Philippine Air Force Visiting Fellow Program

"OUR RADARS"

Fred Reina Llosa
Optimum Utilisation of Radars:
Roles in Air Defence, Air Traffic Control, Reconnaissance and Surveillance

'OUR RADARS'

Fred Resma Llosa

Aerospace Centre
RAAF Fairbairn
Canberra
2000
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About the Author

Colonel Fred R Llosa PAF (GSC) is a graduate of the Philippine Air Force Flying School Class 1974. He first joined the 15th Strike Wing where he was trained as a combat ready pilot of the AT-28D aircraft and experienced his first baptism of fire in February 1975 when he flew his first combat mission in Mindanao. It was the height of the secessionist movement of the Moro National Liberation Front (MNLF).

In 1979, Colonel Llosa transferred to the 205th Helicopter Wing where he flew the UH-IH helicopter aircraft. His assignment with this unit enabled him to be deployed to the different areas of the country, from the northern most tip of Luzon to the southern most islands of Tawi-tawi in Mindanao. He has flown varied missions including troop insertions and extrications, medical evacuations, search and rescue and several disaster, relief and rehabilitation missions.

The author spent most of his military career being assigned in the field particularly in the Visayas area. He was the Executive Officer of CASF 8 for five years, TACP Commander in Bacolod, Negros Occidental during the massive military operation code-named OPERATION THUNDERBOLT in 1989. He was also TACP Commander during the sustained operations in Bagacay, Samar, called OPERATION LUMBERJACK in 1991. All these operations were against the Communist insurgents.

After taking up the Command and Staff Course (CSC) in 1996, he was designated Commander of the Composite Air Support Force V (CASF V), in Legaspi City, Albay where he stayed for more than two years. It was during his tenure that CASF V was adjudged CASF of the Year for two consecutive years, 1996 and 1997.
Prior to his attachment to the Aerospace Centre, Colonel Llosa was the Director for Operations of the 15th Strike Wing. He has been designated to various positions and has commanded several major PAF units. He is a recipient of several awards and decorations including Plaques of Appreciation and Letters of Commendation. He has also flown the OV-10 Broncos and the MG-520 Helicopter gunship.
Acknowledgments

My attachment to RAAF Aerospace Centre has been quite an experience I definitely will not forget. The three months of my stay here has broadened my perspective not just as a ‘Philippine Fellow’ from the Philippine Air Force but much more as a person having experienced for the first time the ‘magic’ of Australia.

My stay was not all a ‘bed of roses’ but with the people I was given the opportunity to work and to spend time with, the task I set out to complete has been greatly alleviated. Their efforts in assisting me made my work easier, bearable and definitely most meaningful.

My profound appreciation and thanks to all the staff of the Aerospace Centre under its able leader Group Captain Allan Crowe. They were all very supportive of me and were always available to share their time and knowledge in assisting me develop this work.

I would make special mention to Wing Commander Colin Price, who has painstakingly provided guidance and intellectual comments as I was developing my work. Most importantly, I would also want to thank him for allowing me to use his golf set all throughout my stay in Australia. Indeed, it made my life here very enjoyable.

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My acknowledgment will not be complete without mentioning the people who directly or indirectly supported me as I developed this work. They include my partner, Major Eric Gloria, who painstakingly taught me ‘how to surf the internet’, and to my friends and classmates back home who one way or the other helped me realise this endeavour. To my family, who is always behind me in all my undertakings, I owe you all my love. Lastly to the Lord Almighty for His guidance and blessings.
# Table of Contents

About the Author iii
Acknowledgments v
Acronyms and Abbreviations ix
Preface xii

**CHAPTER ONE**
- Introduction 1
- History 1
- Research Purpose 3
- Aim of this Paper 4
- Scope 4

**CHAPTER TWO**
- PAF Air Defence System 7
- Current Defence Policies 8
- National Defence Strategy 8
- Concept of Operations 10
- Organisation 11
- Functions of the PADS 12

**CHAPTER THREE**
- Limitations of the PADS 13
  - Context of Modern Air Defence System 14
  - Perceived Limitations 15
  - Multi-Role Fighter Aircraft 15
  - Antiquated Radar Surveillance Equipment 16
  - Limited Radar Surveillance Coverage 17
  - Insufficient Weapons Controllers 19
  - Unreliable Communication Network 19

**CHAPTER FOUR**
- AFP Modernization Law and PAF Modernization Program 23
  - Background 23
  - Rationale 24
  - National Defence Objectives 24
  - Development of AFP Capabilities 25
  - Development of Major Service/General Headquarters Capabilities 26
  - PAF Modernization Program 27
  - Force Restructuring and Organisational Development 28
  - PAF Mid-Term Strategy 29
  - PAF Operational Imperatives 29
| CHAPTER FIVE | PAF and ATO Cooperation | 33 |
| Terms and Conditions | 33 |
| General Provisions | 34 |
| Cost Sharing on Acquisition, Operations and Upgrading | 35 |
| Operating Cost | 36 |
| Joint Training | 36 |
| Joint Operation of Radar and Facilities | 37 |
| Procedures on Air Defence Conditions | 37 |
| Limitation/Delineation in the Use/Operation of Equipment | 38 |
| Security and Access to Classified Matters | 39 |

| CHAPTER SIX | Optimum Utilisation of Radars: Roles in Air Defence, Air Traffic System, Reconnaissance and Surveillance | 41 |
| Background | 41 |
| Definition of Radar | 42 |
| Types of Radar | 42 |
| Radar System | 43 |
| Radar Applications | 47 |
| One Radar for All | 49 |
| System-of-Systems | 53 |
| PADS as System-of-Systems Example | 54 |
| Australian Experience | 58 |

| CHAPTER SEVEN | Conclusion | 61 |
| Systems Advancement Analysis | 61 |
| Systems Acquisition Priority | 63 |
| Mixed Systems Acquisition | 64 |
| Systems Data Fusion | 66 |
| Final Analysis | 67 |

Bibliography | 71 |
## Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCW</td>
<td>Aircraft Control and Warning Wing</td>
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<td>ACCS</td>
<td>Aircraft Control and Warning Squadron</td>
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<td>ACS</td>
<td>Australian Coastwatch Service</td>
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<td>ADC</td>
<td>Air Defence Command</td>
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<td>ADF</td>
<td>Australian Defence Force</td>
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<td>ADFP</td>
<td>Australian Defence Force Policy</td>
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<td>ADO</td>
<td>Air Defence Operations</td>
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<td>ADS</td>
<td>Air Defence System</td>
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<td>ADT</td>
<td>Automatic Detection and Tracking</td>
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<tr>
<td>AFP</td>
<td>Armed Forces of the Philippines</td>
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<td>AIROPS</td>
<td>Air Operations</td>
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<td>AOC</td>
<td>Air Operations Center</td>
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<td>ARC</td>
<td>Air Reserved Command</td>
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<td>ARSR</td>
<td>Air Route Surveillance Radar</td>
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<td>ASCO</td>
<td>Air Space Control Operations</td>
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<td>ASEAN</td>
<td>Association of South East Asian Nations</td>
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<td>ATO</td>
<td>Air Transportation Office</td>
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<tr>
<td>BFAR</td>
<td>Bureau of Fisheries and Aquatic Resources</td>
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<td>BOC</td>
<td>Bureau of Customs</td>
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<td>BID</td>
<td>Bureau of Immigration and Deportation</td>
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<tr>
<td>CA</td>
<td>Civil Agencies</td>
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<td>C-E</td>
<td>Communications-Electronics</td>
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<tr>
<td>CG, PAF</td>
<td>Commanding General, Philippine Air Force</td>
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<tr>
<td>COC</td>
<td>Command Operations Center</td>
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<tr>
<td>CO</td>
<td>Commanding Officer</td>
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<tr>
<td>CRT</td>
<td>Cathode-Ray Tube</td>
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<td>CSAFP</td>
<td>Chief of Staff Armed Forces of the Philippines</td>
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<td>C4I</td>
<td>Command, Control, Communication, Computer, Intelligence</td>
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<tr>
<td>CW</td>
<td>Continuous Wave</td>
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<tr>
<td>DA</td>
<td>Department of Agriculture</td>
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<td>DENR</td>
<td>Department of Environment and Natural Resources</td>
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<td>DEFCON</td>
<td>Defence Condition</td>
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<td>DoE</td>
<td>Department of Energy</td>
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<td>Department of Finance</td>
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<td>DoJ</td>
<td>Department of Justice</td>
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<td>DND</td>
<td>Department of National Defence</td>
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<td>DOTC</td>
<td>Department of Transportation and Communications</td>
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<tr>
<td>EEZ</td>
<td>Exclusive Economic Zone</td>
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<td>EWD</td>
<td>Early Warning Device</td>
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<td>FM</td>
<td>Field Manual</td>
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<td>FM</td>
<td>Frequency Modulated</td>
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<td>Acronym</td>
<td>Abbreviation</td>
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<td>GCA</td>
<td>Ground Control Approach</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHQ</td>
<td>General Headquarters</td>
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<td>GRC</td>
<td>Ground Radio Communications</td>
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<td>GRR</td>
<td>Ground Radio Receiver</td>
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<td>GRT</td>
<td>Ground Radio Transmitter</td>
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<td>HRD</td>
<td>Human Resource Development</td>
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<td>HF</td>
<td>High Frequency</td>
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<td>HF</td>
<td>Height Finder</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>ITS</td>
<td>Intelligent Transport System</td>
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<td>JOC</td>
<td>Joint Operations Center</td>
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<td>JORN</td>
<td>Jindalee Over-the-Horizon Radar Network</td>
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<tr>
<td>JR</td>
<td>Joint Resolutions</td>
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<td>JROC</td>
<td>Joint Rescue Operations Center</td>
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<td>LGU</td>
<td>Local Government Unit</td>
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<td>MARINA</td>
<td>Maritime Industry Authority</td>
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<td>MDT</td>
<td>Mutual Defence Treaty</td>
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<td>MPA</td>
<td>Maritime Patrol Aircraft</td>
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<td>MRF</td>
<td>Multi-Role Fighter</td>
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<td>MOA</td>
<td>Memorandum of Agreement</td>
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<td>NADACS</td>
<td>National Air Defence and Airspace Control System</td>
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<td>NDS</td>
<td>National Defence Strategy</td>
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<td>NEDA</td>
<td>National Economic Development Authority</td>
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<td>NGO</td>
<td>Non-Government Organisation</td>
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<tr>
<td>NM</td>
<td>Nautical Miles</td>
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<td>OTHR</td>
<td>Over-the-Horizon Radar</td>
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<td>PA</td>
<td>Philippine Army</td>
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<tr>
<td>PADCC</td>
<td>Philippine Air Defence Control Center</td>
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<td>PADIZ</td>
<td>Philippine Air Defence Identification Zone</td>
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<tr>
<td>PADS</td>
<td>Philippine Air Defence System</td>
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<td>PADSJR</td>
<td>Philippine Air Defence System Regulation</td>
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<td>PAF</td>
<td>Philippine Air Force</td>
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<td>PAGASA</td>
<td>Philippine Atmospheric and Geophysical and Astronomical Services Administration</td>
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<td>PAJUC</td>
<td>PAF-ATO Joint Use Committee</td>
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<td>PAMP</td>
<td>Philippine Airways Modernization Project</td>
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<td>PCG</td>
<td>Philippine Coast Guard</td>
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<tr>
<td>PMO</td>
<td>PAF Modernization Program</td>
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<td>PME</td>
<td>Professional Military Education</td>
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<td>PN</td>
<td>Philippine Navy</td>
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<td>PNP</td>
<td>Philippine National Police</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>PPI</td>
<td>Plan Position Indicator</td>
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<td>RA</td>
<td>Republic Act</td>
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<td>RAAF</td>
<td>Royal Australian Air Force</td>
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<td>RAN</td>
<td>Royal Australian Navy</td>
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<tr>
<td>ROE</td>
<td>Rules of Engagement</td>
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<tr>
<td>RP</td>
<td>Republic of the Philippines</td>
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<tr>
<td>SAR</td>
<td>Search and Rescue</td>
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<td>SPADATS</td>
<td>Space Detection and Tracking System</td>
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<td>SLOC</td>
<td>Sea Lanes of Communication</td>
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<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
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<tr>
<td>SQDN</td>
<td>Squadron</td>
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<tr>
<td>TAAATS</td>
<td>The Australian Advanced Air Traffic System</td>
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<tr>
<td>TF</td>
<td>Task Force</td>
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<tr>
<td>TWT</td>
<td>Travelling-Wave Tube</td>
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<tr>
<td>UHF</td>
<td>Ultra-High Frequency</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>US</td>
<td>United States (America)</td>
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<tr>
<td>USAF</td>
<td>United States Air Force</td>
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<tr>
<td>VHF</td>
<td>Very High frequency</td>
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<td>VSAT</td>
<td>Very Small Aperture Terminal</td>
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Preface

After more than two decades of internal turmoil in the Philippines, almost all the AFP’s resources were used in internal security operations and the external defence of the country was relegated to the back seat. Somehow the presence of the United States forces in the country had provided a security umbrella and paradoxically imbued us with a false sense of security.

The departure of the United States forces from the Philippines in 1991, due to the abrogation of the Bases Agreement by the Philippine Senate and the sudden eruption of Mt. Pinatubo, left the country devoid of an external defence capability and vulnerable to foreign incursions and intrusions. The country was left to protect itself against possible external threat; unfortunately, its external defence capabilities were in total disarray. The fighter element of our external defence, the F-5 Freedom Fighters that have already seen their heyday, are unable to establish a decent deterrence against external threats. The four surveillance radars that the Americans had provided for our external warning, have been reduced to only two operational radars with very limited capabilities. The rest of the radars were either deactivated, unmanned or were simply left to decay due to non-availability of spares or funds for repair. The present situation finds the Philippines with only two surveillance radars with very limited coverage while the rest of the country is bare and unprotected against external incursion.

In 1995 the Philippines woke up to find Chinese structures being put up at Mischief Reef, locally known as Panganiban Reef, just 120 nautical miles off the west coast of Palawan and well within the 200 nautical mile Exclusive Economic Zone (EEZ) of the country. Without the military strength to confront the Chinese, the country was forced to use diplomacy to deal with the problem at hand, but without any success. Three years after, the country was again shocked to find Malaysian structures at one of its nearest shoals south-west of Palawan. Diplomatic protest, the only available course of action left for the country, again proved futile. These subtle, creeping incursions into our territory, if left unchallenged, will one day find us confronted by more substantial threats on our doorstep.

