in any high intensity operations has been constantly eroded. And while naval assets are currently being addressed, air assets are increasingly becoming insufficient to meet basic security objectives in New Zealand's maritime environment and South Pacific neighbourhood. [24]

There are a number of influences that have the potential to affect New Zealand's strategic interests. A scenario-based approach divides the possibilities into two broad categories: those most likely which are low-level and pose no significant risk, and those most unlikely, which are high-level and pose a high risk. The most likely risks stem from terrorism and political unrest in the Pacific Islands.[25] While neither of these risks is going away in the short to medium term, the threat to New Zealand from terrorism is overstated at times, though it must be a factor regardless. Of increasing concern in the Pacific is climate change, and this is likely to impact on New Zealand. TV One News, while covering the 2008 Pacific Forum, reported that there could be up to nine million refugees from the Pacific region alone due to the effects of climate change.[26] If some of the predictions in regard to rising sea levels are correct, a Pacific diaspora is a distinct possibility. Kiribati for instance, an archipelago of 33 coral atolls barely six feet above sea-level is slowly vanishing under the sea. Kiribati has around 93,000 people and its president, Anote Tong, has warned Australia and New

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23 William M Carpenter, & David G Wiencek, (Eds.). *Asian Security Handbook – Terrorism and the New Security Environment*. NY: M E Sharpe, 2005, p.209.

24 Ibid, p.211.

25 Defence and New Zealand Foreign Policy, http://www.beehive.govt.nz/node/23848, speech by Phil Goff, Minister of Foreign Affairs, 01 Aug 2005, accessed 05 Jan 2009.

26 TV One News, 27 Jul 2008.

Zealand to prepare for a mass exodus within the next decade.[27] It appears that the UN, and the rest of the world seems to be following their lead, is more concerned with mitigating the causes of climate change than dealing with the consequences, such as the relocation of people from swamped Pacific Islands.[28] New Zealand does not have a policy for dealing with human security issues as a result of climate change, beyond normal border security and immigration measures, although this issue is somewhat on a more grand scale. Currently New Zealand has an imposed ceiling of accepting 750 refugees a year of which only ten per cent can be admitted under the humanitarian classification.[29] To counter and/or monitor a potential mass influx of illegal immigrants is something that is likely to require intense maritime surveillance.

To aggravate the apparently real prospect of disappearing land comes an inevitable increase in the world's population. According to the *2006 Revision*, the population will likely increase by 2.5 billion people over the next 43 years, moving from the current 6.7 billion to around 9.2 billion by 2050. To put that in perspective, the forecast increase is equivalent to the entire world population in 1950. Most of the increase will be absorbed by the less developed nations whose population is projected to rise from 5.4 billion in 2007 to 6.7 billion in 2050.[30] In contrast, the population of the more developed regions is expected to remain largely unchanged at 1.2 billion, and would have declined were it not for the projected net migration from developing to developed countries, which is expected to average 2.3 million people a year after 2010. With the food shortages and high prices experienced earlier this year, it does not bode well. The rising price of staple items such as corn, grains and rice, have seen widespread protests across the globe, as well as riots in some parts. The head of the Food and Agriculture Organisation said he saw civil war as a potential danger for countries in sub-Saharan Africa and in Asia and Latin America.[31] Josette Sheeran of the United Nations World Food Programme estimated that the

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[27] Kathy Marks, *Global Warming Threatens Pacific Island States*, http://www.countercurrents.org/cc-marks271006.htm, accessed 09 Oct 2008.

[28]Cherelle Jackson, *UN official: Relocating island populations no answer*, http://www.nzherald.co.nz/climate-change/_news_/article.cfm?c_id=26&objectid=10547375, accessed 07 Jan 2009.

[29] Patti Grogan, *Does a Rising Tide Lift All Boats? Refugee Resettlement, Integration and New Zealand's Settlement Strategy*, viewed at http://www.fulbright.org.nz/voices/axford/2008_grogan.html, accessed 26 Feb 2009.

[30]*Executive Summary, World Population Prospects:,The 2006 Revision*, p.5, viewed at http://www.un.org/esa/population/publications/wpp2006/wpp2006.htm, accessed 28 Feb 2009.

[31] Associated Press, 'World Food Crisis', *Dominion Post*, p.B1, 28 Apr 2008.

food crisis had plunged an additional 100 million people into the urgent hunger category.[32] Competition for space, food, water, and energy will become fierce by the middle of this century. It will be noted that all of the above are likely to be held in relative abundance by New Zealand in the future.

In the context of future global events involving the major players that may affect New Zealand, there are several scenarios. The United States will remain the sole superpower in the foreseeable future,[33] and it will continue to seek coalition partners in any military venture, though it does not really need them. America believes that if a known rule-breaker is getting close to producing or obtaining weapons of mass destruction, then it is normal and right that a superpower should strike pre-emptively for the avowed purpose of regime change.[34] This belief will continue to cause trouble as long as the world order remains unilateral, which may be another thirty years or more. China continues to grow and talk up its military might in the making. It would clearly like to be the regional hegemon,[35] but it is two to three decades away from challenging the US regionally and there are plenty of countries in Asia to prevent it in the short to medium term, with US help.[36] China also appears to have designs in the Pacific and this could impact on New Zealand in the not too distant future.[37] China would undoubtedly act against Taiwan if it made a declaration of independence from the mainland. China is now dependent on trade for its growing wealth and would be loathe going back to the old ways. Across China, there were over 400 million fewer people living in extreme poverty in 2001 than 20 years previously.[38] However, one recent report suggests that due to the current economic recession, up to 40 million Chinese citizens are likely to slide back into poverty.[39] And while China is undoubtedly rebuilding and modernising its armed forces, so is much of

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32 Reuters, '"Silent tsunami" threatens millions with hunger', reproduced in *Dominion Post*, p.B3, 24 Aug 2008.

33 C. Dale Walton, p.40.

34 Thomas M Barnett, *The Pentagon's New Map: War and Peace in the Twenty-First Century*, Berkley Books: NY, 2004, p.57.

35 C. Dale Walton, p.33.

36 Ibid, p.43.

37 Michael Powles, "China and the Pacific: confrontation or co-operation? Michael Powles suggests the advantage of engaging with China on Pacific Islands issues." New Zealand International Review 32.3 (May-June 2007): 8(5). General OneFile. Gale, http://find.galegroup.com.ezproxy.massey.ac.nz/itx/start.do?prodId=ITOF , Massey University Library, 4 Feb. 2009

38 The World Bank, *Fighting Poverty: Findings and Lessons from China's Success*, viewed at http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20634060~pagePK:64165401~piPK:64165026~theSitePK:469382,00.html, accessed 26 Feb 2009.

39 Sky News, 14 Jan 2009.

the rest of Asia. The US Department of Defense's (DoD) Annual Report to Congress remarks that 'China's military appears focused on assuring the capability to prevent Taiwan independence and … is laying the foundation for a force able to accomplish broader regional and global objectives'.[40] What these may be is uncertain. China has suffered significant loss of face in recent history, particularly during the Opium Wars and the Sino-Japanese Wars and appears determined that it will not happen again.

A resurgent Russia is perhaps the greatest threat to peace. It is currently adjusting and consolidating to its new wealth from oil and gas. Russia is unlikely to become a superpower again in the short to medium term but will be a major power nonetheless if for no other reason than it still holds the world's largest stockpile of nuclear weapons. While it is impossible to accurately assess just how many warheads Russia possesses, one report puts its stockpile of tactical nuclear warheads at around 8000 [41], and its strategic arsenal at around 6000 warheads. [42] Because of this, as in the Cold War, the US will only directly confront or challenge Russia as a last resort. Alexander Putin is effectively a dictator, and an unpredictable one at that. He seems intent on punishing those former Communist countries that border Russia. Should any doubt exist over Russia's will to bear the costs of its new rhetoric, one need look no further than its South Ossetia venture. Russia is also at the heart of increasing international competition over potential massive resources in the Arctic. The rapidly retreating ice shelf is opening up access to huge new hydrocarbon deposits. Along with Russia, the US, Canada, Denmark, and Norway are all making claims. While a diplomatic solution is still currently being pursued, there is a real risk of it degenerating into political conflict and military competition.[43] Russia is on the rise, and will once again pose a threat to the West. The first steps to regaining a blue-water navy are underway with four ships having recently visited Venezuela for exercises off the coast of the Americas.[44] It is perhaps only a matter of time

[40] Department of Defense, Annual Report to Congress, *Military Power of the People's Republic of China 2008*, p.22, downloaded at http://www.defenselink.mil/pubs/china.html, accessed 28 Feb 2009.

[41] Thornton, Charles. "Russian Tactical Nuclear Weapons" , p.8, *Paper presented at the annual meeting of the International Studies Association, Town & Country Resort and Convention Center, San Diego, California, USA*, Mar 22, 2006 *Online* <APPLICATION/PDF>. 2009-02-27 <http://www.allacademic.com/meta/p100913_index.html>.

[42] Amy F. Woolf, Foreign Affairs, Defense, and Trade Division, *Nuclear Weapons in Russia: Safety, Security, and Control Issues*, August 2003, CRS Brief for Congress, viewed at www.au.af.mil/au/awc/awcgate/crs/ib98038.pdf, accessed 28 Feb 2009.

[43] Mark Galleoti, 'Cold Calling', *Jane's Intelligence Review*, October 2008, p.9.

[44] Agence France-Presse, *Russia, Venezuela Wrap Up Joint Naval Exercise,* http://www.defensenews.com/story.php?i=3846651, accessed 09 Oct 2008.

before Russia re-enters the Pacific, and this may have implications for New Zealand maritime surveillance.

Measures to protect and enhance maritime security

Home security is the prime responsibility of any government and there are two main areas of concern to New Zealand: border control, and a complementary maritime strategy, the goal being to control the movement of people and goods into and out of New Zealand via secure lines of communication. New Zealand has strict border controls in place to monitor and control the movement of people, though like the rest of the world scrutiny of goods is marginal. In the long term it is desirable to give support to the idea of 100 per cent electronic tagging and scanning of shipping containers. This initiative as well as other new regulations to control sea and air access involves significant costs, and may appear to privilege US security, though the benefits are transnational; it is also in New Zealand's interest to co-operate with the US.[45] A robust maritime strategy is fundamental to New Zealand's security and economic well-being; any interruption to New Zealand's sea-lanes could be disastrous. The introduction of the Naval Patrol Force during 2009 covers surface aspects of maritime surveillance, but without regular and persistent aerial surveillance, the vessels will be operating virtually blind. Aerial surveillance is the eyes and ears that enable the NPF. The pending 'White Paper' must re-examine New Zealand's strategic priorities, as structuring a defence force demands a clear definition of priorities due to economic constraints. Structuring New Zealand defence around a small land expeditionary force in support of coalitions is unrealistic and a waste of resources.[46] To support an adequate maritime strategy would require significant capital costs, but security needs to be balanced by strategic reason, not accountants.[47]

Aerial Surveillance – the options

There are three options for addressing the gaps in the aerial surveillance of New Zealand's maritime environment. Firstly, there is the 'do nothing' option. Should this be the case, the NPF will be provided with around 250 hours per

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[45] Terence O'Brien, 'God defend New Zealand—from what and how?' p.5.

[46] Bruce Brown & Gerald McGhie, (Eds.), *New Zealand and the Pacific: Diplomacy, Defence Development* (pp 15-26). Wellington: NZIIA, 2002, p.67.

[47] Colin S Gray, *Explorations in Strategy*. Westport, Connecticut: Praeger Pub., 1996, p.22.

annum of aerial support, which will contribute little to their effectiveness. Against a requirement of up to 3000 hours,[48] 250 hours of aerial surveillance might translate into around 24 patrols. This is to support a forecast (once they are all in service) 840 sea-days provided by the IPVs and OPVs (plus an unspecified number of days provided by the MRV and the occasional frigate). The time spent at sea will be neither effective nor efficient in general.[49] The 2008-2009 budget for the NPF was approximately $105 million,[50] and that was based on a forecast of only 440 sea-days as the NPF gradually entered service this year.[51] This is a great expense for a force that is considered unlikely to achieve its full potential. While a limited deterrent effect will result, New Zealand will continue to be only minimally aware of what is happening in an area of 4.4 million sq km over which New Zealand has jurisdiction and which provides billions of dollars of income to New Zealand. To do nothing then poses significant risk, and is not a desirable option.

The second option is to increase aerial surveillance using manned aircraft, and here there are two possibilities. New Zealand could either increase P-3 hours, or new aircraft could be obtained that would be dedicated to the task. The P-3s have a total of around 2400 hours allocated to them for 2008-2009.[52] To fully support civilian organisations on non-military maritime security tasks would require all of this time. However, even if only the priority tasks were carried out in the outer reaches of the EEZ, and discounting the short and medium-range tasks completely, at least 1000 hours would still be required.[53] It is forecast that the Orions will need replacing by 2025 based around a fleet total of approximately 2600 hours of flying per annum until then.[54] The fatigue life of an airframe is finite in terms of flying hours, and cannot be exceeded.[55] If the rate of flying hours is increased, then the remaining life in service is shortened. If for instance another 1400 hours per annum were added across the fleet starting in 2009-2010, this

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[48] *MPR*, p.36.

[49] DP Galligan, August 2006, p.1.

[50] *Vote Defence Force 2008-2009*, p.40.

[51] Ibid, p.41.

[52] Ibid, p.28.

[53] DP Galligan, 2003, p.2.

[54] *Defence Long-Term Development Plan* September 2008 Update, p.30. (this date assumes no further major structural issues e.g. corrosion is a major issue in the RAAF Orions).

[55] NZAP 6002-2, *Aircraft and Aeronautical Equipment Engineering: Aircraft Structural Integrity*, defines fatigue life as the operational life of an aircraft or component, expressed as a number of flying hours (the service life) or flights or of applications of load during which the general level of structural safety is not appreciably lowered by fatigue.

could reduce the remaining time in service by around six years. However, it should be noted that the service life of an aircraft is dependent on many variables such as: operating environment; aircraft mission profile; operating weight etc. and that the actual date representing the end of useful service life is nominal and dependent on satisfactory results from ongoing structural inspections.[56] Another option that circumvents this is to reallocate hours used up on other tasking, though this raises the possibility that remaining hours might not be sufficient to remain proficient in the military tasks. However, as most of the major defence documents emphasise dealing with non-military security tasks, this may not be relevant as far as policy is concerned. The systems upgrade which is currently underway was clearly based around providing support for government agencies engaged in non-military security,[57] and was used as the main justification for the price tag of $373 million.[58]

Any additional hours would probably require an additional air-crew (and ground-crew to cover additional maintenance), and historically, providing crews has been problematic.[59] An Orion requires a minimum crew of 11 for operational tasks [60] and to train a crew takes a number of years and millions of dollars. The Orions are expensive to operate; as stated previously $166 million being appropriated as the cost of ownership for 2008-2009. This figure is the cost of an output class and includes air force overheads. Based on Australian figures the *MPR* estimated an operating cost of $40,000 an hour to fly an Orion [61] from an output class costing $105 million in 2001.[62] An increase in flying hours of 500-1000 hours would add considerably to this cost, the lower figure alone accounting for almost another 2000 tons of fuel. Despite hundreds of millions of dollars being spent on airframe refurbishment and systems upgrades, the basic

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[56] NZAP 6215.002-38, Structural Integrity Management Plan (SIMP), for the RNZAF's Orions remarks that the original US Navy design life for Orion P-3 aircraft was for a safe life of 7500 airframe hours. Due to a groundbreaking structural monitoring and inspection regime initiated by the RNZAF the fleet did not require major repairs (under Project Kestrel carried out between 1997-2000 the wings, horizontal stabilisers and engine nacelles were replaced) until a fleet average approaching 17,000 airframe hours. According to RNZAF sources the fleet is now approaching an average of 22,000 hours and according to the SIMP is expected to be able to reach a fleet average approaching 34,000 hours, by which time the aircraft will have been in service for around 60 years, which is four times that originally envisaged by the US Navy.

[57] Hon Mark Burton, Minister of Defence, 5 October 2004, *Background: Royal New Zealand Air Force P-3 Orions* , http://www.beehive.govt.nz/sites/all/files/P3%20Orions%20background.pdf, accessed 13 Oct 2008.

[58] *Defence Long-Term Development Plan* September 2008 Update, p.30.

[59] Timothy Walshe.

[60] Defence Force Flying Orders, table 10-4.

[61] *MPR* p.27.

[62] Ibid p.9.

mechanical systems are 1950s technology, and some systems such as the propellers and air-conditioning are notoriously unreliable. The hot weather performance of the engines can also be problematic.[63] The Orion has a useful dash speed enabling it to transit quickly and can stay airborne for up to 15 hours if required,[64] though this is not routine as with increasing flight duration, crew fatigue becomes an issue.[65] Typically an Orion could fly to the most distant areas of the EEZ and carry out an eight hour patrol. While this is useful, the definition of 'persistence', i.e. the ability to loiter on station for extended periods, has moved ahead significantly. The current and planned crop of maritime surveillance UAVs can remain on station for 24 hours and beyond. In the case of the Predator, flying for 24 hours is equivalent to flying 400 nautical miles, loitering for more than 14 hours, and then flying 400 nautical miles to base.[66] The absence of onboard aircrew mitigates the historic limitations of aircrew fatigue, and while the ground-based aircrew remain integral to the mission there is added flexibility in their management.[67] While the Orion is a capable aircraft, it is expensive to operate, manpower intensive, not available as often as required, and lacks persistence in the contemporary context of maritime surveillance.

The other option for manned aircraft is to obtain a small fleet of short to medium range aircraft dedicated to the maritime surveillance role. The Australian Border Protection Command have selected a multi-role version of the de Havilland Dash 8-300 series as the basis of their maritime surveillance fleet, and this aircraft will be referred to as a typical example of its type.[68] Consideration has been given in previous studies to smaller types such as the Hawker Beechcraft King Air as currently flown by 42 squadron, but it is considered to be unsuitable for the medium-range requirements[69] as it is has only a four hour endurance, which is marginal in this role and is therefore discounted.[70] While the

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63 Phillip McKinnon, The Rolls-Royce Allison T56 is fifty, viewed at http://www.aviationnews.co.nz/downloads/Allison_T56-_is_50.pdf, accessed 13 Oct 2008.

64 See Appendix A p.134 for aircraft details.

65 Defence Force Flying Orders, Ch 10 Table 1, do allow up to 18 hour aircrew duty periods of which 15 can be flying. An article in the ADF safety magazine *SAFETYMAN*, volume 3 part 1 ch 21-6, recommends a maximum duty period of 15 hours with flying hours not exceeding 12 hours for a two pilot crew.

66 RQ-1 Predator MAE UAV, http://www.globalsecurity.org/intell/systems/predator.htm, accessed 11 Jan 2009.

67 *The US Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision* p.7 accessed 23 May 2008 at http://www.af.mil/shared/media/document/AFD-060322-009.pdf.

68 See Appendix A p.135 for aircraft details.

69 DP Galligan, 2004, p.31.

70 A version called the 350ER (Extended Range) is now available with an endurance of around eight hours, http://www.flyingmag.com/turbine/1100/king-air-350er-flying-fuel-tank-page2.html, 14 Feb 2009, see Appendix A p.136.

range in a Dash 8 type of aircraft is inferior to the Orion, endurance is not significantly so.[71] Absolute range is not so crucial in the context of EEZ surveillance, and the benefits of a Dash 8 outweigh the previously stated disadvantages of the Orion. The Dash 8 is less costly to own and operate, requires a crew of only four, requires less maintenance down-time; newer technology should provide greater reliability, and the aircraft would be dedicated to the maritime surveillance task.[72] For the latter reason it would be desirable not to have any such aircraft under RNZAF control. The risk of 'capture' by the NZDF, and aircraft being used for other purposes, would not be acceptable.[73]

Preference would be given to having any additional maritime patrol aircraft owned and operated by a civilian organisation, and there are a number of reasons for this. It would be necessary that NMCC had guaranteed and immediate access to aircraft at all times, which would greatly simplify tasking and provide greater flexibility and continuity of operations. This is not the case with the Orions. Recruitment and retention of NZDF personnel is currently a significant problem for a number of reasons,[74] and it seems reasonable to suggest that recruitment and retention of aircrew to a civilian organisation would be less problematic than in the military. Using the example of a Dash 8, they could be maintained through Air New Zealand, who currently operates the passenger version,[75] and there could perhaps be opportunities for pilot cross-training and employment opportunities with Air New Zealand. There is also a CAA certified Dash 8 training organisation located at Christchurch Airport that could provide type ratings for aircrew.[76] The option of obtaining dedicated short to medium range aircraft is a preferred option to additional Orion hours, due to greater flexibility, lower operating costs, and being available for the required number of hours. While it might be claimed that there is some duplication of services with the RNZAF, the ability of a dedicated organisation being able to supply up to ten times what the Orion fleet can provide makes it justifiable. It is

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[71] *APDR*, Vol..33 No.10, Dec 2007/Jan 2008, p.26, states Dash 8 endurance as 11 hours at low level.

[72] The *MPR*, p.27 estimated an Orion cost 8-10 times more to operate than a more suitable twin turboprop type, though no details of how this estimate was arrived at are given. It is likely to be based on fuel burn, maintenance requirements, and crew requirements.

[73] *MPR* p.25.

[74] These are outlined in The Defence Portfolio Briefing to the Incoming Government 2008 - November 2008 accessed 17 Dec 2009 at http://beehive.govt.nz/sites/all/files/Defence_BIM.pdf

[75] Under the Air Nelson banner.

