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Editorial Board

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EDITORIAL

In an increasingly complex and uncertain strategic environment, the Singapore Armed Forces (SAF) now undertakes a wide range of operations; from fighting a conventional war and maintaining 24/7 vigilance against transnational terrorist threats, to responding to peacetime contingencies and deploying for multinational Humanitarian Assistance and Disaster Relief missions and Peace Support Operations. In these missions, the Republic of Singapore Air Force (RSAF) has a critical role to play, given its high level of readiness, responsiveness and reach.

This year, the RSAF commemorates its 40th Anniversary. From its humble beginnings, the RSAF has transformed itself into a technologically advanced, full spectrum, integrated and operationally ready First Class Air Force. The transformation will strengthen the RSAF's integration with the Army and Navy, so that it can play a more integral role in shaping the land and sea battles as part of the closely networked *ONE* SAF; harness new technologies in the areas of information networking, precision weapons and unmanned warfare; and develop its people to be committed and competent individuals.

In view of these exciting developments, we are honoured to publish the article "Safety and the RSAF Transformation" by the Chief of Air Force, MG Ng Chee Khern. Using an analogy of Eastern and Western Medicine, MG Ng shares his thoughts about how Safety must be approached not just from a clinical and reactive orientation. A more holistic Eastern medicine approach should also be undertaken to deal with the causal factors. As such, the RSAF transformation has taken a holistic view to improve the organisational structure and resources, as well as inspire a people development culture, which will serve well to complement its safety efforts.

In this issue, we are also delighted to publish four essays contributed by a group of RSAF Officers led by COL Lee Ling Wee, Head Air Logistics, with LTC Joseph Tan Boon Kiat and CPT Ong Seow Wei performing the role of the Secretariat. Offering perspectives on some of the pertinent issues associated with the RSAF's transformation efforts, and centring on the theme "Operationalising the 3rd Generation RSAF", the articles focus on the softer aspect of transformation – the heartware of change.

The first essay "Shaping Policy Space: Defence Diplomacy in the 3rd Generation RSAF" elaborates on the importance of the RSAF in the broader national context. It outlines the role of the RSAF in shaping Singapore's policy

space, posits that defence diplomacy does not lie solely with the senior leadership, but also with each and every one of its Airmen, and suggests how the men and women of the RSAF can better contribute to this important mission.

Recent major military operations have demonstrated the need for a full spectrum and integrated force. However, operating as an integrated SAF would entail overcoming significant, practical and even deeply rooted challenges. The second essay "Building an Integrated Force: Overcoming Challenges to Operate as *ONE* SAF" identifies some of the key challenges that the RSAF will face, and highlights five key areas that it will need to focus on in order to achieve the vision of fighting as *ONE* SAF.

Having addressed the higher-level purpose of the 3rd Generation RSAF and the challenges associated with an integrated force, the third essay "Commitment to Defence: Preparing Our People for a First Class Air Force" touches on an important change enabler – Commitment to Defence. It posits that to achieve the successful transformation into a 3rd Generation RSAF, there is a parallel need to develop the 3rd Generation Airman. The article then suggests a three-tier framework that needs to be put in place to not only engage their minds but also their hearts.

The line-up concludes with an article that proposes 7 habits for the 3rd Generation RSAF Airman. Each habit is expounded in a set of yin-yang extremes that sit on the same line. This yin-yang approach implies a balance in the character of the 3rd Generation Airman. Non-exhaustive and open to interpretation, the 7 habits are derivatives of the desired attributes of the 3rd Generation RSAF Airman and offer a refreshing view on what it takes to be a highly effective professional.

In this issue, we are also glad to publish the first article by a Warrant Officer since the revamp of *POINTER* in 2003. In "Professionalism – A Warrant Officer's Perspective", MWO Prakas shares his thoughts on how Professionalism, a fundamental of People Development, can be strengthened. He proposes three attributes which all Warrant Officers, Specialists and Airmen (WOSA) should possess and three key ideas to inculcate the value of Professionalism in the WOSA Corps; ideas that will help the RSAF become a First Class Air Force.

We hope you will enjoy this Air Force-sponsored issue. Happy reading!

Editor, *POINTER*

Safety and the RSAF Transformation

by MG Ng Chee Khern

Introduction

The RSAF achieved something significant in the last workyear. We achieved our first accident-free year since Workyear 2000. The S211 crash on 2 Oct 01 had ended our last zero-accident record. For 6 years in a row since, we have had accidents. But last year, we halted the trend, re-establishing our zero-accident record. There were a few close calls indeed, which we must continue to try to eradicate. But let's give credit where it is due, for many people have put in a lot of hard work to ensure that we had a safe year. No Air Force flies 53,000 hours without accident due to luck. My thanks therefore to the men and women of the RSAF, as well as our partners from Singapore Technologies and Defence Science and Technology Agency. Your efforts have made this zero-accident year possible.

What I like in particular is that nobody has talked much about this achievement. Nobody has made it a big deal, nobody has blown their own trumpet. Perhaps it has not even struck some of our people that we have achieved our first accident-free year since Workyear 2000. This is good because it shows that we are not complacent. I only want to point out this achievement here to thank our people, not to sound complacent.

Some people may think that our zero-accident record was achieved in spite of

our transformation. What I would do in this article is to point out that this is probably not true. At the beginning of our transformation two years ago, I was indeed concerned that as we switched focus to concentrate more on task competence, our fundamental type competence and standards might drop. But as I thought deeper about the relationship between our transformation and safety, I would like to share that our transformation efforts, and in particular the CARDINAL which seeks to develop the 3rd Generation Airman, complement our safety efforts. I think in this respect, last year's zero accident record should give us confidence that indeed, not only is transformation and safety a non-zero-sum game, transformation as we have carried it out can reinforce safety.

In this article, I will share my philosophy towards safety which I have crystallised in the last few months as I thought deeper about how to manage the RSAF transformation in the coming year.

Two Approaches to Safety – Analogy of Eastern and Western Medicine

In medicine, there are two distinct approaches. Western medicine is very rational, scientific and clinical. Remedial actions and medications have to be rigorously tested and measured. This approach has been instrumental in bringing down mortality rates. However, Western medicine is largely reactive and it takes the physical functioning of body parts as the starting point. It has also not brought about long-term well-being. Something seems to be missing.

Eastern medicine, on the other hand, seems less structured. Many of us think of Chinese medicine as grandmother remedies or stories. Some of the practices even verge on the mythical and the superstitious. (I must apologise here as I don't know enough about the other forms of Eastern medicine, such as Indian medicine, to talk knowledgeably about them although I suspect that most of them may be more similar in philosophical approach to Chinese than to Western medicine.) But the strength of Chinese medicine is that it takes a holistic view of how the body as a whole functions. The physical, emotional and psychological well-being of a person rather than the functioning of body parts are taken as the starting point.

We can have two approaches to safety that parallel these two approaches to medicine. The first is akin to the Western approach, to look at safety narrowly, tackle each incident as it arises and take steps to prevent each type of incident. This is an approach that the Air Force has developed for many years and we have a very strong system of doing it now. But looking at safety incident-by-incident seems to leave something out. For instance, we have conducted system reviews over the years, including safety stand-downs after a particularly bad spate of incidents or an accident. Such reviews often found that despite good safety processes, the processes were somehow not followed. We then concluded that it was probably an isolated incident, related to an individual being the weak link. But this conclusion leaves some of us dissatisfied. We feel there is something more fundamentally wrong

that needs to be tackled; some deeply buried reasons and trends not visible by looking at the immediate causes.

This brings me to the second approach to safety, analogous to the Eastern philosophy towards medicine. This approach sees the RSAF as a holistic system. It suggests treatments that not only eradicate the immediate symptoms, but improve the health of the organisation for the longer term. It deals with issues at the core, the roots of the problem, the wider and deeper forces from where the safety compromises may have originated. Later in this article, you will see how our transformation efforts indeed touch on the deeper health of the RSAF.

Akin to the Eastern philosophy towards medicine, providing treatment by seeing the RSAF as a holistic system will not only eradicate the immediate symptoms, but also improve the longer-term health of the organisation.

Let me illustrate with two examples. Some time ago, a retired Air Force officer related to me a story that happened in the midst of the 1980s Skyhawk crisis. After one of the accidents, there was some preliminary talk about making an example of the Squadron Commander involved by removing him from his appointment to send a warning to the rest to buck up. This was not done in the end because somebody was courageous enough to point out that such a remedy missed the point. The problem of the A4s was not caused by any weak squadron commander per se. The real issue was that the RSAF as a whole had expanded too quickly in the late 70s and early 80s and nobody had grasped that the training and engineering resources devoted to handle this expansion was inadequate to sustain the pace of the developments.

A more recent example was the spate of Human Factor (HF) incidents in Peace Carvin II (PCII) last year. We carried out the necessary investigations and corrective actions after the incidents. Clearly, in all the incidents, the individual pilots could have done better; and should have done better. But it is also true that something deeper had happened without the RSAF having taken a conscious decision. When PCII was first set up, it was intended for high-end training and given its challenging conditions, the RSAF sent only experienced pilots there. As time passed however, this changed and the focus of PCII was enlarged. This was reflected in the posting plans. We started to send junior pilots straight to PCII a few years ago. This decision was not wrong per se but we could have done better if we had focused on what framework was needed to allow us to induct pilots from Flying Training School (FTS) to PCII. Otherwise, it would not be a surprise if some of our junior pilots were not equipped to cope with the demanding conditions at the detachment. This issue is not yet totally

resolved; Air Operations Department (AOD) and Air Combat Command (ACC) would be looking into it.

I share these two stories because they illustrate how our corrective actions can be incomplete if we focus only on the incidents and immediate causes. The fundamental problem in both cases was not the lack of operational leadership or discipline at the unit level, but a failure to appreciate the context and conditions under which our people operate. The RSAF is now undergoing a major change comparable to that of the late 70s and early 80s. We have shown great courage and conviction in undertaking to build the 3rd Generation Air Force, but we must learn from the lessons of the 80s and focus our efforts on managing transformation. This cannot be done by looking at safety narrowly. We need to take the Eastern medicine approach and look at the impact on safety from our organisational structure, resources and culture respectively. Only then can we have solutions pervasive enough to tackle safety deeply, for the long term, and at the heart of our daily operations.

Despite initial worries that re-organisation would dilute attention to the development of type competencies and thus compromise safety, there is a growing realisation that re-organisation can actually complement safety.

Eastern Approach – Organisational Structure, Resources and Culture

• Organisational Structure

When we first started our organisational restructuring, some of us were worried that shifting the focus of the Operational Commanders to task development would dilute attention to the development of type competencies. This dilution would in turn compromise safety in the longer term because it could cause our operators to be lacking in strong fundamentals. In current operations, with our Operational Commanders now looking at the task level and no longer focusing on flying and safety, the supervision levels over the squadrons may also be reduced, which could immediately and directly affect safety adversely.

In reality however, I think some of us have slowly come to a realisation that our re-organisation can actually complement safety. The Operational Commanders may have to focus at the higher task level but type competencies have not been compromised. Unlike the previous Base Commanders or Base S3s who had quite diverse responsibilities, the Type Group Commanders dedicate their attention almost entirely to type competencies and training. The feedback I have received from the helicopter squadrons which have operated with the Type Group structure for the last nine months is that the degree of oversight on flying and standards provided by the Group structure is in fact stronger than in the old air base structure.

Let me use yet another football analogy to explain what I mean. Liverpool Football Club would not want their team manager to also be the facilities manager because that would dilute his focus on building a strong football team. Hence, Benitez is not expected by any sensible football fan to look after Anfield Stadium or the football pitch. Well, in addition, Benitez as the team manager is also not expected to be deeply involved in the coaching of the basic footballing skills of his players. Most English Premier League teams have coaches in addition to the team managers. The coaches take care of fundamental football skills and techniques and fitness, while the manager takes care of team selection and strategy. It is the same philosophy behind our re-organisation efforts. The Type Group Commanders take charge of core fundamental skills, while the Operational Commanders take care of how to combine different vocations into an operational team. Under the old air base structure, the Base Commander was in charge of everything – he was the team manager, the coach, and the stadium manager. He basically ended up not being good at any of this. On the one hand, he neglected task competence, and on the other, he was also not able to focus as much on type competence as the current Type Group Commanders can.

The other concern we have with our re-organisation is the issue of group insularity. One of the strong points in the fighter and transport communities previously was the diversity of views amongst the different fighter and

transport pilots spread across three air bases. Grouping all the fighters and transports within one group can potentially stifle this healthy diversity. The implications on safety are real, even if not obvious. If the entire fighter or transport community believes there is only one correct way of conducting the mission, of flying the aircraft, or of the balance between mission and safety imperatives, there will only be one perspective in the whole of the RSAF. In the investigation of the Apache accident two years ago for example, I was surprised and disappointed that the helicopter community appeared to have only one view – the Sembawang Air Base view. When I asked some senior helicopter pilots within AOD for their views, they repeated the views of Sembawang completely. And our concern when we grouped the fighter and transport squadrons together was that this insularity in the helicopter community may in future happen to the fighter and transport communities too. Such insularity is unhealthy. Tensions and diversity of opinion is what brings an organisation forward whether in operational development or safety.

We have therefore ensured that in our re-organisation, check-and-balance mechanisms are created to mitigate this risk. For many years, the Air Force Inspectorate (AFI) has provided a healthy tension with the Formations to ensure that safety is not traded off for other considerations. But we have never had an independent agency to look after training and operational standards. As part of our re-organisation, we have thus set up the Standards Office in the Specialist Staff Group of AOD, to offer alternate views and maintain a healthy check-and-balance with the Type Groups. In the same way that our logistics technicians ensure that our aircraft are airworthy, the Standards Office acts as our standards technicians, checking our people's fundamentals to ensure they are mission-ready. Its relationship to the Type Groups is akin to that of a coach and player. Even the best players, such as Tiger Woods, employ a coach to improve themselves because the coach can see things about them that they themselves cannot see, no matter how good a player they are. The RSAF must therefore ensure that we post the right people and give the right incentives for staffing the Standards Office. Air Manpower Department (AMD) and AOD would have to work to ensure this is true for the longer term.

In sum, our re-organisation efforts are not incompatible with safety. The creation of the Standards Office and the Type Groups supplements our existing safety structures. The building of type and task competencies is not a zero sum game. We can achieve task competencies without diluting our type competencies. To return to the medicine analogy, looking at strengthening the body in a holistic way through Chinese medicine is like using our organisational restructuring to set the conditions at the RSAF level under which individual operators work. If the conditions are not well set, individual operators would be working under greater odds to achieve high standards of operations and safety. In the same way, if a person's overall psychological and emotional health is poor, he would obviously have a higher chance of catching diseases and a lesser chance of fighting successfully against them.

• **Organisational Resources**

Resources determine whether we have sufficient capacity to pay attention to safety. This means at the leadership level, sufficient oversight; and at the operator level, the presence of mind, mental alertness and vigilance to handle situations that could be developing in a dangerous way. Thus, while we transformed, we have ensured that we do not dilute the resources dedicated to safety. In terms of the oversight on safety, AFI has established that after our organisational restructuring, we have in fact a higher number of safety appointment holders than before.

We have also sought to optimise our resources by cutting down on doing the unnecessary. CARDINAL frees up resources in a way that would enhance safety. Since its inception last year, we have reiterated time and again the need to right-size our training and doctrine, and eliminate unnecessary work processes and regulations. Many of you have surfaced useful suggestions that your units and formations have taken up. This is important because creating capacity has to be a top-down as well as ground-up process. By doing your part to remove unnecessary processes and regulations, you would not only improve your own work experience, but also help to optimise our resources in a way that facilitates us to transform safely.

A less obvious but equally crucial way in which CARDINAL enhances safety is its focus on the quality of our human resource. This is the quality of our people, at both the leadership and operator levels. I spoke last year about the importance of leadership in enhancing safety, by ensuring proper follow through, making right decisions, enforcing standards and setting the tone for the rest. I also said that what was really important was not so much experience per se but expertise; that it was important to have people who are expert in what they are doing. When a person is an expert, he will not only be good, but also safe at what he is doing. CARDINAL hence emphasises not only the importance of grooming, but also the selection of the right people for a job. More than just helping to realise our people's potential, it ensures that we place competent people in the positions that can affect safety in the rest of the organisation. And in addition to choosing the right leaders, CARDINAL also reinforces safety by emphasising the need to better train, prepare and develop our operators for the future. No matter how strong a team is, individual weak links can drag the rest down. By

Removing unnecessary processes and regulations will not only improve work experiences, but also help to optimise resources in a way that facilitates the RSAF to transform safely.

nurturing competent people with strong core values, CARDINAL enhances safety at the operator level directly.