On 23 February 1995, the passing into law of Republic Act Number 7898, better known as the AFP Modernization Act, gave a glimmer of hope to the very limited external defence capability of the AFP. Unfortunately, however, the Philippines is one of those hardest hit by the Asian financial crisis of 1997 and the Modernization Program was derailed. One of the options left for the AFP, particularly the PAF, was for a joint use of highly valuable but limited resources. On 16 March 1995, the PAF and the ATO signed an agreement for the joint use of equipment and facilities in the interest of the Philippine Government.

This book supports such endeavours being based on joint use because it is an approach that optimises the application and use of valuable and expensive equipment. This book further recommends that the PAF procure surveillance radars to be used jointly, not just for external defence or for air traffic control use, but also as a source of valuable information for other government entities and instrumentalities. In this way vital equipment will become a national asset, not simply a PAF tool.
Chapter One

Introduction

With effective weapons systems, we aim to be a lead force in addressing external and internal threats and in responding to national development tasks through prompt and sustained air operations.¹

Lieutenant General Willie C Florendo, AFP (Ret)

History

Immediately after the end of World War II, the Philippines was granted full independence by the United States. On 4 July 1946, the American flag, that had reigned supreme throughout the archipelago for almost five decades, was lowered down and the Philippine flag was hoisted high, signalling total independence from foreign dominance ever since.

History will tell that the Philippines was under foreign control since the Portuguese explorer Ferdinand Magellan² discovered it in 1521. Its discovery on 16 March of that year was the start of a long colonial rule by the Spaniards that lasted for more than 300 years. Spain’s defeat by the Americans in the Spanish-American War ended its dominance in the Philippines and the country was ceded to the Americans in 1898. Thereafter, the Philippines became the colony of the United States of America until its granting of independence in 1946. The rule was shortly interrupted during World War II when the Japanese invaded the country in 1941.

4 July 1946. Philippines was granted independence by the United States.

² Ferdinand Magellan was a Portuguese sailor who led the Spanish ships in search for the Spice Islands and instead discovered the Philippines on 16 March 1521.
Nonetheless, the true essence of independence was never really experienced by the Filipinos despite its granting in July 1946. The presence of the US bases in the Philippines symbolised continued dominance by the Americans in the Philippines. Clarke Air Force Base in Pampanga and the Subic Naval Base in Zambales, two of the United States’ largest military installations outside continental USA, projected US dominance not only in to the Philippines but also the entire Asia-Pacific region.

The defence umbrella with which the US forces shrouded the Philippines supplemented the existing air defence coverage of the Philippine Air Force. The surveillance radar used by the PAF and by their USAF counterparts was part of the military hardware that the US government provided for the Armed Forces of the Philippines. The F-86 D/F Sabre Jets and subsequently the F-5 A/B Freedom Fighters, that performed as fighter interceptors providing the first line of the country’s external defence, were handed down to the PAF et gratia.

The extent of coverage by the surveillance radar of the Philippine Air Defence Identification Zone (PADIZ) covered only the whole island of Luzon and the northern part of the Visayas. The rest of the Visayas and the entire island of Mindanao, including its adjacent islands, were outside the radar coverage. Incidentally, the focal point of this coverage was noticeably Clarke Air Base and Subic Naval Base. Congruently, the signing of the Mutual Defence Treaty (MTD)\(^3\) by the two governments is based on the principle of mutual security and cooperation, although it is relatively beneficial to the Philippines. The continued presence of the Americans up

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\(^3\) The Mutual Defence Treaty was signed by the Philippine and US governments to help protect one or the other in case of foreign invasion subject to each government’s Senate approval.
to 1991 however, served more to project their dominance in order to protect their vested interest in this part of the world.

After the abrogation of the US Bases Agreement in 1991 and the departure of the US forces from the Philippines, the problem of external defence came to the fore. The PAF was left with the outmoded F-5 aircraft for air interception and its air defence radars, mostly non-operational due to lack of spares, were unable to provide the necessary surveillance coverage. The deterrent factor of the US forces had gone leaving the whole country vulnerable to foreign incursions or invasions. A glaring example of this is the Chinese occupation in 1995 of Mischief Reef, which is just 120 nautical miles from Palawan Island, well within the 200 mile EEZ of the Philippines.

The need, therefore, for a radar system that can provide the desired early warning for the defence of the entire archipelago is an issue of fundamental importance. The existence of a credible air defence capability is necessary not only to deter adventurism by other countries against the Philippines, but to protect its natural resources within its territorial boundary and inside its Exclusive Economic Zone (EEZ).

Unfortunately however, the economy of the Philippines has been greatly affected by the Asian economic crisis of 1997. The procurement of a new and sophisticated radar system will take up a big portion of the AFP’s already depleted budget.

A joint use of surveillance radars by the PAF for air defence and by the Air Transportation Office (ATO) for air traffic control is proposed as an efficient and sensible application of scarce radar resources.

Research Purpose

Initially, the aim of this paper is to present a comprehensive discussion on the joint use of radars by both the Philippine Air Force (PAF), of the Department of National Defence (DND), and the Air Transportation Office (ATO) of the Department of Transportation and Communication (DOTC). Of particular importance, is the existence of an implementing agreement between the PAF and the ATO on the joint use of equipment and facilities. This agreement was signed 21 August 1997. The need for discussion on the subject of joint use by the two agencies is redundant and irrelevant. Therefore, this paper will discuss the concept of PAF-procured radar providing multifarious application not only for the PAF, but also to other government agencies, the ATO being only one element. This simply means the surveillance radar procured by the PAF is not just for air defence but would also provide a vital source.

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of information needed by other government instrumentalities in the accomplishment of their assigned tasks or missions.

Aim of This Paper

This paper presents a comprehensive discussion on the need and application of PAF procured surveillance radar including its attendant role in providing information to other government agencies in addition to its primary function as an early warning device for air defence.

Scope

The coverage of discussion will include the following areas:

- Definition of Radar
- Types of Radar
- Radar System
- Radar Applications
- One Radar for All
- System of Systems
- PADS as System-of-systems
- Australian Experience

Surveillance Radar at Wallace Air Station

This chapter will provide an introduction and overview of the succeeding chapters. Chapter Two will present the existing Air Defence System of the PAF. This will include important provisions of the current defence policies, how the system will be implemented, how it is organised and what are its functions.

Chapter Three will describe the present status of the Philippines Air Defence System (PADS) with particular emphasis on its limitations.
Chapter Four will discuss the AFP Modernization Act and the PAF Modernization Program (PMO). Provisions of the law and the modernization program will be presented in the context of attaining a credible air defence capability.

Chapter Five will provide an overview of the existing cooperation arrangements between the PAF and ATO. This chapter will also present the mechanics of the recently signed PAF and ATO agreement, its implementing guidelines and its nature.

Chapter Six presents the core and real essence of this paper. Previous chapters provided the introduction that paved the way to the very purpose of this paper. The main topic of discussion here is surveillance radar, its multiple functions and its relevance not just to our security but also its importance to our existence. As an opener, the chapter will discuss what a radar is all about, what are the different types of radars, their application and their use. Additionally, basic radar characteristics and architecture will be explained, including its sub-system. A large part of the chapter will deal more on how this surveillance radar will interface with the systems of other agencies in order to optimise its utilisation.

\[\text{5 Republic Act Nr 7898, An Act providing for the Modernization of the Armed Forces of the Philippines and for other Purposes, Congress of the Philippines, 23 February 1995.}\]
PADCC state-of-the-art radar screens that monitor external defence situation.

The last chapter will summarise all the discussion in the preceding chapters. This will reinforce the need, not only for a joint use of radar by the PAF and the ATO, but specifically the optimisation of its use. This chapter will also recommend other options that will address the need for similar types of equipment that may supplement related information to other government entities in accomplishing their assigned mission or purpose.
Chapter Two

PAF Air Defence System

While it is true that the Constitution does renounce war as an instrument of national policy, it is our responsibility in the Armed Forces to defend our territorial integrity or else there will be no country to speak of. There will be no population to speak of. There will be no territory to speak of...¹

Secretary Orlando S. Mercado
Department of National Defence

The Philippines is blessed with a natural defence barrier provided by the vast expanse of water that surrounds it. The Pacific Ocean in the east and the South China Sea in the west provides the natural deterrence from foreign incursions. Likewise its boundary in the north is covered by the Balintang Channel and by the Celebes Sea in the south.

The fundamental reason for the existence of the Philippine Air Force is to provide air defence and to maintain control of the national air environment. The PAF is the first line of defence of the Philippines. The PAF has as a priority the protection of the territorial airspace, the safety of the skies from unexpected foreign intrusion and the preservation of the country’s territorial boundaries.

The Philippine Air Defence System is part of the overall defence posture of the country. Forces must be maintained in a state of readiness to counter probable threats or attack from without or within its territorial domain.

Current Defence Policies

The defence of the country by the Armed Forces of the Philippines is mandated in the Philippine Constitution.² It specifically states that ‘The Armed Forces of the Philippines is the protector of the people and the state. Its goal is to secure the sovereignty of the state and the integrity of National Territory.’

The role of the defence establishment is to guard the country against external and internal threats to national peace and security and provide support for social and economic development.³

National Defence Strategy

Honorable Orlando S. Mercado assumed his cabinet portfolio as the Secretary of National Defence in 1998. The former senator and erstwhile media personality has laid down his policy guidance that established the purpose and direction for the Department of National Defence, in general, and the Armed Forces of the Philippines in particular, to pursue and accomplish.

The National Defence Strategy that he formulated follows the six defence policies based on the Strategic Planning and Policy Framework developed by GHQ, AFP.⁴ The national defence strategy is a Five-Point Strategy built around the concept of:

DEFEND – RESPOND – BUILD – PROMOTE – PREPARE

• Defend

The AFP shall defend our country against all forms of military threats, be they internal or external. This is the primary task of the AFP which should be ready to defeat all forms of aggression that will threaten our community and our way of life. In defending ourselves, we believe in the concept of self-reliance — that the task of defending the nation is our sole responsibility and it should not be predicated on the assurance of support from other countries.

• Respond

We shall respond to crisis situations. Our country is often ravaged by calamities whether natural or man-made. These calamities threaten lives and properties and we must be able to provide prompt and effective response to protect and rescue people and to rehabilitate and rebuild destroyed communities.

² Article I Section II of the Philippine Constitution of 1987.
³ Revised Administrative Code of 1987 Subtitled II Chapter 1, Section 15.
⁴ Ibid., p. 9-11.
• Build

We must participate in building the nation, not only in maintaining political stability but also in advancing economic growth and promoting social harmony.

• Promote

We shall promote regional and global security. Our national security is invariably linked with regional peace and stability. To promote regional and global security, we must establish good defence relations with other countries.

• Prepare

We must prepare for the future. We must modernise and professionalise the Armed Forces of the Philippines. Modernisation does not necessarily mean state of the art weapons and equipment, it is also important that technology matches our operational strategy which in turn must take into consideration the limited economic resources for defence.

National Defence Strategy Framework
Concept of Operations

The PAF is tasked with the responsibility of maintaining and operating the Philippine Air Defence System. In order to perform this responsibility, the PADS is equipped with radar facilities for early warning, a fighter aircraft for interception and destruction and a control centre that will orchestrate all the actions, for command and control and distribution of essential information.

The concept on how PADS operates is divided into two main functions. These are:

- Air Defence Operations
- Airspace Control Operations

Air Defence Operations

Air defence is defined as all measures designed to nullify or reduce the effectiveness of hostile air action and may be categorised as active or passive. Active air defence is direct defensive action taken to destroy or reduce the effectiveness of an enemy air attack. It includes such measures as the use of aircraft, anti-aircraft artillery, electronic warfare systems and surface-to-air missiles. Passive air defence consists of all measures other than active defence taken to minimise the effects of hostile air action. These include the use of cover, concealment, camouflage, dispersion and protective construction.\(^5\)

The Air Defence Operations is the primary task of the PADS. It consists of the following functions:

a. Provision of tactical early warning of hostile air activity.
b. Identification of all air traffic in the Philippine Air Defence Identification Zone (PADIZ).
c. Interception of unknown aircraft penetrating the PADIZ.
d. Engagement of hostile aircraft.

Airspace Control Operations

Airspace control is defined as a service provided to increase combat effectiveness by promoting the safe, efficient and flexible use of airspace. It involves the application of air defence, airspace management, air traffic control and fire support coordination to achieve a favourable air environment for the safe, flexible and effective conduct of air defence operations.\(^6\)

The primary objective of airspace control is to maximise the effectiveness of the operations and assure the safe, orderly and expeditious use of airspace. Airspace Control Operations is also called Air Surveillance Management and Control. It has the following functions:

a. Detection
b. Identification and classification
c. Continuous tracking of airborne objects

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\(^5\) Definition was adapted and quoted from the ADFP 29, Chapter 3, paragraph 301.

\(^6\) Ibid., Chapter 2, Paragraph 202-203.
d. Control and management of friendly air assets  
e. Interception of unknown airborne objects

Organisation

The PADS is basically organised following the triad concept of Command and Control, Air Surveillance and Weapons Platform or the Intercept aircraft. The Commanding General of the PAF serves as the Air Component Commander of the PADS. He exercises full command and control over all air defence forces using the facilities of the Philippine Air Defence Control Centre (PADCC).

The three major PAF units involved in the implementation of the PADS are as follows:

1. **The Air Defence Command** (ADC) – This is a major command of the PAF that takes charge of the overall air defence responsibility. It undertakes the command and control of the air defence system. It maintains and operates the Philippine Air Defence Control Centre. The headquarters of the ADC is in Villamor Air Base, Metro Manila.

2. **The 5th Fighter Wing, PAF** – This Wing provides the fighter elements for air defence. It is based in Basa Air Base in Pampanga, which they call the home of the fighter pilots of the PAF. Its primary mission is to conduct active air defence aside from its role of providing tactical air support to AFP ground forces.

3. **The 580th Aircraft Control and Warning Wing** – This Wing operates the surveillance radars that provides early warning to the PADS. Its headquarters is in Wallace Air Station in La Union. Its satellite units or squadrons operate the different radar sites located strategically all over the country.
Functions of the PADS

The PAF Air Defence System is designed to operate during peacetime scenario and during actual hostilities.

During peacetime scenario, the primary functions of the PADS are:

1. Maintenance of air sovereignty
2. Intelligence gathering
3. Military air traffic control
4. Search and rescue

During wartime scenario or actual hostilities, the primary functions of the PADS are:

1. Air Defence, command and control
2. Intelligence gathering and evaluation
3. Mission planning

Air Defence operations include target detection, track initiation, tracking, target identification, threat evaluation, weapons assignment, weapons control and reporting all associated with gaining and maintaining air superiority. Intelligence operations include all intelligence activities employed during peacetime conditions.