[76] Contract Aircrew training Ltd, *Dash 8 or ATR Endorsement*, http://www.conair.co.nz/Dash8.htm, accessed 10 Jan 2009.

also likely that most of the Orion's current EEZ surveillance tasks could be carried out by a short/medium range patrol aircraft, thus reducing Orion fleet hours. The main disadvantage of an SMRPA is that they lack the persistence of a purpose designed maritime surveillance UAV.

The final option for increasing aerial maritime surveillance would be to employ a small fleet of UAVs of varying types. To fulfil the SMRPA role would require a Tier 2 UAV similar to the General Atomics Predator B or IAI Heron TP.[77] It is unlikely that obtaining a UAV capability to fulfil the SMRPA role would be any less costly than a manned aircraft such as the Dash 8, and operating costs are likely to be similar, when ground based support services are taken into account. However, operating a small fleet of UAVs will incur considerably less cost than the Orion; the fuel burn alone would save thousands of dollars per flight. Crewing would be half that of an Orion and this will be discussed in more detail later. The main advantage of a UAV is persistence and low-observability.[78] UAVs can loiter around a target without being observed, for more than two times that of a highly visible Orion. This extended endurance results from significant advances in propulsion and aerodynamics. Aircraft designers have historically accepted compromise in these areas, because human pilots cannot take advantage of extended time in the air.[79] Extended endurance would be particularly valuable in covert operations carried out by MFish and Customs.

As in the case of the SMRPA, any Unmanned Aerial System would preferably be owned and operated by civilians for the same reasons. The main issue with operating UAVs in New Zealand, and anywhere else, is deconfliction with manned aircraft. The US Air Force views this in a slightly different context in that they see this issue as one of integration rather than deconfliction.[80] Regardless of whose view is taken on this particular issue, the world is several years away from routine operation of UAVs in controlled national airspace (NAS). Several aerospace companies are currently racing to perfect a 'sense and avoid' system for use by UAVs in controlled airspace, and until its conclusion, this

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[77] Refer Appendix A p.138 and p.140.

[78] Dept of the Air Force, *The US Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision,* pp.6-7, downloaded at www.af.mil/shared/media/document/AFD-060322-009.pdf., accessed 18 Feb 2008.

[79] Ibid, p.6.

[80] *The US Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision 2005,* p14, though in general terms they refer to integration into the 'battlespace' of an operational theatre.

remains a significant hurdle. The US DoD have a goal of 'file and fly' [81] by 2012, and a UK sponsored unmanned aircraft development programme has concluded that UAV flight in non-segregated airspace is 'feasible' by 2012.[82] The US Federal Aviation Administration (FAA) though takes a much more conservative view and their opinion is it will not be achievable till much later.[83] However, as will be discussed later, this may not be such a major problem in New Zealand.

Summary of Strategic outlook

Over the next 30 years the world is likely to become less stable due to a challenging economic climate, the growing assertion of developing nations and increasing population. Overall there will be a slight increase in threat to New Zealand, though it will still be at the low to medium end of the scale. Regardless, old rivalries have already been rekindled and the signs are that a Cool War is imminent. Power politics will reassert itself once again and relegate terrorism to the second-tier threat that it is. A return to the worst aspects of the Cold War are unlikely due to the growing interaction and wealth of those countries who previously opposed the West – though that said, globalisation can bring war and has done since the Spanish Empire. However, the collapse of the World Trade Organisation Doha talks and the current downturn in the economy may open the way for regionalism and attendant protectionism, which could be destabilizing. The recent sharp rises in world food prices were exacerbated by some countries either closing their borders to food exports or imposing high export tariffs.[84] While food prices are now falling the UN has warned that the crisis is not over. Cereal stocks are at their lowest level in three decades and an increase in production of 40 per cent is required in 2009 to restore levels.[85] One of the reasons for the food shortages was extreme weather affecting crops, and climate change is set to play a major role in the future, and probably sooner rather than later in the low-lying Pacific islands. One recent report indicated that the Pacific

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[81] A relatively straightforward process that allows a pilot/operator to file an aircraft flight plan with air traffic services and then go and fly the plan, the same as manned aircraft.

[82] *Flight International*, 25 November-1 December 2008, p.29.

[83] *Aerosafetyworld* July 2008, p.39 viewed online at http://www.flightsafety.org/asw/july08/asw_july08_p34-39.pdf on 10 Jan 2009.

[84] Food and Agriculture Organisation of the United Nations, World Food Situation, *Policy measures taken by governments to reduce the impact of soaring prices (as of 15 December 2008)*, http://www.fao.org/giews/english/policy/index.asp, accessed 27 Feb 2009.

[85] Food and Agriculture Organisation of the United Nations, *Falling prices in perspective*, http://www.fao.org/ docrep /011 /ai474e/ai474e13.htm, accessed 27 Feb 2009.

Islands already appeared to be in a "constant mode of recovery," as food production is variously disrupted by cyclones, flash floods and droughts.[86]

At a time of ever increasing competition for resources, New Zealand, touted by some oil and gas industry experts as a potential North Sea of the South, stands on the brink of potentially unprecedented levels of wealth driven by energy resources.[87] Any discovery of large deposits of oil and gas in the offshore domain, and the installation of associated infrastructure, represents a strategic asset requiring heightened monitoring and security measures. Current and projected levels of maritime surveillance take no account of this, yet they will still be deficient, and will not improve unless the NPF is enabled through significantly more aerial surveillance. The need to support MFish, Customs, and several other government organisations are well known, and are enshrined in defence policy. Yet up till now the NZDF, and the RNZAF in particular, have appeared to be either unwilling or unable to fill the gaps. However, in mitigation, the RNZAF are fulfilling their obligation for MARSURV under the NZDF Strategic Plan, regardless if it appears to be out of step with defence policy. The RNZAF has undergone somewhat of an upheaval since the ACF was disbanded in 2001 and has been heavily occupied in major upgrade projects and deployments. Regardless, it appears that by only providing the minimum service required, which in fairness is all that is required by the Minister of Defence in the output plan, it allows more time for military activities further afield, which in fact are less relevant and contribute little to the immediate security of New Zealand.[88] The time is right for the government to look at a dedicated aerial maritime surveillance service provider for EEZ protection. The evidence suggests that of the three options discussed, the adoption of dedicated maritime surveillance UASs might prove the most efficacious solution to filling the gaps in New Zealand's maritime aerial surveillance, now and in the future.

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[86] UN News Centre, *Food security in Pacific islands at risk from climate change-related disasters – UN*, http://www.un.org/apps/news/story.asp?NewsID=29151&Cr=Climate+change&Cr1=FAO, accessed 10 Jan 2009.

[87] James Weir, 'The North Sea of the South: New Zealand waters may hold wealth of oil', *Dominion Post*, p.C1, 10 Mar 2008.

[88] *MPR*, p.19.

Chapter 4

WHY UAVs?

The main advantage of UAVs over manned aircraft is persistence. Persistence is enabled by a number of technologies such as fuel efficient engines and airframes that can be designed without consideration of human factor limitations. The space and weight normally allocated to on-board aircrew and life support systems can now be made available for payload and/or fuel, or they can be traded for smaller size.[1] A UAV can remain on station for longer as it has no airborne crew to get tired and hungry, and generally suffer from performance degradation as the mission extends in hours. The 'flight-crew' is safely on the ground, often in an air-conditioned trailer, and after four to six hours of duty they can hand-off to the next crew, without then requiring extended rest periods due to prolonged 'flight-time'. Around 50 countries and NATO either have UAVs in service, or on order.[2] Countries as diverse as Botswana to Thailand have recognised their value and are bringing them on inventory.[3]

The main driver of development for any item of military equipment is a war in progress. Since the end of the Cold War the world has lurched from one crisis to the next and this has certainly fuelled progress. The most militarily active nation has been the United States, with almost continuous operations since 1991. Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) have seen a massive increase in demand for information, surveillance, and reconnaissance (ISR) assets and this has primarily been filled by UAVs, and currently there is no sign that demand will slow down; the US alone plans to spend around US$21.5 billion on unmanned systems by 2013. [4]

UAVs – 100 years in the making

The progress of UAVs can be closely linked to the history of conflict in the 20th century, though the current enthusiasm for UAVs probably arose in 1982

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[1] *The US Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, p6.

[2] UAV Forum, Librarian's Desk, http://www.uavforum.com/library/librarian.htm, accessed 15 Oct 2008.

[3] UAV Forum, Users, World Unmanned Aircraft Systems, http://www.uavforum.com/users/users.htm, accessed 11 Jan 2009.

[4] *Unmanned Systems Roadmap, 2007-2032*, p.10.

when Israeli decoys and real-time reconnaissance drones played a significant role in the destruction of Syrian air defences during the Lebanon War. In 1983 following the bombing of the Marine barracks the USN was having difficulty carrying out post-bombardment analysis from action taken by the USS *New Jersey*.[5] Analysis of this issue led to the discrete purchase of an Israeli Mastiff UAV in 1984. In 1985 a marine platoon was formed and deployed to develop a concept of operations (CONOPS) in support of amphibious operations. The success of this led to the purchase of the Pioneer UAV as naval gunfire spotters, and later for aerial reconnaissance.[6] Such is their utility that the inventory was

Figure 4. UAV Inc Pioneer

constantly upgraded and expanded and there remain nine systems in service with two US Navy and two United States Marine Corps squadrons.[7] The type received world-wide notoriety in 1991 when USS *Missouri* (BB 63), using her Pioneer to spot 16 inch gunfire, devastated the defences of Faylaka Island off the coast near Kuwait City. Shortly thereafter, while still over the horizon and invisible to the defenders, the USS *Wisconsin* (BB 64) sent its Pioneer over the island at low altitude. When the UAV came over the island, the defenders heard the sound of the two-stroke engine since the aerial vehicle (AV) was intentionally flown low to let the Iraqis know that they were being targeted. Recognising that with the

[5] Laurence Newcome, p.95.

[6] Ibid., p.97.

[7] Pioneer Short Range (SR) UAV, http://www.fas.org/irp/program/collect/pioneer.htm, accessed 18 Oct 2008.

UAV overhead, there would soon be more 2,000-pound naval gunfire rounds landing on their positions, the Iraqis signalled their desire to surrender.[8]

UAVs are now a permanent and indispensable feature of military and security forces worldwide. Aside from their technical capability, they are a very attractive political tool. By having no aircrew they are politically safe in the sense that should a mission fail there will be no 'bodies in the street', or mock trials of 'sky pirates'. Many commentators remark that UAVs are part of a Revolution in Military Affairs (RMA), though this is not true as today's machines have evolved over 100 years. Thus it is probably more appropriate to use the term Evolution or Transformation in Military Affairs. Those who adopt a revolutionary view argue that the RMA is not necessarily rapid but it is best understood as a profound or powerful change, built on a long foundation of evolutionary change.[9] Regardless, their proliferation in the last 10 years has undoubtedly transformed how war fighters operate.

Classes of UAVs and features

UAVs come in all shapes and sizes and over the years not only have they changed their name; such as, drones, remotely piloted vehicles/aircraft, robotic air vehicle etc., but every major organisation seems to have their own classification system as well. The original Department of Defense system still appears to endure with the US Air Force at least, albeit with some alterations, and this system will be the reference for the remainder of this thesis as follows:

> **Tier 0** by default covers small / micro UAVs such as the BATMAV system built around Aerovironment's Wasp. With an outright range of roughly five miles, a weight of under 1lb, and a wingspan of less than 2ft, this system has a ceiling of around 1,000ft and endurance of an hour. Some UAVs on the drawing board are literally insect-sized.
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> **Tier 1** covers the low-altitude layer up to jet-stream altitudes of around 30,000ft. Alternatively, Tier one stops at the lower end of the tropopause, the somewhat variable five-mile boundary zone

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[8]US Navy Fact File, RQ-2A *Pioneer* Unmanned Aerial Vehicle (UAV) viewed at, http://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=2100&ct=1, accessed 18 Oct 2008.

[9] Clifford Rogers, "Military Revolutions", In Thierry Gongora and Harold von Riekhoff, eds. Toward a Revolution in Military Affairs? Defence and Security at the Dawn of the Twenty-First Century. Westport CT: Greenwood Press, 2000. p. 31 cited by Victoria Edwards at http://www.cda-cdai.ca/symposia/2003/Edwards.pdf, accessed 11 Jan 2009.

between the troposphere and the stratosphere. Sustainability in this layer was the goal of early models such as the Gnat, which in its current improved version has a 500lb empty weight, a 35ft wingspan, a top speed of 160mph and endurance of 48 hours.

Tier 2, which extends to an altitude of roughly 50,000ft, essentially comprises the tropopause. Although jet streams are strongest in this range, weather rarely reaches this high, making it an excellent cruising altitude for Cessna-sized UAVs such as the Predator, which is formally classified as a MALE (medium altitude, long endurance) UAV. Interestingly, even though it weighs 950lb empty and spans 48ft, the Predator's aerial performance envelope is roughly equivalent to the Gnat's. However, the Predator's payload at 1,300lb is more than double that of the Gnat's, and its mission capability is much greater.

Tier 2+ encompasses the lowest slice of the stratosphere – up to about 70,000ft in altitude. Drag is noticeably lower at this altitude, but UAVs generally require more wing area and turbofan engines to generate the necessary lift. As a result, UAVs flying in this tier, such as the Global Hawk, receive the HALE classification. Despite the similarity to the tier two profile implied by the plus sign, the Global Hawk's wingspan is actually close to 2.5 times that of the Predator, and it weighs 14 times as much. In return, the Global Hawk has a top speed of 400mph, can stay aloft 36 hours straight and can carry ten times the payload of a Predator.

Tier 3 is a misnomer, as it actually refers to stealthy UAVs, such as Dark Star, flying in the tier 2+ altitude zone. The Dark Star was originally an experimental competitor of the Global Hawk, but has since been modified with stealth characteristics, the Pentagon is loath to even confirm the existence of operational stealth UAVs, let alone their current specs. [10]

A UAV is not a stand-alone item. The UAV is merely the sensor platform of an unmanned aerial system (UAS). A system such as in Figure 5 typically

[10] Richard B Gasperre, The US and Unmanned Flight, http://www.airforce-technology.com/features/feature1528/, accessed on 18 Oct 08.

comprises a Ground Control Station (GCS) housed in an air-transportable trailer as well as communications and satellite equipment as required. In the case of the General Atomics Predator, a fully operational system consists of four aircraft (with sensors), a ground control station, a Predator Primary Satellite Link, along with operations and maintenance crews for deployed 24-hour operations.[11]

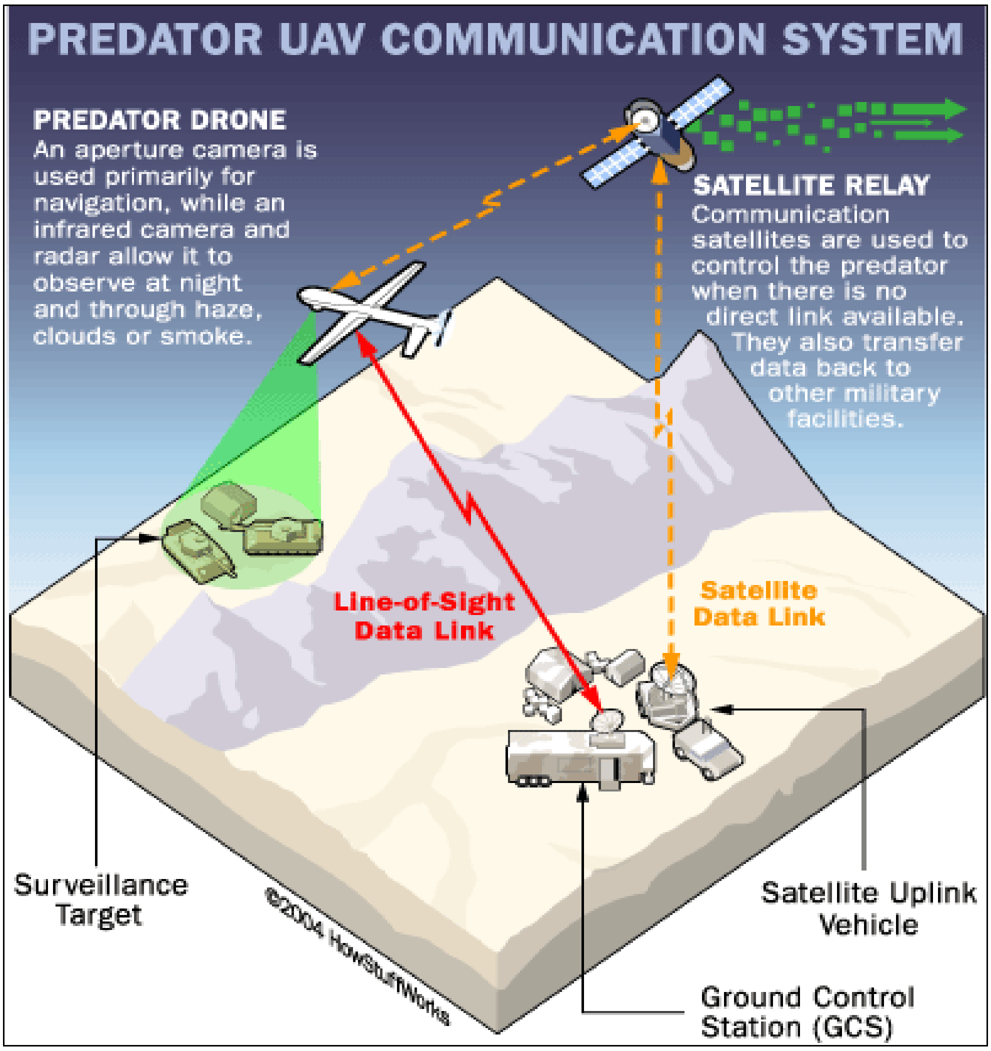

Figure 5. A Predator Unmanned Aerial System (UAS)

The interior of a GCS is shown over the page. Also available is a Multi Aircraft Control station from which one pilot can control up to four aircraft, though each aircraft has its own sensor operator. While the Predator is perhaps the best known UAV, there are currently around 100 significant types with weights ranging from 300 grammes to almost 15 tonnes.[12]

[11] MQ-1 Predator UAS, http://www.af.mil/factsheets/factsheet.asp?fsID=122, accessed 11 Jan 2009.

[12] *Complete Guide to Drones*, pp.18-21.

The variation in size is equally matched by their methods of take off and landing. They can variously be: hand-launched; bungee; hydraulic or pneumatic catapult; rocket assisted take-off (RATO); conventional take-off from

Fig 6. The interior of a Predator Ground Control Station (GCS)

a runway; air-launched, and vertical take-off for those machines with a rotor for lift, just like a helicopter, as well as some ducted fan machines. Raytheon are expecting to carry out a submerged submarine launch of a UAV sometime this year.[13] Methods of recovery can include what is best described as a controlled crash for the smaller machines; conventional landing on a runway; capture in a net or by a skyhook system; aerial retrieval; parachute, and vertical landing. The US Army's latest Sky Warrior UAS, which is a purpose designed multi-mission variant of the Predator, also has dual-redundant automatic take-off and landing capability,[14] which negates the need for a qualified pilot, at least when operating outside national airspace (NAS). The question of operator qualification is a separate issue and is discussed later. Interestingly, the Sky Warrior is powered by a diesel engine in line with the US Army's doctrine of minimizing the types of fuel required in-theatre, which eases logistics considerations. Other machines can be powered by: aviation gasoline

[13] Armed Forces International, *Raytheon Submarine Launched UAV*, http://www.armedforces-int.com/projects/aerial-surveillance/raytheon-submarine-launched-uav.asp, accessed 18 Jan 2009.

[14] General Atomics Aeronautical, Sky Warrior, http://www.ga-asi.com/products/er-mp-uas.php, accessed 19 Oct 2008.

(AVGAS); aviation turbine fuel (AVTUR); motor spirit (MOGAS); or various other blends, as well as electric battery power on the smaller machines. Regardless, it is sensors that ultimately define their utility.

Figure7. MQ-1C Sky Warrior

Payloads not platforms

The price of a UAV system at *Elbit* [15] is three-quarters electronics and one-quarter platform.[16] Payloads for UAVs, either current or planned, come under four categories, which are sensors, relay, weapons and cargo. While all four are likely to eventually find a role in the New Zealand maritime environment, it is principally sensors and relay equipment that are of most interest. Sensors refer to electro-optical, radar, signals, meteorological, and chem-bio, and relay refers to communications and navigation.[17] The greatest attribute of UAVs comes at a cost. The pursuit of endurance demands a high fuel-fraction, and the trade-off is in payload, which typically might be between 10-20 per cent of gross weight. This in itself has provided the impetus for the miniaturisation of sensors, and airframe systems, which has now reached a high state. *imSAR* have produced their *NanoSAR* which is a synthetic aperture radar (SAR) weighing less than one kg,[18] where previous SAR were typically in the 25-100kg range. The *NanoSAR* includes the navigation system, antennas, cabling, real-time processor, and radio frequency (RF) front end. SAR imagery

[15] Israeli defence and electronics manufacturer.

[16] Joseph Ackerman, Elbit CEO, Electronics Rule, The concept, 'Its payloads not platforms that matter', becomes a business model, *AW&ST*, 04 Feb 2008, p54.

[17] Office of the Secretary of Defence, *Unmanned Aircraft Systems Roadmap 2005-2030*, Washington: 2005, p.56.