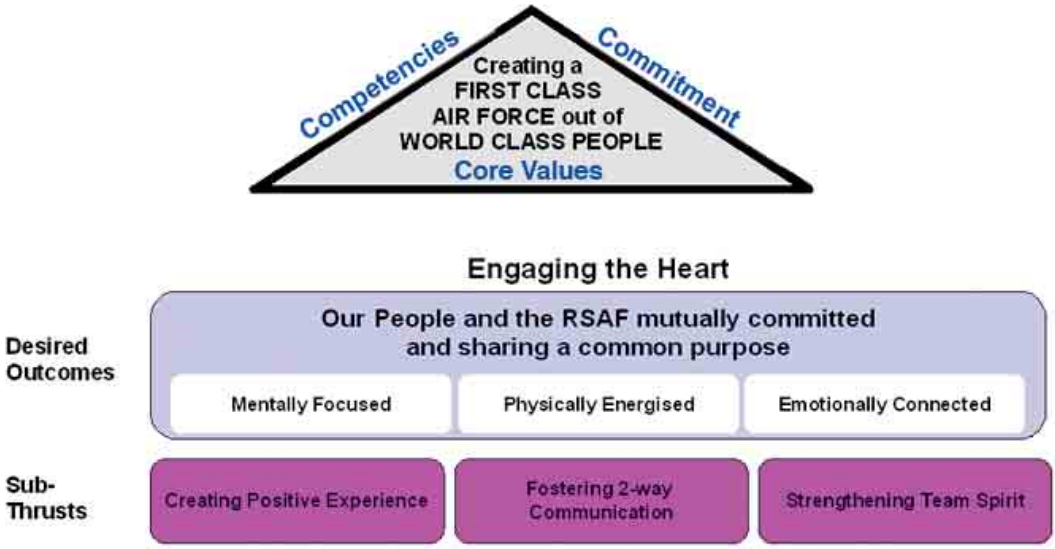
• Organisational Culture

Let me then talk directly and in greater depth the third factor which affects an organisation in a deep way, including its safety standards even though at first sight, this is not something that has very direct or immediate bearing on safety. This is the factor of culture. Culture is what shapes our behaviours, instincts and first reactions in response to a situation. It determines how we relate to one another and to the RSAF. Culture affects everybody and everybody has a part to play in shaping our culture. Through CARDINAL, the RSAF is trying to inculcate a culture of commitment and team spirit. If we take the Western medicine approach of looking at specific incidents, it is almost impossible to pinpoint culture as the main cause of any incident. Yet, like the Eastern medicine philosophy, the consequences of an unhealthy culture can be far more pervasive than the primary or proximate cause of any incident. This is where CARDINAL again strengthens safety. Commitment and team spirit are vital ingredients of a safe culture.

CARDINAL aims to build commitment to Singapore, the SAF, the RSAF and to one another. We want to instil the idea that not only do we belong to the Air Force; the Air Force belongs to each and every one of us. We can all take pride when the Air Force does well, such as when we responded professionally to intercept the unidentified Cessna, or when we put up good shows at the National Day Parade and the Singapore Airshow. It does not matter that it was not us personally getting the plaudits, because as long as the Air Force performs well, we all take pride as part of the RSAF. This is what we mean by commitment; it is the sense that we have a stake in the organisation.

CARDINAL also fosters deeper team spirit in our people. We do not want only a professional 'just-do-it' culture where all that matters is to get the job done. We want a culture where friendship thrives, where going to work is not a drag but something we can look forward to, because we find friends in the workplace and we enjoy being with our colleagues. This is an environment that encourages team and mission success over personal glory.

Commitment and team spirit enhance safety because they are what make us willing to speak up when something is wrong, to not let our friends and the RSAF down. Commitment is what makes an otherwise uninterested party concerned. When our people have such a culture and mindset of commitment and team spirit, they will go further out of their way to rectify things which are not going well. We would not close an eye if for example we see somebody else doing wrong things – whether it is in the regimental and discipline sense of misbehaving or in the sense of something potentially unsafe. The Safety Information System (SIS) would not be as effective if the only people who comment are from AFI and those in the chain of command. We have had many occasions where officers who had



The "Engaging the Heart" thrust of CARDINAL; through CARDINAL, the RSAF seeks to inculcate a culture of commitment and team spirit, and these efforts strengthen safety as commitment and team spirit are vital ingredients of a safe culture.

nothing to do with the units nonetheless raise their views passionately on the SIS. We also had Warrant Officers who shared their thoughts openly on the SIS and during air times and conferences. These are indications of a deeper sense of commitment. It is important that our people are willing to speak up on something that affects the Air Force, even if it has no impact on an individual personally. This is because the Air Force is a team. Mission success and safety depends on every individual pulling his weight regardless of rank, appointment or vocation.

A culture of team spirit also reinforces trust, open reporting and learning. If we feel as part of a team, we trust the people we are working with. We are more receptive to one another. We understand that the person raising a mistake that another serviceman has made is not doing it to be nasty or to score cheap points off him, but to ensure that the team as a whole does better. Team spirit allows open reporting to be accepted for the good of one another and for the team. This trust in turn complements the checks-and-balances in our organisational structure. Having our friends constantly watching over us ensures that we do not become complacent or desensitised to the possible hazards. In addition, open reporting provides the basis for the RSAF to learn as an organisation. It allows us to build up a store of knowledge from where we can learn the mistakes of someone else without needing to go through the experience ourselves.

Finally, a culture of trust with our bosses and subordinates leads to less micro-management, more empowerment, less second-guessing of bosses and a greater willingness and

ability to make difficult decisions. Less micro-management means less stress and less duplication of work. People can then channel their energies towards the real tasks at hand. Moreover, as I have said on the SIS, the Air Force operates in a time-critical environment where split-second decisions are often needed to arrest deteriorating situations. We will not make effective decisions if our first instinct in a situation is to think of how to answer for our actions after the event, or if our first instinct is to second-guess our bosses. A climate of trust with our bosses and subordinates prevents this from happening. A climate of trust and not second-guessing our bosses means that we know that unless we do stupid things, our bosses would support our actions. This means that each level is empowered to dare to make decisions.

Thus, commitment, team spirit, open reporting, trust, learning and safety are all mutually reinforcing. But three recent incidents suggest that we still have some way to go before achieving this desired culture. In one case, a F16 carried out a roller when the clearance was for overshoot, and in another, there was a potential confliction in a circuit. Then, there was a padlock unaccounted for during the end-of-day checks in a fighter squadron. But in all three cases, the incidents were not reported until AFI found out about them. The sharing of incidents must be done timely and proactively. It is only when our people are committed and imbued with a good team spirit that we can openly share and learn from the lessons of our colleagues, so that the Air Force as a whole benefits. CARDINAL has given us the impetus and avenues to build a culture of commitment and team spirit. It is now up to every one of us to do our part to shape this culture.

Western Approach

Before I end, let me say a few words on the Western medicine approach towards safety. This approach of looking at specific incidents has served the RSAF well for many years and it must continue. In the same way that Western medicine often readily cures our sickness, focusing on specific incidents ensures that the causes and symptoms of safety incidents are tackled immediately. We must thus continue to take all incidents seriously, examine them thoroughly, learn the right lessons, and implement the safeguards to ensure that they are not repeated. And it should not be misconstrued that the Eastern medicine philosophy of treating the well-being of the RSAF as a whole implies that individual errors can be rationalised away. No matter how strong a body Chinese medicine can build up for us, one would be silly to think he can stand in front of a moving car. No matter how good the RSAF system is, every individual can still be a weak link and cause accidents. We will continue to demand standards and if there is a need to mete out punishment, it will still be done.

Conclusion

To conclude, having a good safety record gives us the confidence that our transformation is on the right track. But transforming successfully also allows us to strengthen safety in the longer term. Moving forward, we must combine the Western and Eastern medicine

approaches towards safety. Western medicine can cure us as each disease appears, but Eastern medicine will protect and preserve our health for the long term. Moreover Eastern medicine produces a strong body that can react better than any Western medicine approach to tackle an attack from a disease. Similarly, if our transformation efforts can build a robust organisational structure, properly allocate our resources and strengthen our culture as a whole, we would be in a better position to apply the safety tools we have painstakingly built up over the years to tackle each safety incident as it arises. The effects of our transformation may not all be apparent yet but I am confident that it will leave behind a strong safety legacy to the next generation.

MG Ng Chee Khern assumed his current appointment as Chief of Air Force on 24 Mar 06. A qualified F-16 and F-5 Fighter Pilot, he has served as Director of Joint Operations and Planning Directorate, Chief of Staff (Air Staff) and Commander of Tengah Air Base. MG Ng is a President's Scholar and SAF Overseas Scholar. He graduated with a Bachelor of Arts Degree in Philosophy, Politics and Economics, and a Master of Arts Degree from University of Oxford, U.K., and attained a Master in Public Administration from Harvard University, U.S.A. MG Ng has also attended the prestigious Air Command and Staff College in the U.S.A. For his significant contributions to Singapore and the SAF, MG Ng was awarded the Public Administration Medal (Gold)(Military) in 2005.

Shaping Policy Space: Defence Diplomacy in the 3rd Generation RSAF

by LTC Desmond Chong, MAJ Philip Khoo and CPT Amos Yeo

Introduction

Policy space is about choice. In the context of international relations, policy space can be thought of as the conceptual realm within which countries have to make choices that best meet their national interests. Since all – almost all – countries exist within an internationally recognised system, they also have to operate within the constraints of internationally accepted norms of behaviour. Therefore, it follows that every country's policy space is limited or constrained. Having said that, no country is also completely limited in its policy choices by circumstances.[1] So what determines the extent of a country's policy space? One way to look at this is to perhaps think about how a group of friends decide on which movie to catch on a Friday night.

In this "negotiation", each person would have his/her preferred choice of movie to watch, which are based on factors such as individual preferences, past experiences and the prevailing market conditions (e.g. the seats available in the various cinemas). The person with charisma or influence is more likely to be able to persuade the rest of the group to watch the movie he/she prefers. Similarly, the person who will be providing transport for the group will also be a strong position to influence the choice of cinema and movie to catch. The group may also be inclined to accede to the recommendation of the individual who promises to bring attractive friends along to watch the movie of his/her choice. Of course, the underlying assumption here is that the group is inherently open to the idea of mixing around and making new friends. Perception is also a key consideration. It would be much easier to convince the group to agree to watch a movie that has received good reviews from the critics. Conversely, it would be much harder to convince everyone to watch a particular movie if people think that they will subsequently be ridiculed by other friends for having wasted time and money to watch a "silly" movie. Eventually, the movie decided upon will likely be to the advantage of the person with the greatest leverage – in the context of our discussion, the individual with greatest "policy space".

It is also important to remember that for a friendship to be long-lasting and meaningful, it must be built on the principle of mutual benefit and trust. Friends are not out to take advantage of one another, but instead seek to derive win-win solutions that are beneficial to everyone. Of course, the benefits, both perceived and tangible, cannot always be equally distributed. Some give-and-take is inevitable. However, among friends, the process of arriving at the final decision should not involve *quid pro quo* bean-counting or splitting hairs, but instead, should be carried out in a spirit of understanding and cooperation.

The same principles apply when negotiations take place between nation-states. Therefore when we speak of a country's policy space, we refer to a combination of its leverage, bargaining power and room to manoeuvre in the international arena. Another important condition relevant to Singapore is size. In international relations, size matters. Former Indonesian President B. J. Habibie once referred to Singapore as nothing more than a "little red dot" on the map. So how does a little red dot, with almost no natural resources, and nearly zero-strategic depth, survive and thrive? From the onset, the answer for Singapore's leaders was pointed squarely at creating and securing our policy space. What then is the role of the Ministry of Defence (MINDEF) and the Singapore Armed Forces (SAF) in this business of creating and securing of policy space? The answer is right here in the mission statement of the MINDEF.

"The mission of the Ministry of Defence is to enhance Singapore's peace and security, and should ***deterrence*** *and* ***diplomacy*** fail, *to secure a swift and decisive victory over the aggressor."*

It is often said that Singapore punches above its weight in international relations. The extent that the SAF

contributes to this depends on its ability to achieve its stated mission. Hence, by effectively pursuing the twin pillars of deterrence and diplomacy, MINDEF and the SAF play an important role in the creation and shaping of Singapore's national policy space. This essay discusses the role of the 3rd Generation RSAF in shaping policy space and how each and every member of the RSAF has an important part to play. In particular, given the RSAF's international footprint, it argues that defence diplomacy forms an integral part of RSAF operations, and suggests how the men and women of the RSAF can better contribute to this important mission.

The RSAF – An International Air Force

The RSAF currently operates seven long-term training detachments in Australia, France and the United States. It also conducts regular training exercises in more than six other countries throughout the year. On average, up to 50 percent of the RSAF's annual flying hours are flown overseas. These figures provide a glimpse of the RSAF's international footprint. For a small Air Force, it is really quite amazing to think that almost 24 hours every day, some members of the RSAF are likely to be interacting with foreign military or civilian counterparts. Besides the professional benefits that these interactions provide, each and every time we engage our foreign friends is an opportunity for the RSAF to further MINDEF's defence diplomacy goals, and by extension, contribute to shaping Singapore's policy space.

Each and every time we engage our foreign friends is an opportunity for the RSAF to further MINDEF's defence diplomacy goals, and by extension, contribute to shaping Singapore's policy space.

"In defence diplomacy, we seek to develop mutually beneficial relationships with friendly countries and armed forces to contribute to a stable international and regional environment."

MG Ng Chee Khern, Chief of Air Force, Republic of Singapore Air Force

Given its international presence, how can the RSAF better contribute to shaping policy space? To be effective defence diplomats, the RSAF as an organisation, as well as its airmen, must bring value to the foreign forces that we train and exercise with, and do so with cultural sensitivity.

Since its birth in 1968, the RSAF has sought to improve its operational capabilities by learning from other advanced and mature air forces around the world. Professional competence can be a powerful catalyst in enhancing defence interactions: it is more likely

that other military forces will be more interested to interact and engage with a professionally capable RSAF. This in turn promotes further learning and growth within the RSAF to enhance its capability and the virtuous cycle goes on. More importantly, this greater opportunity to interact with other military forces achieves the more strategic defence diplomacy goal of forging mutually beneficial relationships and networks. By being more professionally capable, the RSAF also becomes a more effective deterrent force as a component of the SAF, thus achieving the two objectives of defence diplomacy and deterrence.

Defence diplomacy extends beyond military-to-military interactions. Through various operations, the RSAF has had the opportunity to reach out to the civilians as well. Besides the well-publicised Operation Flying Eagle, the RSAF has also been involved in other Humanitarian Assistance and Disaster Relief (HADR) operations that have provided opportunities for foreign interactions. In September 2005, members of the Peace Prairie Chinook detachment in Texas were presented with the unexpected opportunity to assist in the HADR effort after Hurricane Katrina devastated Louisiana. In carrying out this mission effectively, the RSAF at once demonstrated its operational capability, contributed value to our friends in need, and deepened the local community's understanding of Singapore and the RSAF.

Everyone has a Part to Play

Up to this point, it should be clear that the responsibility of conducting defence diplomacy in the RSAF does not lie solely with the Chief of Air Force (CAF) or the senior leadership of the RSAF. It is a role in which each and every airman in the RSAF has a part to play. But effective defence diplomacy is not easy. It requires thoughtfulness, attention to details and cultural sensitivity. In explaining the importance of defence diplomacy to senior RSAF officers, CAF once estimated that up to a third of his time is spent on such activities. As an organisation, the RSAF also spends a tremendous amount of resources and effort to engage our defence partners. Last year, various RSAF units and agencies hosted more than 70 foreign delegation visits to Singapore, more than one visit per week. This excludes the interactions conducted overseas.

Through activities like multilateral exercises, professional exchange and HADR operations, the RSAF has over the years built for itself a reputation as an operationally capable and credible Air Force.

Although defence diplomacy takes so much of our time and effort, it is a high pay-off investment. Through participation in multilateral exercises, professional exchanges, HADR operations, professional collaborations, social and organisational networking,

the RSAF has over the years built for itself a reputation as an operationally capable and credible Air Force. In its many interactions with foreign friends, the perception of the RSAF as a technologically advanced, operationally competent outfit is a common refrain. These are compliments that all members of the RSAF and the wider SAF should be proud of. Nevertheless, defence diplomacy is certainly not a one-way highway. Through these interactions, the RSAF also endeavours to make sure it brings value to the defence partners that it trains, exercises and shares ideas with.

However, it is equally important to realise that such relationships can be quite fragile. While the benefits of effective defence diplomacy generally take considerable time and effort before they materialise, it does not take much effort nor time to unravel the good work. For armed forces that deploy to foreign countries, whether for training and exercises or operations, this is particularly pertinent. The Abu Ghraib Prison torture scandal in Iraq is a recent example of how the indiscriminate actions of a few can lead to severe effects and consequences much greater than the acts themselves.