The air defence capability of the PADS had been significantly reduced following the departure of the US forces in 1991. The security umbrella it once enjoyed is now replaced with uncertainty primarily because of the dismal state of its equipment and facilities including its intercept aircraft.
Chapter Three

Limitations of the PADS

The command is at present burdened by the restricted number of air
defence aircraft and the limited capabilities of outdated radars...¹

Lieutenant General Willie C. Florendo AFP (Ret)

During the late 1960s and early 1970s, the Philippine Air Force (PAF) was one of the most modern air forces in Southeast Asia, second only to Japan. As a result of the secessionist problem breaking out in Mindanao in the early 1970s and the communist insurgency problem of the 1980s, the primary task of the PAF in addressing external defence was relegated to the sidelines. PAF resources were mostly utilised in the campaign against internal security operations.

The presence of the United States Air Force (USAF) 13th Air Force at Clarke Air Base has ‘provided’, in a way, the external defence capabilities of the PAF.² However, this security umbrella lasted only until 1991 when all US Forces stationed in the Philippines left the country following the abrogation of the US Bases Agreement by the Philippine Senate in November of that same year.

The departure of the US forces has left the air defence capability of the PAF in a depleted state. The presence of the US forces had provided the Philippines with that false feeling of security, their departure has left the country feeling ‘naked and bare’.

The presence of US military bases gave the country a false sense of external security for decades.

¹ Speech of Lieutenant General Florendo, CG PAF, during the inauguration of the ADC Simulator on 11 November 1999.
Context of Modern Air Defence System

The modern context of an air defence system combines the elements of surveillance, response, command and control, communications, computers and intelligence (C4I) to deter or counter violation of one's sovereign airspace. The optimum physical arrangement of these elements enables effective planning, fusion of intelligence data with surveillance information, dissemination of a surveillance picture and warnings, coordination and integration of airspace usage and prosecution of air defence action.

Surveillance Element

Surveillance is the systematic observation of aerospace, surface or sub-surface area, places, persons or things by visual, aural, electronic, photographic or other means. The air defence surveillance element must be able to detect and recognise patterns of activity, provide sufficient response time, and provide sensor data of sufficient resolution to support the response.

Response Element

An air defence system must respond to selected air activity in order to influence air operations within designated airspace. The options for response provided by an air defence system include national initiatives, non-intervention and neutralisation.³

National initiative is normally the first level of response. This may include declaration of an air defence identification zone or the restriction of national or international civil air movements and elevation of defence posture.

Neutralisation is the primary response option associated with air defence and is aimed at making an attack ineffective. Neutralisation of an incursion may be achieved in a non-destructive manner by an intercepting aircraft, which is able to identify, warn-off or shadow an intruder during periods of tension.

Command, Control, Communications, Computers and Intelligence Element

The C4I element of an air defence system comprises command support, tactical data and air traffic systems which fuse data from various sources to provide a time-critical link between the command and control, surveillance and weapons functions.⁴

Using the preceding paragraph as the basis of determining the capability of the existing PADS, the current system is incapable of performing its mandated task and is in urgent need of upgrading and replacement to protect the Philippine national airspace sovereignty.

³ ADFP 13, Chapter 3 Paragraph 305.
⁴ Ibid.
Perceived Limitations

The current Philippine Air Defence System lacks the desired measures designed to nullify or reduce the effectiveness of hostile air action, when viewed in the modern context of an air defence system. The basic doctrine of defending the Philippine territory, its borders and EEZ from foreign threats, incursions, and even poaching, is beyond the capability of the current PADS. Prompt detection, identification and documentation of intrusions and movements inimical to the national interests are inherent functions of an effective air defence system the PADS must possess.5

The following are the perceived limitations that face the PADS today:

1. Aging Multi-role F-5A Freedom Fighters
2. Inadequate and outmoded radar surveillance equipment
3. Insufficient number of combat-ready weapons controllers
4. Unreliable communications system

Multi-Role Fighter Aircraft

The aging F-5 Freedom Fighter provides the leading edge as interceptor of the Air Defence System. This aircraft has been in the PAF inventory since 1965 when it came out from the US as a new multi-role aircraft. In the late 1970s, this aircraft was briefly replaced by a squadron of fledgling F-8 Crusaders, although its service-life lasted only for a few years.

![Image of F-5A Freedom Fighter]

The aging F-5A Freedom Fighter in service since 1965

At present, the F-5 aircraft remains the primary interceptor of the Air Defence System. The present state of the F-5 aircraft is, however, in a dismal state where more than half of the fleet are inside hangars undergoing repairs, rather than doing what they are supposed to do: flying.

5 LEAD TURN, PAF BEYOND 2000.
Antiquated Radar Surveillance Equipment

The 580th Aircraft Control and Warning Wing (ACWW) is the unit tasked to maintain and operate the radar or the surveillance system of the PAF. There are five radar surveillance sites presently manned and maintained by five 580 ACWW squadrons. These are:

- SITE I - Pauquin, Ilocos Norte = manned by 581 ACWS
- SITE II - Lubang Island, Mindoro = manned by 582 ACWS
- SITE III - Jose Panganiban, Camarines Norte = unmanned
- Rio Tuba, Palawan = manned by 584 ACWS
- Wallace Air Station, La Union = manned by 585 ACWS

Existing Radar Sites of the PADS
Limited Radar Surveillance Coverage

The radar coverage is principally affected by the location of the radar site, altitude, surrounding terrain and the environment. The features of the radar in use, like target detection, range, antenna pattern, also affects radar coverage. The following factors are to be considered for the radar coverage to be effective:

1. It should provide continuous, complete and overlapping air surveillance for the whole archipelago.

2. It should give the fighter interceptors sufficient warning of incoming threats to give them a chance to intercept the threat before it reaches landmass.

3. It should have a reliable air-to-ground and point-to-point communications network.

4. The radar must be able to cover 250 nautical miles distance.

5. The radar must be able to detect targets in three dimensions.

Looking at the locations of the radar sites, a true picture of the present capability of the PADS can be determined. Furthermore, only three of the five radar sites are operational and only one is combat ready.

SITE I – Paredes Air Station

The site is located approximately four nautical miles north of the town of Pasuquin in Ilocos Norte. The radar sits on a hill 1,850 feet high and can cover westerly and northerly directions. There is no coverage, however, from the north-east to south-east in a clockwise direction, primarily because of the Cordillera Central Mountains. Based on its functional characteristics, the search radar can pick-up objects at the distance of 200 nautical miles at 15,000 feet and at 25,000 feet the radar can cover 250 nautical miles distance.

SITE II – Gozar Air Station

The site is located approximately four nautical miles south south-east from the town of Lubang in Oriental Mindoro. Its elevation is 1,673 feet above sea level. The radar can cover the direction from south-south-east to the north in a clockwise direction. The north-east sector has a non-uniform radar coverage. This is due to a number of distant terrain obstructions in Luzon. Significant terrain covering is also present in the east south-south-east sector due to the mountain on Ambil Island and the mountain range extending to the south east from the radar site in Lubang Island. The radar equipment installed is the same as that of SITE I. Its radar coverage has a range of 200 nautical miles at an altitude of 15,000 feet and 250 nautical miles at an altitude of 25,000 feet.
OUR Radars

RIO TUBA – Rio Tuba, Palawan

There was no proper evaluation of the location of this radar site. Since 1992 the radar was never brought to full operational status.

SITE III – Jose Panganiban, Camarines Norte.

At present, the site has been deactivated, the equipment removed and the squadron unmanned. A detachment was maintained to secure the area.

WALLACE AIR STATION – Poro Point, San Fernando, La Union

The equipment is basically the same as those installed in SITE I and SITE II. It can cover a distance of 200 nautical miles at 15,000 feet and 250 nautical miles at 25,000 feet altitude.

The present radar surveillance coverage is inadequate based on the criteria for an effective radar coverage. It is only SITE II that is a combat rated site, but it covers only the whole of the western portion of the country up to a distance of 250 nautical miles at an altitude of 25,000 feet. The rest of the country is practically 'naked'. Moreover, all the four radar sites have no operational height finders. In summary, the status of the PAF radars renders the effectiveness of the PADS inutile.
Insufficient Weapons Controllers

The 580th Aircraft Control and Warning Wing is the unit tasked to maintain and operate the radars of the PAF. There are five radar surveillance sites being maintained and operated by the wing. Based on the Table of Organisation and Equipment (TO & E), each radar site on full operational status should have 12 officers (10 weapons controllers and 2 communications – electronics officers) and 150 enlisted personnel (weapons technicians). The present number of radar sites requires a total of 60 officers and 750 enlisted personnel.

Since November 1995, there have been only 22 combat ready weapons controllers for the entire wing, although 12 others are under training. The present number of weapons controllers is sufficient as of the moment since only SITE II is on partial operational status. The desired number of weapons controllers must be met if the other radar sites are to be commissioned.

Unreliable Communication Network

The Philippine Air Defence Control Centre (PADCC) is located at the headquarters of the Air Defence Command in Villamor Air Base. It has a vertical display board used for plotting aircraft positions, but its communication system leaves a lot to be desired. It does not have a UHF/VHF communication capability to monitor aircraft on flights and it has no other means of contacting the radar sites except by the hotlines of the V-SAT.

The existing PADIZ with actual coverage only in Luzon
OUR Radars

The point-to-point communications installed in the different sites are the following:

Site I

<table>
<thead>
<tr>
<th>Equipment</th>
<th>On Hand</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave LOS Radio 778C3/F</td>
<td>4</td>
<td>Out</td>
</tr>
<tr>
<td>Microwave LOX MVX 46A3C</td>
<td>2</td>
<td>Out</td>
</tr>
<tr>
<td>GRT 22 (SINGLE UHF)</td>
<td>8</td>
<td>Out</td>
</tr>
<tr>
<td>GRR 24 (SINGLE UHF)</td>
<td>8</td>
<td>Out</td>
</tr>
<tr>
<td>GRT 175/212 (MULTI UHF)</td>
<td>1</td>
<td>Out</td>
</tr>
<tr>
<td>GRT 21 (SINGLE VHF)</td>
<td>4</td>
<td>Out</td>
</tr>
<tr>
<td>GRR 23 (SINGLE VHF)</td>
<td>4</td>
<td>Out</td>
</tr>
</tbody>
</table>

Site II:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>On Hand</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave LOS Radio 778C3/F</td>
<td>2</td>
<td>In</td>
</tr>
<tr>
<td>TROPO RADIO 6003</td>
<td>1</td>
<td>Out</td>
</tr>
<tr>
<td>TROPO MVX 36A1</td>
<td>1</td>
<td>Out</td>
</tr>
<tr>
<td>RF 230/2301 13200</td>
<td>1</td>
<td>In</td>
</tr>
<tr>
<td>VRC – 187</td>
<td>2</td>
<td>In</td>
</tr>
</tbody>
</table>

Rapid communication between radar sites to PADCC and aircraft is crucial.

The Ground-to-Air communications between the pilots and the radar controllers is another question of reliability. At 250 and 200 nautical miles distance, the fighter pilots report inadequate contact with the weapons controllers. At 100 nautical miles, the fighter pilots are not even sure if they have contact. The ground-to-air communications equipment currently being used are as follows:
GRC 171 (MULTI UHF)
GR 722 (SINGLE UHF)
GRR 24 (SINGLE UHF)
GRC 175/211 (MULTI VHF)
GRT 21 (SINGLE VHF)
GRR 23 (SINGLE VHF)

The present status of the Philippine Air Defence System can aptly be described as inadequate, and to some extent it may be defined as non-existent. Currently there is no complete radar coverage or supporting communications network for the entire Philippine territory to detect and intercept intruding aircraft.
OUR Radars
Chapter Four

AFP Modernization Law and PAF Modernization Program

We are moving ahead with our efforts to modernise the Armed Forces, and I assure you that the Air Force will receive the resources it needs for the improvement of its human assets, training facilities, aircraft, and support systems and facilities...

President Joseph Ejercito Estrada

Recent developments in our external security situation underscore the urgency of establishing a credible self-defence capability to back-up diplomatic initiatives in the resolution of conflicting issues. Geo-political realities are such that we find relevance in a former US President’s advice “to talk softly but carry a big stick”.

In this light, it is imperative to fast track the AFP Modernization Program. Continued postponement of the Program’s implementation will only reinforce international perceptions of our growing military weakness and lack of national will and resolve. It might also serve to encourage further adventurism in the South China Sea.

Background

Republic Act No. 7898, otherwise known as the AFP Modernization Law, declares that it is the policy of the state to modernise its Armed Forces at a level where it can fully and effectively perform its constitutional mandate of upholding the sovereignty and preserving the patrimony of the Republic.

Both Houses of Congress passed Joint Resolution No. 28 (JR 28), approving the three-phased implementation of the AFP Modernization Program over a period of 15 years. The approved Program prescribes the development or enhancement of the capability of the Armed Forces of the Philippines to perform the following: ²

- Uphold the sovereignty and territorial integrity of the Republic, and secure the national territory from all forms of intrusions and encroachment.
- Assist civilian agencies in the preservation of the national patrimony.

1 President Joseph E. Estrada’s keynote speech during the 52nd PAF anniversary, 1 July 1999.
OUR Radars

- Protect the Filipino people not only from armed threats but from the destructive consequences of natural and man-made disasters, and calamities.
- Assist other agencies in the enforcement of domestic and foreign policy.
- Assist the Philippine National Police (PNP) in law enforcement and crime prevention.
- Fulfil the country's international commitment.
- Support national development.

Rationale

For decades, the AFP has virtually engaged all of its resources in internal security operations, since the presence of the United States military facilities in the country some years ago served as deterrence to external threats. Consequently, the AFP regarded external threats as a lesser priority. This situation has continually marginalised the external defence capability of the AFP and the ability to participate in combined operations with other armed forces, thus the need for the AFP to upgrade its capability.

Recent years have shown how countries in the region have developed their military capability to maintain deterrence and the balance of power. While the AFP does not aspire to do the same, it needs to make its defence capability credible. This is to ensure that the AFP will be able to contribute to maintaining the military balance in the region and become an active partner in any security alliance.

In addition, a credible armed force is an essential element in addressing contemporary security concerns such as territorial and maritime disputes; threats of a transnational, nature such as piracy, poaching, smuggling; and environmental degradation. Increasingly, the dynamic and unpredictable nature of the security environment demands a credible military force that can ensure overall national security. While diplomacy is the best policy in addressing security concerns, diplomacy alone may be inadequate without a credible military force behind it.