[18] imSAR, NanoSAR, World's Smallest SAR (Synthetic Aperture Radar), http://www.imsar.com/, accessed 19 Oct 2008.

can be generated through rain, fog, and dust, and independent of day or night. Testing of the mini-SAR has taken place on a Scan Eagle UAV, and on-board real-time data processing has been demonstrated.[19] While its use will be purely tactical, due to the constraints of data transmission range being limited by power requirements, in combination with the usual EO system it provides an extraordinary level of capability in a 20kg machine. Of course, in larger machines with full-sized SAR there are no such limitations in range. The Elta EL/M 2022U which is a designed for UAV maritime patrol radar system, built by Israel Aerospace Industries, is a full multi-mode radar the equal of the latest radars carried by manned aircraft, such as the equivalent radar recently fitted to RAAF Orions,[20] and is currently being fitted to RNZAF Orions as part of their systems upgrade.

Figure 8. NanoSAR weighs in at two pounds

Figure 9. Imagery generated by the above NanoSAR

The Lynx radar developed specifically for the General Atomics family of UAVs by Sandia Laboratories in Albuquerque is probably one of the better known mid-size SARs.[21] The sensor offers a thirty centimetre to three metre

[19] *Boeing/Insitu ScanEagle Flight Demonstrates Real-time Radar Imaging Using NanoSAR*, viewed at http://www.boeing.com/news/releases/2008/q2/080610a_nr.html, accessed 19 Oct 2008.

[20] Jane's, *The Omnipresent Orion, Upgrade Update*, http://www.janes.com/extract/dsm95/dsm00384.html, accessed 11 Jan 2009.

[21] Though obviously its use is not confined to UAVs, and to date it has been qualified in a B200 King Air. and Black Hawk.

resolution stripmap capability and spotlight resolutions of ten centimetres to three metres. Depending on weather conditions and imaging resolution, the sensor can operate at a maximum range of between 25 to 85 kilometres dependent on altitude. In addition to SAR,[22] the Lynx radar includes Ground Moving Target Indicator which distinguishes moving targets from their stationary background. The radar is packaged in two subassemblies weighing less than 50 kg.[23] Clearly, within the context of size, UAVs are not at a disadvantage to their manned counterparts in terms of quality radar systems. Radar though, is generally the domain of Tier 2 and above machines and the primary electronic system for the majority of UAVs remains its optical sensor.

When an area of interest is identified in stripmap mode, Lynx can switch to spotlight mode and zoom in, producing images of up to 4-inch (0.1m) resolution.

Figure 10. Lynx SAR in high-resolution Spotlight Mode.

All UAVs are fitted with an optical sensor, both to view items of interest and to navigate, though even smaller UAVs can carry out fully automatic navigation. These optical, or electro-optical systems, can range from simple miniature black-and-white pen-sized cameras to the large, multiple channel, fully stabilized turret.[24] Some of the larger turrets can have up to six functions. The EO payload selected for the British Army's Watchkeeper UAV called the CoMPASS (compact multi-purpose advanced stabilised system) produced by Elbit, can include: third-generation, 3-5 micron focal plane array FLIR; 8-12

[22] For a description of SAR see http://www.sandia.gov/radar/whatis.html.

[23] Sandia National Laboratories, *Lynx SAR*, http://www.sandia.gov/radar/lynx.html, accessed 23 Oct 2008.

[24] *Complete Guide to Drones*, p.35.

micron FLIR; colour TV camera with zoom; eye-safe laser rangefinder; diode-pumped laser designator; laser target illuminator and auto tracker.[25] While this unit weighs around 38 kg, at the other end of the scale the same company produces the LEV-2 miniature stabilised EO payload consisting of a fairly simple day-camera that weighs 800 grams.[26] A typical larger system consists of three imaging sensors; with infrared for detecting thermal radiation; a wide field of view colour EO for area surveillance; and a narrow field of view mono EO with high magnification for target identification. There is no compromise in optical systems relative to manned systems. A combination of sensors is desirable as it

Figure 11. Electro-optical systems: LEV-2 (above) and CoMPASS IV.

contributes to flexibility in tasking or redirecting missions already underway.[27] To take full advantage of the capabilities and flexibility of a UAV requires a comprehensive and equally capable command and control system.

Command and Control

Command and control of UAVs has two major aspects to consider. Firstly there is the basic issue of controlling the aircraft in all aspects of flight, and secondly, the ability to control the aircraft's sensors so as to fulfil the mission. The smallest Tier 0 machines used at the platoon level have a fixed camera

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[25] Defense Update, CoMPASS IV, http://defense-update.com/products/c/compass-IV.htm, accessed 13 Jan 2009.

[26] Defense Update, LEV-2 Miniature Stabilized EO Payload, http://www.defense-update.com/products/l/lev-2.htm, accessed 13 Jan 2009.

[27] John C DeVane, *Applicability of Unmanned Aerial Systems to Homeland Defence Missions*, Thesis, Naval Postgraduate School, Monterey: December 2006, p.28, retrieved from http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA462422, 15 May 2008.

looking forward and slightly down so as to be able to confirm location and view what is actually there. They will be controlled by a small ruggedized laptop, and allow the platoon commander to see what is over the next hill or around the corner, while it remains in line of sight (LOS) and probably within a kilometre or so. They represent a simple, though very effective, reconnaissance solution, and particularly so in the urban environment. Tier 1 machines are larger and more sophisticated machines, which at the lower end would include machines such as New Zealand's own Skycam range of small UAVs which includes the 2-EB, Hawk, and Silver-eye.[28] These machines, developed for the Army with heavy input from DTA appear to be as sophisticated and capable as any in their class.[29] They can be pre-programmed to carry out a fully autonomous mission, flown manually, or re-programmed during flight (provided LOS is maintained). They navigate using global positioning system waypoints and are controlled via a GCS.

Fig 12. Skycam 'Kahu' Silver-eye

Control can be maintained from a moving vehicle or passed on to another GCS as required. [30] Sensor data can be transmitted in the region of six to ten kilometres. While the army does not officially 'operate' UAVs, 16 Field Regiment have been 'trialling' UAVs for several years, and these trials appear to have been successful. In June 2008 an exercise held at Waiouru using Kahu 'mini-UAVs' demonstrated night-flying, extended range missions, use of IR cameras, and real-

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[28] Skycam UAV NZ, ppt. presentation downloaded at http://www.kahunet.co.nz/, accessed 14 Sep 2008.

[29] Skycam UAV NZ, Kahu UAV series, http://www.kahunet.co.nz/uavs.htm, accessed 13 Jan 2009.

[30] Ibid.

time dissemination of sensor products.[31] Funding is steadily increasing and it is probably only a matter of time, or need, before a unit is declared operational; one source suggesting by 2011. The items used by the army are based on designs produced by DTA, who originally started a project to build up expertise in the area, believing the best way to do this was from the ground up.[32] Rather than purchase an existing system, and in order to give the level of required knowledge, the whole system was developed from scratch, which includes the GCS and autopilot. This has allowed DTA to better inform the NZDF on what features they believe a good UAS should have. Developing their own system also gave them open architecture which allowed changes to be made as required (most COTS systems are closed source).[33] The cost to DTA for their system was in the region of NZ$15,000 whereas a quote DTA received for a similar commercial system was around NZ$150,000.[34] While it is not known which system the quote was for, an Aerovironment RQ-11 system[35], which is basically similar to a Skycam Hawk, consisting of two AVs, a ground control unit, remote video terminal, transit cases and support equipment, is listed on an official USAF web site as costing US$173,000 in 2004 dollars.[36]

While UAVs are seldom mentioned in any domestic defence documents it seems likely that the land ISR system of the Land C^4ISR project will be a UAV, and that it may well be operational during 2010/2011.[37] While these particular machines have obvious uses in a tactical land ISR role with the army, an organisation such as MFish could use these machines now in support of inshore fisheries surveillance and enforcement operations. A price of only $35,000 per airframe has been cited and this is a fraction of similar overseas machines, and as a director of Skycam remarked: 'We can produce UAVs cheaper than the Chinese'.[38] The Skycam 2-EB has a duration of up to six hours with a 3kg

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31 NZDF, *Networked Soldiers sense Nemesis*, http://www.nzdf.mil.nz/news/media-releases/20080620-nssn.htm, accessed 23 Jun 2008.

32 Mark Anderson, DTA, personal correspondence, 14 Jul 2008.

33 Ibid..

34 Ibid.

35 See Appendix A p.142.

36 Air Force Link, RQ-11 Raven Small UAS, http://www.af.mil/factsheets/factsheet.asp?fsID=10446, accessed 15 Feb 2009.

37 *LTDP* Update 2008, p.60.

38 *Unmanned Vehicles*, Jul-Aug 2008, p.27.

payload,[39] which in theory could in future include a NanoSAR or similar type. The possibility is perhaps not so remote as on 05 Aug 2008 TV One News announced Skycam were co-operating with Boeing, who also happen to now own Insitu the makers of the ScanEagle, which was used to develop the NanoSAR. Boeing, who are relatively late entrants in the UAV business have started an aggressive campaign buying up smaller companies,[40] perhaps in an attempt to prevent Northrop Grumman getting too much of a lead in the market. Once OIF and OEF draw to a close and NAS integration issues are resolved, an explosion of civilian applications is expected.

With Tier 2(+) machines, C^2 becomes a lot more sophisticated with remote split operations (RSO) being commonplace. RSO is simply control of a UAV through a geographically separate GCS connected by UHF satellite communications (SATCOM).[41] Typically, a specialised GCS element, using a LOS data link used only for launch and recovery (LRE), conducts take-off and landing in-theatre. Once the unmanned aircraft (UA) is airborne the autopilot will be activated to fly it to the first waypoint and then a remote mission control element (MCE), often located in the US in the case of OEF and OIF, will take control and fly the mission and operate sensors via Ku-band SATCOM, which can also be used for C^2, as in the Predator. When the mission is finished, the pilot at the LRE will retake control once it is within LOS, and land the aircraft. During OIF two LREs operating in-theatre demonstrated 'surge' operations by simultaneously controlling four airborne Predators continuously for seven days before bad weather finally curtailed operations.[42] As much as anything this was a very good demonstration of the reliability of a modern UAS. Though in reality, the resources required to perform such a 'surge' were truly astronomical and are the exclusive domain of the US military, and even so, the operation seems to have been hanging by a thread at times with numerous communications issues.[43] In the New Zealand maritime domain, it is unlikely that a requirement would exist for

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[39] Skycam ppt presentation slide 10. According to Tim Brooks, Skycam's systems engineer, it is hoped to demonstrate an eight hour endurance flight in the near future: personal discussion, 29 Jan 2009.

[40] Flightglobal, *Boeing moves to buy UAS specialist Insitu*, 22 Jul 2008, accessed 13 Jan 2009 at http://www.flightglobal.com/articles/2008/07/22/225969/boeing-moves-to-buy-uas-specialist-insitu.html.

[41] UAS Roadmap, p.C-3.

[42] Ibid.

[43] Ibid.

more than one UAV (Tier 2) to be airborne at a time apart from during occasional high intensity operations.

While a smaller UAV, such as might be used by MFish or Customs in coastal areas, operates on a closed circuit with sensor products likely to be restricted to portable units in the field, this is not sufficient for machines operating in the larger strategic environment. Information may need to pass to a number of agencies simultaneously and this requires a network structure. New Zealand has no such structure at the moment but the latest update to the *LTDP* includes a Network Enabled Capability Strategy for the first time.[44] In it is outlined the intent to provide a modern joint communications system based around a satellite communications capability, which is expected to be implemented over the next five to ten years. It is also expected that the first phase of the JCCS will be in place by 2012 for the purpose of storing, collating, processing, and disseminating a wide range of information as rapidly and securely as possible.[45] These projects have been planned for several years and it is hoped that real progress will be made and that capacity has been factored in for additional ISR assets in the future. The US Common Data Link (CDL) programme provides the means to meet ongoing wide-band, communications requirements. CDL is a full duplex, wide-band data link that connects the UA to its control station either directly or via SATCOM. The control station generally transmits command and control data at 200Kbit/s, but receives sensor product at up to 274 Mbit/s.[46] The interoperable Tactical CDL, which operates on LOS principles, also shows promise for some UAV EEZ surveillance applications and has been demonstrated, it is believed on a Predator, at ranges out to 300 miles.[47]

SATCOM are valuable but they create their own problems due to the long distances involved with geostationary satellites, which might be sitting around 22,000 miles above the equator. This greatly reduces, typically by a factor of a million, the available bandwidth for a fixed antenna size and radiated power, compared to LOS communications. This is why some UAVs either have large bulbous noses or carry large pods, to house the approximately 1m dishes needed

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[44] *LTDP* Sept 2008 update.

[45] *Air Force News*, RNZAF, Wellington: February 2009, p.27.

[46] *UAS Roadmap*, p.C-7.

[47] BAE Systems, Tactical Common Data Link, http://www.baesystems.com/ProductsServices/bae_prod_eis_tcdl.html, accessed 14 Feb 2009.

to talk to distant satellites using transmitters that consume a major fraction of the onboard power.[48] By way of contrast, using only 20 centimetre antennas, a network of LOS UAVs and surface units can exchange a thousand times more data with only one-fortieth of the power. The need to limit antenna footprint makes a theatre AV communications network that does not involve SATCOM very attractive. Efforts are underway to build AVs that have an endurance measured in years and the role of such machines, acting as relays and possibly as nodes in a network enabled JCCS, in expanding the bandwidth and capability of a C^4 network, may end up being as important as their ISR role.[49] The life-cycle cost of operating these 'low-orbital satellites' over a similar 10 to15-year life-span of a satellite promises to be very attractive compared to the around $600million to build and launch a satellite.[50]

In the context of navigating and being equipped to find things, UAVs are at the least the equal of manned aircraft. In the case of the smaller UAVs there is no manned equivalent as such, and they therefore represent a new capability as where once there were no options for aerial surveillance, there is now Tier 0 and Tier 1 UAVs. In general terms of aerial maritime surveillance, by which is meant flying a maritime patrol, New Zealand would mainly be considering Tier 2 machines, such as Heron or Predator B.[51] Until recently General Atomics had a maritime demonstrator version of its Predator B called Mariner, which was a capable machine that was a candidate for the USN Broad Area Maritime Surveillance (BAMS) project.[52] Mariner was also successfully demonstrated to the Australians during August and September 2006 as part of the North West Shelf Unmanned Aerial System Trial hosted by DSTO.[53] The demonstration appears to have answered all of the Critical Operational Issues to be measured, which were; surveillance capability; response capability; and Australian environment.[54] The Australian Air 7000 project aims to replace the AP-3C

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48 Committee on Autonomous Vehicles in Support of Naval Operations, *Autonomous Vehicles in Support of Naval Operations*, National Research Council: 2005, p.169, downloaded from http://www.nap.edu/catalog/11379.html, accessed 24 April 2008.

49 Ibid.

50 Internet VSAT access via satellite: Costs, http://www.satsig.net/ivsatcos.htm, accessed 27 Feb 2009.

51 See Appendix A p. 140 and p.138.

52 Northrop Grumman, BAMS UAS, http://www.is.northropgrumman.com/systems/bams.html, accessed 19 Jan 2009.

53 DSTO, North West Shelf Unmanned Systems Trial, http://www.dsto.defence.gov.au/publications/scientific_record.php?record=8737, accessed 13 Jan 2009.

54 Duncan Craig, p.17.

capability, commencing from 2014, with a mix of manned and unmanned systems. Phase 1 calls for a High Altitude Long Endurance (HALE, Tier 2+) UAV to be introduced prior to the introduction of Phase 2, which is the manned system.[55] The Mariner was a serious contender, but it is likely that a Global Hawk derivative will be selected following the selection of Global Hawk for the USN BAMS project, ahead of the Mariner.[56] Since then the Mariner seems to have been quietly removed from all General Atomics publicity material and web site. This is unfortunate as this particular UAS was used as a model to compare with manned systems. However, the Mariner, as a derivative of the Predator B is so similar that reference can be made to it for the purposes of comparison.

What is clear is that there are as many UAVs with varying capabilities as there are applications for them. In an ideal world a layered approach would be taken by way of a modular force. The variation in operating environment and capability is shown in the illustration below. When looking at the illustration it is

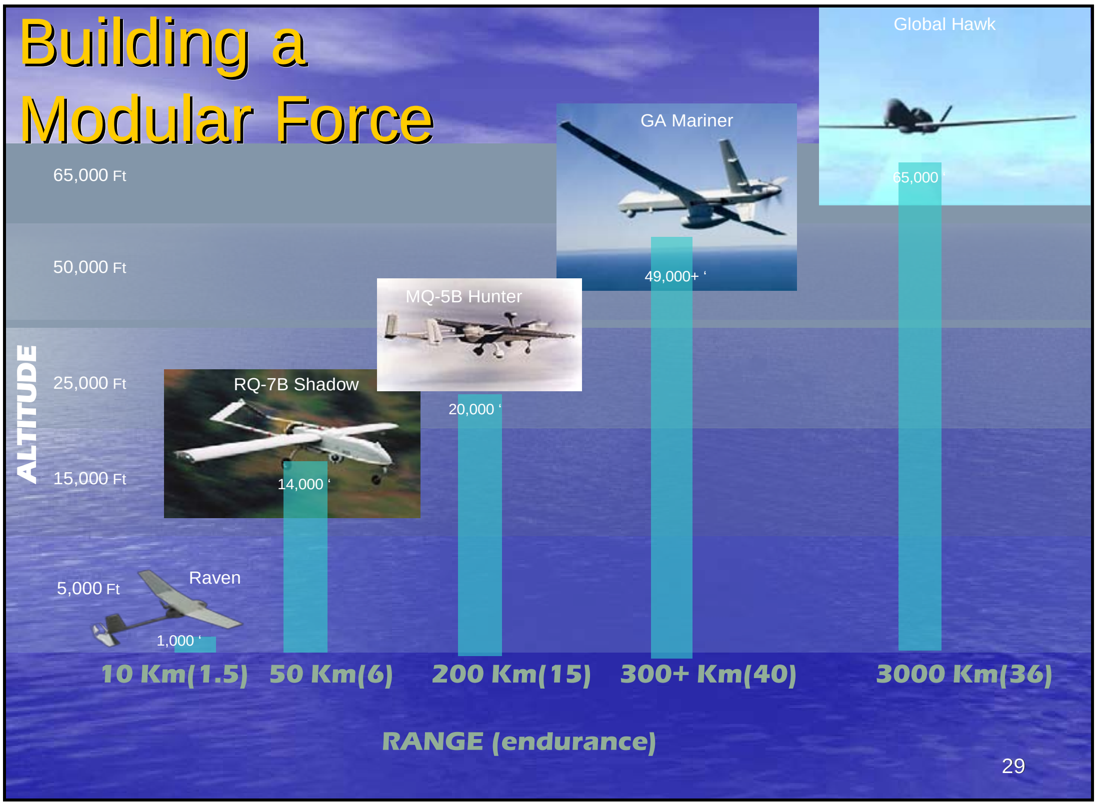

Fig. 13. The Layered Approach

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55 Australian Government, DoD, Projects, AIR 7000: Phases 1B and 2B, http://www.defence.gov.au/dmo/asd/air7000/air7000.cfm, accessed 13 Jan 2009.

56 Gregor Ferguson, C4ISR, *Trans-Pac partner, Australia follows US maritime surveillance lead,* 04 Jan 2008, viewed at http://www.isrjournal.com/story.php?F=3163319, accessed 01 Mar 2009.

worth noting that the RF footprint gets larger as altitude increases, therefore adding to the crowding effect of the sensor product.[57] New Zealand's requirements for aerial surveillance of the littorals and the EEZ probably lie somewhere between the four smaller UAVs shown; there being no justification for a machine with the capability of Global Hawk at this point in time. This may change when the Orions become due for replacement as a machine similar to Global Hawk might be a prime candidate, dependent on the prevailing strategic forecast. As has previously been discussed, both the US Navy and the RAAF will be replacing some of their manned surveillance aircraft with a version of Global Hawk by the middle of the next decade, while the German Air Force is replacing its entire fleet of Breguet Atlantic maritime surveillance and reconnaissance aircraft with a version named Euro Hawk, at around the same time.[58] The next chapter will compare possible options for aerial maritime surveillance in the New Zealand environment and look at the advantages and limitations of each, as well as challenges that are still to be overcome.

[57] If the RF sensor sweep of an aircraft is assumed to be in the form of a cone, then the base of the cone represents the surface area being swept by aircraft sensors. Basic geometry tells us that increasing the height of the cone has an exponential effect on the base area of the cone, e.g. an aircraft flying at 60,000 ft will produce a footprint nine times that of an aircraft flying at 20,000 feet, i.e. one-third of the height. An illustration of this can be seen on a BAMS promotional video at http://www.is.northropgrumman.com/systems/bams_gallery.html.

[58] Defense Update, *German MOD launches a €430 million Euro Hawk*, http://www.defense-update.com/newscast/0207/news/010207_eurohawk.htm, accessed 14 Jan 2009.

Chapter 5

CAPABILITIES AND CHALLENGES – IS THERE A DOWNSIDE?