Having put forth that defence diplomacy is the responsibility of everyone up and down the chain of command, are there areas that need specific attention? The answer could well lie in the middle echelon of the RSAF, i.e. the Commanding Officers (COs), Officers Commanding (OCs), and senior Warrant Officers of line units. Often, the policy makers and military leaders in the higher echelons are able to articulate the strategies to enhance defence diplomacy. Not only are they more experienced, they are also the decision makers who have thought through and are intimately familiar with the issues. It is, however, less intuitive for middle echelon officers who are expected to translate strategic intent and objectives into actual practice on the ground. Given the international reach of RSAF operations as described earlier, this poses a significant challenge. Squadron COs and OCs who are deployed overseas, be it in a multilateral exercise such as Ex. Pitch Black, a HADR mission or Peacekeeping Operation (PKO), must recognise that the decisions they make may have strategic repercussions. Faced with the decision, for example, to push their people to go the extra mile to achieve exercise or mission objectives, vis-a-vis management factors like safety, crew rest, flying hours and manning cycles, middle echelon leaders must realise that their decisions and actions may have consequences and effects at higher strategic levels.

In terms of defence diplomacy, arguably the people who can make the most difference are those on the ground. The best efforts of the senior leadership would go to waste or come undone by ill-informed actions of the people on the ground. The diplomacy effort is a chain, it is as strong as the weakest link. The weak link is not confined to rank or appointment. Everyone up and down the chain needs to work in concert, singing the same tune. The difficulty lies more in creating the awareness throughout the organisation that every person counts. This is true, from the air traffic controller, who communicates with foreign aircraft on a day-to-day

basis, to the squadron pilot participating in overseas detachments and exercises. In their respective circumstances, both are the faces of Singapore and the RSAF that the foreign counterparts see, hear and interact with. Through their actions, tone of voice, professionalism and attitudes, they can make a profound impression, be it positive or negative.

How to Do It Better

If defence diplomacy is the responsibility of each and every person in the RSAF, and the consequences of inappropriate actions and decisions may be profound, it follows that everyone should be properly equipped to play their part effectively. Hence, in the 3rd Generation RSAF, everyone should be equipped with the necessary skills and knowledge to act as effective defence diplomats. How should this issue be approached? In the first place, does the 3rd Generation Airman currently possess the necessary skills and knowledge for effective defence diplomacy? How much training is required? What kind of training would be appropriate? Who should conduct this training? While detailed answers to these questions are beyond the scope of this essay, several areas for further exploration seem obvious.

First, there is a need to create awareness and institutionalise the process of educating 3rd Generation Airmen on how to better conduct defence diplomacy. This subject could perhaps be given some attention within the framework of developing the personal competencies of RSAF personnel. Steps have already been taken in this regard. The RSAF has included Defence Relations modules into the syllabi of courses such as Squadron Commanders Course and

Defence diplomacy is the responsibility of each and every person, thus everyone in the 3rd Generation RSAF should be equipped with the necessary skills and knowledge to act as effective defence diplomats.

the Flight Commanders Course. The key objectives of these sessions include building awareness of the importance of defence diplomacy in the context of shaping national policy space amongst the RSAF middle echelon leaders. While the initiative has been taken, it will be useful for the relevant agencies to explore how this type of training can be further improved upon.

Second, in nurturing the appreciation of defence diplomacy, it would appear that a mentoring programme could serve as a key enabler. It is difficult to teach the finer points of defence diplomacy through lectures or reading alone. It requires "on-the-job" experience. Therefore, a mentor approach to teaching expertise and skills in defence diplomacy is likely to be more effective. Here, senior officers have an important role to play in actively guiding their subordinates. How often do senior officers take time to explain to their men the rationale, or considerations, when making decisions that may have larger policy implications?

Third, it is important to instil a certain policy instinct in 3rd Generation Airmen. Many situations in a defence diplomacy scenario require that a person act or make decisions without delay. In some cases, the involvement of defence diplomacy may not even be obvious. Faced with this, it is important that the understanding of defence diplomacy and how to respond appropriately become instinctive.

Perhaps a fitting way to close this discussion on how defence diplomacy plays an important role in helping the RSAF shape policy space, is to provide two simple rules of thumb when it comes to the practice of defence diplomacy.

Rule of Thumb 1: Contextualise the Situation. One of the most commonly made mistakes is the blind application of principles. It cannot be said often enough that every situation is different. When we interact with our foreign friends, whether in the military or civilian, it is important to understand and observe cultural and social norms that may be different to ours and others. The recent advertisement campaign by HSBC bank is a humorous take on how different cultures look at and interpret everyday things, like gestures and even how one acts around the dining table, very differently. While the advertisement showed the funny side to cultural differences, mistakes on the diplomacy front may lead to more serious outcomes.

Rule of Thumb 2: Pay Attention to Details. The world of practical diplomacy, both military and non-military, is a well-established one. This should come as no surprise given that practitioners of diplomacy operate within well established norms and protocols. Hence, it is really through careful attention to detail that one can convey that something special to your guest or host. A good example would be in the selection of personal gifts. To many, this would appear to be a straightforward process not worthy of too much brain bytes. To think so would be to miss out on a great opportunity to demonstrate sincerity and genuine friendship. Unlike family or personal friends whom we are familiar with through constant interactions, we do not have the luxury of personally knowing many of our

foreign defence partners very well. In this kind of situation, some extra thoughtfulness in our selection of gifts will go a long way in conveying the significance of the relationship, and more often than not the look of surprise and joy on the recipient's face is truly satisfying – and here, the satisfaction is just the same as if it were from a family member or personal friend. Often in defence diplomacy, a little really does go a long way.

Conclusion

As a small country, creating and shaping policy space is vital for Singapore's survival and MINDEF has an important role to play. Given its international presence and reach, the RSAF is at the forefront of the SAF's defence diplomacy efforts in contributing to the shaping of our national policy space. This essay has argued that the responsibility of defence diplomacy in the RSAF lies not only in the hands of its senior leadership, but also with each and every one of its airmen. To continue to ensure that this important role is effectively carried out, 3rd Generation RSAF Airmen should be sufficiently equipped with the necessary knowledge and skills.

Endnote

[1] Wong Kan Seng, "Continuity in Change in Singapore's Foreign Policy", in *The Little Red Dot – Reflections by Singapore's Diplomats*, ed. Tommy Koh and Chang Li Lin. Institute of Policy Studies, 2005, p49.

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Building an Integrated Force: Overcoming Challenges to Operate as *ONE* SAF

by LTC Tan Ah Han Tommy,
MAJ Teoh Chun Ping and CPT Boh Lee Wee

*"… that end is to build ONE SAF – an SAF that is **integrated**, networked, cohesive, synergistic, self-synchronous and singular in its mission focus to deter threats to our security, territorial integrity and sovereignty …"*

LG Desmond Kuek,
Chief of Defence Force,
Singapore Armed Forces

Introduction

As the RSAF embarks on its 3rd Generation transformation journey, over the next few years, we will continue to see extensive changes to its force structure, concept of operations, people development and organisation to achieve our vision of becoming a Full Spectrum and **Integrated Force**. The need for a full spectrum and integrated force is clearly evident in the recent major

military operations, such as Ops Iraqi Freedom[1], where combining air, land and sea capabilities their mission would have helped to deliver a potent combat power. Our increasing participation in peacekeeping, homeland security and humanitarian relief operations in the regional front also demands tight interoperability across the Services and external agencies. These operations have clearly demonstrated the need to pool resources, expertise and manpower across all Services throughout the planning-to-execution continuum. By bridging and integrating each Service's operational capabilities, the SAF could transit quickly to operations with the most optimised force package.

To this end, while most can understand that "Full Spectrum" is to undertake military operations across the peace-to-war spectrum, there is a need for better clarity and understanding on the RSAF being an Integrated Force. Taking reference from Collins English Dictionary, "integrated" denotes the act to *be made* into a unified whole. Translating to our context, RSAF as an Integrated Force will mean that we must be able to prepare ourselves such that we can *be made* into a unified SAF, together with other Services, to achieve the SAF's overall operational objectives.

Bringing this further, what this means is that in our 3rd Generation transformation journey, the RSAF must harness each and every emerging quantum leap capability, develop the new integrated concepts and re-structure our organisation for better alignment towards an Integrated Force. We must also revise our people development and training programmes to inculcate a more integrated and well-rounded set of skills and perspectives. The end objective is to be able to speak a common language with the Army and Navy, and have standard operating doctrines and procedures so that RSAF could plug in easily and play immediately with other assigned forces within a readily understood set of rules. In the earlier *POINTER* article on "Enhancing Integration in Transformation"[2], the writers had articulated the integration journey in the SAF so far. Moving ahead, we see a greater need and more opportunities for tighter integration across the SAF. The result of integration would be an Air Force able to bridge divides across Services and across functional expertise areas.

However, while we seek to be an Integrated Force, there are significant, practical and even deeply rooted challenges. This is because each Service today is already mature, ready and capable in its own domain competencies. Hence, this article will attempt to (1) identify the key challenges to overcome, and (2) outline the focus areas and efforts towards our vision to become an Integrated Force.

Challenges

"… Modern military organisations and operations are incredibly complex…it will be an advantage in having doctrines of the three Services harmonised under a common system so that the commanders and staff officers in all the Services learn from the beginning to speak one language and work in complete harmony…"

Dr Goh Keng Swee,
Defence Minister, 1970

As the SAF is already a well-established force where each Service is already mature, ready, and capable in its own domain competencies, significant practical and deeply-rooted challenges, such as **disparity in operating languages and standards,** stand in the way of achieving effective cross-Service integration.

Bridge the Operating Language

The rapid expansion of the Services in the SAF over the 80s and 90s had hinged on each Service's close interactions with foreign military partners. While the strong affinity developed had contributed to SAF's overall attainment of world-class status, it has inevitably resulted in deep-rooted foreign influences on each Service's operating processes and lingo. The result is an SAF whose Services share operating processes and lingo with their foreign counterparts more than they do with one another, and these differences form the barrier to tighter interoperability across Services. Hence, it is critical to explore ways to bridge the gap in communicating operationally across domains. With a much faster pace of development in each Service, introducing new acronyms and project names such as CARDINAL, it is even more important to bring aboard other Services in order to close the gap.

Align Operational Standards

The inherent differences in the operating environment for each of the three Services have naturally generated different operating standards. For instance, while the air situation picture requires a stringent refresh rate in terms of minutes and seconds to meet with the dynamism of the air domain, the Army, on the other hand, is tolerant up to a one or two hourly refresh rate for its land battle situation picture. It is therefore not unusual to find Air Force units doing time synchronisation as part of their daily start-of-day briefs. Fundamental issues such as mandatory crew rest period for the flying crew could also be a potential source of misunderstanding when hasty combined mission planning is required between the flying squadron and the Army unit. There had also been tactical-level challenges for cross-domain operations. For instance, in heli-borne operations, there used to be disparity in Standard Operation Procedures when it came to the sequence of donning of the life-vests and the SBOs, which when taken individually, had their unique purpose.

Hence for effective integrated operations, tighter inter-Service alignment in terms of synchronisation and coordination is pivotal to deliver timely and precise effects. From the larger perspective, it would also mean overcoming the disparity in operating standards and expectations. Moving ahead, the SAF will be phasing in new and more complex systems that transcend domains, such as the naval helicopter. We will have to be even more deliberate in bridging the operating standards and needs between cross-Services units, such that we can employ the new systems effectively with no compromise to safety.

For effective integrated operations, tighter inter-Service alignment in terms of synchronisation and coordination is instrumental towards the delivery of timely and precise effects.

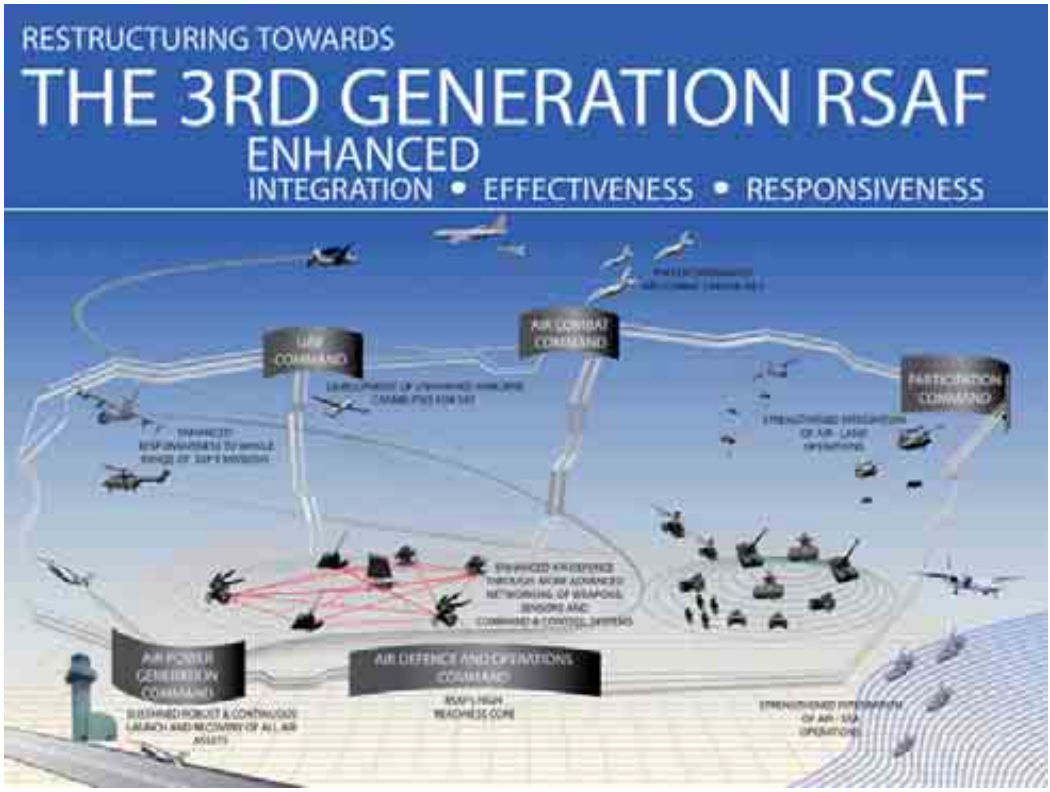
Towards an Integrated Force

"… within the Air Force and the SAF, we are serious in bridging the domain and functional divides so that we would operate together more strongly as a team. This is particularly important at a time when technologies respect no domain or functional stove-pipes."

MG Ng Chee Khern, Chief of Air Force, Republic of Singapore Air Force

The first step towards an Integrated Force is to overcome the challenges as stated above by enhancing the interoperability amongst previously Service-specific capabilities. Greater interoperability at all levels, across different platforms, missions and Command Posts (CPs), would translate to better synergy towards integrated operations, preventing fratricide and achieving credible operational effects across domains. For example, at the platform-to-platform level, seamless interoperability between the fighters and the artillery gun would help to enhance our strike precision capability. Similarly, close mission-to-mission integration would optimise air support for the land battle; and tight CP-to-CP connectivity would allow sharing and understanding of plans and operating pictures. To do all these, we will need to focus on five key areas.

First, we need to **leverage on emerging, high pay-off technologies** to enhance interoperability between Services. C4I systems, if properly harnessed and assimilated within our force structure, will serve as useful tools to address inter-dependency issues within the SAF, and create capacity for us to handle a wider span of operations for the SAF in greater breadth and depth. For example, a common IKC2 platform will help the Services to interact effectively across different information domains. However, we must also be cognisant that different operational demands within different domains engender different information requirements in the war-fighting processes. For example, as the RSAF plays an increasingly important role in participation missions to support the Army and Navy, timely cross-domain intelligence support is vital to prevent fratricide and enhance mission success. This translates to the requirement for a fused common operating picture,



It is important to review our structures and organisation to expand our competency in shaping the land and maritime battles by employing airpower where and when it matters most.

that, while maintaining the integrity of individual Service's operating norms and expertise, must be well-understood and aligned to the other two Services' operational demands. Certainly, the same IKC2 infrastructure cannot be optimised for integrated operations and be just as optimised for each domain. Nonetheless, it would be essential to be able to share a common operating picture across cross-domain partners.

Second, it is important to ***review our structures and organisation*** to expand our competency in shaping the land and maritime battles by employing air power where and when it matters most. Our establishment of the Participation Command (PC) was the first step taken to ensure integrated development of air power application in the Land and Maritime theatres. PC is envisioned to develop the structures and processes that will catalyse integrated training and exercises with the Army and Navy at the tactical to operational level, bringing together cross-functional capabilities from across the RSAF and integrating them into the land and sea campaigns. For example, during Ex. Wallaby, PC will enhance air-land and air-sea interoperability in the SAF by bringing the participation elements together and ensuring that the team assigned for a mission trains regularly as an integrated team. Such a role is enabled by two-way cross-Service reporting channels between PC and related Army and Navy

staff branches, in addition to the tri-Service staff composition organic to HQ PC itself to equip PC with the requisite tri-Service expertise.