National Defence Objectives

The National Defence Strategy (NDS), which is the basic reference in formulating the civil and military strategies, prescribes the defence and security policies of the Government as well as the defence objectives as enumerated:

- To uphold the sovereignty and defend the territorial integrity of the Philippines.
- To secure the border areas from smuggling, piracy, drug trafficking, poaching and other illegal activities.
- To assist in the protection of the country's natural resources and ecological environment.
- To assist in socio-economic development, including relief and rescue during disasters and calamities.
- To protect the exclusive economic zone (EEZ).

3 Ibid.
To support the Philippine National Police (PNP) in the maintenance of peace and order.

To contribute to the stability of the Association of Southeast Asian Nations (ASEAN).

To support regional and United Nations (UN) initiatives for stability such as peacekeeping activities.

To assist in transnational border efforts with other countries, as in anti-piracy on the high seas, anti-maritime pollution operations and search and rescue in calamities and disasters.

Development of AFP Capabilities

The aforementioned defence objectives are translated into operational requirements of the AFP and ultimately determine the capability development program under the AFP Modernization Program. As prescribed, the overall capability development program must focus on the following areas:

- Command, Control and Communications
- Maritime Surveillance
- Air Defence
- Maritime Patrol and Response
- Protection of Offshore Territories and Strategic Resources
- Intelligence Collection and Evaluation
- Integrated Logistics Support
Development of Major Service/ General Headquarters (GHQ) Capabilities

The Major Services and GHQ shall develop their capabilities to effectively carry out their respective missions. To achieve this, the AFP Modernization Program shall be geared towards the development of the following defence capabilities:

- General Headquarters capability – the General Headquarters shall develop its capabilities for command, control, communications, and information systems.

- Naval Defence capability – the Philippine Navy (PN) shall develop its capabilities for naval defence, amphibious warfare, sealift and transport, and surface warfare, naval gunfire support, detection and maritime surveillance, search and rescue, disaster response as well as capabilities for anti-submarine and mine warfare.

- Ground Defence capability – the Philippine Army (PA) shall develop its capabilities for ground defence and internal security as well as its capability for assistance to national development, search and rescue operations, relief and rehabilitation, natural resources and environment protection.

- Air Defence capability – the Philippine Air Force (PAF), being the country’s first line of external defence, shall develop its air defence capability by acquiring multi-role aircraft, air munitions, avionics, air defence radars, point and area defence missile system, maritime patrol and reconnaissance, and early warning and control system, as well as capabilities for strategic and battlefield airlift and limited ground attack in support of surface forces.

\[4\] Ibid.
PAF Modernization Program

The Philippine Air Force must be modernised, today more than ever. A lot has changed in the decade triggering the emergence of uncertainties and threats to national security. The PAF is compelled to be more responsive to these challenges, providing credible deterrence to external aggression and contributing to the peace and stability of the ASEAN region.

The Philippine Air Force Modernization Program seeks to fit into the demands of the times. It shall be technology driven to achieve potent power projection, perform a variety of roles in defence as well as in socio-economic activities, and modular in execution to attain ease and flexibility in meeting defence priorities. The approach
shall be holistic in perspective capable of achieving: a modern air force with cutting edge technology for its equipage and bases support; an effective command and control; a manpower pool gifted with critical thinking and adept in new and emerging technologies; a total force cognisant of the fundamental doctrinal precepts in the employment of air power. Its success shall be achieved through the five component programs: force restructuring and organisational development, capability development, bases development, human resource development, and doctrine development.  

Force Restructuring and Organisational Development

The Modernization Program requires the PAF to be compact and responsive while developing its capabilities to enhance unity of command and economy of forces. It is the evolution of a simplified command structure towards a resultant organisation with five (5) functional Air Commands and eleven (11) PAF Wide Service Support Units, responsive to the ever-changing internal and external security environment.

Capability Development

In order to project credible deterrence, the PAF is focused on developing or enhancing its capabilities that are either weak or non-existent, as follows:

- Air capability to establish decisive control of our sovereign airspace and its immediate fringes.
- Air support to defence and socio-economic requirements.
- Surveillance, reconnaissance and electronic warfare capability.
- Air strike capability.

Base Development

Taking into consideration the amount of work and limited resources available, base development is prioritised vis-a-vis the equipment acquisition schedule. PAF airbases and stations directly concerned with air defence and those located in strategic areas will be developed initially. Infrastructure support will be put in place for command and control centres to sustain 24-hour flight operations.

Human Resource Development

Vital to the success of modernisation is Human Resource Development. The PAF Human Resource Development Program endeavours to develop its human resource into professionals equipped with the proper knowledge, skills and value essential to the accomplishment of the assigned mission and tasks.

The HRD Program primarily addresses the need for air defence personnel and experts in the field of management science and base development. Professional Military Education (PME) will be pursued, to give the Officers and Enlisted Personnel a wider perspective of matters that are intertwined with military affairs.

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Doctrine Development

The PAF doctrine development dovetails the doctrine organisational structure with the dynamics of the doctrine process. This ensures the continuous formulation, review, updating and validation of all air power concepts, PAF strategies and doctrine consistent with the AFP strategy towards the new millennium. PAF basic doctrine provides the guiding principle for the employment of air power in supporting national security objectives.

PAF Mid-Term Strategy

The Philippine Air Force engages a new approach to strategy for the succeeding years. It is the way of the millennial PAF, the path of the air power-conscious, air power-trained airman. It is the PAF's flight plan for 2000–2005.

The PAF Vision: A Credible Air Force in Peace and War

The PAF Modernization Program envisages a modernised Air Force with key commands and capabilities, with active air defence, manned by highly trained and motivated airmen, and flying at par with the best in Asia. An Air Force capable of meeting internal and external defence requirements and engaged with equal commitment in national development. In particular, an Air Force enjoying increased operational effectiveness, improved logistics and communications, totally developed forces, greater popular support, and capability for self-reliance. In short, a credible Air Force in peace and war.

The PAF Operational Imperatives

- Active Air Defence
- Dynamic Interoperability
- Integrated Support
- Joint Security
- Progressive Non Traditional Engagement

These five operational imperatives are the key requirements to obtain credibility. These imperatives define and determine the must-have capabilities of the 21st century PAF. Each corresponds to a specific role or a combination of roles for the Air Force, and each one reinforces the other to address national security’s traditional as well as asymmetric requirements. When present together, these operational imperatives constitute the desired capabilities essential to credibility. They also encompass all the various missions and functions of the PAF.

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* Ibid., page 7 - 8

29
Active Air Defence

The first requirement for Air Force Credibility is the capability to project air power as the nation’s first effective line of defence, to deter aggression, or discourage the enemy to wage war. This Active Air Defence capability will be brought to the public’s awareness by PAF’s array of new fighters, weapons, air defence systems, radars, and a comprehensive ground environment.

Dynamic Interoperability

Dynamic interoperability shall optimise the synergy and effect of all engaged and supporting forces on PAF’s mission effectiveness, speed of execution and environment impact in any theatre. Common protocol, command and control arrangements, connectivity, and compatible system with other forces will determine the best ‘force multiplier’ effect.

Interoperability – PAF Hueys conducting ship-board landing on Philippine Navy vessel.

Integrated Support

This imperative will commit the use and management of all available resources to support capability build-up, enhance security, train personnel, and execute strategy to bear on the success of any PAF engagement. It entails the secure, anticipated, and timely delivery of support requirements across the broad range of activities of the Air Force.

Joint Security

This will set and sustain the conditions for PAF’s unchallenged readiness and unimpeded action in the course of operations through interrelated defence measures provided by other AFP forces, non-military units, government agencies, and the
populace, as well as through forged commitments from bilateral defence agreements with allies.

**Progressive Non-traditional Engagement**

Separate from PAF traditional concerns but nonetheless factors that constitute a threat to the national security and well being of the Filipino people include such events as, forest fires, flash floods and other forms of calamities which are included in PAF’s tasks. Through Progressive Non-traditional Engagement that focuses on development and relief and recovery efforts, the PAF will remain as the people’s winged provider in crisis as well as partner in progress.

These dreams and aspirations, this strategy for a ‘Credible Air Force in Peace and War’ is best reflected and summarised by Lieutenant General Willie C. Florendo, former CG PAF when he said ‘Just like before any take-off, the Philippine Air Force must chart its direction, an accurate “flight plan” to reach our destination is crucial. This flight plan must reflect how we will negotiate our climb, visualize the challenges enroute, and handle unexpected contingencies. As it were, our vision is to be an Air Force that every member of the command will aspire to and will be proud of; an organisation worthy of respect by its Allies and neighbouring Air Forces. This then is the route we’ll follow. This document shall fix our headings.’

Unfortunately for the PAF, the Philippines is one of those countries hardest hit by the Asian economic crisis. Realisation of all the dreams it aspires to will be difficult to achieve. Nonetheless, the vision of modernisation should never waiver and ways have to be found. Pooling of resources is one practical means of accomplishing that goal. Optimum utilisation of common equipment or facilities is another way.

In this context, this paper proposes the joint use of PAF air defence and ATO civil air traffic radars to more efficiently and effectively achieve the aims of a secure ‘one sky’ policy, thus maintaining control of Philippine national airspace in peace and in conflict.
OUR Radars
Chapter Five

Philippine Air Force and Air Transportation Office Cooperation: Joint Use of Equipment and Facilities

*The Philippine Air Force had always advocated the ‘joint-use concept’ with the civil government agencies in the utilisation of major equipment, infrastructure and facilities...*

Lieutenant General William K. Hotchkiss III AFP (Ret)

The Philippine Air Force entered into a Memorandum of Agreement with the Air Transportation Office on 16 March 1995. The agreement related to the joint use of equipment and facilities between the two organisations in the interest of the Philippine government and the Filipino people. The PAF was represented by Lieutenant General William K. Hotchkiss III AFP, then the Commanding General of the PAF, while the Air Transportation Office was represented by Assistant Secretary Major General Carlos F. Tanega (Retd), then the Undersecretary of the Department of Transportation and Communication.

The terms and conditions of the joint use and the operation of said equipment and facilities, as well as assistance in pursuit of their respective missions and functions, are mutually formulated in an implementing agreement.

Terms and Conditions

The terms and conditions of the implementing agreement shall include but not be limited to:

a. Sharing of acquisition cost, as far as existing laws and regulations allow.

b. Maintenance, repair and operating costs.

c. Upgrading of equipment.

d. Joint training.

e. Procedures on Air Defence Conditions.

f. Relationships between the PAF and ATO.

g. Limitation and delineation in the use and operation of equipment.

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2 Taken from the approved Implementing Agreement between PAF-ATO on Joint Use of Equipment and Facilities, dated 21 August 1997.
General Provisions

The PAF is tasked primarily for the detection, identification, interception and if necessary, destruction of hostile aircraft within the Philippine Air Defence Identification Zone (PADIZ). As such, the PAF is primarily responsible in determining what equipment, facilities and services it shall acquire, operate and maintain to ensure the effective and efficient accomplishment of its mission. The equipment and facilities under this agreement include radars, communications equipment, navigational aids and other support equipment and facilities.

Existing Philippine Air Defence Identification Zone

The ATO, on the other hand, is responsible for the safe, orderly and expeditious management of air traffic within the Flight Information Region (FIR). As such, the ATO shall be primarily responsible for determining what equipment, facilities and services it shall acquire, operate and maintain to ensure the effective and efficient accomplishment of its mission. The equipment and facilities necessary for its operations include radars, communications, navigational aids and other support equipment and facilities.

Both parties agreed to create a committee in order to identify and determine what equipment, facilities and services will be jointly used for the benefit of both parties. The committee is called PAF-ATO Joint-Use Committee (PAJUC).
The PAJUC is composed of a minimum of eight members, four of who came from the PAF and the other four came from ATO, with one member from each group to act as co-chairman and preside over the Committee.\(^3\)

The functions of the Committee are as follows:

a. Oversee the implementation of this agreement.
b. Identify and determine what equipment, facilities and services are applicable for joint use.
c. Determine the cost sharing schemes, which are applicable for a particular acquisition, upgrade, operation, use and/or maintenance of an equipment, facility and services to include cost of training provided by any of the contacting parties.
d. Determine the revenue sharing scheme on any income derived from the joint-operation effort.
e. Determine joint training programs and requirements.
f. Serve as coordinating body in the exchange of information with respect to technical matters to include descriptions of specific equipment and facilities that are programmed for acquisition, upgrade and even for the phase-out of existing equipment.

Cost Sharing on Acquisition, Operations and Upgrading

The procurement/acquisition of facilities or equipment may be made under a separate agreement between the two parties. Under such an agreement, cost sharing may be and/or in the form of capital contribution or capital and interest payment, lease of facility or equipment. Capital and interest payments can be offset by counter-provisions of any mutual transactions. The value of such contract agreement must be declared and is the subject of written agreement.

Leasing of facilities or equipment may be inclusive or exclusive of maintenance or upgrade agreements. Equipment may be leased with the lessee providing security, maintenance, power, buildings and operating staff. Likewise, equipment may be leased with associated security, maintenance and or power and building.

In all cases of cost sharing, the specific agreement shall contain a service guarantee clause that will guarantee minimum service standards to be maintained by the owner/operator. Should the service fall below the guaranteed level, the cost sharing agreement may be suspended until the service is resumed at the required standard.

In the case of existing equipment, it is the responsibility of both parties to measure and record coverage and performance for inclusion in agreements. Subsequent failure to meet such established coverage or performance standards may be considered a breach of a service agreement and penalties may be imposed as agreed by both parties.

Cost sharing agreements may be in Philippine currency. Where foreign currency is required, the parties shall in this case agree on the exchange rate.

\(^3\) Ibid.
Operating Cost

The cost of the technical operation of equipment, including maintenance, repair, security, power, land, building etc., may be subject to a specific agreement which shall either be a stand-alone agreement or a supplementary agreement to a Capital Cost Sharing agreement. In case of equipment upgrading, an upgrade agreement must be effected to ensure that there is no breach of existing service agreements. It is expected that all upgrades will be planned and deliberated by technical committees of both sides in a joint session. Technical support agreements may be contracted with third parties. These agreements are usually made by the owner party and a cost sharing agreement with the other party may be created where appropriate.

Joint Training

Training of personnel on the operation and maintenance of radar, communication, navigational and auxiliary support equipment is provided by the party who has the capability to train the other party free of charge. However, the incidental expenses incurred by the students is the responsibility of the parent organisation.

Both parties agreed to support the conduct of Search and Rescue Training Exercises. The PAF will provide the SAR aircraft, including paramedics, nurses, etc., while ATO will provide the Command and Control facilities and personnel.

Each party will provide for the funding requirements of their respective personnel in the conduct of training. In cases where training is done abroad, each party selects and determines the number of personnel to be trained and be provided with funding support.

Both parties agreed to accept the personnel of one party to train in its facility on Command, Control, Communication and Information free of charge.