Should a decision ever be made to increase aerial maritime surveillance of the EEZ there are three possible solutions. In general terms it would be useful to briefly expand on any advantages and disadvantages of each option. However, before discussing the positives and negatives of the options it is timely to point out that New Zealand has been a signatory of the Missile Technology Control Regime (MTCR) since 1991. The aim of the MTCR is to:

> restrict the proliferation of missiles, complete rocket systems, unmanned air vehicles, and related technology for those systems capable of carrying a 500 kilogram payload at least 300 kilometres, as well as systems intended for the delivery of weapons of mass destruction (WMD). [1]

The Regime rests on adherence to common export policy guidelines applied to an integral common list of controlled items i.e. it restricts the proliferation of the items described above through voluntary export controls. The majority of major international players are signatories apart from China and North Korea, and in the context of major UAV producers, Israel is unsurprisingly absent. Being a signatory does not extend any privileges and it is clearly stated: 'that membership in the MTCR does not involve an entitlement to obtain technology from another partner and no obligation to supply it.'[2] So at first glance it might appear that should New Zealand ever wish to obtain a Tier 2 type machine for maritime surveillance, which is a Category I restricted item under the terms of MTCR, it might be necessary to reassess its principles beforehand.

However, since the inception of the MTCR in 1987, international events have moved on and are not quite so clear cut. In 1987 the Cold War was drawing to a close and no one was really sure what the new world order might look like. The MTCR was established with this in mind, being unsure if chaos or peace would prevail, and specifically what might happen to the stockpile of

[1] MTCR, Objectives of the MTCR, http://www.mtcr.info/english/objectives.html, accessed 27 Nov 08.

[2] Ibid.

weapons held by the Soviet Union. The main concern at the time was to prevent the proliferation of the means of delivery of WMD,[3] possibly to what are now commonly referred to as 'rogue states'. However, since the attack on the World Trade Centre, of perhaps more concern now is to prevent individuals and terrorist groups from obtaining the means to deliver WMD. The MTCR though is not a block to trade; it is merely an undertaking by signatories to act responsibly in their dealings.[4] The MTCR has not prevented the United States, for instance, from exporting Predators to Italy and the United Kingdom. However, it may be perceived by some action groups and individuals in New Zealand as a means of preventing UAVs from being obtained regardless of their intended purpose. UAVs, and in particular, derivatives of Predator, have had a sinister aspect attributed to them by the media and various other groups, being likened to aerial assassins.[5] Whether such hurdles have to be jumped in New Zealand remains to be seen.

Background

As has been discussed in the previous chapter, facilities for data transmission and dissemination in real-time do not currently exist in New Zealand, though a network enabled capability strategy is now in place.[6] Any option would need to be able to capture video evidence as it unfolds, by standing-off and taking advantage of low-observability characteristics and then provide near real-time streaming video to whoever needs to see it; be it other aircraft, patrol vessels, or MFish and Customs legal and operations people sitting in their offices. Such a capability is the minimum that needs to be provided for the people who are at the front-line of New Zealand home security to achieve the desired effect of increased MDA. Any costs associated with this particular capability would be common to all, and is not a point of difference between options. Capital costs for initial purchase of equipment are not considered either, for the following reasons. A number of documents and publications purport to provide costs of various items of equipment, but they vary considerably

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[3] MTCR, Objectives of the MTCR.

[4] MTCR, MTCR and Trade, http://www.mtcr.info/english/trade.html, accessed 18 Jan 2009.

[5] Typical examples being http://warisboring.com/?cat=24,http://minstrelboy.blogspot.com/2008/03/war-is-boring-israels-aerial-assassins.html, and http://www.cnn.com/2006/TECH/06/23/supersonic.bomber/index.html, accessed 18 Jan 2009.

[6] *Defence Long-Term Development Plan: Update September 2008*, p.11.

dependent on numbers, types of sensors, spares acquired, the level of contractor support etc. While acknowledging the difficulties of providing an answer I approached General Atomics as to what a typical Mariner UAS might cost that could generate three to four sorties a week, and received the following answer in part:

> the requirement will determine the number of aircraft, ground control stations, communications equipment, sensors and payloads, spare parts, support equipment, training, contractor support, etc. What is certain is that the life cycle cost is substantially less than manned aircraft (very much less than the P-3). [7]

A guide to initial cost is that the (US) Department of the Air Force fact sheet on the MQ-9 Reaper UAV states a unit cost of US$53.5 million (fiscal 2006 dollars) which includes four air vehicles complete with sensors.[8] This does not include GCS or C^3 equipment.[9]

General Atomics referred to life cycle cost (LCC) and this is an often used term with reference to military equipment acquisition, so an explanation of its meaning is appropriate. According to Barringer: [10]

> Life cycle cost is the total cost of ownership of machinery and equipment, including its cost of acquisition, operation, maintenance, conversion, and/or decommission (SAE 1999). LCC are summations of cost estimates from inception to disposal for both equipment and projects as determined by an analytical study and estimate of total costs experienced in annual time increments during the project life with consideration for the time value of money. The objective of LCC analysis is to choose the most cost effective approach from a series of alternatives (note alternatives is a plural word) to achieve the lowest long-term cost of ownership. LCC is an economic model over

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[7] John Porter, Deputy Director, Business Development, General Atomics Aeronautical Systems Inc., Aircraft Systems Group, San Diego, personal correspondence, email 12-29 July 2008.

[8] http://www.af.mil/factsheets/factsheet.asp?fsID=6405, accessed 18 Mar 2008.

[9] A recent report in *AW&ST*, November 10, 2008, p.31, stated that Predator now cost $5 million and Reaper $13 million, which would indicate that the cost in real terms is coming down, for the US Air Force at least..

[10] H. Paul Barringer, Barringer & Associates, Inc., Humble, Texas, *A Life Cycle Cost Summary*, paper presented to the International Conference of Maintenance Societies (ICOMS®-2003), Perth, Western Australia, May 20-23 2003, p.2.accessed 09 Nov 2008, viewed at, http://www.barringer1.com/pdf/LifeCycleCostSummary.pdf.

the project life span. Usually the cost of operation, maintenance, and disposal costs exceed all other first costs many times over (supporting costs are often 2-20 times greater than the initial procurement costs).

When the Orions were obtained in 1966, it can be certain that no one anticipated a projected in-service life of around 60 years. The major factor that is likely to have contributed to the longevity of the Orion is that there has simply not been anything better available. However, inevitably a point is reached where the costs of upgrading aircraft together with ever increasing maintenance costs associated with age no longer make it economically viable.[11] The Australians appear to have made the decision to retire their Orions between 2014 and 2018.[12] The Australians are currently negotiating to participate in the P-8A Poseidon multi-mission maritime aircraft (MMA) programme and it is expected they will begin to enter service from 2014.[13] However, a recent report stated that a joint Lockheed Martin/Australian Aerospace proposal to re-wing ten of the RAAF's AP-3C Orions might see changes to project AIR 7000, though no official response has yet been given.[14] The re-wing would add at least 15 years to the airframe life of each aircraft. While a decision on the proposal is not expected until the publication of the 2009 Defence Capability Plan, to enable the current aircraft out to their projected retirement date, 18 Australian AP-3Cs underwent a not dissimilar upgrade to that which the New Zealand Orions are undergoing at the time of writing. Under Project Air 5276 the Upgrade Project replaced five major sub-systems on the aircraft, namely the radar, acoustics, navigation, communications, and data management system (DMS – the aircraft's central computer). The Upgrade Project also included the acquisition of operational support systems, comprising an Operational Mission Simulator (OMS) for the training of operational crews, a Systems Engineering Laboratory (for software maintenance and development, technical research and modification

[11] *JSCFADT Defence Sub Committee, Inquiry into Defence Annual Report 2006-07, 29 August 2008, Responses to questions taken on notice, and in writing, by the Department of Defence* , gives a summary of the problems faced by the RAAF during 2006-2007, http://www.aph.gov.au/house/committee/jfadt/defenceannualreport_2006_2007/subs/sub10.pdf, accessed 03 Feb 2009

[12] Gregor Ferguson.

[13] Multi-mission Maritime Aircraft based on a modified Boeing 737-800ERX which will enter low-rate initial production for the USN from c2010. It is planned to replace 196 P-3C Orions with 108 P-8 aircraft plus Global Hawks, http://www.globalsecurity.org/military/systems/aircraft/p-8.htm, accessed 27 Oct 2008.

[14] Nick Merret, 'Orion to Poseidon: Defence Ponders bid to extend Orion, delay P-8 buy', *Australian Aviation*, March 2009, pp.28-31. As this is merely a proposal at this stage, no account is taken of it in the remainder of the thesis.

development) and a Mission Replay and Analysis Module (for pre- and post-flight mission support).[15]

Such complex upgrades are fraught with risk and this one proved no different. Initially a budget for the upgrade was set at around $775 million with delivery of the first upgraded aircraft set for around April 1998. The first aircraft was accepted by the RAAF in July 2002, 51 months late, and delivery of the final aircraft took place in December 2004. Final costs came in at around $1.17 billion.[16] The final stage of the upgrade has recently been committed to and will cost another $77 million to equip the 18 AP-3Cs with electro-optical/infrared sensors, tactical common data-links and replacement video recorders, by 2011.[17] The final costs for the Australian upgrade will come in at around $1.2 billion for 18 aircraft. These costs for what has turned out to be an effective system, puts in perspective the forecast $600 million for the previously proposed, and subsequently cancelled, 'Sirius' upgrade which in effect was going to cost 50 per cent more than the Australian upgrade and this makes no consideration on any cost overruns on the New Zealand project. In retrospect it appears the Labour government had every right to be alarmed. The simple truth is that upgrading small numbers of aircraft with a custom made system is not economically sound, as a great deal of the cost is consumed in development regardless of how many aircraft are modified. New Zealand has on more than one occasion ended up with unique equipment that is difficult to support.[18] Simple extrapolation, though in itself unscientific, might imply the current New Zealand upgrade is similarly priced to the Australian upgrade, though the Australian upgrade is more comprehensive and geared as much to war-fighting as surveillance.[19]

It is perhaps not entirely appropriate to compare the Australian situation with that of New Zealand, as circumstances are somewhat different. The

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[15] Australian National Audit Office report, http://www.anao.gov.au/director/publications/auditreports/2005-2006.cfm?item_id=1EB34679F43AC17265AB2585868404F3, accessed 12 Nov 2008.

[16] Ibid

[17] *Flight International*, 26 August-1 September 2008, p.18.

[18] The RNZAF's MB 339 advance trainer being the most recent example.

[19] http://www.defencetalk.com/forums/archive/index.php/t-2211.html, accessed 19 Jan 2009, while unofficial and in the face of lack of detailed official information, this site seems to provides a useful summary of the upgrade which included updates both to the acoustic suite and the magnetic anomaly detection (MAD) system, both of which are used to detect and track submarines. The Australian National Audit Office Report on Project Air 5276 refers to 'upgrading the aircraft's combat systems to ensure its military effectiveness', http://www.anao.gov.au/director/publications/auditreports/2005-2006.cfm?item_id=1EB34679F43AC17265AB2585868404F3, accessed 20 Jan 2009.The RNZAF upgrade does not include upgrades to these systems.

reasons as to why the Australians chose to upgrade was that a suitable replacement was not available, and that the aircraft mission systems were becoming increasingly difficult and costly to support. Project Air 5276 specifically addressed mission systems obsolescence, though any further airframe upgrades are unlikely.[20] The RAAF aircraft are also more likely to be involved in raised threat operations than New Zealand aircraft, which is a reflection of Australian foreign and defence policy. The RAAF Orions for instance are heavily tasked in the Middle East.[21] In other words the Australian need was more urgent from an operational viewpoint. Hence, this may explain why the New Zealand upgrade does not include the aircraft's combat systems, which are those used in the anti-submarine and anti-surface roles. The consequence of this is that the New Zealand Orions have no stand-off weapons capability,[22] are incapable of dealing with all but the lowest level surface threat, and are also largely unsuitable for routine patrols of the EEZ due to their high operating costs.[23]

The Australian government has given first pass approval for the forecast $4.5 billion project to obtain the manned aircraft component that will replace the AP-3C.[24] However, they have also recognised that the increased need for resource and border protection, among other types of surveillance, will be better met with specialised aerial ISR platforms that are an alternative to manned aircraft. Phase 1B of AIR 7000 has approved up to $1.7 billion to consider and further develop options leading to the acquisition of a HALE unmanned aerial system that can perform all-weather, long endurance surveillance and reconnaissance tasks over maritime and land environments. The Phase 1 capability is an essential adjunct to the manned capability acquired under Air 7000 Phase 2B. [25] In the pure aerial maritime ISR role the Americans and the Australians clearly believe that an UAS can perform the job better than a manned system.

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20 Australian Government, DoD, Projects, AIR 7000: Phases 1B and 2B.

21 Gregor Ferguson.

22 The *NZDF Annual Report 2007*, p101, remarked that: Aircraft self-protection, under-surface sensors and weapon capability are inadequate for full employment across all contemporary P3 roles' and further that 'The MPF had insufficient weapons, expendables and technical stores to generate OLOC for other than short term, low threat environments'.

23 *MPR* p.27.

24 DIISR, AIR 7000, http://www.innovation.gov.au/General/MEC-JSFIT/Pages/Air7000.aspx, accessed 12 Nov 2008.

25 Australian Government, DoD, Projects, AIR 7000: Phases 1B and 2B.

However, in the context of the current situation in which the decision was made to upgrade the RNZAF Orions, the government appears to have had little choice. The systems are obsolete and unsuitable for effective surveillance in the modern sense. The surface detection systems date from the early 1980s and the underwater detection systems are based on 1960s technology. [26] Given that the upgrade to the Orions is costing, at least, $373 million,[27] one might suggest that a similar figure might be a reasonable capital cost to apply to any SMRPA or UAS.[28] However, this thesis is neither an exercise in accounting, nor a detailed analysis of life-cycle costs. In the context of maritime security, this thesis examines New Zealand's awareness of activities in its direct areas of interest, being principally the EEZ, and will suggest in general terms how any gaps might be closed. However, even in general terms, reasonable assumptions can be made in regard to operating and maintenance requirements. Beginning with 'aircrew', at first glance the UAV might appear to have a significant advantage. Unmanned is somewhat of a misnomer though, in the general sense of who actually operates them; unmanned merely means the operator is not in the air vehicle.[29] Proponents also talk of autonomy in UAVs though in reality it is limited, in the sense that they are not self governing. They are yet to be able, as a matter of routine, to alter their flight pattern automatically to investigate a self-identified item of interest; although this technology is being developed it is probably some time off. Some systems such as the Global Hawk UAV have embodied high levels of 'automation', based on pre-planning activities, through the provision of an autopilot which controls not only the flight trajectory, but also the management of the sensors and contingency plans for malfunctions or flight options. This technology goes some way to easing communications and operator control pressure, but requires large investment in pre-mission planning, and has an element of inflexibility.[30] In the foreseeable future, autonomy is likely to remain a

[26] *Navy Today*, September 2006, pp.22-23.

[27] Controller and Auditor-General, P-3 Systems Upgrade, http://www.oag.govt.nz/2008/defence/appendix/appendix3.htm, accessed 19 Jan 2009.

[28] The Greek Navy is seeking to replace its fleet of six ageing P-3B Orions with five newer twin-engined types and a budget of US$ 342 million has been identified, but these aircraft will feature ASW and anti-surface warfare equipment which adds considerably to the cost, *Flight International*, 14-20 October 2008, p. 17.

[29] Robert Frampron, UAV autonomy, *Codex*, Issue 1, Summer 2008, viewed at http://www.science.mod.uk/codex/Issue1/Journals/documents/Issue1_2Journals_UAV_autonomy.pdf, accessed 19 Jan 2009.

[30] Ibid, p.2.

decision partnership between the human and the machine.[31] As vehicles they are unmanned, but as a system the 'men' have just been relocated. Depending on the type of UAV and the mission being flown, quite a few 'men' are required to support them.

Manpower and support

The P-3 Orion needs an aircrew of 11 highly trained specialists.[32] To produce a pilot from scratch and to train them to a basic level of competence in maritime operations takes around three years and millions of dollars.[33] The RNZAF trains its own aircrew; it cannot hire civilian qualified pilots and simply convert them to type due to the specialised nature of military flying. Apart from the two pilots, and an engineer, the rest of the crew are largely systems operators. It appears that despite the upgrade in sensor systems, data management systems, and flight management systems, this is still a labour intensive aeroplane, as no evidence has been noted that indicates a reduction in crew levels.[34] The greater quantity of information being produced by the new systems possibly negates this. The Orion is also a labour intensive aircraft in that it requires many hours of maintenance for each hour of flight. A Tier 2 machine such as the Predator B would be much less demanding of maintenance. The Predator is a much simpler airframe and only has those systems on-board that are absolutely necessary to support the surveillance mission. It is likely that a team of four or five technicians would comfortably cope with maintaining a fleet of three machines, dependent on usage, and that maintenance would be relatively straightforward and not too demanding of time compared to a multi-engined manned platform. The airframe itself is made of graphite composite, which behaves much differently to traditional aluminium. The US Air Force has airframes with over 10,000 hours on them with no signs of fatigue.[35] The way in which the systems are operated place very little stress on the aircraft and General Atomics reasonably expect an airframe life of 25,000 hours or more.[36]

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[31] Robert Frampton, p.3.

[32] RNZAF, About Us, P-3K Orion, http://www.airforce.mil.nz/about-us/aircraft/orion.htm, accessed 12 Oct 2009.

[33] RNZAF source.

[34] The opposite appears to be the case with the updated RAAF AP-3C Orions which have a full mission crew of 13, http://www.airforce.gov.au/aircraft/orion.aspx.

[35] John Porter.

[36] Ibid.

As regards 'aircrew' the difference is not as great as one might imagine. With a Predator or Predator B the US Air Force runs its unique system of Remote Split Operations whereby an in-theatre crew, for instance in Afghanistan or Iraq,[37] comprising a pilot, a systems operator and mission co-ordinator housed in a Launch and Recovery Ground Control Station (LRGCS), will launch the Predator and set it up for the mission, and then hand control over, via satellite link, to the mission crew in a Predator Operations Centre (POC) in the US[38] There are a two reasons for this. Firstly, each LRGCS is capable of controlling the launch and recovery of up to four UAVs at a time, which negates the requirement for multiple LRGCS units, and allows the crew to focus on launch and recovery without having to be concerned with the actual mission. Secondly, and more importantly according to the US Air Force: 'The POC is the primary command and control node for MQ-1 Predator mission execution, and is crucial for operation and initial intelligence exploitation of MQ-1 full motion video capability. MQ-1 Predator ISR operations are not possible without an established POC'.[39] In other words the intelligence experts are back in the US at the POC or some other remote station, and there is likely to be a senior officer available to approve strikes and shorten the kill-chain.

In effect the US Air Force operates two crews simultaneously plus exchange duty crews as required dependent on the mission length, which given the endurance of Predator may be up to 40 hours.[40] An unusual consequence of this is that a crew might leave duty partway through a mission, and when they return later pick up a different mission that is already in progress, perhaps rarely finishing what they start and vice-versa.[41] To date the issue of continuity does not appear to be a problem. A maritime surveillance mission would not require two control stations and crews operating simultaneously as the missions would be quite discrete and normally only involve one machine. The exchange crew

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[37] At a base in southern Afghanistan, UAV pilots work 12 hours on and 12 hours off for 120 days straight with no time off, http://www.airforce-magazine.com/MagazineArchive/Pages/2009/January%202009/0109UAV.aspx, accessed 03 Feb 2009.

[38] Ian Kemp, Flying the Predator, *Unmanned Vehicles*, September 2007, p.16.

[39] Ibid.

[40] Ibid.

[41] The example of a Predator mission is given as whereas a number of maritime aerial surveillance trials have been carried out, and a number of projects are underway, such as BAMS and AIR 7000, currently there are no reports of regular and routine long-endurance maritime surveillance missions being carried out by UAVs that the author is aware of. The only

arrangement has the advantage of greatly mitigating the issue of crew-fatigue. Typically four air vehicle operators (AVOs) would be required for a long endurance mission, two for each shift.[42] The crew that launched would carry out the first phase of a flight and hand over to an oncoming crew. The minimum crew required would be an AVO, who would also usually be the mission commander (MC), a sensor operator (SO), and a data exploitation manager to record, annotate and disseminate information as required and act as an adviser to the MC.[43] This is significantly less in number than an Orion crew. If continuous coverage over 24 hours was required the difference between a UAV and a maritime patrol aircraft, such as the Orion, is even more marked, given that two manned aeroplanes and two crews would be required.

A request was made to General Atomics for a detailed breakdown of personnel requirements for the operation of a Predator type machine, which was not forthcoming for similar reasons as to why they could not provide costs.[44] General Atomics did remark that:

> The number of personnel required to operate and maintain the system is based on CONOPS, operational tempo, and manning policy (US Air Force mans their systems with many more personnel than we as a company do). You could easily support sustained 24/7 operations of a single aircraft with a crew of 25-30. [45]

This figure, which at first glance, seems quite high to support just one machine, should be viewed in the context of 24 hour a day high-intensity military operations, with probably four 'aircrews' and perhaps two or possibly three crews of technicians. Regardless, a UAS such as Predator still requires significant support and infrastructure. A typical US-deployed Predator A system configuration would include four aircraft, one ground control system and one

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known routine use of large UAVs for civilian security purposes, is the use of Predator Bs by the US Customs and Border Patrol covering the Mexican border.

42 Robyn Hopcroft, Eleanore Burchat, and Julian Vince, *Unmanned Aerial Vehicles for Maritime Patrol: Human Factors Issues*, Air Operations Division, DSTO, May 2006, p.20.