The UAV Command (UC) follows a similar Joint and cross-Service staffing to effectively exploit UAVs for cross-Service and cross-functional applications, integrating UAV-borne capabilities at the SAF level, across the air, land and sea domains. As UAV operations increasingly straddle across the Services, UC plays a key role to instil a common operational outlook and standards of governance amongst the SAF community of UAV operators. The establishment of such integrated Operational Commands entails intimate cross-Service operational understanding, close coordination, and establishment of linkages and processes between the Services throughout the peacetime training to wartime planning-to-execution continuum. The end result is an intuitive and automatic synchronisation of planning norms, coupled with real-time, effective, and dynamic swinging of air power to support and dominate the land and sea domain battles, with efficient resource-allocation and minimum risks of fratricide, while capitalising on the RSAF's flat command structure and network-centric domain expertise.

The RSAF has already seen progressive developments towards closer working relationships between Services, with the many cross-Service representations in development teams and in the many staff functions. Such close ties are important in promoting sharing of cross-domain perspectives to achieve greater integration. As we undergo organisational changes in the RSAF and across the SAF, we will see the propagation of the microcosms of cross-Service representations downwards. With cross-Service representations at every level, we can expect to think, develop and operate much more closely for integrated capabilities and operations.

Third, we have to ***focus on refining the Command and Control (C2) structure and streamlining the processes and linkages*** to enhance interoperability and increase interdependency with other Services. As we develop and integrate more multi-role capabilities, we must develop the necessary C2 structure and processes to optimise the command and control of assets that may be employed across domains. With shared assets and shared awareness, decision-making during high operational intensity will become more dynamic and challenging, increasing the complexity of integrated operations and cross-domain force employment. Therefore, it is important to develop and improve C2 processes for integrated operations and for dynamic C2 over shared capabilities, accompanied by the necessary training for commanders and operators in these new systems and processes.

Tri-Service workshops, seminars and sharing sessions are some of the means to foster closer relationship and streamline work processes between the Services. Through these sessions, we can better appreciate the intricacies and complexities of integrated planning and campaign orchestration, determining the actions needed to harmonise air, land and sea powers to realise the concerted integrated operations. It will

also deepen our knowledge of current thinking and ideas with regards to integrated operations, gleaning the important lessons derived from the years of experience through training, exercises and past integrated efforts during contingency operations. In doing so, we will be able to better bridge the operating language and align operational standards.

Fourth, we need to ***review our training system and exercises*** to inculcate a more integrated and well-rounded set of skills and perspectives to function as an effective integrated force. The shift of operational focus from low-probability-high-intensity to high-probability-low-intensity operations in peacetime will necessitate the raising of integrated force units that are flexible and can offer calibrated options to a wide variety of operations. These include Operations Other Than War and Peace Support Operations type missions, which are unstructured, lean in scale and extended in duration compared to that of conventional war typified by dynamism, massiveness and intensity in scale. Hence, the development of integrated and interoperable training and training systems to raise an effective integrated force will be necessary in the form of integrated training exercises, integrated simulation and instrumentation.

Last but not least, integrated training should be predicated upon a ***common culture*** in order to produce sustainable results. The development of a common culture should not have to displace Service roots and identity. Rather, the fostering of a *"ONE"* culture should complement individual Service culture.

To function as an effective integrated force, we will need to review our training system and exercises to inculcate a more integrated and well-rounded set of skills and perspectives.

It can even leverage on existing Service-unique values to be promulgated to the other Services as part of the educational and training process through Core Values and instillation of commitment to one another, to the organisation, to the mission and the country so that there is a sense of true and sustained purpose.

To this end, while we focus on integrating our capabilities across the air, land and sea domains to shape and influence the campaign outcome, it is important that our cross-functional, cross-domain developments be anchored on strong professionalism and depth competencies. Our Operational Commands must also be tightly integrated within themselves – maintaining a fine balance between cross-Service integrated Concept of Operations, capability, doctrine and training development – while not diluting the raising, training and sustaining of type-level depth competencies. A possible solution to

achieve this balance lies in the raising of an integrated HQ consisting of tri-Service and Joint personnel to oversee the former in peacetime, and then assigning various specialised Task Forces under Operational Command to the HQ as we transit into wartime mission execution. The sufficient and efficient attainment of both functions is the key to a smooth transition from peacetime training to wartime mission success. This, in turn, requires our people to clearly understand **both** the RSAF and SAF mission across the strategic to tactical levels so that the strategic intent of the SAF can be achieved within the context of tactical operations. The newly-established Air Combat Command exemplifies such a balanced structure.

Conclusion

The 3rd Generation RSAF seeks to become a Full Spectrum, Integrated Force exploiting cross-domain capabilities and concepts to achieve the SAF's operational objectives. To achieve this, we will need to explore and experiment new concepts, harness new technologies and force structure, and develop our people to realise our vision of becoming a Full Spectrum, Integrated Force. An Integrated Force approach for the RSAF will also mean that warfighting will increasingly involve a collaborative and task-oriented approach from all the three Services. Service boundaries will be increasingly overlapped, and we will be able to achieve the integrated effect of fighting as *ONE* SAF.

Endnotes

1 In 2003, coalition forces under the leadership of the United States invaded Iraq and captured Baghdad in three weeks through the execution of what was envisaged to be simultaneous air and ground assaults.

2 LTC Tan Ying Kiat, MAJ Lee Siew Hui, MAJ Aldrin Tan and CPT Tay Shulin, "Enhancing Integration in Transformation", *POINTER* Vol 33 No 1, 2007.

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Commitment to Defence: Preparing Our People for a First Class Air Force

by LTC Chang Kim Sai, MAJ Ian Tan and CPT Anandan Mugam

"Transformation, even with its strong technological focus, does not displace the man at the heart of warfare; hardware can never substitute for heartware. Motivating soldiers to serve and fight in the defence of our nation is always a particular leadership challenge."

Minister for Defence, Mr Teo Chee Hean, at the 6th National Service Command and Staff Course Graduation Ceremony, 10 Nov 05

Introduction - The 3rd Generation RSAF and the 3rd Generation Airman

The 3rd Generation (Gen) RSAF is envisioned to be an Air Force characterised by its integrated-ness[1] with the other Services, as well as by its ability to conduct the full spectrum of operations from peace to war. However, to achieve the successful transformation into a 3rd Gen RSAF,

there is a parallel need to develop the 3rd Gen Airman, as it is the *people* that make any organisation. The RSAF's People Development framework, under the ambit of CARDINDAL, has been built around this fundamental aim. Through CARDINDAL, the RSAF aims to nurture and cultivate, in all airmen, the three 'C's of Competency, Core Values and Commitment. With these aims in mind, the RSAF's initiatives have been categorised into the three key thrusts of 'Developing Professionals', 'Realising Potential' and 'Engaging the Heart'. It is notable that the RSAF's People Development efforts are progressing in line with the wider SAF's aims of nurturing First Class People in a World Class Organisation and engaging our People towards stronger commitment and greater excellence.

With the key thrusts of 'Developing Professionals' and 'Realising Potential', the RSAF will develop a 3rd Gen Airman who is steeped in vocational skills. Moving forward to the 3rd Gen RSAF, he will continue to display the depth in knowledge and vocation-specific skills that he acquires as part of his training and education. This will allow him to meet the challenges and complexities of the operational environment of the future. However, this is not all. The 3rd Gen Airman will be versatile enough to understand and appreciate operational considerations and the language spoken by his counterparts in the Army and the Navy. He will have an understanding that extends beyond his own vocational domain, allowing him to bridge existing gaps between operations, logistics and manpower, for instance. At the same time, he will be sensitive to broader political considerations and strategic imperatives. To achieve this desired end-state, initiatives have been put in place (and are well under way) to equip the airman with the requisite competencies, skills and core values.

However, the RSAF's efforts will not stop there. Having the right Competencies and being grounded in the Core Values will only amount to having 'World Class People'. These 'World Class People' have to come together as a team, with a sense of common purpose and commitment, to create a 'First Class Air Force'. This is where 'Engaging the Heart' comes into play. To develop the 3rd Gen Airman for the 3rd Gen RSAF, it is imperative to cultivate and inspire each and every single airman to be committed to the RSAF, to be part of the team and to be willing to go the extra mile to help the organisation succeed. In fact, looking at the 3 'C's, Commitment is arguably the most important 'C' that the RSAF must cultivate. It is important to note here that being committed to defence is distinct from being committed to the organisation – an airman can still be committed to the notion of defending the nation without necessarily possessing commitment towards the organisation. CARDINDAL (and this essay) will focus on nurturing what Porter et all term as Organisational Commitment, that is, *"the acceptance of the goals and values of the organisation, a willingness to exert considerable effort on behalf of the organisation and a desire to maintain membership in the organisation"*.[2]

To develop the 3rd Generation Airman, it is imperative to cultivate and inspire every single airman to be committed to the RSAF, to be part of the team and to be willing to go the extra mile to help the organisation succeed.

The motives of this essay are two-pronged. Firstly, it will discuss three avenues through which commitment can be fostered in an airman – Creating a Positive Experience, Fostering Two-way Communication and Strengthening Team Spirit. Secondly, the essay will propose that the success of the RSAF's People Development initiatives depends very much on the efforts of the RSAF's Commanders, i.e. 'middle-echelon' officers such as Squadron Commanders and Branch Heads. These officers, in their day-to-day interaction with their subordinates, represent the very 'face' of the organisation. Hence, they play a significant role in inspiring the kind of commitment that is desired in the 3rd Gen Airman.

Commitment in the Military Context

Before proceeding further, it is important to make a mention of existing literature on the concept of Commitment in the military context. Given the intangible nature of Commitment, it is not surprising that conclusive academic research has been limited. Available research though, has cited beliefs, values, organisational knowledge, need for affiliation, experience, perceptions of superiors' behaviour, duration of service, prevailing economic conditions, strategic vulnerability, level of domestic and regional stability, conscription and workplace environment as factors that influence an airman's level of commitment. Also, given the complexity in measuring empirically the level of a serviceman's commitment, it is equally difficult to devise plausible means to increase that commitment to a desirable level. Despite this, the SAF has invested substantial resources to study this issue. MINDEF's Applied Behavioural Sciences Department (ABSD) helps the organisation to gain an understanding of the commitment of servicemen. Recent studies conducted by ABSD point to some interesting and enlightening conclusions. For example, one study[3] examined the concept of 'Organisational Enculturation?', which refers to the processes by which an organisation inducts newcomers to align their beliefs and values with its own. From the perspective of the individual airman, it refers to the processes in which newcomers acquire cultural knowledge, make sense of that knowledge and internalise (or reject) the organisational beliefs and values as part of their self-concept. Another study[4] has revealed that servicemen who reported having positive experiences and having superiors who engaged in pro-organisational behaviour, showed an increase in their collectivism.

Furthermore, there was a significant overall decrease in the recruits' individualistic beliefs and values. This bodes well for the RSAF's efforts to foster commitment in the airman.

Fostering Commitment by Engaging the Heart

Creating a Positive Experience

This essay suggests that an airman's level of commitment is very much influenced by his experience in the workplace.[5] A positive experience entails providing work that is **meaningful** enough for the airman to develop what Allen and Meyer refer to as 'Affective Commitment', which refers to *'an identification with, an involvement in and a emotional attachment to the organisation'*.[6] It may seem a given that an organisation needs to create a positive and meaningful work experience if it is to foster commitment in its people. However, this is not so straightforward in the military context. To foster commitment, the RSAF must help the airman understand the importance of his role, adjust to the requirements and rigours of military life, place the right airman into the right job, and develop and motivate him. The very nature of military duty entails hard work, varying work environments and sacrifice. However, if an airman is to be focused on his tasks and contribute to the success of the RSAF's mission, it is imperative that the organisation creates a work experience that he finds meaningful.[7] The essay suggests that one way of creating meaningful work is to increase the airman's confidence, esteem and conviction to want and dare to do things and take on challenges.[8] The airman must feel motivated enough for him to want to *influence* his immediate environment. This can be brought about by focusing on the non-vocational aspects of an airman's development, beyond his vocational skills. With regards to this, the RSAF has put in place initiatives to create differentiated development strategies for each individual, taking into account his strengths, needs and areas for improvement.

Fostering Two-way Communication

Communicating with subordinates is perhaps one of the most important (and most difficult) tasks of a Commander. However, by fostering open Two-way communication and feedback, a commander can engage an airman's intellect and emotion and foster commitment in the process.[9] An airman will feel motivated (and committed) to an organisation if he knows and believes that his superiors are trying their best to look out for his best interests. To achieve this, basic yet important methods of engagement such as Commander/CO dialogue sessions, Commander's visits at the workplace and regular interviews, will be further reinforced under CARDINDAL. Going further, the RSAF will explore means to use these sound ideas more effectively to listen to what the airman wants and to show him that his Commanders are sincerely concerned about his needs, welfare and aspirations. This has become extremely important because as argued by T. Wyatt and R. Gal, *"[with] youth becoming better educated and more sophisticated, [they] are no longer going to see themselves as compliantly executing orders. They will examine carefully the sources of the military legitimation before furnishing the unconditional commitment that is the backbone of the military fighting spirit".*[10]

Strengthening Team Spirit

This essay posits that by strengthening team spirit, an organisation can foster 'Normative Commitment', which refers to commitment based on a sense of obligation to the members of the organisation.[11] In the 1st and 2nd Gen RSAF, the organisation successfully developed 'Team Excellence' as a necessary condition (and Core Values) to meet mission demands. During this period, a culture of interaction and mutual understanding between different vocations was forged. Moving forward to the 3rd Gen RSAF, not only will it be important to continue building 'Team Excellence' amongst the various vocations, the RSAF will also need to foster greater camaraderie between the Services. Ultimately, the RSAF aims to create the kind of environment whereby the airman is not only committed to the missions of the Air Force but is 'normatively committed' to the SAF and his fellow airmen too. The Commander's role in strengthening Team Spirit will be discussed in greater detail in the next section.

Moving forward, the 3rd Generation RSAF will also need to foster greater camaraderie between the Services; whereby the airman is not only committed to the Air Force, but to the SAF and his fellow airmen too.

The Role of Commanders

The RSAF's Commanders (as Squadron Commanders, Branch Heads and the like) have in their capacity, several attributes and strengths through which they can determine the success (or failure) of the RSAF's People Development efforts.[12] In fact, this section of the organisational hierarchy is probably the best equipped to achieve this difficult yet necessary task.

Firstly, Commanders have the advantage of 'visibility'. Commanders, through their daily personal interaction with their subordinates, represent the very 'face' of the RSAF. They must optimise this valuable exposure to promote, explain and implement the RSAF's People Development efforts to inspire the kind of commitment that is desired (and required) in the 3rd Gen Airman. Starting from the unit as a whole, moving down to teams of airmen and further down to each individual, Commanders are in the best position to establish means of constant dialogue to explain and clarify key policies, to address concerns, to understand motivations and expectations and even to seek consultation and solicit ideas. No system or policy is perfect and Commanders, with their knowledge and experience, are best able to explain and clarify organisational rationale and constraints to their airmen. Ultimately, in spite of the RSAF's high operational tempo, Commanders should take advantage of the 'personal' time they have with their airmen, to communicate, to get into their personal lives, to show them that the RSAF cares for them and to convince the airman that

It is important for Commanders to impress upon their airmen the importance of 'Team Excellence' and how the success of the RSAF depends largely on airmen functioning well in their teams.

his commitment plays a huge part in determining the success of the RSAF.

Secondly, a Commander's motivational abilities and knowledge of his airmen are crucial in strengthening team spirit. Commanders play a very large role in fostering *esprit de corps* within the unit, such that each airman will feel that he belongs to a cohesive team with a common sense of purpose and belonging.[13] The RSAF's People Development framework proposes measures through which Commanders can foster bonding not only between airmen but across the various levels of the unit hierarchy. As stated by D. Henderson, *"common attitudes, values and beliefs among soldiers in a unit can promote individual commitment to the unit, its leaders and the mission of the unit".*[14] It is important for Commanders to impress upon their airmen the importance of 'Team Excellence' and how the success of the RSAF depends largely on airmen functioning well in their teams.

Thirdly, Commanders are endowed with vast resources. They can reinforce existing measures, such as induction programmes for newly posted-in personnel, Unit Cohesion Days and team-building activities to galvanise their airmen and inspire confidence and commitment. In addition to that, they are accorded the necessary mandate and authority to use their creativity and discretion to formulate strategies that will foster commitment in their subordinates.

At this juncture, it is important to note that the RSAF's leaders have been fostering commitment in their airmen since the inception of the Air Force. What has changed now is that the RSAF's People Development framework provides a systematic and robust structure to aid Commanders in their efforts. However, even with the framework, it is important for Commanders to seek greater effectiveness and efficiency

in operations and administrations simultaneously. The main challenge when transforming into the 3rd Gen RSAF, will be ensuring that operational readiness is not compromised. To this end, the organisation has streamlined existing procedures and processes to create the capacity to undertake expanded operational demands as well as pushing forward with the transformation. The RSAF's Commanders play the most important role in creating this capacity.