505 Search and Rescue Group conducting rescue operations

4 Ibid.
Joint Operation of Radar and Facilities

Access to the use and operation of both party’s radars and facilities, without interfering or affecting the utilisation and operation by the respective owners, may be granted. However, both parties must adhere to the following objectives:

1. Ensure PAF effectiveness on Air Defence as well as benefits on joint-use concepts in terms of Air Traffic Control, flight safety and responsiveness during emergencies.

2. Ensure flexibility of both parties during actual operations.

3. Ensure interoperability of radar and facilities so that sharing of information and other radar technology related resources will be harnessed.

4. Ensure maximum utilisation of financial resources in terms of supporting information system requirements of PAF-ATO radar joint operation and use.

5. To effectively and efficiently implement interoperability, joint-utilisation, and co-location of both party’s SAR teams, radars and facilities, the Joint Rescue Operation Centre (JROC) is organised at each site and will be manned by both PAF and ATO personnel.

Procedures On Air Defence Conditions

During increased air defence conditions, both agencies agree that:

a. The PAF may opt to cease giving out air traffic information to the ATO. However, the ATO is obliged to continuously provide the agreed services for security reasons.

b. The PAF will endeavour to provide information with as much notice as possible on such actions.

Both parties agree that an emergency exists when:

a. A major attack is made upon the Philippine Forces, or on allied forces in the Pacific and is confirmed by the Commanding General PAF, Commander of a Major Service, or a Higher Authority.

b. An overt action of any type is made upon the Philippines and is confirmed either by the Commanding General PAF, Commander of a Major Service, or Higher Authority, and

c. A condition of DEFCON 3 or Air Defence Emergency is declared by the Chief of Staff AFP, CG PAF or Commander, Air Defence Command.
Limitation/Delineation in the Use/Operation of Equipment

Sharing of Equipment and Services

Each agency will provide, upon request, availability of Communication-Electronics (C-E) assets and services in the furtherance of this agreement. The required assistance will be provided by either agency on a case-by-case or necessity basis.

Each agency will formulate respective maintenance procedures inherent in each particular equipment. A joint group may be organised to realise these end results.

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5 Ibid.
Connectivity

For purposes of this agreement, interfacing of communications for all information sharing will be done at a nationwide control agency level.

Responsibilities

The facility commander or the designated officer-in-charge of the installation, as mentioned for 'joint use' is responsible for implementing communication security. A periodic review of existing communication linkages and security will be scheduled to update standing operating procedures (SOPs). It is also his responsibility to disseminate any changes that will affect the efficient and prompt exchange of information.

Security and Access to Classified Matters

Security

Joint security surveys and inspections shall be undertaken by both parties on all facilities subject to joint use, on a regular basis dependent on the level of threat or the sensitivity of the equipment/facilities to the missions of both parties.

All personnel who have access to the facilities will undergo a personal security investigation consistent with AFP RG 200-053.6 Personnel will be issued with a security clearance certificate if they have passed the requirements of loyalty, integrity and character stipulated in said regulations.

6 AFP RG 200-053, Armed Forces of the Philippines Rules and Regulations Number 200-053.
A joint pass system will be adopted to control access of personnel and visitors to controlled/restricted areas. Security ID tags and vehicle stickers will be developed and adopted to ensure that only authorised personnel are allowed entry to PAF-ATO facilities.

Access to Classified Matter

Access to vital information affecting the mission of both parties and the security of PAF-ATO resources will be granted on a need-to-know basis. Personnel who have been issued security clearances and therefore allowed access to classified documents must adhere to the provisions of AFP RG 200-013 that pertains to all facets of document security.

Under all circumstances, the principles of defence-in-depth/concentric circle defence will be adhered to, the extent of which will depend on the prevailing threat situation or defence condition defined by Philippine Air Defence System Regulation (PADSR). A community-based or barangay intelligence network must be installed as the outer layer defence that will serve as a warning or listening post. Joint patrols immediately outside the facility’s perimeter may be conducted in coordination with PNP/AFP Forces and local government officials in the area. Physical barriers may be constructed according to the security needs of the installations.

Key personnel who have access to PAF-ATO resources in joint use will undergo a security indoctrination seminar to be conducted by PAF to ensure that security principles and procedures are applied to the maximum benefit of both parties.

Persons found to have committed severe breaches of security will be banned from operating any equipment. Based on the outcome of the joint investigation, they may be transferred from the facility, be terminated and/or meted out appropriate administrative sanctions.

The facility commander or the designated officer-in-charge of the installation will designate a security officer who would design and implement a Security Action Plan that will address all aspects of security. The plan will be based on the location of the facility or equipment, on the estimate of the prevailing situation, and on the criticality of the equipment/facility. The facility commander may link up with the PNP/ AFP forces in the area for a combined, coordinated security action in the event of any hostilities or imminent threat.

Sharing of Information

Both parties agreed to provide air traffic information through their respective facilities such as radar, weather sensors/instruments, navigational aids, flight facilities and other C-E equipment including training facilities. Both parties agreed to provide each agency data access to flight information related to creating a one-sky one-picture concept through joint use of facilities.

In general, the agreement signed by the PAF and ATO signifies cooperation amongst government entities where commonality of equipment and facilities may augur practicality and cost savings, especially during these times when our government is experiencing its worst economic situation. These kinds of initiatives have to be encouraged throughout the whole of government in order to optimise very limited resources.
Chapter Six

Optimum Utilisation of Radars: Roles In Air Defence, Air Traffic System, Reconnaissance and Surveillance (OUR Radars)

*When you develop a modern armed forces, you just don't prepare for war. You also have to be concerned with the requirements of peace and development.*

Major General Benjamin P. Defensor, Jr AFP

Background

The preceding chapters are systematically and chronologically arranged in order to present a growing picture of what the purpose of this research is all about. What is now being presented is the validation for a credible air defence system in a small country like the Philippines. Corollary to that is the need to acquire the desired radar types albeit within the limits of the financial constraints we now face. It is in this context that practical approaches must be considered and optimum utilisation and applications must be realised from a singular equipment or facility.

The common equipment being discussed here is the surveillance radar. This particular piece of equipment provides necessary information for air defence, the primordial role of the PAF and also for air traffic control, the primary function of the Air Transportation Office. Additionally, this same equipment can provide information to other government agencies such as the Bureau of Fisheries on illegal fishing and poaching, or to the Bureau of Customs on smuggling of goods in some isolated shores of the country. Most importantly, this radar equipment can be an ‘eye-watch’ on the entire Exclusive Economic Zone (EEZ) of the country. The Philippine Navy can also access information relevant to its mission accomplishment. Some law enforcement agencies such as the Philippine Coast Guard and even the Philippine National Police can benefit from data obtained from these radars. Many other government agencies can gain directly or indirectly from this equipment. With a total of 7,100 islands comprising the Philippines, the function of this equipment is limitless and essential to national sovereignty. At present, the country has yet to boast an effective surveillance radar system that will cover the entire archipelago.

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1 *Flight to the Future*, Chapter 3, p. 120.
Definition of Radar

Radar is an ‘active’ sensing device in that it has its own source of illumination for locating targets.² It is an electromagnetic device used to detect objects at great distances and under conditions of lighting or obscuration that would render the unaided eye useless. It also provides a means for measuring precisely the distance, or range, to an object and the speed at which the object is moving toward or away from the observing unit. Radar is an acronym for Radio Detection and Ranging.

A typical radar operates by radiating a narrow beam of electromagnetic energy into space from an antenna. The narrow antenna beam is scanned to search a region where targets are expected. When a target is illuminated by the beam, it intercepts some of the radiated energy and reflects a portion back toward the radar system. Since most radar systems do not transmit and receive at the same time, a single antenna can be used on a time-shared basis for both transmitting and receiving.

Types of Radar

There are several types of radar. Each variety involves different kinds of signal from the radar transmitter and makes use of different properties of the received echo. Radar systems may be categorised according to the function they perform – e.g. aircraft surveillance, surface (ground or sea) surveillance, space surveillance, tracking, weapon control, missile guidance, instrumentation, remote sensing of the environment, intruder detection, or ground probing.³

While there are many types of radars, this paper will limit its discussion only on the type of radar relevant to the study. Among the common types of radar are as follows:

a. **Simple Pulse Radar** – this is by far the most widely used technique and constitutes what might be termed ‘conventional’ radar. It is so called because the transmitter is keyed to send out short, very intense bursts or pulses of electromagnetic energy, with a relatively long interval between pulses.

b. **Tracking Radar** – this kind of radar continuously follows a single target in an angle and range to determine its path, or trajectory, and to predict its future position. There are two classes of tracking radars: conical scan and monopulse. The conical scan tracker is simpler but not as accurate as the monopulse variety. Furthermore, monopulse tracking is not as susceptible to some forms of electronic countermeasure as is the conical scan. The single-target tracking radar provides target location almost continuously. A typical tracking radar might measure the target location at a rate of ten times per second.

c. **Track-while-scan Radar** – this form of surveillance radar can provide tracks of all targets within its area of coverage by measuring the location of targets on each rotation of the antenna. Though called track-while-scan radar, it is more often known as automatic detection and tracking, or ADT. The output on a visual display from such a radar usually consists of the tracks of the targets (vectors showing direction and speed) rather than individual detection (blips).

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² Definition was taken from Encyclopedia Britannica, [http://www.britannica.com/bcom/ebarticle/printable/6/0,5722,117366,00.html](http://www.britannica.com/bcom/ebarticle/printable/6/0,5722,117366,00.html).
This type of tracking is suitable for surveillance radars, while continuous tracking is more appropriate for weapons control and instrumentation-radar applications.

d. **3D Radar** – conventional air-surveillance radar measures the location of a target in two dimensions - range and azimuth. The elevation angle, from which target height can be derived, also can be determined. The so-called 3D radar is an air-surveillance radar that measures range in a conventional manner but has an antenna which is mechanically rotated about a vertical axis to obtain the azimuth angle of a target. It has either fixed multiple beams in elevation or a scanned pencil beam to measure its elevation angle. There are other types of radar that measure the target location in three dimensions, but the radar that is properly called 3D is an air-surveillance system that measures the azimuth and elevation angles as just prescribed.

e. **Electrically scanned phased-array Radar** – an electronically scanned phased-array antenna can position its beam rapidly from one direction to another without mechanical movement of large antenna structures. Agile, rapid beam switching permits the radar to track many targets simultaneously and to perform other functions as required.

f. **Continuous-wave (CW) Radar** – since a CW radar transmits and receives at the same time, it must depend on the Doppler frequency shift produced by a moving target to separate the weak echo signal from the strong transmitted signal. A simple CW radar can detect targets, measure their radial velocity, and determine the direction of arrival of the received signal. However, a more complicated waveform is required for finding the range of the target.

g. **Frequency-modulated continuous-wave (FM-CW) Radar** – if the frequency of a CW radar is continually changed with time, the frequency of the echo signal will differ from that transmitted and the difference will be proportional to the range of the target. Accordingly, measuring the difference between the transmitted and received frequencies gives the range to the target. The most common form of FM-CW radar is the radar altimeter used on aircraft to determine height above the ground.

Radar System

Radar can be better appreciated by knowing how they operate. Traditionally, radars have been seen as one single unit. Modern technology has changed all these situations. One radar alone can serve many organisations.

The radar is composed of several sub-systems and these are:

- Antennas
- Transmitters
- Receivers
- Signal and data processors
- Displays

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4 Encyclopedia Britannica, [http://www.britannica.com/bcom/eb/article/printable/60,5722,117366,00.html](http://www.britannica.com/bcom/eb/article/printable/60,5722,117366,00.html)
Antenna

A widely used form of radar antenna is the parabolic reflector. A horn antenna or other small antenna is placed at the focus of the parabola to illuminate the parabolic surface of the reflector. After being reflected by this surface, the electromagnetic energy is radiated as a narrow beam. A paraboloid, which is generated by rotating a parabola about its axis, forms a symmetrical beam called a pencil beam. A fan beam, one with a narrow beamwidth in azimuth and a broad beamwidth in elevation, can be obtained by illuminating an asymmetrical section of the paraboloid.

The half-wave dipole, whose dimension is one-half of the radar wavelength, is the classic type of electromagnetic antenna. Radar requires a narrow beam in order to concentrate its energy on the target and to determine the target location with accuracy. Such narrow beam can be formed by combining many individual dipole antennas so that the signals radiated or received by each elemental dipole are in unison, or in step. This is called the phased-array antenna.

In the phased-array antenna the phase shifters at each radiating antenna-element shift the phase of the signal, so that all signals received from a particular direction will be in step with one another. Similarly, all signals radiated by the individual elements of the antenna will be in step with one another in some specific direction. Changing the phase shift at each element alters the direction of the antenna beam. An antenna of this kind is called an electronically steered phased-array antenna. It allows rapid changes in the position of the beam without moving large mechanical structures. In some systems, the beam can be changed from one direction to another within microseconds. The electronically steered phased-array is attractive for applications that require large antennas or when the beam must be rapidly changed from one direction to another.

The phased-array antenna is also used without the phase shifters. The beam is steered by the mechanical movement of the entire antenna. Antennas of this sort are preferred over the parabolic reflector for airborne applications, in land-based air surveillance radars requiring multiple beams (as in the so-called 3D radars, which measure elevation angle in addition to azimuth and range). They are also used in applications that require ultralow antenna sidelobe radiation.

Transmitters

The transmitter of a radar system must be efficient, reliable, not too large in size and weight, and must be easily maintained. It must also have the wide bandwidths and high power that are characteristic of radar applications.

It was observed earlier that the invention of the magnetron transmitter in the late 1930s resulted in radar systems that could operate at the higher frequencies known as microwaves. The magnetron transmitter has certain limitations but it continues to be widely used as a radar transmitter. The magnetron is a power oscillator in that it self-oscillates or generates microwave energy when voltage is applied. Other radar transmitters usually are power amplifiers in that they take low-power signals at the input and amplify them to high power at the output. This provides stable high-power signals, as the signals to be radiated can be generated with precision at low power.

The klystron amplifier is capable of some of the highest power levels used in radar. It has good efficiency and stability. The disadvantage of the klystron is that it is usually large and it requires high voltages. At low power the instantaneous bandwidth
of the klystron is small, but the klystron is capable of large bandwidth at high peak powers of a few megawatts.

The travelling-wave tube (TWT) is related to the klystron. It has very wide bandwidth at low peak power, but, as the peak power levels are increased to those needed for radar, its bandwidth decreases. As peak power increases, the bandwidth of the TWT and the klystron approach one another.

Solid-state transmitters are attractive because of their potential for long life, ease of maintenance, and relatively wide bandwidth. An individual solid-state device generates relatively low power and can be used only when the radar application can be accomplished with low power. High power can be achieved, however, by combining the outputs of many individual solid-state devices.