43 Ibid.

44 Refer p.82.

45 John Porter.

Trojan Spirit II data distribution terminal.[46] The Predator air vehicle is 27ft in length and has a 49ft wingspan (36 ft and 66 ft for the B). The system operates at an altitude of 25,000ft and at a range of 400 nautical miles.[47] The endurance of the air vehicle is more than 40 hours and the cruise speed is over 70 knots. The air vehicle is equipped with UHF and VHF radio relay links, a C-band line-of-sight data link which has a range of 150nm and UHF and Ku-band satellite data links.[48]

The system would require around 55 people for deployed 24-hour operations in US Air Force service, as well as two C-130s to transport them.[49] If a UAV was to operate out of LOS, which would be a must in the maritime surveillance role in New Zealand's EEZ, it would need SATCOMs and associated hardware, as well as a hangar for storage and servicing of the UAVs. In New Zealand in the maritime surveillance role, permanent infrastructure would be installed which would greatly simplify things and significantly reduce manpower, and it is well recognised that civilian organisations run ‘lean and mean’ compared to their military counterparts.[50] While it is not specifically known what the turnaround time is between sorties, experience would suggest that such a relatively conventional machine would probably require minimum maintenance between sorties. The aircraft could probably be ready for flight again in an hour or two, with some form of more detailed phase inspection required every 200 hours or so, similar to a small commercial type such as the Hawker Beechcraft King Air.[51] In reality it is difficult and probably pointless to try and compare what manpower requirements would be for sustained manned aircraft operations. There is no real comparison to be made with a manned aircraft, as a Predator B can fly for up to 30 hours[52] which is really a whole new capability, with its own discrete set of requirements.

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46 Airforce-technology.com, Predator RQ-1/MQ-1/MQ-9 Reaper, http://www.airforce-technology.com/projects/predator/, accessed 20 Jan 2009.

47 Nautical miles are commonly used in the aviation industry. 400nm equals approximately 460 statute miles or 740 kms.

48 Airforce-technology.com, Predator RQ-1/MQ-1/MQ-9 Reaper.

49 Air Force Link, MQ-1 Predator UAS, http://www.af.mil/factsheets/factsheet.asp?fsID=122, accessed 18 Mar 2008.

50 John Porter.

51 Beech Super King Air 200 Series Maintenance Manual AF101-0010-19.

52 John Porter.

While the NZDF expects its Orions to continue in service until 2025, as previously stated the Australians are not prepared to invest in any further major airframe upgrades and will begin replacing their Orions with a mix of manned and unmanned systems from 2014, probably comprising Global Hawk UAVs and P-8 Multi-Mission Maritime Aircraft (MMA).[53] The AP-3C replacement is part of the AIR 7000 project which was initiated to consider whether to refurbish the Orion fleet, or replace them. All the indications are that no more money will be spent beyond the recent systems upgrades, and a new aircraft is the preferred choice, for good reason. The preamble to the AIR 7000 Project introduction stated:

> The life-of-type for the AP-3C is being driven by the increasing cost of addressing airframe fatigue and corrosion, aircraft system supportability and mission system obsolescence. The airframe and aircraft systems, including engines, hydraulics, electrical and fuel systems will become more costly to support as the aircraft ages. [54]

It appears the attraction that each generation of aircraft brings, such as being more capable, while also being a less demanding to own and operate, together with the Australian view that there are limits to airframe refurbishment, has proven compelling. The USN are also experiencing severe difficulties with corrosion in their aircraft [55] and are hoping to move the introduction of the P-8 forward by six months.[56]

The RNZAF Orions were valued by the Australian government as a complement to their own fleet and they were keen for Project Sirius to go ahead as it would have meant a high level of interoperability between the two nations' aircraft. Australian displeasure was made known when Project Sirius was cancelled.[57] The RNZAF Orions are unlikely to be an attractive option for further upgrades, and one can only speculate at what level of serviceability and supportability will be attainable in the future; given that the Americans, the Australians and possibly the Canadians are likely to have only a few in service by

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[53] DIISR, AIR 7000.

[54] Australian Government, DoD, Projects, AIR 7000: Phases 1B and 2B.

[55] Defense Industry Daily, *P-3 Recovery Plan Tries to Keep the Fleet in the Air*, 30 Nov 2008, accessed 14 Feb 2009 at. http://www.defenseindustrydaily.com/P-3-Recovery-Plan-Tries-to-Keep-the-Fleet-in-the-Air-05051/.

[56] Flight International, 13-19 Jan 2009, p.15.

[57] Hon John Moore, New Zealand Defence Acquisitions, accessed 20 Jan 2009 at http://www.minister.defence.gov.au/MooreTpl.cfm?CurrentId=130,.

2020. As far as patrolling the EEZ in support of civilian organisations is concerned, the RNZAF will have the right sensors in the wrong platform.

A SMRPA such as a multi-mission Dash 8 Q series appears to be more suited to patrolling New Zealand's EEZ for a variety of reasons.[58] Any new aircraft would be significantly less manpower intensive in regard to the hours flown versus the maintenance required. Civilian aircraft maintainers have a different maintenance philosophy to the military, especially so with newer aircraft. Many items are 'condition monitored' rather than regularly removed for servicing as in a military aircraft.[59] An aircraft such as a Dash 8 is meant to be flown every day, not once or twice a week, and in airline service they would probably accumulate 40-50 hours of flying a week. It is not unusual for medium sized commuter airliners to operate at a greater than 95 per cent serviceability rate over their projected initial life of around eight to ten years from new[60] – a figure beyond comprehension in the context of a 40 + year old military aircraft. It would not be beyond expectation that a Dash 8 would be out on patrol every day. A minimum of two aircraft would be required for maritime patrol activities amounting to around 3000 hours a year as indicated by the *MPR*. Aircrew is typically four with two pilots and two sensor operators.[61] Both the Orion and the Dash 8 can accommodate specialist personnel (for example MFish or Customs officers) as required. As previously stated, pilots would be qualified at recruitment and could be qualified on type through a local flight training organisation if required. Training requirements for sensor operators are usually via equipment suppliers courses or conceivably through the Australian Border Protection Command if similar equipment were fitted. Unlike their military counterparts any SMRPA would be dedicated to maritime surveillance of the EEZ, and not be encumbered with other types of operations that involve additional training. Air Nelson could probably maintain the aircraft through their existing facilities, and most local

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[58] See App A p. 124 for technical overview.

[59] Condition monitored maintenance means a maintenance process that monitors maintenance trends, and relies upon analysis of the operating experience of the whole population of specified items to indicate nascent failures requiring corrective action, NZ Civil Aviation Rule Part 1 p.31.

[60] Air New Zealand Beechcraft 1900 commuter aircraft currently achieve around a 96.5% serviceability rate according to Mike Mitchell, a maintenance engineer and systems trainer for Eagle Air; remarked during a B200 systems course held at RNZAF Base Ohakea 28 Oct-07 Nov 2008.

[61] Annex IIIA of MPR, *Review of Maritime Patrol Requirements*: Ministry of Fisheries, November 2000, p.53.

airports have some level of support for the type which would facilitate operating from different parts of the country.[62]

Other factors

The previous Labour government introduced a carbon neutral public service programme that supports the wider government strategy to reduce the impact of climate change; including the emissions trading scheme, increasing renewable electricity generation, improving energy efficiency, and initiatives for sustainable land management.[63] Reducing the country's carbon footprint is now a high priority. As a nation New Zealand is becoming increasingly environmentally aware and now seems to expect the government of the day to take whatever steps necessary to protect it. There is no reason why, in the context of routine activity, such as maritime surveillance of the EEZ, the NZDF or any agency associated with national security, should be immune from any government policy associated with reducing carbon emissions. Simple logic would indicate that, for instance, a General Atomics Predator UAV with a take-off weight of 4,537 kilograms and powered by a state of the art 900 shaft horse power (shp) turboprop,[64] has less of a footprint over any given distance than an Orion with a take-off weight of 54,950 kg (27,300 kg of which is fuel) powered by four engines producing 18,400 shp.[65] U.S. Air Force Secretary Michael Donley recently signed into effect The Air Force Energy Program Policy Memorandum that will function as the blueprint for its energy initiatives, being aimed at changing the air service's energy usage habits. Major goals outlined in the memorandum included cutting aviation fuel-use per operation hour by 10 percent (from a 2005 baseline) by 2015, as well as to "be prepared" by 2016 to "cost-competitively" acquire half of the Air Force's domestic aviation fuel from a domestic alternative fuel blend.[66]

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[62] Air Nelson operates a fleet of 20 Dash 8 Q300s which it maintains in-house, http://www.airnelson.com/about_us/company_facts.htm , accessed 19 Jan 2009.

[63] Steve Chadwick, *New projects to reduce carbon footprint under Kyoto*, 12 Dec 2007, http://www.beehive.govt.nz/release/new+projects+reduce+carbon+footprint+under+kyoto, accessed 05 June 2008.

[64] *Complete Guide to Drones*, p.19

[65] RNZAF, About Us, P-3K Orion.

[66] Bettina H. Chavanne, USAF Unveils Energy Program Policy, *Aviation Week*, 07 Jan 2009, viewed at http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=defense&id=news/ENERGY010709.xml&headline=USAF%20Unveils%20Energy%20Program%20Policy , accessed 27 Feb 2009.

The Orion accounts for a significant amount of MFish's carbon footprint, which given the hours is quite revealing.[67] A Dash 8 would probably produce around 25 per cent or less of an Orion's carbon footprint over a given distance. In pursuit of range, especially in larger aircraft, the point is eventually reached where a significant amount of the fuel burn is used just to keep the remaining fuel aloft. MFish were sufficiently concerned to enquire of the RNZAF if the carbon emissions could be lowered.[68] It is understood that the RNZAF is currently in the initial stages of assessing the suitability of bio-fuels for its aircraft.[69] A Tier 2 machine, such as a Predator B with only one modern and efficient turboprop of modest power, is probably only producing around 25 per cent of the footprint of the Dash 8, based on the amount of fuel carried and the potential endurance. While the impact on the environment would be mitigated, the impact on the size of the government's fuel bill is also an advantage. It is possible that in future, government decisions in regard to all future activity or projects will be scrutinised for environmental impact, and the NZDF will not be totally immune.

An advantage of a UAV or SMRPA is that as part of a dedicated service they would be available 24/7 and could respond quickly to urgent requests for surveillance or tracking or a SaR should the occasion demand.[70] An Orion is available for search and rescue on around 2 hours notice,[71] and it would be reasonable to expect a similar response from any dedicated service in carrying out their core function. Of course, on any mission, be it routine patrol or a response sortie at short notice, the UAV does have a significant advantage. A Predator B has an endurance double that of either manned option. While this would not always be called upon, it would be an invaluable capability to have when required, and also lends itself to potential 24/7 coverage should the need arise. It is by no means speculation to consider the Predator B as a suitable basis for a dedicated maritime surveillance machine as two United States

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67 Gary Orr.

68 Ibid.

69 RNZAF source.

70 Annex II to *MPR*, under heading Operational Response, no page numbers given.

71 The author states this as fact having served on 5 Squadron.

agencies are currently considering their unmanned aerial systems needs and Predator is emerging as the obvious candidate.

Customs and Border Protection (CBP), who are the only civilian federal agency operating a fleet of UAVs, and the US Coast Guard (USCG), are both seeking to carry out maritime surveillance with UAVs. [72] It appears that both organisations may have a similar requirement for land-based maritime surveillance. A Predator B fitted with maritime radar has already been jointly funded and tested off the coast around Florida and the Caribbean in support of Coast Guard and Homeland Security missions.[73] The Coast Guard have been considering a vertical take off and landing unmanned aerial vehicle (VUAV) for some time, but the Bell Eagle Eye VUAV which was at the heart of the project was cancelled. Since then the MQ-8 Fire Scout VUAV has emerged as a suitable machine to fly off the Coast Guard's new National Security Cutter. Rear Admiral Gary Blore, the USCG's Chief of Acquisition, remarked that the suggestion had been made that rather than just flying a VUAV from the backs of the cutters, a land-based MALE UAV was also needed for maximum effect. [74] In the short-term, focus is on a VUAV for the cutters and over the longer-term a land-based UAV is considered necessary to improve situational awareness at Coast Guard command centres,[75] though officially there is no acquisition project in place for this capability.[76]

CBP states that its main requirement is to detect fast boats smuggling drugs and people into the US, usually at night, while the Coast Guard require a machine to assist with its full range of missions including SaR and environmental monitoring.[77] It is planned that an example of a marinised version of the Predator B will be flying with CBP in 2009. It appears that to convert the Predator B into a dedicated maritime surveillance machine requires

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[72] John M Doyle, 'Spreading the Wealth: US Border patrol Predators head out to sea as Coast Guard looks at joint program', *AW&ST*, 09 Jun 2008, p.48.

[73] Ibid, p.49.

[74] Ibid, p.48.

[75] Hunter C Keeter, , Coast Guard Partners with Government, Industry in Unmanned Aircraft System Evaluation, *Delivering the Goods* , USCG Acquisition Directorate newsletter, Vol. 12, p.4, November 2008, viewed at http://www.uscg.mil/acquisition/uas/default.asp, accessed 01 Mar 2009.

[76] USCG, Acquisition Directorate, Acquisition Programs and Projects, http://www.uscg.mil/acquisition/programs/acquisitionprograms.asp, accessed 01 Mar 2009.

[77] John M Doyle, p.49.

only a moderate amount of work. Apart from engineering detailing to make it suitable for the maritime environment, the radar could be provided as a mission kit that could replace the 'normal' land oriented radar in a couple of hours.[78] Such a versatile type modular approach UAV could become the way in the future, and it would provide a country such as New Zealand with a dual-purpose machine to cover a number of desired effects. The Coast Guard's realisation that one type of machine could not fill the roles, or provide the effects required, probably has implications for any New Zealand application in support of the Naval Patrol Force. While the USCG's new cutters at around 4,300t displacement [79] are actually larger than a New Zealand frigate,[80] they will spend most of their time performing a similar role to the OPV.

The OPV has a flight-deck and can operate the Seasprite helicopter, but given that the RNZN only has five aircraft, it may be a rare sight to see a Seasprite onboard an OPV. The Seasprite is a capable multi-role machine but it is expensive to operate and maintain, and the flying hours allocated are limited.[81] It is doubtful that it would be cost-effective to operate such machines in support of EEZ surveillance, on all except such rare occasions as when both frigates are in port, and an excess of machines are serviceable. The benefits of aerial surveillance over surface surveillance have been discussed. The area covered by an aerial platform over that covered by a surface platform in the same time-span does not bear comparison. For this reason it appears logical that the NPF would benefit greatly by providing the OPVs with an organic VUAV, for exactly the same reasons that the security of New Zealand's maritime domain in general would be enhanced by the availability of UAVs - to fill the gaps in aerial maritime surveillance. There are a number of useful machines either available now or under development. The Schiebel S-100, or Camcopter as it is better known,[82] is a proven machine and is the latest

[78] John M Doyle, p.49.

[79] USCG, Acquisitions Directorate, NSC, http://www.uscg.mil/acquisition/NSC/features.asp, accessed 28 Oct 2008.

[80] Navy, HMNZS Te Mana-F111, http://www.navy.mil.nz/visit-the-fleet/te-mana/default.htm, accessed 28 Oct 2008.

[81] An official estimate in 2006 put operating costs at around $25,000 per flying hour.

[82] See Appendix A p.146 for technical detail.

development of a line going back almost 20 years; some reports suggest more than 100 are already in service with military operators.[83]

The Camcopter would be classed as a Tier 1 machine having a maximum take off weight of around 200kg of which up to 50kg is payload. This covers most of the sensors one might expect in a tactical type machine in the maritime and coastal surveillance role and can include a Stabilized Daylight/Infrared Gimbal, Synthetic Aperture Radar, Light Detection and Ranging, and Multi-Spectral Imaging. The Camcopter has an endurance of up to six hours dependent on payload and can operate a data link up to around 70 miles range.[84] The S-100 is of course a UAS and the Camcopter is merely the UA component. The UAS is designed to be integrated into existing higher-level networks for disseminating payload and audio visual data. Piloting vertical take off and landing aircraft requires skillful operators and the Camcopter is no exception if flown manually. However this machine is capable of fully automatic take off and landing from the deck of a moving ship in moderate seas.[85] The mission can be flown automatically via pre-programmed waypoints or changed in mid-flight to suit a developing situation. The cost of such a machine is believed to be quite modest; one unofficial source puts it in the region of US$2 million for one complete system with two UAVs and a full support package.[86] This particular machine runs on a 55 hp rotary aircraft engine,[87] and its operating and maintenance costs would be a fraction of those of a Seasprite engaged in the surveillance role.

The RNZN is showing a strong interest in UAVs and has sponsored trials carried out by DTA, some of which took place in May last year.[88] The purpose of these particular trials was to assess whether a miniature UAV could be used to detect vessels beyond the line of sight of the parent vessel, while providing 3D coverage of vessels of interest and conducting covert surveillance. The trial

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83 TFOT, Camcopter S-100 UAV, http://thefutureofthings.com/pod/288/camcopter-s-100-uav.html, accessed 29 Oct 2008.

84 Camcopter S-100, Technical Data, http://www.schiebel.net/pages/cam_techdata.html, accessed 29 Oct 2008.

85 In the northern summer of 2008 the S-100 demonstrated over 130 successful take offs and landings on German Navy K130 class corvettes operating in the Baltic, with up to 40 knots of deck wind at deck angles of 8+ degrees, http://www.asd-network.com/press_detail/17847/CAMCOPTER_S-100_Completes_Extensive_German_Navy_Flight_Trials.htm, accessed 03 Feb 2009.

86 UAV forum, UAV Programs, http://www.uavforum.com/vendors/systems/schiebel.htm, accessed 01 Mar 2009.

87 Camcopter S-100, Technical Data.

88 MA Anderson, *Exploring the Effectiveness of a Miniature UAV to Conduct Tactical Maritime Surveillance for the Naval Patrol Fleet*, DTA, Auckland: November 2008.

UAV was DTA's own 'Kahu' which has a mass of around 3 kilogrammes and an endurance of up to two hours. A Tier 1 miniature UAV such as this might prove ideal for operation from the navy's new IPVs. It is probably the only aircraft that could be launched and recovered from an IPV.[89] The trials were considered successful, achieving the desired effects that a patrol vessel would have difficulty achieving if operating on its own. It is intended that more trials be carried out for the purpose of testing various sensor configurations and also to develop and test a suitable ship-based recovery system.[90] The level of activity being generated by the Navy might suggest that they are aiming to provide the 'Protector' fleet with some form of UAS perhaps within a couple of years or so.

Advantages of UAVs

The major advantage of a UAV being used in preference to a manned machine in the surveillance role is persistence.[91] A UAV of the Tier 1 type might typically have an endurance advantage over a Cessna[92] sized machine of up to two times, as in the case of a Skycam 2-EB, or up to four times or more for a Boeing/Insitu Scan Eagle.[93] Machines such as this with streaming video would be a very useful asset for MFish or Customs engaged in littoral surveillance work, either on regular patrols or enforcement duties. They would be a genuine force-multiplier to the small numbers of operations people on the ground trying to monitor and maintain control of developing situations. And the quality video evidence they could produce would strongly support any subsequent prosecution. Any Tier 2 machine would typically have an endurance advantage over a manned MPA of two to three times. The Heron TP has a powerful 1200hp turboprop and can cruise for over 36 hours at heights above commercial traffic routes if required.[94] The Heron 1 UAV, which weighs less than 25 per cent of the TP and is powered by a 115hp Rotax engine, has an endurance approaching 50 hours with a 250 kg payload.[95] The

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[89] MA Anderson, November 2008, p.9.

[90] Ibid, p.18.

[91] F Craigan Pearson II, Lt Col USAF, *The Way Ahead for Maritime UAVs*, Naval War College, Newport, RI, 23 Oct 2006, p.5.

[92] For instance a typical general aviation light aircraft such as a Cessna 177 Cardinal has an endurance of around 4 hours, http://www.pilotfriend.com/aircraft%20performance/Cessna/2/17.htm, certified aircraft database, accessed 27 Jan 2009.

[93] Air Force Link, Scan Eagle UAS, http://www.af.mil/factsheets/factsheet.asp?fsID=10468, accessed 27 Jan 2009.

[94] Defense Update, Heron TP (Eitan), http://www.defense-update.com/products/e/eitan-UAV.htm, accessed 01Nov 2008.

[95] Israeli Weapons, Heron, http://www.israeli-weapons.com/weapons/aircraft/uav/heron/Heron.html, accessed 27 Jan 2009.

main difference between the two machines is operating altitude, four times the payload in the TP, and a much higher dash and patrol speed. Both machines are designed to cope with maritime surveillance and no doubt do it very well, but clearly there are different ways of approaching the same problem.[96] While both of these machines represent an impressive technical feat their capabilities also translate into effects, such as deterrence and the difference between obtaining evidence and not obtaining evidence.

It is worth reiterating that the capabilities of the P-3 are well known to owners of fishing vessels [97] and, one can logically assume, anyone who aims to profit illegally in New Zealand's maritime domain. If, for instance, a fishing boat is engaged in some form of illegal activity; be it dumping, using illegal nets, or fishing species outside their quota, and a P-3 arrives, then they can simply stop, and wait until it goes away, sound in the knowledge of the approximate loiter time of a P-3 at various distances offshore. Further confidence is given knowing that follow-on is very unlikely. In such circumstances a Tier 2 UAV has two distinct advantages. Firstly there is persistence, but this in itself, while being at the very least an effective deterrent, may not be enough to achieve the entire desired effect. Initially the desired effect would be to reduce current illegal activity through prosecutions. This then sends out the message that illegal activity is no longer tolerated, is actively and routinely pursued and detected, and successfully prosecuted, and this is followed up with regular patrols as a deterrent to further illegal activity.