Conclusion

The fundamental building block of any partnership is the appreciation and achievement of mutually shared goals and priorities. For the RSAF to transform into a 3rd Gen RSAF, committed airmen are the key. Over the years, the RSAF has taken extensive efforts to engage its airmen. The new People Development framework will provide the robust structure that would tie all these efforts together. However, to be truly successful in reaching out to our airmen, matters of the heart cannot be the responsibility of a few departments within MINDEF / SAF. The RSAF's Commanders will play the most important role in strengthening commitment.

Endnotes

1 The 3rd Gen RSAF is envisioned to be an Integrated Force that will decisively influence the land and maritime domains. Please see the article, "Building an Integrated Force", for further details.

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Seven Habits of Highly Effective 3rd Generation Airmen

by MAJ Gaurav Keerthi, MAJ Mark Lim and MAJ Lim Kok Hong

"You can do nothing with an army that is an amalgam of a hundred people here, a hundred people there, and so on. What can be achieved with four thousand men, united and standing shoulder to shoulder, you cannot do with forty or even four hundred thousand men who are divided and pulled this way and that by internal conflicts..."

Mubarakshah, Persia, Rules of War and Bravery[1]

Among most large organisations, there is a tendency for restructuring to emphasise on the organisational hierarchy, the introduction of new technologies or the adoption of advanced concepts and processes. These are simpler to conceptualise, easier to formulate and subsequently, implement. These plans are simple and intellectually appealing because, like basic economic theories, they simplify humans to a collective of rational beings who respond effectively and efficiently to the proposed incentive structures and thus will not "deviate from the plan". However, the major fallacy of such logic is that individuals who fill up the rungs of the organisational hierarchy, operate the new technologies and put the new concepts into practice are diverse and complex beings. They are motivated by multifarious forces and

driven by different beliefs and habits. Thus, any successful transformation must take into account the alignment of its people. It has to try and imbue in her men and women a common ideological standpoint and more predictable behaviour set based upon core values. To assess the "core values" of an individual is quite challenging as these are principles that are internal to the person and hence, cannot be easily evaluated. They do, however, manifest themselves externally as habits, and this article aims to round up the outward manifestations (hence "habits") that we envisage in our 3rd Generation (Gen) Airmen.

The seven habits that we list here are, in their own way, full spectrum, integrated and ready. As we move away from the giant "On-Off" switch of the military to a more refined capability, to apply scalable and adjustable pressure as required by the political situation, there is a need for our people to step away from the comfort of rigidly defined behaviour patterns. Thus, the habits we present in this article draw on both extremes of the same line (like the yin and yang, a delicate but necessary balance between potentially opposing forces), explaining that the 3rd Gen Airmen may be required to calibrate his response along the "full spectrum" of that particular "habit balance", based on the situation. There is much overlap and "integration" of the habits, because no behaviour is ever effected in isolation from others. Hence, we can expect a person to choose a response or a course of action that draws upon multiple elements listed below. While this list itself is "ready" for consumption, it is far from exhaustive and naturally, is open to interpretation. There are new challenges ahead and while we are not sure exactly what to expect, we can be sure that we should not expect to stay stagnant with the habits that are entrenched in our world today. The speed of our new fighter aircraft, the agility of our new attack helicopters, the revolutionary new organisational structures and the concepts that are being experimented with all point in one clear direction: our People need to transform themselves to catch up and lead the change at every level.

The qualities of our equipment, and the revolutionary new organisational structures and concepts, all point to the need for our People to transform and lead the change at every level.

Habit #1: Innovate but Regulate

An organisation that taps on the combined intellectual potential of its people is able to achieve much more than an organisation that relies on the thoughts and ideas of the few on the top of the hierarchy. In a future environment littered with unknown complexities at every step, for every sphere of operations, and at every level from strategic to the micro-tactical, we cannot expect higher management to come up with solutions for every single contingency. We need our airmen to exploit and utilise the benefits of our mature education system, to be creative, resourceful, and imaginative to come up with solutions (especially when faced with resource constraints). Ground-level initiatives, no matter how seemingly trivial, can result in disproportionately huge outcomes when applied cumulatively. The PRIDE movement are good examples of ground-led initiatives contributing to significant cost savings and enhanced productivity that have benefited the organisation immensely as a whole.

There is, however, a flip side to empowering our men and women with the license to deviate from established protocols with "creativity". Creativity here is unfortunately a euphemism for the short cuts and work-arounds that exploit loopholes in the system for the benefit of an unscrupulous soldier, rather than for the efficiency or effectiveness of a mission or outcome. Thus, the balance to innovating by "thinking outside the box" is to regulate by "playing within the rules". Should the situation that requires the mission to take precedence arise, some rules can be bent; but this should only be done if the core values of the organisation and that individual are not compromised. Forcing an aircraft to launch for a flight at the expense of safety will only lead to negative consequences should things go wrong with the aircraft – this "bending of the rule" has violated a core value. However, in the case of Operation Flying Eagle, the helicopter pilots who were sent overseas before an SAF HQ could be established in-theatre had to make real-time decisions without the benefit of open communication lines to their commanders – and there were some decisions that, although they violated specific training regulations, were made rationally, with clear focus on mission outcome and an understanding that none of their values were in question. An example of such a decision was when the CH-47 first landed in the disaster-struck region of Meulaboh – crowds of Indonesians approached the helicopter, desperate for a flight out to seek medical attention or to avoid the feared second aftershock. To balance the need to expedite the withdrawal of the injured to medical facilities in Medan with the need to ensure that the maximum loading of the helicopter was not compromised, the aircrew calculated that they could take on more than the stipulated peacetime norm of 28 passengers safely, and did so, informing the commander of their decision once communications was established en route. The balance between coming up with creative solutions to this operational challenge and playing within the confines of the inviolable rules of safety were met in this positive demonstration of how 3rd Gen Airmen

must make intelligent decisions using both sides of the same habit.

Habit #2: Firm but Flexible

"Deliberate with caution, but act with decision; and yield with graciousness, or oppose with firmness."

Charles Caleb Colton (1780 - 1832)

The confidence to defend your beliefs and ideas can stem from a number of sources – an unwavering commitment to the cause, an in-depth knowledge of the subject matter or more importantly a strong sense of self-belief – all of which can be desirable characteristics for personnel involved in warfighting operations. Indeed, the era of yes-men has long gone. We need to groom our airmen to give them the chance and strength to find their own voice and to form opinions on how issues should be handled, using their training, experience and understanding of the subject as their guides. Colton's quote above illustrates that a leader, once decided, should be firm with his decision to inspire the faith and following of his subordinates. The 3rd Gen Airmen need qualities like this as immense power is vested upon them with the technology and thus, there is an immense responsibility for them to act with fortitude and determination; in other words, they need to be firm. The Navy extols the virtue of Firmness as a core value, as the merit of having resoluteness among the men will align the organisation naturally when the battle starts. It allows us to move past the slightly more deliberative stage of decision-making and into the realm of fast-paced deliberate and firm execution.

"I am firm. You are obstinate. He is a pig-headed fool."

Katharine Whitehorn

We need to groom our airmen to give them the chance and strength to find their own voice and to form opinions on how issues should be handled, using their training, experience and understanding of the subject as their guides.

To be firm without thought is a flaw; our airmen must be able to adapt themselves and thereby respond rapidly to evolving (and possibly unexpected) developments and information in this new environment. Rigidly sticking to dogma, as Whithorn muses above, does not make you a hero, but obstinate, or in the worst case, a "pig-headed fool". The natural inflexibility of the firm mind is not one that is desired by the RSAF, hence our airmen must know when to be firm and stand up to the test, and when to be flexible and roll with the punches.

Habit #3: Gung-Ho but Composed

In the movie *300*, the Spartan King Leonidas proclaims to his men: "We Spartans have descended from Hercules himself. Taught never to retreat, never

to surrender. Taught that death in the battlefield is the greatest glory he could achieve in his life. Spartans – the finest soldiers the world has ever known." The movie portrays the Spartan warriors as fiercely loyal, courageous, and bloodthirsty at times, going to any length to ensure the safety and survival of their loved ones back home, and thus able to battle an army of millions and hold them off against all odds. While we can easily correlate this scenario with air combat, it must also be highlighted that a significant proportion of our RSAF airmen work with servicing equipment in sheltered hangars far from battle front lines or orchestrate air battles largely through buttons and computer screens. Have our airmen slowly begun to move away from the fundamental business of all soldiers and military men and women – to fight?

Our military ethos and fighting spirit should remain as the core and in fact, should be a deciding factor when our combatants engage the enemy on the battle ground, drawing upon courage and tenacity (even aggressiveness) to inspire fear in the hearts of the enemy. If deterrence is our ultimate aim, a nation full of committed and courageous warriors (like the Spartans) must surely be the greatest weapon of all. This is even more critical in the Information Age, as some youth become desensitised to war on CNN, and choose to fire words as weapons from the comfort of their anonymous blogs. The importance of instilling strength of heart in our warfighters cannot be understated; a nation whose soldiers would rather send their families outside the borders at the first sign of trouble rather than stand fiercely to protect the borders, is a nation that has already lost the war psychologically. The term Gung-Ho, derived from the Chinese term Gōnghé, is used as a military adjective (popularised in the 1943 war film on the Battle of Makin Island) for the enthusiasm and fighting spirit of their men and is a habit that would befit our airmen to meet adversity head-on when the need arises. Drawing back to the earlier article on "Deterrence", the benchmark of a strong deterrent is its credibility in the eyes of a potential aggressor – knowing that our men and women display the will to fight (coupled with our capability) is a natural formula for success in this respect.

There is a danger in "unbridled courage" though – recklessness and rage, which, in addition to being negative qualities on their own, serve only to distract and lower the quality of decisions made by that individual. Our airmen must be so comfortable dealing with the pressures and stresses of battle that they can maintain composure even in the toughest of times. Rudyard Kipling comments on the importance of maintaining composure amidst chaos in his poem "If", and says that the mark of a true Man is *"If you can keep your head when all about you / Are losing theirs ..."*. When complex missions require quick decisions, speed of thought must never give way to rashness from blind courage; and as our environment begins to demand quicker reflexes from every one of our operators and decision-makers, the ability to maintain our cool in "hot" situations will be a habit that is necessary to draw upon.

Habit #4: Focused but Wide Angle

"Train yourself to: Keep BOTH eyes OPEN, Focus on your target."

USMC Combat Marksmanship Center of Excellence

To maintain focused on one's primary task, and at the same time have an appreciation of one's surroundings and an understanding of how it dynamically interacts with the task, is not a habit that occurs naturally. It is human instinct to block out distractions and presumably unrelated inputs so that one can channel all the required attention towards the primary task. Expert marksmen recognise the importance of this habit, so that they can enhance the aim through better appreciation of the surroundings, or in a combat scenario, knowing when surrounding threats warrant a response. The 3rd Gen Airman must understand how his task fits into the multi-piece jigsaw puzzle of today's complex missions and how each piece is coming together in relation to his own to form the complete picture. The ability to focus and perform his mission to the best of his abilities is a given. However, the execution of his mission with only his specific objectives in mind, without an understanding of the larger intent, is like trying to read the newspaper through a drinking straw, only seeing the individual alphabets. Our airmen must be clearly focused on the task at hand to achieve mission success. A clear understanding of the organisation's intent and key priorities is critical in guiding our airmen's attention and efforts to the mission.

The 3rd Generation Airman must understand how his task fits into the multi-piece jigsaw puzzle of today's complex missions and how each piece is coming together in relation to his own to form the complete picture.

The 1st *POINTER* article in this series, *"Shaping Policy Space"*, explained the contributions of our airmen in Humanitarian Aid and Disaster Relief (HADR) missions and the role they play in expanding Singapore's policy space. These airmen could be delivering food supplies or air-lifting disaster-struck inhabitants with cold, clock-work efficiency, purely focused on achieving the mission objectives. However, a true 3rd Gen Airman strives to maintain focus on the mission objectives, as well as constantly evaluate the periphery inputs against the higher intent. In addition to maintaining mission effectiveness and efficiency, they will be interacting and establishing warm relationships with the community and local authorities or going the extra mile when required. In the event that they are called upon for tasks which fall outside the specific mission objectives or would result in mission delays, the "strategic corporal and captains" would be able to evaluate the task against the larger intent. The 3rd Gen Airman understands that the tactical decisions and actions taken in today's environment often lead to larger strategic consequences. The strategic value gained by going the extra mile could possibly be amplified by the "CNN Effect", and greatly outweighs the value of the specific mission objective.

Habit #5: Impart but Acquire

"By viewing the old we learn the new."

Chinese Proverb

The creation, accumulation, distribution and application of knowledge are processes that many organisations are increasingly paying attention to, given the explosion of information and data brought about by the proliferation of computers and the Internet. In the military context, however, this Chinese proverb takes on an added level of importance. The RSAF has emphasised the importance of a strong safety culture of documenting lessons learnt to prevent a recurrence of mistakes, especially for flying operations which can be highly dynamic and unpredictable at times. Equally important is the culture of imparting knowledge, where senior and more experienced individuals share their knowledge, expertise and skills to develop and groom those below them. For these reasons, the familiar end-of-day debrief or EODD sessions, instructor-led phase briefs or even beer sessions at the mess all contribute towards the development of professional standards.

"You cannot teach a man anything; you can only help him find it within himself."

Galileo Galilei

As pointed out by Galileo in the quote above, there are clear inadequacies to a knowledge management model solely based on 'imparting' or teaching. As operations become more complex and diverse, our airmen can no longer expect to upgrade themselves through information relayed in a classroom environment. Looking forward, a paradigm shift from 'teaching' to 'learning' is thus necessary. Junior echelons need to take a more proactive role in exploring boundaries, seeking out information and managing their own development. The use of on-line portals as a virtual storage bank of knowledge

is one of many possible solutions that can facilitate such learning. Such portals can serve as repositories of lessons learnt, while encouraging discussion and debate on new air combat tactics, creative engineering solutions or even revolutionary ideas on warfare and the mode we operate. Educational programmes and training packages can also be restructured to incorporate real-life problem solving, research-based learning and interactive group discussions. A balance between 'imparting' and 'acquiring' must thus be struck for the 3rd Gen Airmen if we are to maintain our core competencies while broadening our skill sets for future operations.

Habit #6: Specialised but Integrated

"The way a team plays as a whole determines its success. You may have the greatest bunch of individual stars in the world, but if they don't play together, the club won't be worth a dime."

Babe Ruth,
Baseball legend and American icon

The past generations of the RSAF toiled to build strong type-competencies and specialisation in their individual vocations. The 3rd Generation must be able to bring their specialisation to the mission and be able to effectively integrate across vocations and Services. On first look, the requirement to achieve integration may seem to contradict the focus on specialisation. After all, integration requires concerted efforts across the organisation to bridge Service divides and functional expertise areas. Since new technologies such as precision weapons and UAVs respect no Service boundaries, our 3rd Gen Airmen can no longer afford to maintain a Service-centric mindset in operations. An understanding of campaign-level imperatives, as well as a keen appreciation of the land and maritime operations, is necessary as we build an integrated SAF. To achieve integration, the appreciation must transcend all levels; from doctrines to tactics, procedures, culture and operating lingo. It is also critical that integration be built upon a strong foundation of core skills and vocational competencies, else it will be an integrated force made up of "jacks-of-all-trades but masters of none". While striving to achieve the necessary knowledge and appreciation to be part of an integrated force, our 3rd Gen Airman must also maintain the strong Service-centric core skills that form the bedrock of the strength in the RSAF.

"You alone can never play all the instruments, and your music might not find voice in all the instruments. All you can do is find the instrument that suits you best, play it as well as you can, and add your music to the great symphony of divine creation."

Kent Nerburn,
American Author, Sculptor and Theologist

The 3rd Gen Airman must overcome the challenges, as pointed out in the 2nd article in this series, "Building an Integrated Force". Structural, cultural and mindset changes must be addressed from within, and can be eased through cross-Service networking both on a professional and social basis. Cross-Service interaction will allow cross-pollination of ideas, mutual understanding of operations and

capabilities. During the process of training for their core-competencies, a 3rd Gen Airman is able to understand how each skill-set and mission contributes to the capabilities of the integrated force, and how procedures and tactics can be shaped to increase its relevance in an integrated environment. With this attitude, the 3rd Gen Airman can develop and train in ways which encompass the essence of Service core-competencies within the context of integrated operations, and work towards the articulated vision for *ONE* SAF.

The 3rd Generation Airmen must be able to bring their specialisation to the mission and be able to effectively integrate across vocations and Services.

Habit #7: Committed but Impartial

Commitment is an attribute that is valued in every organisation. The level of commitment can be seen from the amount of effort an airman puts into training, and the sense of responsibility towards the mission. The previous discussions in the "Commitment to Defence" article elaborated the importance of commitment and how the SAF has taken initiatives to engage the servicemen and develop the "heartware". Commitment is one of the manifestations of 'Loyalty to Country', the first of the SAF Core Values. Besides being committed in effort, the loyal airman will tend to stand by the views of the organisation, determined to execute and follow the decision through.