While the solid-state transmitter is easy to maintain and is capable of wide-band operation, it has certain disadvantages. It is much better suited for long pulses than for the short pulses. Long pulses can complicate radar operation because signal processing is needed to achieve the desired range solution. Furthermore, long-pulse radar generally requires several different pulse widths.

Every kind of transmitter has its disadvantages as well as advantages. In any particular application, the radar engineer must continually search for compromises that give the results desired without too many negative effects that cannot be adequately accommodated.

**receivers**

Like most other receivers, the radar receiver is a classic superheterodyne. It has to filter the desired echo signals from unwanted clutter signals and receiver noise that interfere with detection. It also must amplify the weak received signals to a level where the receiver output is large enough to actuate a display or a computer. The technology of the radar receiver is well established and seldom sets a limit on radar performance.

The receiver must have a large dynamic range in situations where it is necessary to detect weak signals in the presence of very large clutter echoes by recognising the Doppler frequency shift of the desired moving targets. Dynamic range can be loosely described as the ratio of the largest to the smallest signals that can be handled adequately by a receiver without distortion. A radar receiver might be required to detect signals that vary in power by a million to one and sometimes much more.

In most cases, the sensitivity of a radar receiver is determined by the noise generated internally at its input. Because it does not generate much noise of its own, a transistor is usually used as the first stage of a receiver.

**Signal and Data Processors**

The signal processor is the part of the receiver that extracts the desired signal and rejects clutter. Most signal processing is performed digitally with computer technology. Digital processing has significant capabilities in signal processing not previously available with analog methods. Without modern digital methods of processing, many of the signal processing techniques found in today's high-performance radars would not be possible. Digital processing also has made practical data processing, such as that required for automatic tracking.
Pulse compression is sometimes included under signal processing. It too benefits from digital technology, but analog processors are used rather than digital methods when pulse compression must achieve resolutions of a few metres or less.

Displays

The cathode-ray tube (CRT) has been the traditional means of displaying the output of a radar system. Although it has its limitations, the CRT has been preferred technology ever since the early days of radar. The CRT has undergone continual improvement that has made it even more versatile.

Plan position indicator (PPI) is a map like presentation in polar coordinates of range and angle. The CRT screen is dark except when echo signals are present the sweep beam. The PPI is called an intensity-modulated display because the intensity of the electron beam of the CRT is increased sufficiently to excite the phosphor of the screen whenever an echo signal is present. The PPI is the most common form of display in use in radar.

All practical radar displays have been two dimensional, yet most radars provide more information than can be displayed on the two coordinates of a flat screen. Colour coding of the intensity-modulated signal on the PPI is sometimes used to provide additional information about the echo signal. The PPI displays targets as if seen in a horizontal plane. On the other hand, a range-height indicator (RHI) is an intensity-modulated display that presents the echoes that appear in a vertical plane.

The radar display has benefited from the availability of digital technology. Digital memory allows the radar to store data from an entire scan period (usually one rotation of the radar antenna) and present the information to the operator all at once rather than display targets only when they are actually within the antenna beam. This allows the operator to view the entire scene all the time and to manipulate the output to display the type of target information of most interest.

Modern surveillance radars rarely display the output of a radar receiver without further processing. When automatic detection of targets is employed in a radar system, the rejection of unwanted echoes such as land or sea clutter, the addition of the radar pulses received from a target, and the decision as to whether a target is present or not are all performed electronically without assistance from a human operator. The display then shows only detected targets without the background noise. This has been called a ‘cleaned-up’ display or processed video. When automatic tracking is performed electronically, only processed target tracks are displayed and no individual target detections are indicated. The speed of target and its direction of travel can be indicated on the CRT by the length of the line defining the track and its orientation.
Radar Applications

Over the years, radar has found many and varied uses for both civilian and military purposes. The main outlines of radar-system design were reasonably well defined at the close of World War II. Since the late 1940s radar development has included improvements of components and circuitry, with an increasing use of solid-state electronic devices from transistors to very-large-scale integrated (VLSI) circuits. The introduction of new scanning methods and the adoption of high-speed digital computers for signal processing have also contributed significantly to the efficiency and reliability of radar equipment.

These and other technology advances have given rise to a wide variety of new radar applications.\(^5\)

Military Applications

Radar originally was developed to meet the needs of the military, and it continues to have significant application for military purposes. It is used to detect aircraft, missiles, artillery and mortar projectiles, ships, land vehicles, and satellites. In addition, radar controls, guides, and fuses weapons; allows one class of target to be distinguished from another; aids in the navigation of aircraft and ships; performs reconnaissance; and determines the damage caused by the weapons.

The importance of radar in modern warfare is borne out by the many measures designed to negate its effectiveness. Attempts to degrade military radar capability include electronic warfare (jamming, deception, chaff, decoys, and interception of radar signals), anti-radiation missiles that make detection more difficult (stealth), and high-power microwave energy transmissions to degrade or burn out sensitive

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receivers. A major objective of military radar development is to insure that a radar system can continue to perform its mission in spite of the various measures that will attempt to degrade it.

In military uses, remarkable achievements in transmitters of higher power and in receivers of greater sensitivity have made possible networks of extremely long-range radars for early warning of intercontinental ballistic missiles. In the late twentieth century the United States and Canada jointly operated a radar network known as Space Detection and Tracking System (SPADATS) for identifying and monitoring artificial satellites launched into earth orbit. Other modern-day applications include the use of radar for missile guidance and for surveillance (e.g., mapping radar carried by reconnaissance planes).

Civilian applications

Radar has found numerous and varied civilian applications as well. It has become an important navigational aid for commercial aeroplanes and marine vessels. Here are the common civilian applications of the radar:

Air traffic control

Virtually all major airports have surveillance and precision-approach radar systems, which enable air-traffic controllers to monitor and direct the movements of approaching and departing aircraft so as to prevent collisions. With these systems, controllers also are able to help guide pilots to safe landings when visibility is poor. This is called ground-controlled approach (GCA) by the military.

Aircraft navigation

The air route surveillance radar (ARSR), which has a range of about 200 nautical miles, tracks aircraft en route. Radars carried aboard aircraft also provide information about the location of dangerous weather so that it can be avoided. Military aircraft can fly at low altitudes with the aid of terrain-avoidance and terrain-following radars that warn of obstacles.

Maritime safety

More and more ships, including small fishing and pleasure craft, are equipped with simple radar units suitable for coastline navigation. In many ports large radar surveillance sets have been installed ashore overlooking the harbour and approach waters in order to assist shipping. The radar operator observing ship movements in the confined waters advises pilots of harbour traffic conditions from moment to moment via radiotelephone.

Meteorology

Another field of science that has benefited from radar is meteorology. Ground-based radars are used to aid weather forecasters in making short-range predictions. Such equipment can locate and track approaching storms for several hundred kilometres because strong radar echoes are reflected from cloud droplets, ice crystals, raindrops, and hailstones. Other kinds of meteorological observations, such as those
of atmosphere aerosols, dust, and molecules, are commonly conducted with laser radar.

**Law enforcement**

Radar has been used in security systems for intrusions and on sensing the movements of people attempting to penetrate a protected area. Continued miniaturisation of circuitry and auxiliary equipment has enabled the designing of smaller portable radar units. The handheld continuous-wave radar gun employed by the police for detecting speeding vehicles is a notable example.

**Astronomy**

Radar also serves as a valuable tool in astronomical studies. Radar techniques not only permit more accurate measurement of distances than optical methods do but also make possible the study of planetary and satellite surface features. So far, astronomers have employed radar to map the surfaces of the Moon, Mars, and Venus in considerable detail.

**Coastal surveillance**

One important use of radar is coastal surveillance. The Philippines, being an archipelagic country, has one of the longest coastlines in the world. The use of radar for detection and intervention of illegal activities within the coastal region and including the 200 nautical mile EEZ is necessary. Among the activities desirable for detection are illegal fishing and poaching of marine resources, illegal entry of migrant people and more importantly, the control of smuggling not only of goods but illegal drugs.

There are many other significant applications of radar that affects our everyday lives. Instrumentation radars are employed at missile test ranges for precision tracking of targets. Surveyors make use of special radars to measure distances. An even smaller, lightweight unit is a laser-radar sensory device developed for use in canes for the blind.

**One Radar For All**

The previous chapter discussed the agreement entered into by the PAF and the ATO in so far as the utilisation of their common equipment and facilities. The concept of such an agreement is to optimise the use of common equipment that may otherwise have required the government to commit substantial resources procuring separate equipment for both agencies. For a small nation like the Philippines, optimising the use of such valuable equipment is a sound investment. Indeed, gaining maximum return for investment in remote sensors as a national asset rather than one organisation’s tool is a wise idea.

Today’s technological advancements enable present radar systems to provide information not just for air defence and air traffic control but information or data requirements for other government agencies as well. Previous paragraphs described the varied civilian applications of the radar. In this context, PAF procured radar can
provide valuable information in assisting other agencies of the government accomplish their specific objectives. Consider the following civilian applications:

Coastal and Off-shore Surveillance on Marine and Aquatic Resources

As described earlier, the Philippines is one archipelagic country that has a very long coastline, and where marine products are exploited not only for domestic consumption but more so in the export market. The Philippines is the world’s second largest producer of tuna and tuna-type fish and ranked twelfth among the largest fish producers in the world.\(^6\) Locally, the fishing industry is one principal source of livelihood among Filipinos. It has provided livelihood to about one million Filipinos or five per cent of the country’s labour force. In 1998, The Department of Agriculture and more specifically the Bureau of Fisheries and Aquatic Resources placed annual fish production at 2.740 million metric tons valued at 83.639 billion pesos with total export amounting to 15.6 billion pesos. This accounted for 3.7 per cent of the country’s annual gross domestic product.\(^7\)

On the other hand, occurrence of illegal fishing perpetruated by foreign fishing vessels is rampant way inside the country’s EEZ. Last year alone, the Philippine Coast Guard apprehended numerous foreign fishing vessels, including Chinese caught in the seas off Palawan and Sulu islands, Taiwanese fishermen caught in Northern and eastern Philippines and Indonesian and Malaysian fishermen were detained in the southern seas of the country.\(^8\) According to the Director General of the National Economics and Development Authority (NEDA), Secretary Felipe Medalla, in 1998 and 1999 alone, the Philippines lost almost 20 billion pesos worth of aquatic and marine products to illegal fishing and poaching inside the country’s EEZ.\(^9\)

Additionally, another major problem is illegal fishing in the nation’s protected fish sanctuaries. Four fishing boats, for example, were apprehended for blast and cyanide fishing in the Apo Reef Park, a protected fish sanctuary off Occidental Mindoro that is rich in fishing resources,\(^10\) and also in the world famous Tubbataha Reef in the Sulu. More often than not, the country’s maritime watchers and enforcers are unable to monitor these illegal activities because of shortage of personnel and lack of equipment.

The PAF procuring surveillance radars will definitely alleviate situations such as these. A round-the-clock surveillance by this equipment on the country’s coastal seas can be effectively provided in any weather conditions.

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\(^6\) Colonel Dexter O. Huerto PAF (GSC), *Command and Control of Philippine Maritime Air Surveillance*, Aerospace Centre, Canberra, 1999, p. 16.

\(^7\) Ibid, p. 17.


\(^9\) Taken from NEDA report of 1999.

Coastal surveillance on Smuggling, Illegal Drugs, Etc

The Philippines lies strategically located near the Sea-Lanes of Communications (SLOC) between the Asia-Pacific region, the Middle East and Europe. Its location becomes an ideal transhipment point for goods and services especially with the operation of one of the world’s largest carrier networks, the Federal Express (FedEX) operating from the Subic Bay Freeport.

This strategic location has also made the Philippines an ideal transhipment point of illegal goods including prohibitive drugs. In 1999, the Philippine National Police confiscated billions of pesos worth of metamphetamine hydrochloride better known locally as shabu. These illegal drugs, usually coming from Hong Kong and mainland China, are intended not only for distribution in the Philippines but moreso for the United States. This substance, considered a ‘poor man’s cocaine’, is one of the primary drug menaces the Philippines is now facing.

On the other hand, Task Force Aduana, a Presidential Task Force created to combat smuggling in the country, has reported to have seized assorted goods

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smuggled into the country to the value of billions of pesos. In September 1999, members of the task force confiscated smuggled sugar loaded in an ocean-going vessel from Vietnam worth 150 million pesos. This seizure is just a fraction of the total number of smuggling activities that, if remaining unchecked would constitute a widespread economic sabotage to the country’s ailing economy.

Additionally, the Philippines is also considered a jump-off point of human smuggling, especially for those of Chinese origin wanting to enter America. Knowing the inadequacy of the Philippine authorities, in particular the Coast Guard and Philippine Navy, make the Philippines a favourite site for such Trans-Pacific operations.

Timely and accurate information coming from the surveillance radar to these government agencies will definitely restrict or even stop these illegal activities.

**Maritime Safety**

The Philippines, an archipelagic country, is very much dependent on inter-island vessels and sea craft for its domestic travel. In 1998, the Maritime Industry Authority (MARINA), an agency under the DOTC responsible for administering and planning maritime industries and enforcing maritime laws and safety, has accounted for a total of 774 merchant and inter-island passenger vessels, 4,000 commercial vessels and almost 500,000 bancas or indigenous vessels. Sea travel is the favourite mode of transportation among the average Filipinos. It is not only convenient but is also affordable to most Filipino travellers.

Proportionately, the substantial number of sea-going vessels that ply the different domestic routes has also caused a great number of maritime accidents. In the past decade alone, there have been many major maritime accidents, resulting in a loss of lives unequalled throughout the world. The Philippines ranks number one as far as worst maritime accidents are concerned. Two of these major accidents were caused by ship collisions. A vivid example was the collision of an inter-island vessel with an oil tanker off the coast of Mindoro in the early morning of 19 December 1989. M/V *Dona Paz*, an inter-island vessel utterly overloaded with passengers wanting to spend their Christmas in Manila, collided with an oil tanker the M/V *Don Vector*. At the time of the accident, the tanker was fully loaded with gasoline and diesel fuel that immediately burst into flames upon collision. This accident is considered the worst maritime accident in the world with approximately 4,000 lives lost, the greatest number in one single maritime accident. This overshadows the number of lives lost in the sinking of the famous luxury vessel, the *Titanic*.

One probable cause of these accidents is the Coast Guard’s inability to check overloading of passengers. One contributory factor why such accidents happen, especially during the night when visibility is limited, is the lack of navigational instruments such as radars aboard these vessels.