MFish prosecutions have steadily declined over the last few years. The number of defendants facing fisheries offences has dropped by 35 per cent from 370 in 2002 to 239 in 2007. In addition, the number of infringement notices that have been issued has decreased 43 per cent from 2,265 to 1,490 over the same period.[98] In the said period the number of full-time employees at MFish rose 38 per cent. The optimistic view of these figures is that fewer

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[96] Israel are planning to begin flying maritime patrol sorties over the Mediterranean Sea by mid-2009 using modified Israel Aerospace Industries Heron (Shoval) unmanned air vehicles, with a prototype having undergone flight testing over recent months. A senior Israeli air force source said the use of UAVs will enable better maritime coverage than the service's current manned IAI Westwind 1124 business jet-based Seascans, which entered use from 1978. Cited in an article taken from http://www.flightglobal.com/articles/2009/01/21/321411/iais-heron-uav-to-make-maritime-patrol-debut.html, accessed 27 Jan 2009.

[97] Gary Orr.

infringements are occurring. However, it is of note that during this period the number of honorary MFish officers has declined significantly. In other words, overall there are fewer 'boots on the ground' doing the monitoring and the enforcement.[99] Unfortunately this is a sign of the times as compliance and regulatory issues seem to be all consuming and these have to be addressed.[100] The reduced prosecutions are more likely to be a result of less monitoring and surveillance. It is of course impossible to be definitive as the resources required to survey the extent of illegal activity are not available. The extent of illegal activity that is being carried out at a commercial level within New Zealand's EEZ will not be accurately assessed until surveillance is increased in line with the recommendations of the *MPR*.

The need for more surveillance is compelling, as has already been outlined, and persistence brings advantages that will often, if not always, be enhanced through covert operation; which highlights the second major advantage of UAVs over current manned platforms - that of stealth. Most UAVs have a degree of stealth when compared to their manned equivalents - those that have an equivalent. Most have a composite airframe and this reduces its radar reflectivity. They are also smaller than their manned counterparts and this also reduces their observability. The smaller and lighter the airframe, dependent on payload requirements, the smaller the engine needs to be for any given altitude and speed requirements. A small rotary engine producing 50hp would be expected to make less noise than a turboprop producing 20 times the power. Many of the smaller machines used at the platoon level while out on patrol, such as Tier 0 micro air vehicles (MAV),[101] have an electric motor to power them and are virtually invisible and inaudible to those being observed, and such are their flying

[98] The figures are taken from an answer to parliamentary questions raised by Phil Heatley the MP for Whangarei., http://heatley.co.nz/index.php?/archives/25-Fisheries-bureaucrats-up,-prosecutions-down.html, accessed 02 Nov 2008.

[99] Ibid.

[100] The National party has previously stated that it intends to 'Remove all administrative, operational, or policy focus that is unnecessary for the sustainable utilisation of the fishery', though this remains to be seen and is likely to be some way off in the future, http://www.decision08.co.nz/FisheriesandAquaculturePolicy/tabid/86/articleID/710/cat/203/Default.aspx.

[101] It is a given that a machine weighing two pounds, and less than two feet long will be unmanned hence the U is dropped. A video vignette showing their capability is available at http://www.youtube.com/watch?v=pqVs2G62lJ4.

characteristics that those that are observed are likely to be passed off as birds, without much conscious thought being given.[102]

Such machines though would be of limited application in the New Zealand maritime security environment however, and a more suitable machine for coastal work operating in LOS might be one of a range of machines produced locally by Skycam. The 2E-B for instance could stand-off a target at several thousand feet, dependent on the sensor parameters, producing data for around six hours while being virtually invisible to any target. The GCS can be fitted in a small 4x4 and the machine can be controlled while the vehicle is moving.[103] There is no reason to suppose a similar machine could not act as a relay if required, to provide sensor product to other users over a network enabled data distribution system. These systems are available now, they are mature technology of world class, and it appears they are available at a fraction of the cost of overseas machines. A number of civilian government agencies such as DoC, MAF, and the NZ Police could potentially use these machines for a myriad of purposes. The maritime domain though is the focus, and Tier 1 machines could be performing now for MFish, and Customs, in covert operations in littoral areas. The fact that they are not, nor are there any plans to do so, requires examination. Perhaps the biggest block at the moment is that there is no specific Civil Aviation Authority (CAA) of New Zealand rule (CAR) in place for UAV operations.

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[102] Work is currently progressing at Maryland University, sponsored by the National Science Foundation and US Army, to produce practical flapping wing MAVs, http://www.flightglobal.com/articles/2008/10/30/318176/flapping-mav-boosts-lift-by-folding-wings.html, accessed 29 Jan 2009.

[103] Nick Lee-Frampton, 'Skycam launches UAVs in NZ', *Unmanned Vehicles*:, Jul-Aug 2008: p.28.

Chapter 6

OPERATING UAVS IN THE NATIONAL AIRSPACE

Operating UAVs in New Zealand

There are severe restrictions placed on the operation of UAVs in New Zealand. CAANZ Transition Rule 19.105 states:

> No person shall operate a pilotless aircraft except with the authorisation in writing of the Director and in accordance with such conditions as may be specified in the authorisation.

Such conditions include a 400 ft altitude limit, except in tightly controlled conditions where this can be extended.[1] There are also specially classified areas such as Danger Area 521 west of Pahiatua specifically authorised by the CAA as a UAV training area and which is cleared for operations to 2000ft above mean sea level (AMSL),[2] as well as those areas designated for military operations. Clearly, such restrictions cannot remain if UAVs were to be required for use in maritime surveillance and would require urgent attention. The issue of airspace integration is a vexatious one all over the world and potential commercial operators engage in heated debate with the authorities for not making more progress.[3] American UAS manufacturer General Atomics is at the core of a pressure group that has the aim of bringing forward routine operation of civil UAVs in the NAS by 2012.[4] Most civilian operations are restricted to limited and tightly controlled trials, or in specific areas for specific purposes, such as in the case of the Predators that patrol the United States border with Mexico.[5]

Primarily, a UAV, by virtue of not having a human operator on board, lacks situational awareness. UAVs are either pre-programmed to fly a particular pattern and/or they are manually flown in an area of interest either searching for

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[1] There are no specific regulations relative to UAVs beyond those regulations covering radio controlled aircraft up to 25 kg mass as outlined in CAR 101.205 and CAR 101.207.

[2] Slide 8 of Skycam UAV NZ ppt. presentation available at http://www.kahunet.co.nz/.

[3] John Croft, 'Flying Sense', *Flight International*, 3-9 June 2008, p.38.

[4] Ibid.

[5] UAV operations along the Arizona and New Mexico borders are conducted in civil airspace, but are protected by a controversial temporary flight restriction in effect from 17:00 to 07:00. This has attracted criticism from the general-aviation community., http://www.flightglobal.com/articles/2006/04/27/206239/general-atomics-predator-b-uav-crashes-on-mexican-border-on-customs-and-immigration.html, accessed 29 Jan 2009.

or investigating specific targets. Either way, visual clues in relation to their surroundings that are available to the operator/controller are severely limited. The experience of operating a UAV has been likened by US Air Force pilots as similar to looking through a straw while trying to flying an aircraft.[6] While this may be somewhat of an exaggeration, as can be noted from various video clips that appear on the internet,[7] it is nevertheless challenging, which is why with a Predator, for instance, there is a pilot and a sensor operator. It is this lack of ability to sense and avoid other airspace users that is a major concern as a flight safety hazard.[8] As has been previously mentioned, many companies around the world are working to solve the problem and forecasts of when full integration of UAVs in controlled air space will be available vary from around 3 to 15 years.[9] Predictably it is industry that is taking the optimistic view while the aviation safety authorities take the more conservative view, and this is as it should be, as ultimately it is their responsibility and the stakes are high.

In New Zealand the CAA held a seminar in October 2006 to identify issues relating to the regulation and operation of UAVs, including certification, flight operations and airworthiness, and this resulted in a paper being published that highlighted the issues raised.[10] The three main issues that would require addressing are airworthiness and type certification, operator qualification, and UAV operation in all types of airspace. While these are the main issues there are many other (in fact, all other) issues to be resolved, as there are basically no rules to cover UAVs at the moment except on a case-by-case basis of a temporary nature. At this point in time there appears to have been no concrete progress in the regulation of UAV operations, though another meeting is being planned for mid-2009.[11] The main reason for this may be that UAV operations in New Zealand are limited and the issue of regulation is not of any particular urgency, and this is unlikely to change in the short-term. At the heart of

[6] Richard B Gasparre, 'The US and Unmanned Flight – Part II', *airforce technology*, http://www.airforce-technology.com/features/feature1529/, accessed 28 Oct 2008.

[7] http://www.youtube.com/watch?v=RYnYEl4di94, shows a number of operator views while in flight, accessed 17 Feb 2009.

[8] David Hughes, New Age Anti-Collision, *AW&ST* , 14 Jul 2008, p163.

[9] The FAA estimate a timeline of 2020-25 for integration as noted in *Flight International*, 3-9 June 2008, p38, whereas the European Defence Agency are aiming for a timeline of 2012-14, *Unmanned Vehicles*, June 2007, p.10.

[10] Civil Aviation Authority of New Zealand, *Issues Paper: Unmanned Aerial Vehicles*, 22 January 2007.

[11] Rex Kenny, NZCAA, personal correspondence, 12 Feb 2009.

regulation appears to lay the somewhat confused issue of classification, because it is around this issue that everything else will be based.

Classification of UAVs

The CAA paper appears to suggest that the best way to classify UAVs is by their kinetic energy levels, which the paper explains as;

> Kinetic energy is the product of an aircraft's mass (in kilos) divided by two and the square of its speed (in metres per second) i.e. ½ MV^2, the units of energy being joules. Logically the maximum values of each variable would be used i.e. the UAV's MCTOW [maximum certified take-off weight] and maximum true air speed. [12]

As an example of how this formula applies to machines that might be operated in New Zealand, a Tier 1 machine such as the SKYCAM 2-EB, which has a mass of 15 kg and cruises at around 90 km/hr,[13] would have a kinetic energy level of around 4.7 kilojoules. A Tier 2 machine such as the Predator B which has a mass of around 4500 kg and cruises at 400 km/h would have a kinetic energy level of around 27.8 mega joules.[14] In this particular example a machine weighing 300 times more actually generates nearly 6000 times the energy level due to the logarithmic nature of the scale relative to speed. The paper suggests three classes for UAVs as follows:

1. Class 1 UAV – maximum energy level of 10,000 joules.
2. Class 2 UAV – maximum energy 10,000 joules to 1,000,000 joules.
3. Class 3 UAV – maximum energy 1,000,000 joules and above. [15]

Adopting this method appears to be based upon the potential for damage caused by collision with another aircraft or crashing into a populated area. Basing their classification around their potential for harm is somewhat negative and not particularly useful in the sense of gaining acceptance among the aviation community, nor from the practical viewpoint of airworthiness. Using this analogy it might appear that CARs Part 121, 125, and 135, which regulate the operation of large, medium, and small aircraft and helicopters, are based around the

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[12] NZCAA paper, p.17.

[13] SKYCAM PPT. presentation available at http://www.kahunet.co.nz/home.htm, accessed various times.

[14] One joule is the kinetic energy of a mass of two kilograms moving at a velocity of 1 m/s.

[15] NZCAA paper, p.17.

number of people that might be killed if they crashed. Of course this is not the case, and the rules are based on sound principles of airworthiness and airmanship.

As aircraft get larger they are invariably more complex and have higher performance, and it is these which should be the driver for regulation, and not kinetic energy levels; the fact they are bigger is merely incidental. It is generally true that the more complex the aircraft, the more demanding they are to both operate and maintain; thus creating the issues of operator qualification, and type certification, in addition to airworthiness. The CAA suggest two possible approaches to regulation of UAVs, the first being having a single rule covering all requirements for UAV operation similar to CAR 103 for micro-light aircraft, and the second being to develop several rules along the lines of CARs 119 (Air Operator Certification), and 121, 125, and 135 as previously mentioned.[16] The paper suggests that due to the level and scope of the stringent requirements for operating in the national air space that the latter would be the preferable approach, and this would certainly appear to be the correct approach.[17] It would be inconceivable to have one set of rules covering such diverse aircraft as a Cessna general aviation type carrying four people out to multi-engined airliners carrying 300 people. And while that particular facet is not applicable to UAVs, the inherent complexity associated with matters of scale certainly is. The Global Hawk for instance, which is the largest UAV currently flying, is the only UAV so far that the US Air Force has seen fit to issue a certificate of airworthiness in the same manner that it applies to its manned aircraft.[18] Complexity is not only an issue of size; it is also a consequence of the operating environment and its intended role. An example might be that if an aircraft is to be operated in controlled air space, such as a UAV operating in the maritime surveillance role off New Zealand's northern approaches, then it will need to be able to be tracked, identified, and capable of avoiding other traffic. A Tier 2 type machine might normally be required for this kind of role and it requires specific additional equipment to enable this; such as transponders, VHF radio relays, and multi-mode radar capable of detecting aircraft. It would also be required to have

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16 NZCAA paper, p.19.

17 Ibid.

18 Chris Pocock, *U.S. to share its Hawk intel data*, AINonline, http://www.ainonline.com/news/single-news-page/article/us-to-share-its-hawk-intel-data/?no_cache=1, accessed 30 June 2008.

double, if not triple redundancy built in to its control systems to cover any equipment failures.

This level of safety is now becoming common on Tier 2 machines that typically now have dual redundant flight controls and automatic take off and landing systems and triple redundant avionics systems.[19] Even small Tier 1 machines have redundancy built in and in the event of loss of operator control are programmed to automatically return to their point of origin.[20] It can be seen that the levels of complexity are now similar to manned aircraft, and specifically, have similar levels of protection against system failure. It therefore appears logical that if a UAV has systems similar in complexity to a manned aircraft that are required for their basic flight and operation, or if they are similar to a manned aircraft in size and weight, then they need a type certificate for that aircraft and that it should for all intents and purposes be operated as an aircraft, and be subject to similar rules. However, blindly applying manned certification requirements would lead to unnecessary complication and economic penalties.[21] It would appear unnecessary that the rules for flying a 15-30 kg Tier 1 UAV around a notified and closed area of the coastline in support of fisheries operations should be the same as those applying to a manned aircraft flying the length of the country. It would be onerous and make it difficult to regulate satisfactorily. In summary, a common sense approach is required for smaller machines, though for machines of a comparable size to manned aircraft, they probably should be similarly treated for the purposes of airworthiness and operation.

Sense and Avoid

The issue of operating UAVs in the national airspace system is a hot topic in aviation circles and the subject of much current debate. 'Sense and avoid is the Holy Grail', according to Rich Fagan, director of commercial UAS programmes for AAI, a Textron subsidiary.[22] That sense and avoid must be

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[19] The General Atomics Sky Warrior is typical of the latest generation of UAVs to adopt this level of redundancy. Perhaps one major driver for this is that the US Army does not require its operators to be qualified pilots and has therefore provided high levels of automation, http://www.ga-asi.com/products/er-mp-uas.php. The British Army's Watchkeeper UAV due to be introduced by 2010 will have similar levels of redundancy and automation, http://www.army-technology.com/projects/watchkeeper/.

[20] The Elbit Skylark II is powered by a 4 kw dual-channel Permanent Magnet Brushless electric motor which can have one channel turned off during the cruise to save power. This also introduces powerplant redundancy while still having only one motor, http://defense-update.com/products/s/skylark2.htm, accessed 31 Jan 2009.

[21] EASA UAV Workshop, Paris, February 1st 2008, http://www.easa.europa.eu/ws_prod/g/doc/Events/2008/February/9-Dassault%20Aviation%20presentation.ppt , accessed 31 Jan 2009.

[22] John Croft, 'Flying Sense', *Flight International*, 3-9 June 2008, p.38.

solved is due to the Federal Aviation Authority's (FAA) insistence that UAS operations have an equivalent level of safety to those of manned aircraft. The FAA's unmanned aircraft programme office predicts that 'file and fly' will not be available in the US at least until 2020-2025.[23] Current authorisations for flying UAVs in US airspace require a certificate of authorisation that is issued on a case-by-case basis, and are subject to numerous stipulations. There were 85 such certificates issued in 2007 and that is only expected to increase to around 100 a year in the next five years, each certificate typically lasting for at the most, one year.[24] The great majority of these certificates are for the military or manufacturer test-flights, and not commercial operations as such. Such a conservative approach, particularly in the case of the US which has some of the busiest airways anywhere is logical and justified. [25]

When a special FAA committee was first set up in 2004 to investigate and create minimum aviation system performance standards for sense and avoid, and command and control, a deadline of 2009 was set. However it was soon recognised that this was not achievable. It was pointed out that the traffic alert and collision avoidance system (TCAS), an apparently simpler system than what is required for sense and avoid, cost around $2 billion to develop and around 30 years to institute.[26] An FAA official remarked that: 'What we are looking at is far more complex. It's more than collision avoidance; it's separation assurance'.[27] FAA officials believe that an acceptable detect, sense, and avoid system for UAVs could cost up to $2 billion to complete and is still many years away.[28] With larger machines, 'conflict avoidance, especially in a fully autonomous, lost-link situation will be the "Achilles Heel" challenge for the FAA to approve'.[29] The issue clearly is complex and needs to be subject to a high degree of rigour, and those who believe a solution is only three to five years away are uninformed and somewhat optimistic.

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[23] File a flight plan with air traffic services and then fly the aircraft according to the plan.

[24] John Croft, 'Flying Sense', p.38.

[25] The ICAO Annual Report 2007, pp.7-8, states that North American carriers account for almost 59% of the world's domestic traffic and 31% of international traffic.

[26] John Croft, 'Flying Sense', p.39.

[27] Ibid.

[28] GAO-08-511, *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System*, United States Government Accountability Office, Report to Congressional Requesters, May 2008.

[29] Department of Defense, *Defence Science Board Study on Unmanned Aerial Vehicles and Uninhabited Combat Aerial Vehicles*, Washington: 2004, p.38.

However, the FAA is referring to operation of UAS in the context of the crowded national airways of the US. Not all parts of the world are so encumbered with such high density air traffic. Australia's Border Protection Command recently completed a series of trials off the north coast designed to assess the ability of UAVs to assist in the civil surveillance and protection of Australia's maritime borders. The trials were held in May 2008 using an IAI Heron UAV [30] and were used specifically to find out if UAVs were a viable means of detecting, classifying and identifying targets while operating in the maritime environment of its designated area. The Heron's payload included an Elta EL/M-2022 multi-mode maritime patrol radar similar to the one being fitted to RNZAF Orions as part of their upgrade. It has 360 degree aircraft detection capability which was a critical requirement for the trial to enable aircraft separation in non-controlled airspace.[31] The aviation VHF relay also allowed contact with air traffic control and other airspace users. The Heron was given a civilian registration and was for all intents and purposes a civilian aircraft. It was issued with a special certificate of airworthiness in the experimental category, and authorised for both visual flight rules (VFR) and instrument flight rules (IFR) in non-controlled airspace. An official from the Australian Customs Service, associated with the trial remarked: 'We would basically file and fly. We filed a flight plan and we had full IFR reporting, and with the sensors on board we were essentially, to all other aircraft in the area, just another aircraft – be it manned or unmanned is irrelevant at least to aircraft and air traffic control'.[32]

The above trials comprised 10 flights totalling 80 hours. The operational sorties were between nine and ten hours with one flight lasting over 15 hours including night flying, and were flown up to an altitude of 8,000 ft out to 300 nm range. The trials took place in the Gulf of Carpenteria, the Torres Strait, and to the east of Cape York. While conclusions as to the success or otherwise of the trial are still being assessed, there were no issues in relation to air traffic control. The UAV had a transponder to indicate its position at all times; it was likely in ATC radar contact; the UAV's own radar would have displayed to the operators all other traffic in the vicinity, and the operators were in radio contact with other

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[30] See Appendix A p.143.

[31] Darren Lake, 'Blazing the trail', *Unmanned Vehicles*: Sep-Oct 2008, p.28.

[32] Ibid, p.30.

aircraft and air traffic services.[33] The major difference between this trial and the US context is traffic density and airways. In the US the FAA and manufacturers are working towards an 'equivalent level of safety' to manned aircraft in the context of detect, see, and avoid, before it will allow medium and large UAVs under 'file and fly',[34] in what is some of the busiest and crowded airspace there is. In the case of the recent Australian trial it was held in an offshore area of low density air traffic. A commercial airport was used throughout the trial with no reported problems fitting in with normal aircraft operations.[35] While the trial was not a major test of 'sense and avoid' it did prove that in areas of airspace where traffic is light, the technology and systems are available and in place for safe operation of Tier 2 UAS. A pragmatic approach to risk and a willingness to make things work appears to have been successful. Given the relatively light air traffic around New Zealand's coastline and EEZ there appears to be no major obstacles as to why similar arrangements could not be made here, providing all involved want to make it happen.