"When debating an issue, loyalty means giving me your honest opinion, whether you think I'll like it or not... But once a decision has been made and the debate ends, from that point on, loyalty means executing the decision as if it were your own."

Colin Powell,
Chairman of the US Joint Chiefs of Staff
(1989 – 1993)

Commitment does not mean subscribing to the organisation's view in blind faith, but having the moral courage to disagree or take the necessary actions for the benefit of the organisation. To do this, the airman must be able to detach oneself from the urge to conform, then take an objective and impartial view and make the necessary changes.

"The participant's perspectives are clouded while the bystander's views are clear."

Chinese Proverb

The operational concepts of the 3rd Gen RSAF will be innovative, revolutionary, and be pushing all boundaries into the unknown. Successive concept development not only relies on experimentation and

validation, it requires analytical airmen who are unafraid to take objective views, offer honest critiques or make changes as required, even if it is against the consensus. The 3rd Gen Airman will be able to judiciously detach while staying committed, so that he can take an objective view of the developments before diving in to commit his full effort.

Conclusion

An organisation like the RSAF (and the SAF as a whole) that is driven by a strong sense of vision needs people who share a common set of values, and those values must manifest themselves externally as habits. The Seven Habits highlighted in this essay are presented not as an exhaustive list, but as a catalyst for individual exploration and thought. Defining the specific requirements for a new technology is simple, with enough experience and research. Defining how the 3rd Gen Airmen should act and think is a higher order of challenge – and each of us, be it the lowest-rung soldier, the ground commanders, or those who lead at the operational and strategic level, have a responsibility for being, and helping to define, what we search for in the 3rd Gen Airman.

Endnote

1 Robert Greene, *The 33 Strategies of War*, p80.

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Professionalism: A Warrant Officer's Perspective

by MWO Prakasarao S/O Gancunaidi Ramanidu

Introduction

Today the RSAF is transforming to become a 3rd Generation Air Force that has the ability to fight as an Integrated Full Spectrum Force; an Air Force that is capable of decisively influencing and shaping the air, land and maritime campaigns. The RSAF can achieve this vision via the essential building blocks of innovative concepts, organisational restructuring, world-class people, advanced technology and force structure. While these are important, the People component is still the fundamental foundation of any successful organisation. The recognition of the RSAF as a credible Air Force comes not only from modernisation of our equipment but also from the training our servicemen and servicewomen receive. Hence, People Development is a key ingredient for the success of the RSAF's transformation into a 3rd Generation Air Force.

Therefore in this article, I will be sharing my perspective on how we can strengthen a fundamental of People Development – Professionalism.

What does Professionalism mean?

Professionalism is the pursuit of excellence in everything we do and that we accomplish the tasks with pride and passion. It has to be self-motivated, to take ownership and responsibility for our tasks; it is about doing right the first time and every time; it is about having a sense of duty and service to the nation and being ready to respond to her calls. As professionals, we must know our roles and responsibilities and execute them with a sense of duty, service, pride, honour and integrity.

A good example of professionalism would be our response to the tsunami disaster in 2004. Our people were able to conduct large-scale relief work in remote areas like the town of Meulaboh that initially had no land or sea access. We were forthcoming, responding within four hours upon activation. On the ground, we were competent and highly adaptable to the unknown. The swift response with zero accidents is a testament to our people's professionalism. Defence Minister Teo Chee Hean commented on our HADR effort in Meulaboh: *"we do have a versatile set of capabilities and were able to assemble them together for the mission. Our people are professional and are trained in a flexible way when faced with circumstances never experienced before"*.

The lack of experience in real-time relief operations was made up for by the amount of effort put into our usual training. Our training enables servicemen and servicewomen to enhance their professional knowledge and competencies in their own areas of expertise, thereby empowering them to better overcome operational challenges. This could only have been achieved if the people were professional and strove to attain the best results in every scenario. Hence, in order to fulfil the mission objectives at Meulaboh, we needed to work around the constraints with our acquired skills and knowledge.

Attributes of Professionalism

There are many aspects of the human character which can be associated with professionalism. Among the many important attributes, Competency, Integrity and Tenacity are three which all WOSAs should possess.

Competency

Like any professional, we must first be **competent**. We must know what the job is, how to do the job and to do it well. It is our responsibility to ensure that we are equipped with the fundamental skills and knowledge of systems, processes and regulations. With sufficient preparation and a good understanding of the job we are designated to do, we will then be able to enhance the RSAF's fighting capabilities.

A good example of competency would be that of a Flight Line Crew in a fighter squadron who, during his walk-around check of the aircraft, observed a thin line at the top of the vertical stabiliser, about 13 feet off the ground. The thin line was confirmed to be a crack and subsequently, it was revealed that the aircraft has sustained a lightning strike. Had this crack gone undetected, safety would have been

compromised and the consequences, unimaginable. The Flight Line Crew's high level of competency is indeed highly commendable.

Competency will play an even more important role in the SAF's transformation to a 3rd Generation fighting force. As the three Services become more integrated, personnel have to be more knowledgeable of their work scope and be proficient at working with the other Services. Hence, competency will definitely be raised to a higher level and this will prove to be a core factor in the RSAF.

Integrity

The next attribute we must have is **integrity**. It is about doing the right thing even when nobody is watching. Warrant Officers and Specialists must discern what is right and also have the moral fortitude to do it. Sometimes, when under pressure to achieve goals or produce results, people may take the easy way out by cutting corners or deviating from standard operating procedures. Here, integrity comes into play as we must not allow such "short cuts" to happen.

One way of reinforcing integrity is open reporting. Open reporting is the correct course of action when one commits a mistake. It is important to admit the mistake for people to know because it ensures that others understand the situation and work towards preventing further repercussions arising from the initial mistake. More importantly, open reporting encourages people to be more honest about their work. They will follow the lead of others who have reported their mistakes and this reinforces the notion of integrity. This cycle of action can spread across the organisation and another positive return of open reporting is that it allows personnel to learn from others' mistakes.

Integrity is about doing the right thing even when nobody is watching, or when under pressure to achieve goals or produce results.

A good example was a case highlighted in Safety Information System, where a pair of tongs used by the airfield inspector for picking up foreign objects was found missing. The inspector immediately reported the missing item. Operations were halted and they were able to trace the journey he took before finding it. Simple mistakes like these should not be allowed to go unnoticed. Once they go unreported, others will see it as "normal" to make mistakes and pretend nothing happened. Small matters will subsequently grow to become big ones, and they can be serious and detrimental to the operations of the RSAF.

As a result, we must stay true to the attribute of integrity and do the right thing always. When we have demonstrated a high level of integrity, people will see us as reliable and we will be able to gain the trust of our superiors, peers and subordinates. Trust is an important component to "gel" the organisation together and propel it to greater heights.

Tenacity

As professionals, we must be tenacious in our search for excellence. It is the determination and perseverance to overcome obstacles safely, no matter how difficult the situation is. There are many times in our trainings where we may experience extreme fatigue but it is the tenacity that pulls us through to the end, and to accomplish what we set out to do. Every individual's tenacity plays a part in how the team functions and ultimately, it leads to the RSAF's pursuit for excellence.

In this aspect, I would like to share an experience which happened in 1984 but still remains vividly in my mind. I was a young Sergeant then, and my team was deploying our Hunter aircraft for an overseas detachment to Australia. One of the aircraft experienced a fuel transfer problem while we were in Bali on transit. It took us three days to recover the aircraft as the defect kept appearing for the next two subsequent sorties. The rectification process required us to carry out fuel transfer checks, involving manual de-fuelling of the aircraft into a drum and carrying it to a nearby area for disposal. Many of the Specialists who were not directly involved in the process volunteered to assist, even though the work was very tedious. In spite of having to work three consecutive days and nights, I was amazed at the tenacity of our seniors and the incredible team spirit and determination shown by my colleagues. The experience left a deep impression on me.

Today, our people are still showing the same commitment and teamwork, especially during detachments, exercises, tasking and relief missions. The rise of Operations Other Than War (OOTW) opens a new dimension

Tenacity will be essential to be operationally ready for a full spectrum of operations.

for the military as there are now more unknown frontiers for military personnel to operate in. The UN peacekeeping missions and disaster relief operations are examples of such frontiers. Tenacity will thus be essential for us to overcome new challenges and show professionalism.

Strategies to Bring WOSAs' Professionalism to the Next Level

There are three key areas which Warrant Officers and senior Specialists should emphasise on to inculcate the value of Professionalism in our WOSA Corps. These are: **Innovative Training, Ownership, New Technologies and Concepts**.

Innovative Training

As subject matter experts, Warrant Officers and senior Specialists can play a leading role to devise innovative methods to make training more effective and realistic. For example, we have set up the Composite Work Force (CWF) to improve standards. As part of Air Logistics Squadron (ALS) Specialists' first line operational training, they will take on the additional tasks of receiving, carrying out quick inspection and launching the aircraft, in addition to their core role of rectifying aircraft. They are also required to learn how to strap the pilots in the cockpit. The previous training course encompassed briefings, followed by a number of demonstrations of how an experienced first line operational Specialist straps the pilot, and finally getting the Specialist-in-training to strap the pilot a couple of times under close supervision before being certified as qualified. This previous training method was not only time-consuming, but did little to beef up the confidence of the trainee. To improve our training methods and learning effectiveness, a video clip of the whole process of strapping the pilot was produced with narration, highlighting the significant areas to note. A dummy parachute was also used to conduct ground training prior to actual strapping of the pilot. This improved training method has increased the trainees' confidence and more importantly, ensured the consistency among all Specialists trained to carry out this process.

New training methods as mentioned above depend very much on the WOSAs' ability to think out of the box and implement new ideas. As we are similar to the front-line "educator" roles in a "Ministry of Education", we must be more observant and make improvements to the learning environment whenever possible.

Ownership

Another aspect of inculcating the values of professionalism is to instil a sense of ownership among the WOSAs. When I was a member of the Base Warrant Officer Conference, I felt a strong **sense of ownership** as I could now assist the Base with our proposals and look into issues that are of concern to WOSAs. I felt that we were transforming to become "Thinkers" and not just "Doers."

However this taking of ownership must also be brought forward to more Warrant Officers and senior Specialists. This is to create in them the desire to do their best for the organisation. Therefore

it is important to constantly involve them in projects undertaken by Senior Warrant Officers. With proper guidance, they will become more confident and in due time, be able to take ownership of other projects on their own.

When we introduced the CWF, I witnessed this burgeoning sense of ownership among the Specialists. Equipped with the skills and knowledge to carry out their tasks, they are now empowered in CWF to make a certain level of judgement and be accountable for their decisions. This has strengthened their confidence and given them the opportunity to take more ownership of their areas of responsibility.

New Technologies and Concepts

Finally, as we strive to enhance our WOSAs' professionalism, we must continue to be innovative and exploit new technologies and concepts to enhance our work performance. As the axiom goes, "Change is constant". Our mindsets must be geared towards change. We must recognise that, technology and innovation help to create spare capacity for us to carry out our tasks more effectively. Hence we must strive to incorporate them into our roles to assist us in improving the RSAF.

The initiation of the Tactical Mission Support System (TMSS) by Air Logistics Squadron in Paya Lebar Air Base (PLAB) serves as a good example. TMSS monitors and manages real time logistical information of all aircraft availability and readiness in PLAB. This new concept requires us to update the management information system all defects and rectification done. Many of us found it difficult to do away with the traditional method of recording in our hard cover book, which we were used to. However after some persuasion, we embarked on the new concept. Today we have added new initiatives and modules and are fully utilising this system. TMSS has made our job very much easier, with total visibility of the defects and rectification done. Within seconds, we can draw out the past defect history of the aircraft, instead of having to retrieve all data manually.

As the force multiplier of the SAF, technology must be actively embraced by us. No doubt some of us may feel uncomfortable working on a computer or find it difficult to use new systems but the 3rd Generation RSAF requires adaptation to change for it to succeed. History has shown that new technologies will bring about new powers. In this Age of Information, it is no different. Hence, RSAF airmen have to be up-to-date with the changes to stay ahead of the competition.

Conclusion

Today, the RSAF faces a more complex and dynamic environment that requires us to meet the challenges of war, terrorism, peacekeeping and humanitarian assistance. To be a true professional we must embrace these changes with open minds and harness our skills, knowledge and adaptability to face the challenges ahead. We must never be complacent. We have to be true to the values and attributes which I have stated in this essay. Our vision of a First Class Air Force can be achieved if we, as WOSAs, believe in it and possess the desire and the correct attitude to make it happen.

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Doppler-only Synthetic Aperture Radar

by MAJ Charles Chua

I. Introduction

In conventional synthetic aperture radars (SAR) or inverse synthetic aperture radars (ISAR), the radar imaging process is based on collecting and processing high-range resolution data. Thus, it is conceptually viable that such an imaging process can also be performed using high-doppler resolution data only. This is the subject of this thesis.

The concept of doppler imaging is not entirely new. Doppler-only imaging has been applied to radar based planetary imaging, but it appears that this work is restricted to very limited geometries.[1] The reconstruction of a scattering density function from its integral over hyperbolas has also been developed[2] for wideband range-doppler radar imaging. Doppler imaging of a planar surface, however, has not been found to be studied in its own right.

The advantages of imaging based on high-doppler resolution are conceivably straightforward. The imaging system requires only a relatively simple and inexpensive continuous wave transmitter. The signal returns are inherently confined to a narrow band as doppler shifts are expected to be in the region of tens to hundreds of kilohertz. Conversely, pulse radars, due to the requirement for narrow pulses, will have a correspondingly larger bandwidth. The narrow bandwidth characteristic of a doppler-only imaging system is especially useful for covert operations or operations where the frequency spectrum use is restrictive, as well as for low frequency operations such as ground or foliage penetration imaging systems.

With a doppler-only imaging system, the high-doppler resolution data collected can be processed in a similar manner (to that from high-range resolution data) to reconstruct the original image. The original image can be obtained via the mathematical procedure of tomographic reconstruction, a process that is perhaps better known in the Medical context of a Computed Axial Tomography (CAT) scan.

II. High Doppler Resolution SAR

A. Introduction to High Doppler Resolution SAR

Standard synthetic aperture radar imaging systems transmit high range resolution (HRR) waveforms and the radar returns are used to obtain

estimates of the distances to the various scatterers of a target, thus mapping out the range profile of the target. With a HRR system, the radar return at each time step t is a superposition of all the returns from the scatterers at a distance $2t/c$ from the radar. The imaging problem is formulated in terms of reconstructing the scattering density function ρ from it integrals over all circles centred on the flight path of the antenna.

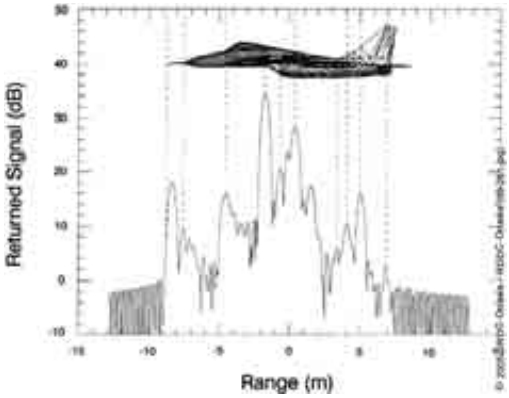

Figure 1. Return signal corresponding to individual target scatterers computed using a CAD model at High Range Resolution.[3]

The complementary system to the HRR imaging system is to transmit high-doppler resolution waveforms (such as fixed-frequency, continuous wave or CW waveform) in order to determine the relative target velocity from the doppler frequency shift of the radar return.[4] For an antenna moving at a constant velocity over a flat surface, the return at a given doppler shift is a superposition of all the returns due to scatterers with the same relative velocity lying along a hyperbola, termed the isodoppler curve. The imaging problem is thus to reconstruct the scattering density function from the integrals over the isodoppler hyperbolas.