Accessibility of information essential to effective Coast Guard operations from surveillance radar, may help deter the future occurrence of these horrendous incidents.

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Weather Predictions

The Philippines is one country often visited by typhoons. According to the Philippine Atmospheric and Geophysical and Astronomical Services Administration (PAGASA), the country’s weather bureau, an average of 32 typhoons pass through the Philippines annually. This weather phenomenon plus other calamities such as earthquakes, floods, volcano eruptions and other man-made calamities often appear to make the Philippines look the disaster capital of the world.

Ordinarily, typhoon forecasts are taken from satellite pictures provided by meteorological stations of other friendly nations such as Japan and the US. These forecasts are periodically provided every six hours. However, during rainy seasons, usually from June to November, local weather phenomenon occurs spontaneously and satellite pictures are sometimes not available. The accurate and timely dissemination of these weather occurrences are vital to flying aircraft or navigating sea vessels, which may be directly affected by these weather disturbances. Ground-based radars can readily provide short-range predictions to aid weather forecasters in locating approaching storms, gales or other destructive weather phenomena in order to give enough time to warn aircraft in flight and sea travellers.

There could be other government functionaries that may also use the information and other related data supplied by the surveillance radars. As mentioned earlier, one radar alone can provide information to many organisations.

System of Systems

The term ‘system-of-systems’ has no clear and accepted definition, nonetheless, the term is widespread and generally recognised. There is an emerging class of systems that are built from components that are large-scale systems in their own right. Prominent examples include integrated air defence networks, the Internet, intelligent transport system (ITS), and enterprise information network.

System-of-systems is distinguished from large but monolithic systems by the independence of their components, their evolutionary nature, emergent behaviours, and a geographic extent that limits the interaction of their components to information exchange. The independence and extent of these super-systems result in an even greater emphasis on interface design than in traditional system architecture and engineering. Since the components are often developed independently of the super-system, the super-system emerges only through the interaction of the components.

System-of-systems can be defined by communication standards. Different problems require standards at different levels. Five principal characteristics are useful in distinguishing very large and complex but monolithic systems from true system-of-systems.

1. Operational Independence of the Elements – If the system-of-systems is disassembled into its component systems the component systems must be able to usefully operate independently. The system-of-systems is composed of systems that are independent and useful in their own right.

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14 Adapted from annual PAGASA report Re Typhoon Predictions for the Last 10 Years, 1995.
2. *Managerial Independence of the Elements* – The component systems not only can operate independently, they do operate independently. The component systems are separately acquired and integrated but maintain a continuing operational existence independent of the system-of-systems.

3. *Evolutionary Development* – The system-of-systems does not appear fully formed. Its development and existence is evolutionary with functions and purposes added, removed, and modified with experience.

4. *Emergent Behaviour* – The system performs functions and carries out purposes that do not reside in any component system. These behaviours are emergent properties of the entire system-of-systems and cannot be localised to any component system. The principal purposes of the system-of-systems are fulfilled by these behaviours.

5. *Geographic Distribution* – The geographic extent of the component system is large. Large is a nebulous and relative concept as communication capabilities increase, but at a minimum it means that the components can readily exchange only information and not substantial quantities of mass energy.

Communications is the principle enabling technology for system-of-systems.\(^{16}\) The inability to exchange mass and energy implies that only information can be exchanged. Emergent properties can appear only if information exchange is sufficient. If elements are procured semi-independently the standards of communication are more important than any particular systems. Communication is the principal substrate of system-of-systems.

When the components of system-of-systems are highly independent, operationally and managerially, the architecture of the system-of-systems is the interface. An integrated air defence system, once you extract the sensors and weapons as independent elements, is the command, control, and communications network.

**PADS as System-of-System Example**

One example of system-of-systems is an integrated air defence system. The Philippine Air Defence System, in itself, is a system composed of a geographically dispersed network of semi-autonomous elements. These include the surveillance radars, passive surveillance system, airborne surveillance, fighter aircraft, and anti-aircraft artillery. All units are tied together by a communications network, with command and control system applied at local, regional and national centres. Likewise, the Air Traffic Control is by itself a system that can function individually. A combination of these two systems makes it a system-of-systems. As discussed earlier, these two independent government agencies have one common resource which is the surveillance radar. Their individual missions or objectives may differ but their means in attaining their objectives is in a way congruent. The preceding chapter discussed how these two separate entities had entered into an agreement to utilise their common equipment and facilities.

The common ingredient in this system is communications so it is essential that related information vital to the operational activities of the supported agencies is promptly passed on. Therefore, in order to optimise the use and application of surveillance radars to other government agencies, an effective and efficient

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\(^{16}\) Ibid.
communications network must be established. Communication links down to the
lowest element of the organisation have to be constructed to ensure a prompt response
to any information relayed. Whenever possible, communication links among and
between government agencies are also essential for coordination functions.

System Interface with Civil Agencies

The wide coverage of the PAF surveillance radars has a lot to offer to the
different line agencies of the government. The wide range of activities conducted
simultaneously and concurrently by these line agencies can create confusion or
jurisdictional problems. The common ‘area of operations’ that creates a high degree of
complexity and overlapping interest to theses agencies are coastal and offshore areas
of the country.

The following government agencies may interface with the PADS in order to
utilise real-time information relevant to the accomplishment of their objectives.

Department of Agriculture (DA)

This department is mandated to ensure the stable supply of food from land or
sea. Under this department, the agency most concerned with maritime interests is the
Bureau of Fisheries and Aquatic Resources (BFAR). It manages and supervises the
development of fisheries and aquaculture to guarantee the supply of food derived
from the sea.\(^\text{17}\)

The Philippines is a signatory to the United Nations Convention on the Laws
of the Seas (UNCLOS) and as such, the country will have sovereign economic rights
over an area of about 652,800 square nautical miles of seas that will comprise the
nation’s EEZ.\(^\text{18}\) The addition of this extra area assumes additional responsibilities of
maintaining maritime security and developing potential industries.

These additional responsibilities can be supplemented by the existence of the
PADS surveillance radars. Security of the country’s coastal and offshore areas is one
specific function of the PADS surveillance radars to ensure no incursions or intrusions
of foreign elements whether armed or otherwise occur.

Department of Transportation and Communication (DOTC)

This department is tasked to ensure a safe and efficient transportation and
communications network exists for the country. Within this department is the Air
Transportation Office that is primarily responsible for air traffic control. The
Maritime Industry Authority (MARINA) is another line agency of the DOTC whose
responsibilities include the administration, planning, policy formulation, and
management of information on maritime industries, and the enforcement of maritime
safety.

Surveillance radars can provide information to safely guide vessels and other
sea craft to ports especially during inclement weather conditions.

\(^{17}\) Huerto, Colonel Dexter O. *Command and Control of Philippine Maritime Air Surveillance*,
Aerospace Centre, Canberra, 1999, p. 15.

\(^{18}\) Ibid., p. 17.
Element of S-211s conducting reconnaissance flight

Department of Environment and Natural Resources (DENR)

The DENR is mandated to develop, manage and administer programs for the harnessing and conservation of the nation’s natural resources and protection of the environment. The Mines and Geosciences Sector is a line agency of the department that enforces laws on mining, the environment and pollution control, as well as controls for the development and conservation of energy resources. Among the major indigenous sources of energy is oil, coal, hydro-power, geothermal and other non-conventional sources. Offshore oil exploration is being undertaken in El Nido, Cadlao, Tora Galoc, and Matinloc-Pandan-Libro in Palawan which has an estimated oil reserves of 218.8 million barrels of which 81.3 million barrels are recoverable. 19

Utmost security of these oil exploration areas must be provided at all times and in any weather conditions. Our surveillance radars can provide the desired security surveillance for these highly valuable areas.

Department of Finance (DOF) and Justice (DOJ)

The Bureau of Customs and the Bureau of Immigration and Deportation are two line agencies of the Department of Finance, while the National Bureau of Investigation is under the Department of Justice. All these line agencies are responsible for monitoring the illegal entry of goods, other prohibited exports or imports including illegal drugs and narcotics, and other activities inimical to the laws of the country. 20 Unfortunately, all these agencies have no air or surface surveillance platforms and they rely mostly on intelligence inputs from their operatives. They also rely on cooperative exchanges of information from other internal government and non-government agencies.

Real-time information that is vital to the accomplishment of these agencies' operation can be provided by the surveillance radars anytime they need it.

**Philippine Atmospheric and Geophysical and Astronomical Services Administration (PAGASA)**

This line agency is under the Department of National Defence and is responsible for monitoring and predicting climactic conditions of the country. As discussed earlier, the Philippines is one country often visited by typhoons. An average of 32 typhoons passes the country annually. Most information about this weather phenomenon is provided by friendly countries such as Japan and the United States via satellite pictures. In the absence of satellite pictures, weather disturbances hundred of miles away can still be predicted and monitored by the surveillance radars, providing ample time to provide warnings to sea farers and air travellers.

**Philippine Coast Guard (PCG)**

The Philippine Coast Guard, at the moment, lacks the necessary equipment and facilities to effectively perform its mandated tasks. Its limited resources could not monitor all maritime activities all throughout the archipelago. It is physically impossible for the PCG to check every nook and cranny of the country's 7,100 island and then there are its long coastlines or its vast offshore areas. Information from the surveillance radars related to its functions and tasks will negate its shortages in resources and will definitely help overcome this handicap.

**Philippine National Police (PNP)**

The Philippine National Police has enough manpower to perform its mandated tasks. It may also have enough resources necessary to accomplish its assigned mission of peace and order. However it will be of great benefit to the PNP for information from the surveillance radars to assist its fight against crime and lawlessness.

There may be other agencies of the government that can also use related information from the surveillance radars possessed by the PAF. The point here is that this vital equipment can be a source of varied and related information or data that is important, not necessarily to all line agencies, but at least to one or two at any given time. This equipment is a national asset worth the price of investment.
PADS as System of Systems

Australian Experience

Australia is an island continent with a land area of about 10 million square kilometres. Just like the Philippines, it has long coastlines with a vast exclusive economic zone that extends 200 nautical miles from its territorial coastlines. The Australian government is also interested in the detection and prevention of illegal fishing, drug trafficking, illegal immigration, and also the monitoring of land and ocean resources.

The Australian Defence Force (ADF), as with the Armed Forces of the Philippines (AFP), is mandated to maintain military control over national territory, airspace and territorial waters. Both armed forces are also relatively small as compared to the military organisation of other neighbouring countries. Coincidently, Australia and the Philippines have similar threat scenarios since both countries perceive threats to be coming from the north and the north-west, although the Philippines has threats also coming from the south and south-west. Similarly, the ADF is having difficulty maintaining surveillance in all its territories as the AFP is having difficulty securing its territories particularly the Spratly group of islands. The Philippines does, however, have the advantage of smaller areas able to be covered by sufficient surveillance radars.

The similarity, however, ends here. Surveillance and reconnaissance are conducted across continental Australia by the ADF with support from the Australian Coastwatch Service (ACS), using sea, air and land resources.21 Additionally, Australia operates its over-the-horizon surveillance radar, the Jindalee operational radar

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network (JORN), the only true wide area surveillance network that provides a wide area of surveillance coverage far beyond Australia’s continental boundary.

The ADF and ACS are physically unable to monitor all incursions into the Australian EEZ, it is however, supplemented by other conventional surveillance assets. These include the Royal Australian Navy (RAN) patrol boats, ships and submarines, the Royal Australian Air Force (RAAF) maritime patrol aircraft P3C, Coaswatch aircraft and patrol vessels, and various ground resources. Furthermore, Australia has a number of space-based assets that support key strategic surveillance activities.

Additionally, Australia has one of the most modern air traffic control systems in the world. Air Services Australia has the responsibility for managing the airspace and air traffic services of the Australian domestic and international aviation industry. It has recently introduced a fully integrated airspace management and air traffic control system called The Australian Advanced Air Traffic System (TAAATS). The extensive and overlapping air traffic control radar coverage of the TAAATS, especially on the east coast, adds to the entire air defence surveillance picture of Australia. The fusion of the air traffic radars to the air defence surveillance picture was made possible under the scheme known as the National Air Defence and Airspace Control System (NADACS).22

The ADF has the support of other civilian agencies in its requirement for surveillance of mainland Australia, its offshore territories and maritime approaches. The AFP, particularly the PAF, has the sole responsibility of providing the surveillance activities of the Philippines using its surveillance radars with probably limited support from other government agencies.

What makes the Australian experience an ideal concept for the Philippines to follow is the fusion or integration of data from its surveillance sensors and sources. Once all these data are integrated, coordination among agencies is centralised to fully exploit its limited resources. Australia was able to recognise the necessity for effective data fusion of surveillance information.

It is in this light that the utilisation of PAF surveillance radars will be optimised by integrating all information and data from the different sensors and providing other government agencies pertinent information they require. The limited resources available in the acquisition of surveillance radars will be justified by optimising its capabilities in providing real time information to other government agencies. Without the ‘one radar system for all’ concept, the territorial sovereignty of the Philippines remains vulnerable.

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OUR Radars
Chapter Seven

Conclusion

The strategic level of war involves the interaction of government and the instrument of national power, in particular, the military component. At this level, other civil agencies will also require surveillance information and intelligence.

Air Commodore Peter Nicholson
Royal Australian Air Force

The main role of a surveillance system, particularly air defence radar, is to provide systematic observation of the area of direct military and strategic interest to the Philippines. This role allows us to develop a long term, enduring picture of activity in the air and sea approaches to the country. This area surveillance also permits us to monitor activity between and among points which are critical centres for military operations that may be conducted against us.

The role therefore of surveillance radar should never be underestimated. Much of the security of the entire country relies on it since it provides the first information that triggers the chain-reaction of the air defence system, the first line of defence for the country.

Essentially, we should be continually looking to improve our surveillance capability to make it more effective and more efficient as a system by identifying current technological advances and trends. Our obsolescent existing capabilities must be addressed, identified deficiencies rectified or replaced and opportunities for better exploitation of surveillance technology presented.

Systems Advancement Analysis

Recalling the main functional components of a surveillance system, we have to consider the impact of technological advancement on these components. The system components most affected by the technological advances are the sensors, the communication links for sensor control and transfer of data, the information integration or data fusion mechanism, and the command system for sensor management.¹

Sensors

Advances in technology are likely to be confined to improvements in resolution and this would include the capacity for self-contained processing to match

¹ Nicholson, Air Commodore Peter, 'Surveillance', in Stephens, Alan (ed), Defending the Air Sea Gap, Australian Defence Studies Centre, Canberra, 1992, p. 44.
the frequency band in use to the task at hand and the prevailing environmental conditions. In other words, the sensor will become more like a ‘package’ with multi-mode capabilities which will be switched on and off, assessing the quality of the information being gathered and adapting itself to optimise the output.