There appears to be three contexts for see and avoid. There is the FAA version which appears to require fully automatic integration into the national airspace system. And while the actual technical detail of what is required has yet to be decided, it seems as if they require a system which responds as if there is a pilot on board in the context of situational awareness and response by requiring an 'equivalent level of safety' to that of manned aircraft.[36] This might require that the UAV senses other traffic with its onboard systems and automatically takes avoiding action if required while still acting predictably, and in accordance with standard procedures, while in controlled airspace. An example might be when traffic is nearby and air traffic services need to know the pilot has 'visual' contact, so as to avoid by 'seeing' and then 'avoiding'; currently this is not consistently possible with UAVs. While there are cameras on board UAVs, they are not as capable either at detecting or acting as quickly as a pair of eyes sweeping a vertical and horizontal scan of the airspace visible from the flight deck of a manned aircraft. Limited bandwidth does not allow 'telepresence' to a degree, which gives the same level of situation awareness that pilots of regular aircraft

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[33] Ibid, pp.28-30.

[34] John Croft, 'Sensor could help UAVs operate in civil airspace', *Flight International*, 6-12 May 2008, p.12.

[35] Darren Lake, p.29.

[36] John Croft, 'Flyng sense', p.38.

have.[37] Secondly there is the case, such as in the Australian trial, where the aircraft is situationally aware of other traffic via its on-board sensors and air traffic control, just like a normal aircraft, and the operator manually changes the flight path of the aircraft to avoid conflict if required.[38] Everything is done manually and this is not a problem in areas such as those where the trial took place. While this has similarities to the previous case, being able to see other traffic with one's own eyes is significantly more confidence inspiring to all concerned. The issue appears not to be so much that the operator of the UAV is confident of airspace separation, but that the traffic around him has confidence in a UAV not to do something unpredictable; in other words a human factors issue. It may take years before aircrew reaches this level of confidence as a matter of routine.

The final example of see and avoid is currently being addressed by Northrop Grumman for application to its Global Hawk Tier 2+ UAS. The package will be based around new radar which will lie at the core of a four sensor system. The radar will have reduced size, and thus weight and power requirements, which is a must to mitigate unwanted range/payload penalties. The US Air Force Research Laboratory has inevitably come up with a new and appropriate acronym, so beloved of the military, specifically for the sense and avoid application, called PEER, which stands for Pilot Electronic Eyes Radar. The other sensors that make up the system are an EO camera, automatic dependent surveillance-broadcast transponder, and a traffic collision avoidance system.[39] The architecture defines the way that data is collected from different kinds of UAV sensors (such as electro-optical, infrared and radar) and it is then '*fused*' to create an overall picture of the airborne environment.[40] The UAV's autonomous flight-control system uses this data to make appropriate adjustments in the air vehicle's speed, altitude etc., to avoid a mid-air collision. At the time of writing (November 2008), the system is due to be functionally tested with two aircraft acting as intruders. The purpose of the tests is to ascertain the systems ability to detect and manoeuvre away from incoming traffic. And while Global Hawk is the only UAS to meet the military and the FAA's airworthiness standards and have

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[37] Gary Kuvich, *Unattended/Unmanned Ground, Ocean, and Air Sensor Technologies and Applications VI*. Edited by Edward M. Carapezza, Proceedings of the SPIE, Volume 5417, pp. 206-217 (2004). Citation from abstract accessed 31 Jan 2009 online at http://adsabs.harvard.edu/abs/2004SPIE.5417..206K,

[38] Darren Lake, p.30.

[39] Stephen Trimble, 'Northrop's sense and avoid solution', *Flight International*, 26Aug-1 Sept, p.19.

[40] Northrop Grumman news release, *Northrop Grumman helps Air Force develop collision-avoidance system for UAS*, http://www.irconnect.com/noc/press/pages/news_releases.html?d=61490, , accessed 31 Jan 2009.

approval to fly regular flights within US airspace, it is unique in that most of its flying is done at 50,000 feet plus, well above traffic routes.[41] Regardless, if successful it may represent a way forward by ensuring flight safety for medium and large UAS in the national airspace generally.

Operator/Pilot Qualification

The third major issue raised by the CAA paper was that of pilot/operator qualification. There are basically two schools of thought in this respect. Firstly that operators of all but the smallest UAVs (and this has not been specifically defined) should be qualified pilots. And secondly that operators can be qualified to 'fly' UAVs with no formal piloting experience or qualifications in the traditional sense. A DSTO report remarks that literature on the subject of UAV operator training requirements appears split.[42] This polarity of views is typified in the US military where the army sees no compelling reason to have qualified pilots, or officers in particular, operating its UAVs. The army's operators are trained from scratch and represent a discrete career path. It has to be noted that the army's UAVs, be it a Tier 0, 1, or 2 machine, generally operate either at the tactical or theatre level, and will rarely venture anywhere near airways routinely flown by commercial traffic. However, they are still subject to tight control. According to *Defense News*, on a typical day about 100 aircraft, of which a third may be unmanned, pass through the 30 mile square above Baghdad, and at any one time there may be 40 aircraft airborne.[43] As Colonel Gary Bowder, the deputy director of the Combined Air Operations Centre in Qatar put it: 'The chances of putting a manned aircraft into a UAV are extremely real'.[44] Clearly, to operate in such an environment requires high levels of skill and training, but it does appear that being able to fly a conventional aeroplane is not a prerequisite. For the army at least, it is perhaps a matter of risk management. In a combat zone such as Iraq or Afghanistan, there will be frequent occasions where the launching of a UAV is a life or death matter, and sometimes the risk of circumventing the rules is justified. This is not how the US Air Force sees it and they enforce strict air traffic

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41 Northrop Grumman, RQ-4 Block 20, http://www.is.northropgrumman.com/systems/ghrq4b.html, accessed 13 Jun 2008.

42 DSTO-GD-0463, Unmanned Aerial Vehicles for Maritime Patrol: human factors issues, Hopcroft, R; Burchat, E; Vince, J, Defence Science and Technology Organisation, Victoria: Australia, May 2006, p.21.

43 Gayle S. Putrich, "Unmanned and Dangerous: How UAV-Plane Collisions Are Changing US Air Control," *Defense News*, June 11, 2007, p.7.

44 Ibid.

procedures at all times.[45] It is perhaps symbolic of the cultural division that exists between the army and the Air Force, whereas to the army, aviation, and every other machine they own, is simply a tool to support troops in the field.

The US Air Force on the other hand has always insisted on its operators being qualified pilots and has drawn its operators from the existing pool of aircrew who convert to UAVs for a normal tour of duty, and then can return to 'normal' flying duties. The belief is held by some that officer pilots of today, just like cavalry officers on the eve of ground force mechanisation, could impede the introduction of UAVs and put in place unwarranted delays to its operational employment.[46] The view being that UAV 'pilots' were somehow not true aviators (the so called 'white scarf' mentality) and that being labeled as such would have a detrimental impact on one's career. [47] However, a survey of nearly 400 officers with aviation specialties, who were attending intermediate and senior military educational institutions, carried out in 2006, indicated that most aviators were motivated by career advancement and not flying.[48] While no formal research was carried out on this issue relative to the RNZAF, informal enquiries during the course of this study revealed a similar view. This supports the notion that 'a secure career path for promotion and command would be an inducement to attract officers into emerging fields such as unmanned system control.'[49] A study carried out in 2000 also found, 'no parochial, pilot resistance standing in the way of UAV development in the [US] Air Force, only a general enthusiasm for UAVs that in retrospect was not supported by the technology of the time.'[50]

This repudiation of stereotypes is about to be tested by the US Air Force. Defence Secretary Robert Gates criticised military leaders for the slow buildup of unmanned aerial vehicles patrolling the skies over Iraq and Afghanistan at a speech he made during April 2008 to officers at Air University, Maxwell Air

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[45] Gayle S. Putrich, p.8.

[46] James R Fitzsimonds and Thomas G Mahnken, Military Officer Attitudes Toward UAV Adoption: Exploring Institutional Impediments to Innovation, Joint Force Quarterly, issue 46, 3rd quarter 2007, p.97.

[47] WW1 scout or fighter pilots occasionally wore streaming white scarves around their necks while in flight, which added to the romantic notion of 'Knights of the Air'. It was of course a nonsense as most of them never made it past their first tour of the front and usually died in horribly unromantic circumstances.

[48] James R Fitzsimonds and Thomas G Mahnken, p.97.

[49] Ibid.

[50] Thomas Paul Erhard, *Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapons System Innovation*, Ph.D. diss., The John Hopkins University, June 2000.

Force Base.[51] As the Air Force struggled to meet the demand for rated pilots Gates also echoed the call for unrated officers to be allowed to fly the Predator. Air Force Chief of Staff General T. Michael Moseley opposed this and he was removed from office for his, among other things, stance on UAVs. This was a clear demonstration to senior officers of 'if you can't do it, you will be replaced by someone who can'. The US Air Force was working on a plan, due to be released in December 2008, which will lay out plans for UAV development through to 2047, according to *Defense News*.[52] And in a major turnaround, from January 2009 the Air Force will, for the first time, train UAV pilots who have no previous flight experience. *Aviation* reported that while the initial batch of 10 trainees form part of what is essentially a 'beta test', should it prove successful, the Air Force hopes to create a separate training stream specifically for UAV operators, rather than selecting trainees from the pilot pool as is current practice.[53]

The new trainees will enter the regular Air Force Undergraduate Pilot Training (UPT) scheme as per normal with the major difference being that all their flying will be done in a simulator. They will then move on to joint air ground training before graduating to formal Predator conversion at Creech Air Force Base. While the fate of the dedicated UAS stream is decided, the US Air Force is concurrently embarking on a program to take 100 new graduates from UPT per year and send them directly to a Predator, Global Hawk or Reaper posting.[54] Unlike the participants of the trial who will be initially restricted to the Predator aircraft, the UPT graduates will be allowed to fly any UAS in the inventory to which they are assigned. This is a sensible approach and should the RNZAF ever operate large UAVs, it would be the best option as it provides trainees with a choice of paths later in their careers. Also unlike those graduating from the beta test program, the UPT graduates will not remain in the UAV business permanently. Colonel Curt Sheldon, an air operations officer at US Air Force headquarters remarked that: 'Fully half of the aircraft that the Air Force will be buying in the future are going be unmanned. This community is

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[51] Michael Hoffman, Gates Issues Call for More UAVs, Fresh Thinking, *Defense News*, viewed at http://www.defensenews.com/story.php?i=3490138, accessed 26 Nov 2008.

[52] 'Future UAV pilots may skip real flying', NWDC E-newsletter received 24 Oct 2008.

[53] Dave Majumdar, 'Revolution in the Air: Non-Aviators to Take Flight, 17 Oct 2008, *Aviation*., viewed at http://www.aviation.com/technology/081015-unmanned-aerial-combat.html, accessed 25 Oct 2008.

[54] Ibid.

going to be the second largest after the F-16 community. Getting in early is not a bad thing.'[55]

It appears that even that most conservative of military institutions, the United States Air Force, is taking an innovative, and pragmatic, approach to the issue of UAV operator qualification. Regardless of underlying political pressures and the fact that it is but the first tentative step, it seems inevitable that this should be the case, given the level of intensity of operations that the US armed forces are currently faced with, and the 'US military's insatiable demand for UAVs'.[56] Therefore, if the two major users of UAVs in the world, being the US Army and US Air Force, are of the view that operators do not necessarily have to be qualified pilots, then this is a strong pointer for other users. However, the CAA Issues Paper, which is now two years old but nothing new has emerged since, stated that consensus was reached in that, 'human UAV "pilots" did require some flying experience'.[57] It also suggests that, since any UAV operations in New Zealand would be of a commercial nature (excluding military operations over which they have no jurisdiction in regard to personnel qualifications), then the minimum pilot qualification should be a commercial pilot's licence (CPL).[58] No qualification is given as to what commercial operations might specifically be, though generally it encompasses anything that involves 'hire or reward'. One might expect activities such as aerial photography and mapping, or sports/news coverage etc, is what they had in mind. But, for instance, if a contractor was engaged to carry out surveillance flights around isolated coastal areas using a Tier 1 machine on behalf of MFish, or any other government department with an interest in homeland security, it would appear onerous to require a CPL. Taking manned aviation as the precedent (for the lack of any other) would suggest that all UAV flights other than those carried out by the military would be so classified, and subject to CAA rules.

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[55] Ibid.

[56] Anna Mulrine, UAV Pilots, January 2009, *airforce-magazine.com*, http://www.airforce-magazine.com/MagazineArchive/Pages/2009/January%202009/0109UAV.aspx, accessed 31 Jan 2009.

[57] NZCAA Paper, p.15.

[58] AC61-1.5 requires a minimum of 150 hours for aeroplanes and 125 hours for helicopters, of approved flight instruction, before an application can be made for a CPL. Rule 61.205(a)(3) allows a commercial pilot licence holder to act as pilot-in-command of an aircraft that is certificated for multi-pilot operation and is engaged on an operation for hire or reward but not for an air transport operation.

CAA seems to imply that even the smallest UAV would require a CPL if it was operated beyond visual range or in controlled airspace,[59] though the concluding comments state that: 'Self-regulation may be possible at the sub-100kg (or 10,000 joule) weight/energy level via certificated UAV organisations, but above this level specific UAV operator certification is likely to be essential'.[60] This appears to be a more sensible starting point, though ultimately it may be that the type of airspace flown in governs operator qualification. If all UAV flights were deemed to be for 'hire or reward', requiring a CPL, this could cause problems. If, for example, MFish were to obtain something like the SKYCAM 2-EB (which weighs around 15 kg) to use on operations against poachers in an area of controlled airspace, the operator would be required to hold a CPL. There are possibly two problems with this. Any person who has gone to the trouble and not inconsiderable expense of gaining a CPL may be unlikely to want to fly what is not much more than a model aircraft, in the physical sense. Secondly, it is doubtful that it would be cost-effective from MFish's point of view, to train a number of their people to CPL level to then go and operate a small UAV on an as required basis.

What UAV operators do need at a minimum is 'air sense', and this might best be initiated through that part of a regular pilot's training that enables them to operate safely and comply with the rules in force in controlled airspace. Clearly a lot more thought needs to be given to this issue, particularly in regard to the operation of smaller UAVs of say up to 100 kg mass as suggested by the CAA. The New Zealand Army, who plan to expand their UAV trials over the next couple of years, see the benefits of both sides of the argument. Captain Rowland Harrison, the Army's UAV Troop commander, remarked that there was no compelling need for formal pilot qualifications for micro and miniature UAVs, such as the Kahu, which have limited performance and application.[61] However, with the larger higher performance machines, it is believed there are proven benefits of having previous flying experience, and this is especially the case when there are in-flight problems.[62] A small number of the Army's UAV personnel have undergone pilot training to private pilot's licence (PPL) level. These personnel

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[59] NZCAA Paper, p.15.

[60] NZCAA Paper, p.20.

[61] Captain Rowland Harrison, NZ Army, personal communication, 30 Jan 2009.

[62] Ibid.

are preferred as mission commanders, and it is seen as desirable that they have some experience flying manned aircraft (a figure of 80-100 hours was suggested) with at least some of that time under instrument flying rules (IFR). Regardless of what the Army's UAV operators fly they all complete the RNZAF's basic airman-aircrew (non-pilot) course at RNZAF Base Ohakea, for the purpose of instilling 'air sense' and as an introduction to aviation culture.[63]

Larger UAVs of the Tier 2 type would of course require a different approach, but still not necessarily a CPL to operate them. A machine of this class would be expected to operate out to the limits of the EEZ and would inevitably at some point be required to transit through controlled airspace used by commercial traffic. Given the already high level of automation available and the expected introduction of a workable sense and avoid system in the medium-term, by the time New Zealand faces these issues, it may be decided that a CPL is not required and that some other form of specialist UAV operator certification is adequate. As the DSTO report notes: 'Operators of highly automated UAVs may not need to be rated pilots'.[64] However, in the realm of the larger machines, should it be decided that a CPL is required, it should not be quite so difficult to recruit holders of a CPL to fly them, due to their similarity to manned aircraft.

There are no easy solutions, and even if it was decided that a large UAV would be used to patrol the EEZ, in reality it is more than likely that operation of the UAS would be given to the RNZAF both because of their aviation expertise, and the need to avoid unnecessary duplication of infrastructure and personnel. If the military were to fly a Tier 2 type UAV in New Zealand, it might be assumed that their operators would be qualified pilots being either new pilots trained to wings level prior to conversion to UAVs, or simply recruited from the pool of existing pilots. The reason for this assumption is that the RNZAF had representatives at the CAA seminar at which tentative consensus requiring a formal pilot qualification appeared to be reached. From the RNZAF's perspective they are perhaps too small to have a specialist stream for training UAV operators, and it would be logical and convenient to utilise the existing system, and have all pilots qualified to 'wings' level.

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[63] Captain Rowland Harrison..

[64] DSTO-GD-0463, p.22.

In summary, this chapter has highlighted the everyday issues of operating UAVs in the national airspace. It is a complex issue and one for which there is no easy answer. The FAA have a committee of experts working on minimum operational standards with a deliverables timetable between 2010 and 2019 just to scope the requirements of UAV operations to enable 'file and fly'.[65] This is both understandable and necessary in the context of North American air space; and Europe and parts of Asia for that matter. The common factor of these regions is traffic density. It is therefore perhaps overly conservative to suggest, as in the CAA issues paper, that it may be best to wait and see what develops overseas, to avoid the risk 'that it will be out of step with the rest of the world', so harmonisation can be considered when developing UAV regulations.[66] Given that the majority of New Zealand's coastline and EEZ has little air traffic flying in it on a routine basis, this appears to be unnecessary. Reasons for this approach may be that, as previously stated, there is little current or projected UAV activity in New Zealand and consequently the issue is of no urgency, and what there is can be dealt with on a case by case basis. New Zealand has the opportunity to take the lead in this issue, and devise its own solution, to its own unique situation. New Zealand is not North America, or Europe, or anywhere else. New Zealand is isolated in the south west Pacific Ocean; a sparsely populated island with relatively light levels of air traffic. It is questionable whether any solution forthcoming from the FAA, or the European Aviation Safety Agency, will be suitable to New Zealand's unique situation, and provide more than a starting point. Routine operation of UAVs will eventuate in New Zealand in time, and the sooner the rules are set for their operation, the sooner the country can benefit from the opportunities and capabilities they bring.

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[65] John Croft, 'Flying sense', p.39.

[66] NZCAA Paper, p.19.

C h a p t e r 7

CONCLUSIONS

New Zealand derives significant income from its EEZ, but in reality the country has barely begun to exploit its potential. Despite the finite and fragile nature of New Zealand's fisheries, it supports a $4.5 billion industry which contributes over $1 billion to the balance of payment sheet through exports. With careful management from MFish it is hoped the current level of income can be sustained, but the delicate nature of the resource gives no guarantees. In addition to the pressures of sustainability there are also pressures from unscrupulous foreign fishing vessels with little regard to conservation of stocks. And while MFish have some success in deterring these vessels, the size of the problem is unknown, and is likely to remain so with limited surveillance assets. New Zealand's other source of income from its EEZ is oil and gas production, with oil production in 2007 being around 14.6 million barrels, and gas production being around 150 billion cubic feet.

While current energy production is modest, New Zealand is predicted to become a significant player in the energy market in the future. The Petroleum Conference held earlier in 2008 was optimistic in regard to the potential of New Zealand's offshore oil fields and some estimates put the combined potential of these oilfields around New Zealand at up to 70 billion barrels of oil. Currently, New Zealand has proven oil reserves of 500 million barrels. If only one per cent of the industry's predictions prove correct, the country's current known reserves will more than double. And while most of this oil is in deep water and costly to extract, oil exploration companies continue to show interest, and with one eye on the future are pressing ahead with exploration. One reason for this is that New Zealand is regarded as a stable country, and should oil production reach significant levels, even in times of international tension, supply is almost certainly guaranteed, unlike many parts of the world. Similarly the natural gas industry is buoyant, with current estimates putting reserves out to at least 15 years of consumption, with gas hydrates off the East Coast potentially holding at least similar reserves. New Zealand was also recently granted exclusive rights through UNCLOS to an additional 1.7 million km^2 of seabed as part of the confirmation of the extent of New Zealand's continental shelf. It is thought that at least parts of the area are likely to be rich in mineral deposits.

Not only is New Zealand deriving significant income from its EEZ at this point in time, the potential for increasing this in the medium to long term through the energy sector is enormous. As valuable as the EEZ is to New Zealand, very little is done to monitor or protect it. The incoming Labour Government of 1999 recognised this and set in motion a sequence of defence documents and reviews with the aim of scoping the issue and identifying opportunities for improvement, and there were many. The *MPR* of 2001 was scathing in its portrayal of the then current state of maritime surveillance, both from the perspective of surface and aerial surveillance. It found that New Zealand knew almost nothing of the activities in its own EEZ, and that the means available to gather information was inadequate, uncoordinated, and ineffective. The review regarded the Navy as being completely lacking in suitable patrol vessels, and the Air Force contributing relatively little by way of aerial surveillance, recommending a ten times increase in the then current aerial surveillance hours given over to government agencies with an interest in maritime security; being mainly Customs and MFish. The subsequent *Government Defence Statement* ordered a review of maritime forces and also called for options to fill the short/medium range patrol aircraft deficiency. The *Maritime Forces Review* was largely based on the civilian requirements for coastal and mid-range offshore patrol capability, and largely echoed the findings of the *MPR*. The *MFR* recommended a Naval Patrol Force of up to nine ships made up of five inshore patrol vessels, three offshore patrol vessels, and one multi-role vessel that could also provide tactical sealift. Subsequently an order was placed in mid-2004 for four inshore patrol vessels, two offshore patrol vessels, and one multi-role vessel, to fill the role of a Naval Patrol Force.