B. Isodoppler Contours

The locus of points for constant doppler shift on the Earth's surface is called an isodoppler contour. In the monostatic case with a flat earth, these isodopplers are conic sections in three

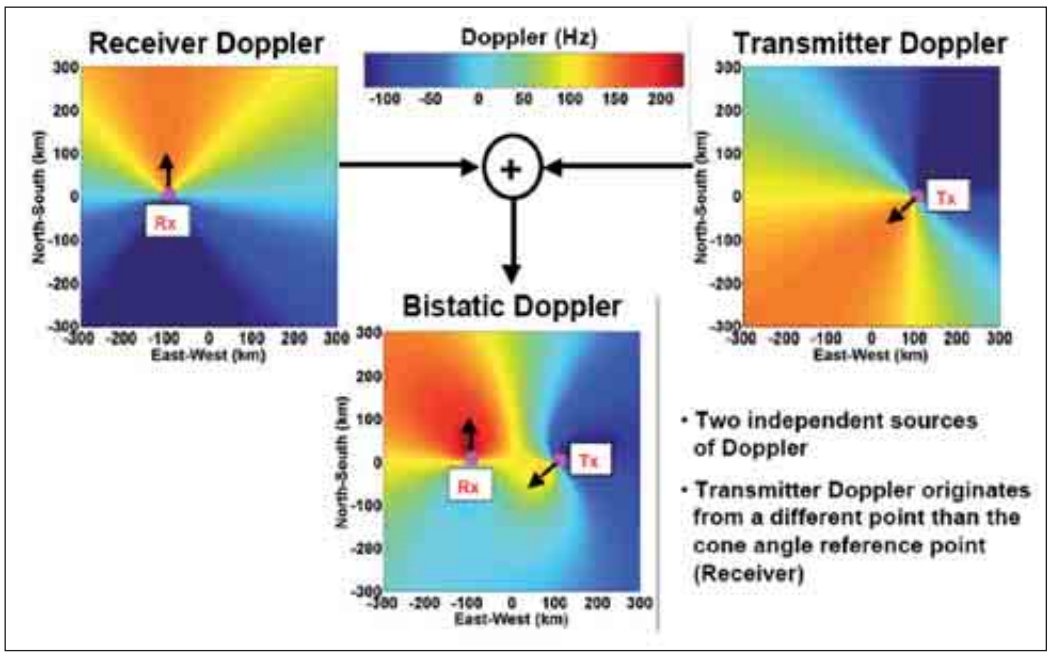

Figure 2. Isodoppler Contours from Bistatic radar.[5]

dimensions, in which the cone is a consequence of the radar's beamwidth. In the bistatic case, the isodopplers are skewed, depending on the transmitting and receiving site kinematics. These curves can be developed analytically for a simple case of a coplanar flat earth and bistatic plane as illustrated in Figure 2.

C. Current Uses of Doppler Imaging

High doppler resolution (HDR) imaging systems require only a relatively simple (inexpensive) transmitter and may thus have advantages over high range resolution systems (HRR) in some situations. In addition, doppler imaging systems may be useful in scenarios in which the radar must penetrate through a medium with a frequency dependent attenuation.

The concept of doppler imaging appeared in Mensa's work[6] in the context of a rotating target and stationary radar to motivate the development of range-doppler or inverse synthetic aperture imaging. Doppler-only imaging has also been applied to radar-based planetary imaging.[7] The High Resolution Doppler Imager (HRDI) was one of the instruments on board the Upper Atmospheric Research Satellite used to observe the emission and absorption lines of molecular oxygen, as well as other atmospheric components, in small volumes above the limb of the Earth. From the doppler shift of the lines, the horizontal winds can be determined, while the line shapes and strengths yielded information about the temperature and atmospheric species such as mesospheric ozone. The reconstruction of a scattering density function from its integral over hyperbolas has also been developed[8] for wideband range-doppler radar imaging. Doppler imaging of a planar surface, however, has not been found to be studied in its own right.

D. Analogy Between HRR SAR and HDR SAR

To illustrate the concept of obtaining a HDR SAR image, a simplified explanation of the process of how a SAR image from HRR is discussed, and an analogy will be drawn between the more common HRR SAR process, and the proposed process using HDR methods.

1. Image Formation Based on HRR Data

Traditional methods of imaging radars reply on high range resolution techniques to map out an image of the target. With one-dimensional high range resolution profiles, the range profile of a target can be mapped. Given a sufficiently narrow time-domain pulse (relative to the major scatterers of the target), the relative locations of the scatterers can be differentiated to produce the range profile of the target.

In order to build upon the information available from a range profile so as to extend the radar imaging concept to two dimensions, it is necessary to collect multiple sets of range profiles (each from different directions), process them, and finally synthesise an image. This process of building a two-dimensional image from multiple one-dimensional range profiles is similar to the idea of triangulation.

Consider a set of three simple point targets with the radar located relative to the target such that target 2 and target 3 are equidistant from the radar, as shown in Figure 3. The return signal to the radar will only indicate two targets in this configuration. If the radar is aboard a moving platform, and the platform moves directly towards the targets, the return signal will continue to indicate only two targets. This illustrates the condition where ambiguity exists due to targets lying along the lines of constant range from the radar.

However, if the platform has a component of velocity that is not parallel to the line-of-sight of the radar to the targets, the range profile will now start to show three targets. From a different perspective, the targets no longer line up along the same line of constant range, as shown in Figure 4. With multiple data sets from different directions, the concept of triangulation will allow the gradual buildup of the relative locations of the three targets using multiple sets of these one-dimensional range profiles. With the correct correlation methods (which will be discussed in the following sections), a two-dimensional image of the target as a whole can be obtained. Using just radial profiles, the cross-range information of the target has thus been obtained.

Fundamentally, there are two different schemes used to collect target data from different perspectives (as described above) to obtain the cross-range information. The target can be stationary whilst the radar moves around the target to collect different range profiles of the target; or in the second scheme, the target is in motion whilst the radar is stationary and stares at the target to collect a different perspective of the target. In the former case (where the radar is in motion), the radar is described as collecting data over a synthetically larger aperture, and thus termed as SAR. In the later case, the converse happens and the data is described as being collected by an ISAR.

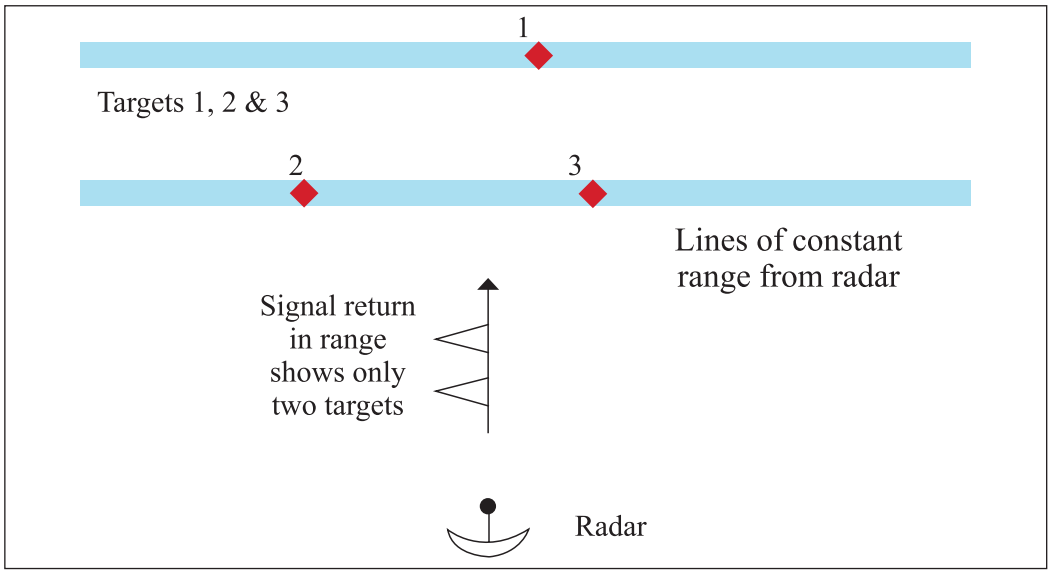

Figure 3. Ambiguity scenario due targets lying on lines of constant range from radar.

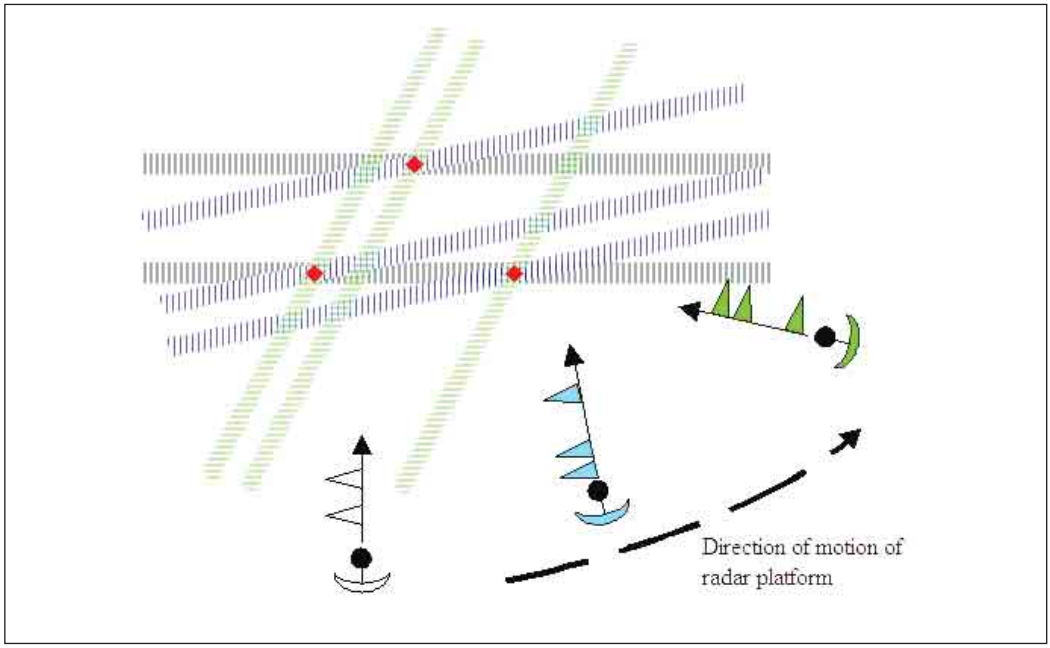

Figure 4. Down-range and cross-range information facilitates image reconstruction.

2. Image Formation Based on HDR Data

In high range resolution SAR, the image is built up by a correlation of range profiles taken at different locations. Each "line" of the range profile is an iso-range line at a specific time that actually originates from the fact that the radar pulse takes a finite amount of time to reflect off a scatterer and return to the receiver.

In high resolution doppler, another set of "lines" can be used to build up the image. These will be the isodopplers as previously discussed, lines of constant doppler shift at a specific frequency based on the relative motion between the target and the radar. The return at a given doppler shift is a superposition of all the returns due to scatterers with the same relative velocity lying along the isodoppler hyperbola. Conceptually, iso-range lines and isodoppler lines can be thought of as taking "slices" of the image, and the difference between the former and the latter is that these "slices" are orthogonal to each other, as illustrated in Figure 5. Similar to the HRR scenario, there will be ambiguities due to multiple scatterers along isodoppler, and thus doppler profiles of the target from different perspectives are required. Subsequent correlation of the data sets of doppler profiles will allow reconstruction of the image.

When imaging is based on high range resolution data, each profile will inherently have high resolution in the down-range direction, and the correlation of each profile from different perspectives will provide the cross-range resolution in order to build up a two dimensional picture. Conversely, when imaging is based on high doppler resolution data, each profile will have high resolution in the cross-range

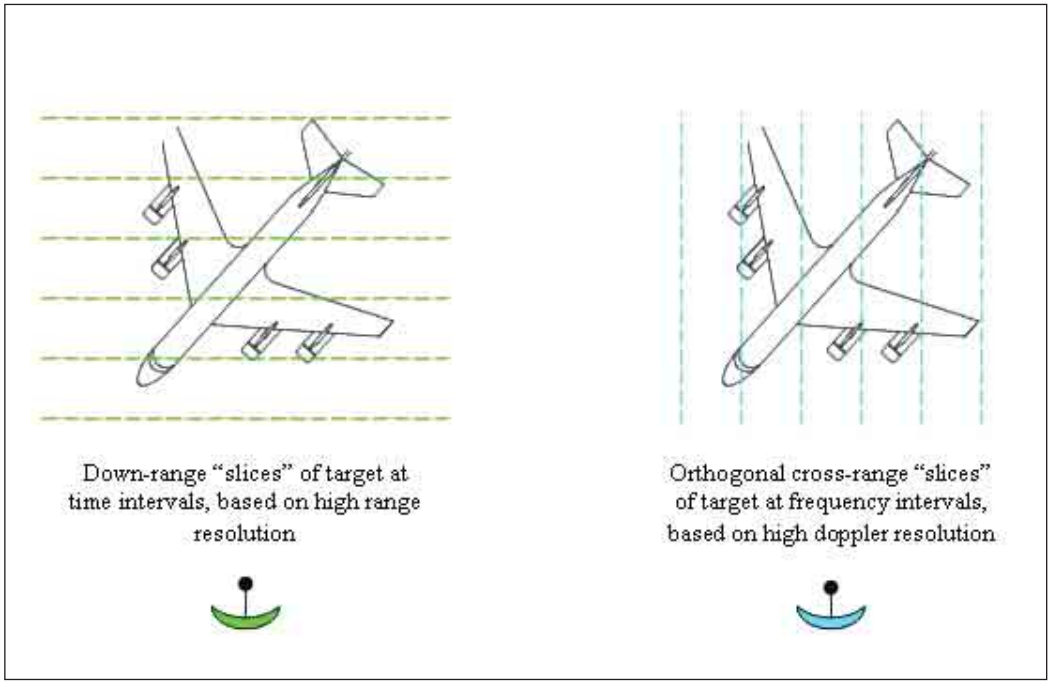

Figure 5. Different "slices" of the target when using HRR (left) and HDR.

direction, and the correlation process will provide the down-range resolution. These are the underlying concepts of SAR based on doppler-only data.

E. Mathematical Approach to HDR SAR

This section will broadly discuss the mathematical concepts[9] required to generate the SAR image based on high doppler resolution data. The specific implementation of these concepts and theorems will be discussed in the next section.

1. Radon Transform and Tomography

A line integral represents the integral of some parameter of an object along a line. Taking the case of the radar and target scenario, the line integral represents the total reflection of the electromagnetic wave as it travels in a straight line to the target and back from it.

Consider a target represented by a two-dimensional function f(x,y), and line integrals defined by the parameters (τ,θ) as shown in Figure 6. Let the equation of line AB be $x\cos\theta + y\sin\theta = \tau$. For a fixed θ, there can be many possible other lines A'B' that are parallel to AB, each corresponding to a different value of τ. The line integral of along AB is defined as:

$$\Re_\theta(\tau) = \int_{\theta,\tau} f(x,y)\,ds$$

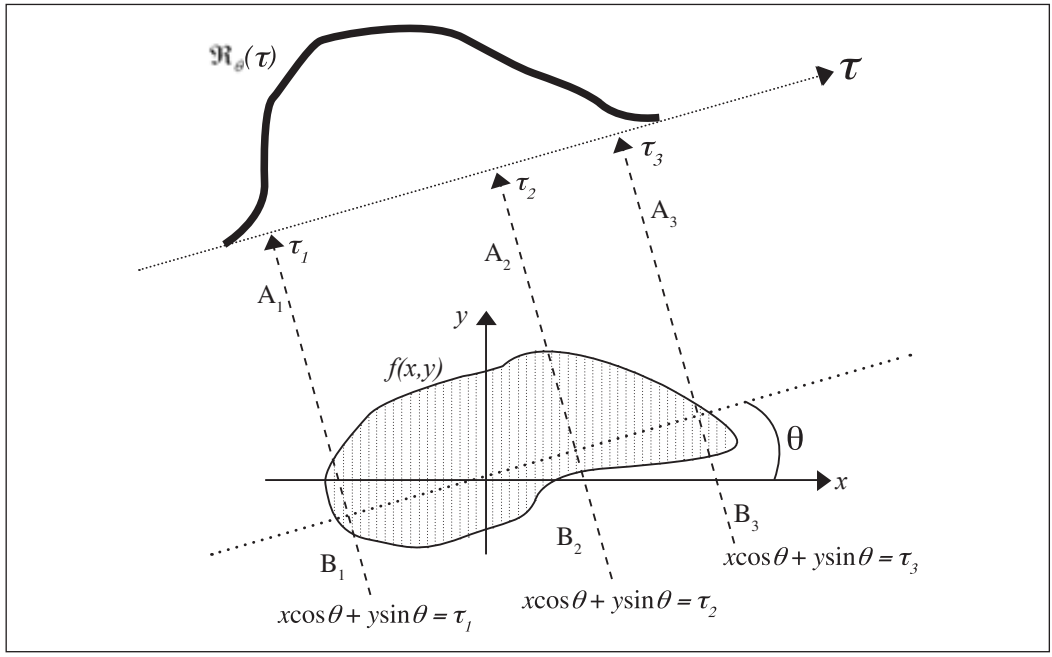

Figure 6. Concept of Line Integrals and the Radon Transform.

Consider the delta function $\delta(\tau - x\cos\theta - y\sin\theta)$. This function is zero everywhere except when its argument is zero, which is along the straight line $x\cos\theta + y\sin\theta = \tau_1$. It is thus a representation of the line AB. Thus, the above function can be rewritten as:

$$\Re_\theta(\tau) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\tau - x\cos\theta - y\sin\theta)\,dx\,dy$$

$\Re_\theta(\tau)$ is known as the Radon transform of the function $f(x,y)$.