Communications

This is the next area to be considered that has the potential to significantly enhance the effectiveness of surveillance operations. Instead of the existing microwave links, this should be upgraded to handle higher information data rates by using fibre optic terrestrial communications links that permit the transmission of very broad bandwidth data around the country. Furthermore, the essence of communications for high volume data applications associated with military surveillance sensors is speed, security, capacity and resistance to electronic attack. At the very least, commercial linkages have to be taken into consideration in areas where military linkages are absent. Most importantly though, security of the communication lines has to be assured.

Data Integration

The greatest advances have to come from this component to best utilise the information already imbedded in the output from our sensors, but which presently cannot be accessed or interpreted. It was only recently that the processing capabilities became available through the process of data integration which comes in four steps. These are:

1. **Alignment** – This is the transformation of target state vectors as detected by the sensors to a common coordinate system, an adjustment for systematic errors, and interpolation to account for the different granularity of sensors.
2. **Correlation** – This is the determination of the closeness of sets of data from different sensors to establish if the same target is being detected and tracked.
3. **Association** – Means determining when two or more sets of data are measures of the same entity. For example, the distance between two tracks is less than some threshold meaning the two tracks could be associated with one or two targets.
4. **Merging** – This is the combination of data sets which have been associated to get the best combined estimate of the position and velocity of the target.

The process of data integration indicates the potential of combining ‘smart’ sensors, distributed processing, faster speed and greater capacity processors. It may be that this last step is simply too complicated and has to be performed too fast for there to be any place in the process for the human operator and thus must be done by computers.

Command System

Adequate and timely information is a prerequisite to the planning and conduct of air and maritime operations of the country. In peacetime, it is necessary as a routine function to establish the pattern and nature of normal activity in the sea/air gap. Also,

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2 Ibid., p. 46.
civil surveillance assets may make a major contribution to the total surveillance picture. Whatever the threat, the surveillance mission is a national task and should have command and control arrangements appropriate to this level of operation. Furthermore, for optimum and effective use of surveillance resource, tasking and system management needs to be centralised in a single organisation so that a balance of complementary sensors can be brought to bear on the problem at hand and ensuring the proper integration of available information. In this particular case, it is suggested that the command and control should be placed at the Philippine Air Defense Control Center. The reasons are quite obvious since national security is paramount in determining the ideal command and control structure for this system.

![Philippine Air Defense Control Center](image)

**Philippine Air Defense Control Center where command and control is situated**

**Systems Acquisition Priority**

Modern and state-of-the-art surveillance/air defence radars with advanced technological capabilities must be vigorously evaluated and acquired as a basic requisite for an effective air defence system even before the acquisition of a modern fighter aircraft. It appears illogical to acquire modern fighter aircraft while maintaining outmoded and unreliable sensors since targets cannot be reliably acquired or monitored. Modern surveillance radars would not just provide sufficient and timely warning information, they will also monitor and check unabated poaching and other illegal encroachment to the country’s EEZ with loss of maritime resources probably worth millions of pesos. Additionally, the presence of these sensors would act as a deterrence to the commission of illegal activities such as entry of illegal goods, drugs

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3 Letter addressed to President, Joseph E. Estrada by Lieutenant General William K. Hotchkiss III, Re. DOTC/ATO Philippine Airways Modernization Program (PAMP) dated 1 December 1999.
and illegal immigrants since these activities will be monitored and eventually apprehension would ensue.

This paper does not, in anyway, imply that priority in the procurement of surveillance radar takes precedence over the acquisition of fighter aircraft or, for that matter, any other equipment related to modernisation. In the event, however, that availability of funds limits the procurement of equipment, then that procurement may need to be phased and scheduled. If this needs to happen then this paper suggests that procurement of surveillance radar has to be given priority due to the reasons stated previously.

This paper limits its suggestions and proposals solely on the basis of optimising the use of the surveillance radars. This paper does not suggest, recommend, or propose the brand or manufacturer of radars to be acquired and thus lets authorised planners do the selection and the actual procurement. However, this paper does suggest an acquisition strategy of specifying capability and functions of proposed surveillance radars and allow prospective suppliers and bidders to offer hardware and software as a complete system. The aim of this strategy is to lend these suppliers to the evolutionary acquisition, whereby we acquire each subsystem sequentially and allow advances in technology to be incorporated over the operational life of the equipment. Indeed, with such an approach, it may be more effective to lease hardware and software of the system so that the rapidly changing world of Information Technology (IT) does not leave us behind. Certainly, if our capability specification is couched in relative terms, such as the system must be capable of detecting ninety per cent of low level traffic over water, or of surface vessels within certain number of miles, then the supplier will need to constantly upgrade the system as the target sophistication and technology increases.

Incidentally, government planners may enticingly decide to procure surveillance radars for air defence as well as for air traffic control all as one package. This may sound tedious and one-sided but taking everything into consideration, this may turn out to be a wise and economical endeavour. A considerable advantage one can derive from this scheme is maintenance and commonality of spares. Training of personnel both from the PAF and from the ATO is another beneficial advantage since the manufacturer of the radar is one and the same. This package deal may have a lot more to offer and there is no denying buying wholesale entails added promotional advantages than retail procurement.

Mixed Systems Acquisition

Planners of the PAF Modernization Program have determined a requirement for the acquisition of six modern surveillance radars for air defence to be deployed in strategic radar sites of the country. These sensors will provide airspace surveillance for eighty five per cent of the country’s entire territory leaving the rest of the archipelago covered by the ATO surveillance radars.

In order to maximise the full capability of these surveillance radars, this paper proposes that a mixture in types of radar be considered for procurement. Firstly, this paper agrees that the proposed six land based radars be prepositioned in six permanent sites. In addition to these permanently based radars there are some significant advantages to have them supplemented with two deployable or easily transportable radars. Modern technology allows new radar types having similar capabilities to the permanently located ground based radars but highly mobile to be deployed to areas
where they are required. There are rapidly deployable surveillance radars that are air transportable by C-130 aircraft or by truck. The possibility exists that transportable surveillance radars can be deployed in Pagasa Island to monitor the entire Kalaya-an group of islands or in Tawi-tawi island to monitor our country's backdoor. The Australian Defence Force is also utilising highly transportable and deployable surveillance radars to fill-in gaps in areas not covered by their permanently based ground radars. Aside from optimising its use, the risk of it being subjected to an enemy’s threat of attack is diminished since its location is not permanent. It also has the advantage of moving to an area where a threat has developed or may be developing.

![Surface-wave Extended Coastal Area Radar](image)

**Surface-wave Extended Coastal Area Radar**

Secondly, there are some areas of the country where the vast expanse of seas and oceans can have better surveillance coverage if another type of radar is used. New technology in Australia has resulted in the development of a powerful new radar used for detailed surveillance of coastal waters. The technology is known as the Surface-wave extended coastal area radar (SECAR) and it has a 5 kilowatt transmitter and a linear receiving array. SECAR employs high frequency surface wave radar to provide surface surveillance of surface vessels and aircraft up to 300 kilometres away. This type of radar can complement existing microwave radars that are limited to line of sight. This type of radar can be prepositioned in Palawan island to oversee the vast seas and oceans in the South China Sea. Another ideal site for this type of radar to be employed is in the southern Philippines, specifically in southern Mindanao where there are lots of movements of surface vessels. The kidnapping of tourists in a Malaysian tourist spot is a classic example where uncontrolled and unmonitored seacraft movements in the southern border of the country are unrestrained. This

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incident will have a negative effect on the country's tourism industry as the world will perceive the area as dangerous and will not want to visit there. This incident may not have happened if there had been an effective surveillance radar there with back-up from law enforcement forces.

Thirdly, there is no better alternative than to have maritime patrol aircraft (MPA) that can perform wide area surveillance, complementing surveillance radars, providing identification and targeting functions as required. The Philippines, being an archipelagic country, has a wide extended area of EEZ to monitor and protect and having MPA definitely will provide a broader coverage and faster transmittal of surveillance information. The MPA has a very long endurance that can be translated into an operational range. For search, location and tracking, this aircraft has on board precise sensors which are not too sensitive to the sea state and are linked to other sensors that are integrated, using considerable processing power and data correlation capacity. The maritime patrol aircraft should be equipped with a capable communication system that allows it to establish the appropriate links with sea, air and land stations for an extended range of missions, and in the most diverse conditions. The MPA will also be able to clearly identify and report targets detected by surveillance radars.

![One of the Two RF-27 Aircraft acquired by the PAF for Maritime Patrol](image)

### Systems Data Fusion

Data fusion offers the potential to greatly improve the Philippines' overall surveillance system capabilities by integrating data and information from a range of different sensors and sources. The PAF, for example, can make use of data routinely available from agencies such as the Air Transportation Office and other intelligence organisations to assist in developing and maintaining an overall surveillance picture. Collaborative sources such as civil aircraft flight plans, shipping schedules and other intelligence sources can also provide supporting information to assist in making platform intercept decisions. Data fusion can involve the overlaying of data from different sources, as well as the manipulation and interpretation of data.

The cost of surveillance is high and fusion may help to optimise the effectiveness of the systems available. Therefore, data fusion is the key to our

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comprehensive surveillance network. As stated earlier, for a small country such as the Philippines, optimum utilisation of equipment is the only way to wisely spend very scarce resources with systems integration and data fusion being an essential component.

Final Analysis

Current situations developing in the Asia-Pacific region particularly in the South China Sea, place the Philippines in a very sensitive situation especially as it lies near the Sea Lanes of Communications (SLOC) between Asia, the Middle East and the US. The potential ‘powder keg’ in the South China Sea, the Spratly group of islands, that is claimed not only by the Philippines but by several other countries, including Vietnam and China, put additional pressure on the already highly volatile situation. China’s subtle creeping incursions on some shoals and reefs within the disputed area adds greater dilemma to a country such as ours that has no capability of securing and controlling its territorial boundaries which include its vast Exclusive Economic Zone (EEZ). This weakness, exacerbated by the dismal state of the existing defence capability of the country, justifies the need to modernise our ineffective air defence system particularly, at the very least, its radar surveillance systems. In a way, having a credible surveillance system will depict a picture of sovereign jurisdiction over our recognised territory.

The cost however of a modernised surveillance system is very expensive and there is always the possibility that its procurement may be relegated second priority to what might be considered a more essential requirement. The financial difficulty the country is currently experiencing further places the acquisition of these radar system into near limbo. At the moment, the only solution the country has agreed is for the joint use of facilities and equipment between the PAF and the ATO. This endeavour was made possible through an existing Memorandum of Agreement (MOA) signed by both the PAF and the ATO in 1995.

However, the problem of an ineffective surveillance system still remains. Both government entities still have the old unreliable radar system in use. In the mean time, the country’s external perimeters and defences are still bare and vulnerable. Its territorial domain is still open to illegal incursions and intrusions including smuggling, drug trafficking and illegal entry of immigrants. The vast expanse of its maritime areas including the expanded EEZ are still subjected to illegal fishing and poaching where billions of pesos worth of marine resources are lost.

The government has to do something about this situation and has to do it fast. Inevitably, the modernisation of the country’s external defence is a major concern, particularly its first line of defence, its air defence system. Along this line, acquisition of modern surveillance systems has to be given top priority. The best justification for its priority acquisition is to optimise its use through data fusion or systems integration. These surveillance radars, aside from its primary function as sensors for air defence and air traffic control, can simultaneously provide essential, real time information to several other government agencies in the accomplishment of their individual tasks and concerns. Modern surveillance systems can project sovereign jurisdiction over the country’s territorial domain, safeguard its maritime areas against illegal intrusions and more importantly provide other government agencies with vital information for their operations.
In conclusion, optimum utilisation of PAF procured radars will be through systems integration. The PAF and the whole country in general will gain maximum return for investing in these surveillance radars as a national asset rather than as solely Air Force equipment.
Surveillance Radar coverage for the entire archipelago
Full line – PAF Radars Dotted line – ATO Radar
Bibliography

SPEECHES

President Joseph E. Estrada, Keynote Speech during the 52nd PAF Anniversary, 1 July 1999


Defence Secretary Orlando S. Mercado, 'The Roles and Functions of the Armed Forces', *Policy Directions for Defence*, DND, Quezon City, November 1998

GOVERNMENT/DEFENCE PUBLICATIONS

AFP RG Nr. 200-053 Armed Forces of the Philippines Rules and Regulations Number 200-053

AFP Modernization Program, approved by Philippine Congress, 23 February 1995

ADFP 29 – *Surveillance and Reconnaissance*, Director Publishing, Department of Defence, Defence Centre, Canberra, 1995


*Defence Magazine*, July 2000

Implementing Agreement between PAF-ATO, dated 21 August 1997

Lead Turn, PAF Beyond 2000, Office of the Special Studies, Headquarters Philippine Air Force, J. Villamor Air Base, Pasay City, Philippines, 2000

Letter Addressed to President Joseph E. Estrada by Lieutenant General William K. Hotchkiss III, DOTC/ATO Philippine Airways Modernization Program (PAMP) dated 1 Dec 1999


PAF- ATO Joint Use of Equipment and Facilities, Philippine Air Force, Villamor Air Base, Pasay City, Philippines, 8 September 1997
OUR Radars

PAGASA Report ‘Typhoon Predictions for the Last 10 Years’, Philippine Astronomical, Geophysical Atmospheric Services Authority, DND, Quezon City, 1995

*Philippine Fisheries Profile*, Bureau of Fisheries and Aquatic Resources, Department of Agriculture, Republic of the Philippines, 23 February 1995

Policy Directions for Defence, Department of National Defence, Quezon City, Philippines, November 1998

Revised Administrative Code of 1987 Subtitled II Chapter I, Section 15

The Mutual Defence Treaty signed into by the Philippine Government and the United States Government

The Philippine Air Force Modernization Program (PMP), Headquarters Philippine Air Force, Villamor Air Base, Pasay City, Philippines, 1995

The Philippine Constitution of 1987, Article I Section II, Republic of the Philippines, Manila

**BOOKS/JOURNALS/ARTICLES**


Gale, SQNLDR Wayne, *The Potential of satellites for Wide Area Surveillance of Australia*, Air Power Studies Centre, Canberra, 1992

Huerto, Colonel Dexter O., *Command and Control of Philippine Maritime Air Surveillance*, Aerospace Centre, Canberra, 1999

Lacuarta, Gerald G., ‘Gov’t Deports Six HK Fishermen’, *The Philippine Daily Inquirer*, Philippines, 6 November 2000


Orticio, Major Arturo Jose G. Jr., *Philippine Air Force Air Operations*, Aerospace Centre, Canberra, 2000


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