While these vessels will ultimately fill the gaps in surface maritime surveillance, it will be under the disadvantage of only being provided with limited aerial support. The enabling role that maritime patrol aircraft play in supporting surface patrol assets is well acknowledged. They can cover much greater areas over a shorter period of time, being able to quickly gain a picture of events, and identify targets of interest. This information can then be passed on to surface assets acting as response units to further investigate any suspicious activity and take action as required. It appeared that this effect was what was desired in the maritime domain, when a report was commissioned with DTA to provide options for providing a short/medium range aerial maritime surveillance capability. The report was released in late 2004, however, no follow-up was initiated and the requirement for the capability was quietly dropped from the *2006 Long Term Development Plan Update*. The *MPR* had also recommended that should the government decide to retain the RNZAF's Orions they should be upgraded with surveillance equipment that was suited for use in supporting civilian agencies engaged in the maritime security of the EEZ.

At the time it was suggested that each aircraft could be upgraded for a cost of around $10-12 million. The *MPR* made it clear at the time that one of the major reasons for retaining the Orions was for their potential utility in supporting civilian agencies with maritime surveillance of the EEZ. Subsequently, it was announced that the Orions were to have a systems upgrade at a cost of $374 million for the fleet. It is possible that any funds earmarked for use in obtaining a SMRPA were absorbed by the Orion upgrade. As a consequence there is no more aerial maritime surveillance carried out now than there was at the time the *MPR* was released, and the prospects of their increasing over the short to medium term are virtually nil under current plans. This appears to contradict various current government documents which declare that protection of the sovereignty of New Zealand and its EEZ is paramount. A satisfactory explanation had not been forthcoming, despite enquiry. It appears the RNZAF are either unable or unwilling to play a full and active part in meeting its obligations as laid out in defence policy. A great deal of the Orions time is apparently being spent further afield engaged in activities previously accorded a low priority, such as ASW training, which was noted by the previous government as being virtually redundant in the south west Pacific.

The gaps continue to exist and it is a case of how much longer the country can afford to ignore it. There is a compelling case to increase maritime surveillance as stated in the *MPR*, and since then the additional spectre of transnational terrorism has been added, to go along with Customs regular concerns of illicit movement of drugs, people, and contraband in general. Should the acknowledged deficiencies be addressed, there are three options, if the option of doing nothing is ignored. Firstly, it was suggested by the NMCC that with the Orions upgraded systems and their capacity to produce more and better intelligence, the current levels of service, i.e. around 250-300 hours, possibly increasing to around 400 hours over the next three years or so, is adequate to meet all the aerial maritime surveillance requirements of civilian organisations. Considering the *MPR* called for 3000 hours to meet minimum requirements, and a DTA report put the figure even higher, this suggestion goes against the wisdom of both the end-users as well as experts in the field and can be dismissed. It is also an option to increase Orion hours, but there are both drawbacks and consequences to this. The Orions are a very expensive aircraft to operate, and there are issues with both the availability of crews and the reliability of a 42-year-old aircraft. It is also doubtful that the Air Force would be agreeable to cutting back on other roles; which would then require an increase in allocated hours from the current of around 2500 hours per annum for the fleet. Then not only are the previously mentioned issues of crews and reliability exacerbated, but the airframe life is reduced at a greater rate than projected, which reduces the timeline for airframe retirement. For the stated reasons, any solution involving additional hours flown by Orions can be dismissed.

The second option is to employ a dedicated short/medium range maritime patrol aircraft of the class that is usually a medium sized twin turboprop powered regional passenger aircraft, converted to the role. There are a number of this type currently on offer in the maritime surveillance role, and in the case of the Australian Border Protection Command, they use the de Havilland Dash 8, a version of which is in regular domestic airline service with Air New Zealand. The advantages of such an aircraft are several. It is envisaged that any such aircraft would preferably be operated by civilian contractors, along the lines of Coastwatch which serves Border Protection Command. This would ease recruitment and servicing issues compared with a military set up and with it being a new and modern aircraft, reliability levels would exceed those of the Orion by a considerable factor. As part of a dedicated unit they would be available around the clock and would not be used for any other purpose or tasking which would probably be the case if they were operated by the military. They would require significantly less aircrew and training, and their fuel costs would be drastically reduced compared to an Orion, and perhaps most importantly, their endurance is only fractionally less than an Orion. In the context of maritime surveillance of the EEZ, a short/medium range patrol aircraft represents an attractive option which even with purchase costs included is likely to be a more cost-effective option than the Orion over the long-term.

The third option is to introduce UAVs to the maritime surveillance role. There are three aspects to the operational context in which they might operate, and each requires a different solution; there being no 'silver bullet' in the world of UAVs. Firstly there is in coastal regions, targeting, for instance, a specific shellfish bed or boats operating in closed areas adjacent to the shore, or in the case of customs, illegal landings associated with transnational crime. In these instances a Tier 1 machine, such as the New Zealand developed Skycam 2-EB, would appear to be suitable. Such a machine has no manned equivalent and introduces a new capability from this alone. It can loiter for six hours or more, with a low visual and noise signature, and it would not be too technically demanding to distribute the sensor product in near real time to appropriate agencies for recording as evidence as required. These machines are available now, they are of only modest cost both to acquire and run, and do not require years of training to operate. There is a need for the capability they bring, and the issues with operating in the national airspace are not insurmountable, if there is a desire to come up with a solution. What is sure is that if those inclined to illegal activity are aware that the authorities have the means to greatly increase their chances of discovery, it will act as a strong deterrent.

At the next level is oceanic surveillance of the EEZ which requires a more capable machine in the Tier 2 class. These machines and their supporting infrastructure are complex, and appear to offer no cost advantages, in respect to acquisition at least, over a small fleet of manned short/medium range patrol aircraft. There are a number of choices in this class, with a type such as the Heron 1 at the lower end, and a derivative of Predator B at the high end. In either case both offer a number of advantages over a manned alternative. Apart from lower operating costs in the context of maintenance and fuel burn, they have the major advantage of endurance, which is the essence of this class of UAV. While bringing the obvious advantage of persistence manifested in 30 to 40 hour endurance, they also offer the advantages of inherent low-observability, associated with small size, low noise levels, and composite airframes. They can stand off at a distance, unobserved while gathering intelligence; in a manner which no manned aircraft can replicate. One further option would be to provide the Navy's two OPVs with an organic UAV for the purpose of EEZ surveillance. These vessels are equipped for helicopter operations and there is no apparent reason why they could not operate a VUAV in the class of the S-100 Camcopter. It seems unlikely that Seasprites will be available on a regular basis, and a VUAV could be a permanent fixture. The Camcopter is a relatively small machine and it is likely that should a Seasprite be embarked then the Camcopter could also be carried. Their operating costs are only a fraction of a Seasprite and they would provide a major increase in the ISR capability of the surface vessels.

Ownership of a Tier 2 type machine is problematic. It is not believed that the RNZAF show a great deal of interest in non-military tasks, and for this and issues of misapplication and manpower resources it might be desirable to have them operated by civilians. New Zealand Customs, as the lead agency in homeland security, which includes border control, should oversee their operation, as well as control access to the intelligence product. However, issues with CAA certification of such an organisation may put barriers in place that are some time away from being resolved. It therefore appears logical that the RNZAF should maintain and operate any such machines to their own standards within their own system, which does not have to follow CAA rules and requirements. This would unquestionably simplify matters, but the issue of manning in the RNZAF remains. Regardless, Customs would control their tasking through the NMCC, who are capable of much greater involvement and responsibility in operational matters. However, being such a potentially complex issue, it would also be desirable that some form of specialised airworthiness authority or lead agency, possibly an offshoot of the CAA, be formed to coordinate all issues pertaining to operation of UAVs in New Zealand, be they civil or military. And if the RNZAF are to eventually to become involved with UAVs, as seems inevitable, it would be considered desirable to form some kind of guiding body or command with the army and navy to provide a joint effort and minimise duplication of services, processes, and infrastructure peculiar to the operation of UAVs.

In summary, it is beyond doubt that major gaps currently exist in the aerial maritime surveillance of New Zealand's EEZ. With the predicted increasing importance of the EEZ as a source of wealth to the nation and possible greater pressures from future external sources, it is vital that some form of action is taken to remedy this in the near future. A number of options have been presented and assessed. It is clear that the RNZAF's Orion fleet, could at best, only provide minor relief to the situation and at a significant cost that is considered unsustainable in the long term and is therefore discounted. The two remaining options of manned short/medium range patrol aircraft, or UAVs (preferably operated in a layered approach), both offer viable solutions. In the short to medium term, the former probably offers the best solution as there are no barriers in place to their operations within the current CAA regulations, and they could be acquired and operational within a short timeframe. However, for state of the art capability, UAVs are the first choice as a long-term solution. The advantages they bring, and in particular their persistence and inherent low observability would be highly desirable, and knowledge of the presence of such a capability in the EEZ of New Zealand would act as a powerful deterrent to illegal activity. UAVs are without doubt the way of the future. The opportunity is there to be a leader, particularly in the area of UAV operation in the national airspace. The introduction of such a capability would send a strong message to those who may challenge New Zealand’s sovereignty, that New Zealand takes homeland security seriously and that the high chance of discovery and punishment makes it no longer worth the risk.

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APPENDIX A

Maritime Surveillance Aircraft and UAS referred to in the text

P-3K

Manufacturer	Lockheed
Power plant	Four Allison T56-A 14 engines, (4,600 shaft horsepower).
Length	36m (117ft)
Wingspan	30.4m (99ft)
Height	10.3m (34ft)
Basic weight	30,450kg (67,000lbs)
Gross weight	54,950kg (127,500lbs)
Max fuel	27300kg (60,000lbs)
Cruising speed	630km/h (340kts)
Ferry range	approx 7,100km (3,850NM)
Typical performance	Radius of action of 1,850km (1,000NM) with 4 hours on station. Endurance of 15 hrs with two engines shut down to conserve fuel.
Crew	Normally 12 comprising of two pilots, two flight engineers, two navigators (including tactical co-ordinator), one air electronics officer and four air electronics operators, one air ordnanceman. Can carry a maximum of 21 personnel including crew.
Fleet History	The RNZAF currently operates six P-3K Orions. It took delivery of five P-3B Orions in 1966 (NZ4201 - NZ4205). In 1985 an ex-RAAF P-3B was purchased (NZ4206). All six Orions were upgraded (avionics and radio systems) under project RIGEL in the early 1980s. Following the upgrade the designation P-3K has been applied to these aircraft.
Sensors	Wescam MX-20 EO/IR Turret Elta EL/M 2022A(V)3 (Upgrade)

Dash 8 (multi-role variant)

Manufacturer	de Havilland (Canada)
Power plant	Two Pratt & Whitney Canada PW123B turboprops 2500 shp
Length	25.7m (84 ft 3in)
Wingspan	27.4m (90ft)
Height	7.49m (24 ft 7 in)
Basic weight	11,791kg (25,995 lb)
Gross weight	19,505kg (43,000 lb)
Max fuel	3,160l (695 imp gals)
Cruising speed	528km/h (285kts)
Range	approx 3,000km (1,800SM) with extended range tanks
Typical endurance	Up to 11 hours at low altitude.
Crew	Normally 4 comprising two pilots, and two systems operators.
Sensors	Wescam MX-15 EO/IR
	Raytheon SV-2022 SAR/ISAR

King Air 350 ER ISR special mission

Manufacturer	Hawker Beechcraft (USA)
Power plant	Two Pratt & Whitney PT6A-60A 1050 shp
Length	14.23m (46.7ft)
Wingspan	17.65m (57.9ft)
Height	4.36m (14.3ft)
Basic weight	4626kg (10,200lb)
Gross weight	7484kg (16,500lb)
Max fuel	2355kg (5192lb)
Cruising speed	303 kts
Range	approx 2,400 nm
Typical endurance	Up to 8 hours at low altitude.
Crew	Normally 4 comprising two pilots, and two systems operators.
Sensors	Wescam MX-15 EO/IR
	Lynx II SAR or similar

Predator A (MQ-1)

Manufacturer	General Atomics Aeronautical Systems Incorporated (USA)
Power Plant	Rotax 914F four cylinder engine rated at 115 hp
Wingspan	14.8 meters (48.7 feet)
Length	8.22 meters (27 feet)
Height	2.1 meters (6.9 feet)
Weight	512 kilograms (1,130 pounds) empty
Max takeoff weight	1,020 kilograms (2,250 pounds)
Fuel Capacity	665 pounds (100 gallons)
Payload	204 kilograms (450 pounds)
Speed	Cruise speed around 84 mph (70 knots), up to 135 mph
Endurance/range	24 hours at up to 400 nautical miles (454 miles)
Ceiling	up to 25,000 feet (7,620 meters)
Armament	two laser-guided AGM-114 Hellfire missiles
Crew (remote)	Two (pilot and sensor operator)
Sensors	Raytheon Multi-Spectral Targeting System (MTS) AN/AAS-52
	Northrop Grumman TESAR synthetic aperture radar
IOC	March 2005

Predator B (MQ-9 Reaper)

Manufacturer	General Atomics
Wingspan	20.1168m (66ft)
Length	10.9728m (36ft)
Weight	4,536kg (10,000lb)
Internal Payload	363kg (800lb)
External Payload	1,361kg (3,000lb)
Engines	Honeywell TPE 331-10T
Altitude	50,000ft (15,240m)
Endurance	Over 30 hours
Airspeed	Over 407km/hr (220kt)
Ground Station	Trailer 30ft x 8ft x 8ft (9.14m x 2.44m x 2.44m)
	C-130 transportable
Sensors	Two-Colour DLTV Television - Variable zoom, 955mm spotter
	High-Resolution FLIR - Six fields of view, 19mm to 560mm
	Synthetic Aperture Radar - All weather surveillance, 1ft resolution

Global Hawk

Manufacturer	Northrop Grumman
Empty Weight	9,200lb
Payload	1,900lb (RQ-4B - 3,000lb)
Take-Off Fuel	14,500lb
Take-Off Gross Wt	25,600lb (RQ-4B - 32,250lb)
Engine	Rolls-Royce North America AE3007H turbofan
Max Endurance	42 hours (RQ-4B - 33 hours)
On-Station	24 hours @ 3,000nm
Loiter Speed	343kt TAS
Maximum Altitude	65,000ft
Wingspan	116.2ft (RQ-4B - 130.9ft)
Length	44.4ft (RQ-4B - 47.6ft)
Height	15.2ft
Ferry Range	14,000nm
Communications:	SATCOM Datalink, 1.5Mbps, 8.67Mbps, 20Mbps, 30Mbps, 40Mbps, 47.9Mbps
	Line of Sight (LOS) Datalink, 137Mbps
Sensors:	Synthetic Aperture Radar (SAR),1m/0.3m resolution (WAS / Spot)
	Moving Target Indicator (MTI) Mode, 4kt minimum detectable velocity
	Electro-Optical, NIIRS 5.5 / 6.5 (WAS/Spot)
	Infrared NIIRS 5.0 / 6.0 (WAS/Spot)
	Location Accuracy, 20m Circular Error of Probability (CEP)
	Wide Area Search, 40,000nm²/d
	Target Coverage, 1900 spot targets per day

Heron TP

Manufacturer	Israel Aircraft Industries
Endurance	36 hr
Range	Beyond Line of Sight (BLOS)
Altitude	45,000 ft
Max take-off weight	4,650 kg
Typical payload	1,000 kg
Overall length	14 m
Wingspan	26 m
Engine	1,200 hp Turbo Prop (possibly PT6)
Payloads	EO/IR/LRF, SAR, MPR, ELINT, COMINT
Data Links	Line of Sight, Satellite communication (SATCOM)

ScanEagle

Manufacturer	Boeing/Insitu
Max Takeoff Weight	37.9 lb / 18 kg
Payload	13.2 lb / 6 kg
Endurance	20+ hours
Service Ceiling	16400 ft / 5000 m
Max Level Speed	70 knots / 36 m/s
Cruise Speed	49 knots / 25 m/s
Wing Span	10.2 ft / 3.1 m
Fuselage Diameter	7.0 in / 0.2 m
Length	3.9 ft / 1.2 m
Camera Range	100+ km
Payload	EO/IR camera and SAR

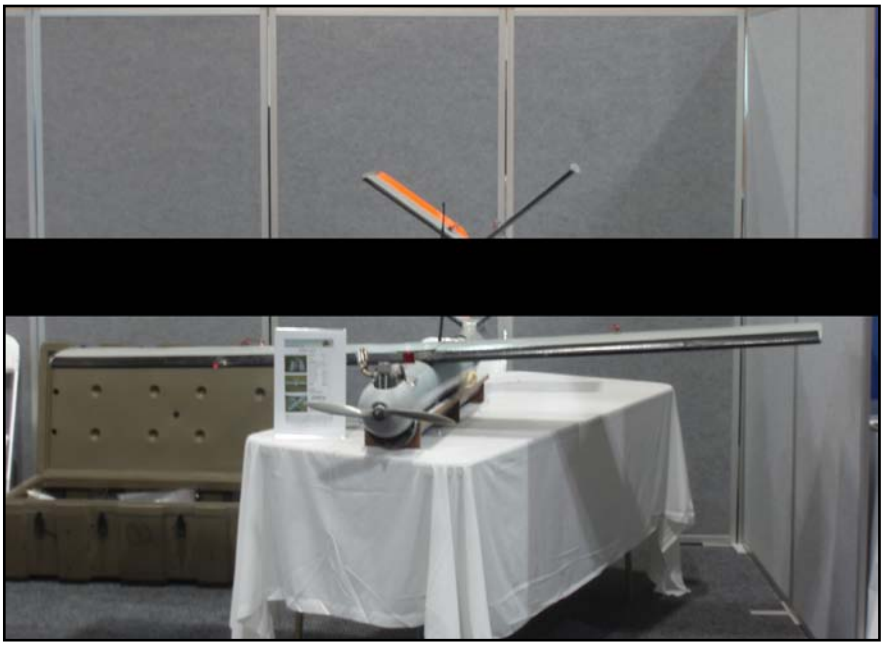
RQ-11 Raven

Manufacturer	AeroVironment (USA)
Range	10 km
Endurance	60–90 minutes (Rechargeable Battery), 80–110 Minutes (Single Use Battery)
Speed	32-81 km/h, 17-44 knots_
Operating Altitude	100-500 ft (30-152 m) AGL, 14,000 ft MSL max launch altitude
Wing Span	4.5 ft (1.4 m)
Length	3.0 ft (0.9 m)
Weight	4.2 lbs (1.9 kg)
Launch Method	Hand-launched
Recovery Method	Deep-stall landing
Payloads	Dual forward and side-look EO camera nose, electronic pan-tilt-zoom with stabilization, forward and side-look IR camera nose (6.5 oz payloads).
GCS	Lightweight, modular components, waterproof softcase, optional FalconView Moving Map and Mission Planning. Laptop interface, digital video recorder and frame capture.

Heron 1

Manufacturer	Israel Aircraft Industries
Endurance	45 hr
Range	350 km
Range with satellite coverage	Beyond Line of Sight
Altitude	30,000 ft
Max take-off weight	1,150 kg
Max Payload Weight	250 Kg
Overall Length	8.50 m
Wingspan	16.60 m
Payloads	Electro Optical (TV & IR Combi or Triple Sensor TV/IR/LD)
	Synthetic Aperture Radar (SAR)
	Maritime Patrol Radar (MPR)
	COMINT & ESM capability
	Communication relay package
	Integrated ATC Radio
Datalinks	Direct Line-of-Sight (LOS) data link
	UAV airborne data relay for beyond LOS missions
	Ground-based data relay for beyond LOS missions
	Satellite communication

Kahu 2-EB



Manufacturer	Skycam UAV (NZ)
Span	2.46m
Length	1.53m
Weight	15Kg
Cruise speed	90 Km/hr
Power plant	35cc Gasoline
Endurance	6-8 hours
Recovery	Parachute assisted landing
Payload	Able to carry a range of sensor packages up to 3Kg.

Hawk

Manufacturer	Skycam UAV (NZ)
Span	2.3m
Length	1.1m
Endurance	90min+
Weight	3kg
Cruise speed	30 knots
Motor	Electric powered, Lithium-Polymer batteries
Payload:	8 Mega pixel still camera, or full motion video 2 X digital zoom
Range (Data Comms)	50+ (Kms)
Range (Video Comms)	25 Km Line of Sight

CAMCOPTER S-100

Manufacturer	Schiebel (Austria)
Dimensions	length 3110 mm (122“)
	height 1040 mm (41“)
	width 1240 mm (49“)
Navigation	redundant INS and GPS
Power plant	55 HP rotary engine
Data/video link	fully digital, compressed video (up to four simultaneous feeds)
Typical D/L range	80/180 km (43/97 nm)
Dash speed	120 kts
Cruise speed	55 kts (for best endurance)
Endurance	6 hours with 25 kg (55 lbs) payload
Maximum payload	50 kg (110 lbs)
MTO weight	200 kg (440 lbs)
Empty weight	100 kg (220 lbs)
Main rotor diameter	3400 mm (133.9”)
Autonomy	fully autonomous takeoff, waypoint navigation and landing
Payloads	Stabilized Daylight/Infrared Gimbal
	Synthetic Aperture Radar (SAR)
	Light Detection and Ranging (LIDAR)
	Multi-Spectral Imaging
	Ground Penetrating Radar (GPR)