If θ is kept fixed at value θ_1 while τ is varied, then $\Re_\theta(\tau)$ constitutes the projection of the density function $f(x,y)$ onto the line $\theta = \theta_1$ as a function of τ. The resulting profile is referred to as a single scan. A projection of the function $f(x,y)$ is formed by combining a set of line integrals. For a constant θ, the collection of parallel ray integrals forms a projection as shown in Figure 7.

The function $f(x,y)$ is a representation of the reflectivity of the target, and the Radon transform of the target represents the superposition of all the returns due to scatterers with the same relative velocity lying along the isodoppler. The Radon transform data is often called sinogram because the Radon transform of a delta function is the characteristic function of the graph of a sine wave. Consequently, the Radon transform of a group of point scatterers making up the target appears graphically as a number of blurred sine waves with different amplitudes and phases.

Given the scans $\Re_\theta(\tau)$, usually for continuous τ and a discrete set of scanning directions θ obtained by looking at the target from different perspectives, the aim is to invert this transformation so as to arrive back at the unknown target function f(x,y).

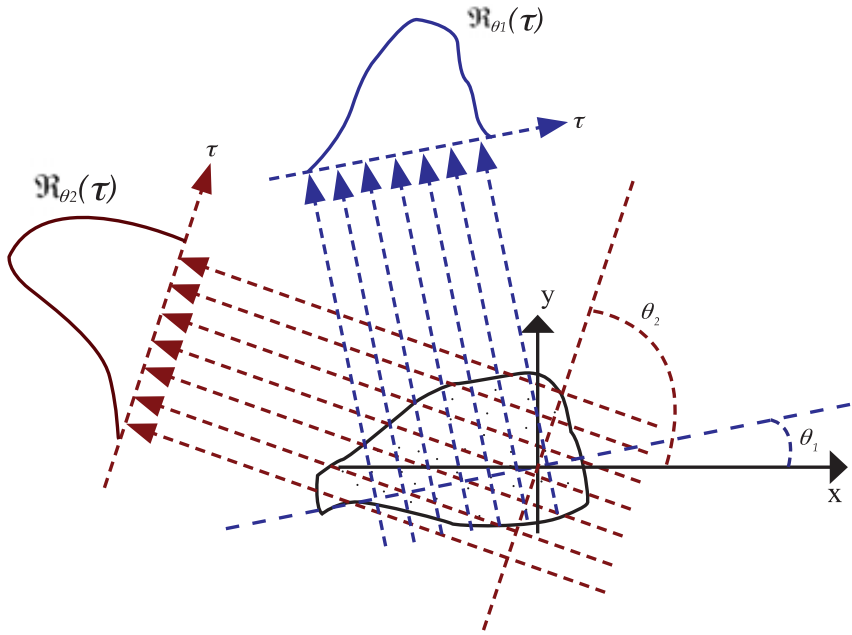

Figure 7. Radon Transform of f(x,y) based on Parallel Projections.

This concept is similar to computer-assisted tomography that is used in the medical field of CAT scans and magnetic resonance imaging.

2. Projection Slice Theorem

The two-dimensional Fourier transform of a function is defined as:

$$F(u,v)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)e^{-i2\pi(ux+vy)}dxdy$$

Likewise, for a projection at an angle θ and the corresponding $\Re_\theta(\tau)$, its Fourier transform is given by:

$$\Im(w)=\int_{-\infty}^{\infty}\Re_\theta(t)e^{-i2\pi wt}dt$$

Consider $F(u,0)$, the slice through $F(u,v)$ along the u-axis given by setting $v = 0$ in the two-dimensional Fourier transform definition, to get:

$$F(u,0)=\int_{-\infty}^{\infty}\left[\int_{-\infty}^{\infty} f(x,y)dy\right]e^{-i2\pi ux}dx$$

From the definition of a parallel projection, it is noted that the item in square brackets is the projection of $f(x,y)$ onto the x-axis, i.e.,

$$\int_{-\infty}^{\infty} f(x,y)dy=\Re_{\theta=0}(x)$$

Thus,

$$F(u,0)=\int_{-\infty}^{\infty}\Re_{\theta=0}(x)e^{-i2\pi ux}dx$$

$$F(u,0)=\Im_{\theta=0}(u)$$

From the above equation, we see that the result is independent of the orientation between the object and the coordinate system. If the coordinate system is rotated by an angle θ, the Fourier transform of the projection is equal to the two-dimensional Fourier transform of the object along a line in the u-v plane, which is also rotated by an angle θ.

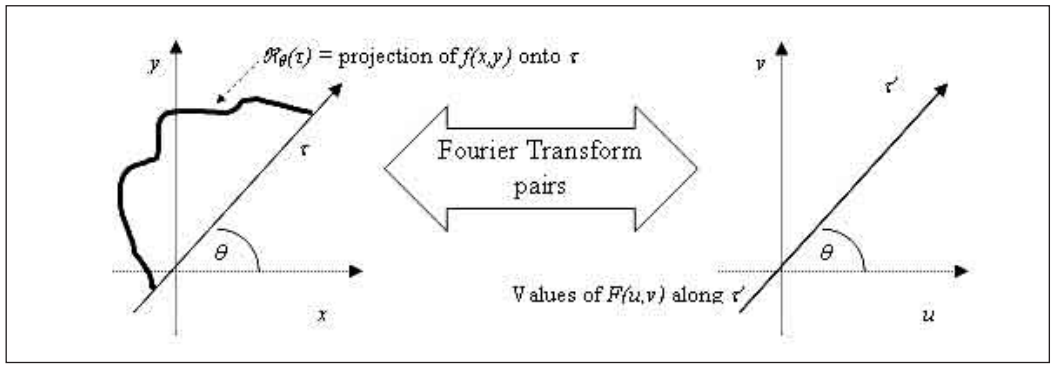

Figure 8. Graphical illustration of Projection Slice Theorem.

The Projection Slice Theorem states that the Fourier transform of a parallel projection of an image $f(x,y)$ taken at an angle θ gives a slice of the two-dimensional transform, $F(u,v)$, subtending an angle θ with the u-aixs in the u-v plane. In other words, the Fourier transform of $\Re_\theta(\tau)$ gives the values of $F(u,v)$ along the line τ' in the u-v plane. This is shown graphically in Figure 8.

3. Reconstruction by Filtered Backprojection

The Projection Slice Theorem relates the Fourier transform of a projection to the Fourier transform of the object along a single radial. Thus, given the Fourier transforms of projections taken at different angles, these projections could be assembled into a complete estimate of the two-dimensional transform, and then simply inverted to arrive at an estimate of the object. Conceptually, this provides a simple model of tomography, but practical implementations require a different approach.

The algorithm that is currently used for most applications of straight ray tomography is the Filtered Backprojection algorithm[10]. It has been shown to be accurate and amenable to fast implementation.

There are two steps involved in the Filtered Backprojection algorithm. The filtering portion can be visualised as a simple weighting of each projection in the frequency domain; the backprojection portion is equivalent to finding the elemental reconstruction corresponding to each of the filtered projections mentioned above.

The process of tomography is to project a certain $f(x,y)$ at various angles θ, which are preferably numerous and equally spaced. Consequently, those parts of the transform $F(u,v)$ can be deduced to lie on slices at corresponding angles. From knowledge of $F(u,v)$, one can recover $f(x,y)$ by a two-dimensional Fourier transform. It is noted that in the u-v plane, the data points resulting from various one-dimensional transformations lie on diverging spokes of constant θ. The density of points is thus inversely proportional to the radius, a non-uniformity that can be corrected for by multiplication with a weighting function. This is the rationale for the weighting process described in the

first step of the Filtered Backprojection algorithm. The exact form of this weighting function will be discussed in the next section where the detailed implementation is discussed.

The final reconstruction is achieved by adding together the two-dimensional inverse Fourier transform of the weighted projection. As each projection only gives the values of the Fourier transform along a single line, this inversion can be performed very fast. This step is called a backprojection since it can be perceived as the smearing of each filtered projection back over the image plane.

In summary, based on the high doppler resolution data collected at different perspectives, the target image can be obtained by the following procedures:

- Extract the frequency components of the signal to obtain the sinogram (i.e., determine the Randon transform $\Re_\theta(\tau)$ of the image).
- Fourier transform the projections to obtain $\Im_\theta(\tau')$.
- Multiply $\Im_\theta(\tau')$ by a weighting function.
- Sum over the image plane the inverse Fourier transforms of the filtered projections to obtain the reconstructed image.

III. Implementation of Doppler Imaging

Based on the doppler-only SAR concept introduced earlier, a procedure for implementation will be described and presented in Part III based on a simple test scenario.

A. Scenario Setup

Consider the case of an aircraft flying a circular path around O, of radius R_0 at a constant speed V_0. Its angular speed along the circular path is Ω_0, where $\Omega_0 = V_0 / R_0$. Within this circle lies a fixed target at a distance R_T from the centre of the aircraft's flight path. The angle subtended between the aircraft and the target with respect to the centre of the circular flight path is θ. The axis system is chosen such that the origin of the x-y axis is always with respect to the aircraft itself. Thus, the y-axis always points towards the centre of the circular flight path, O. The aircraft carries a continuous wave radar transmitting at a frequency f_0. This configuration is shown below in Figure 9.

Suppose at time $t = 0$, the angle subtended between the aircraft, the center of the circular flight path, and the target is θ_0. Therefore, at time t, the angle subtended between the aircraft and the target is:

$$\theta_t = \theta_0 - \Omega_0 t$$

With the axis system centred on the aircraft itself, and if $\hat{\mathbf{x}}$ and $\hat{\mathbf{y}}$ are the unit vectors along the x- and y- axis respectively, then the position of the target with respect to the aircraft is:

$$\vec{r}_t = (R_T \sin\theta_t)\hat{\mathbf{x}} + (R_0 - R_T \cos\theta_t)\hat{\mathbf{y}}$$

If $\hat{\mathbf{r}}$ is the unit vector along $\vec{\mathbf{r}}$, then the position of the target with respect to the aircraft along $\hat{\mathbf{r}}$ is:

$$\vec{r} = \left[\sqrt{(R_T \sin\theta_t)^2 + (R_0 - R_T \cos\theta_t)^2}\right] \hat{r}$$

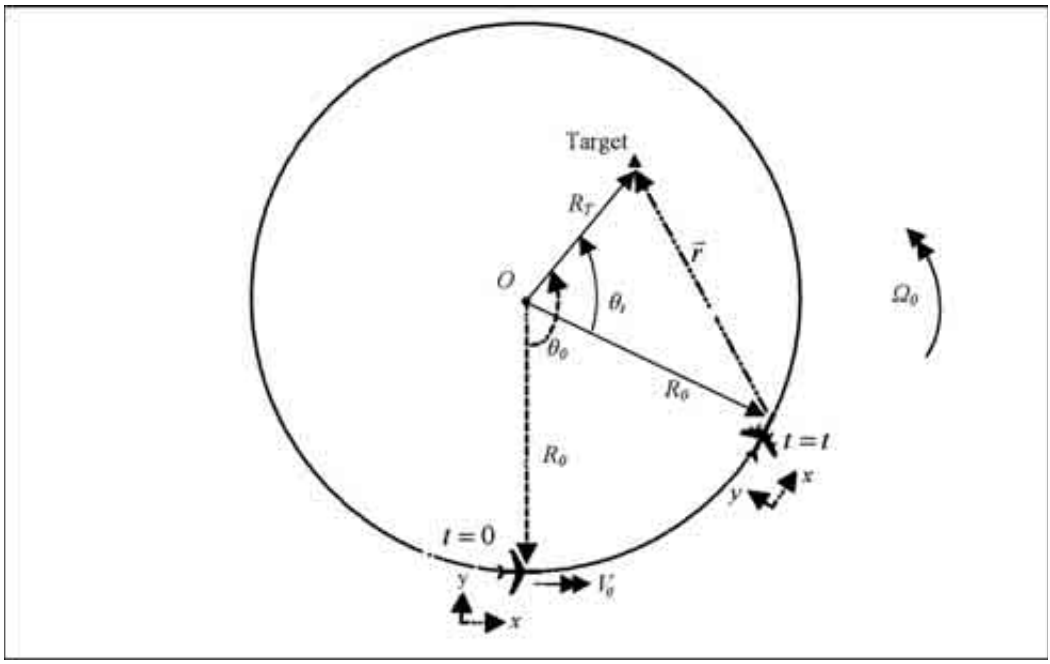

Figure 9. Aircraft flying a circular path enclosing a non-centred target at time t.

Differentiating $\vec{\mathbf{r}}$ with respect to t, we get $\vec{v}_r$, the velocity of the target with respect to the aircraft along $\vec{\mathbf{r}}$, where $\vec{v}_r$ is:

$$\vec{v}_r = \frac{d\vec{r}}{dt} = \frac{1}{2}\left[(R_T \sin\theta_t)\vec{i} + (R_0 - R_T\cos\theta_t)\vec{j}\right]^{-\frac{1}{2}} \times$$
$$\left[2(R_T\sin\theta_t)(R_T\cos\theta_t)(-\Omega_0) + 2(R_0 - R_T\cos\theta_t)(R_T\sin\theta_t)(-\Omega_0)\right]$$
$$= \frac{-\Omega_0 R_T R_0 \sin\theta_t}{\sqrt{(R_T\sin\theta_t)\vec{i} + (R_0 - R_T\cos\theta_t)\vec{j}}}$$

Since $\vec{v}_r$ is already the radial component of velocity between the target and the aircraft, the doppler shift resulting from the relative motion between these two objects are directly attributed to the full magnitude of $\vec{v}_r$.

Note that in this scenario, the aircraft and radar are moving, and the target is stationary. This essentially prescribes a SAR case where the imaging radar is in motion and the target is stationary. As mentioned earlier, it will now be shown that mathematically there is an equivalent ISAR scenario to the SAR one just described above.

For an ISAR imaging system with a stationary radar and rotating target, consider the following scenario. A radar is located a distance of R_0 away from the centre of rotation of the target, O. The target is rotating with a radius R_T, and the speed of rotation is Ω_0, where the direction of rotation is clockwise as shown in Figure 10.

Suppose at time $t = 0$, the angle subtended between the radar, the centre of the rotating target, and the target itself, is θ_0. Therefore, at time t, the angle subtended between the aircraft and the target is:

$$\theta_t = \theta_0 - \Omega_0 t$$

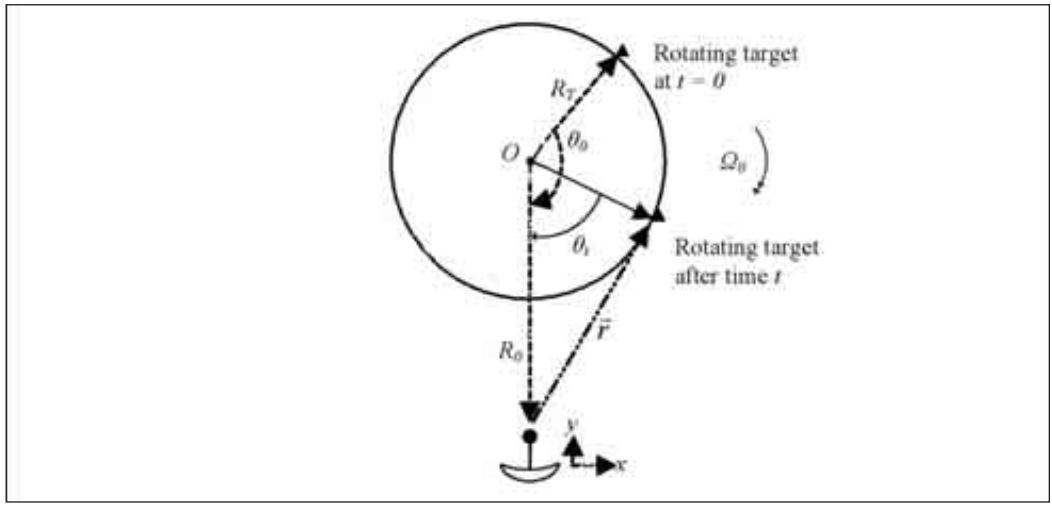

Figure 10. ISAR scenario which is mathematically similar to the SAR one in Figure 9.

An axis system is chosen whereby the origin is stationary, and is located at the position of the radar. With such an axis system, and if $\hat{\mathbf{x}}$ and $\hat{\mathbf{y}}$ are the unit vectors along the *x*- and *y*- axis respectively, then the position of the target with respect to the radar is:

$$\vec{r}_t = (R_T \sin\theta_t)\hat{\mathbf{x}} + (R_0 - R_T \cos\theta_t)\hat{\mathbf{y}}$$

With the exception of the direction of rotation of Ω_0, the expressions for θ_t and $\vec{r}_t$ are exactly identical for both the SAR and ISAR scenario described above.

B. Signal Analysis for Doppler-only SAR

In the previous section we derived expressions for $\vec{\mathbf{r}}$ and $\vec{v}_r$, relating the positional and kinematic properties of the target from the radar for both the SAR and ISAR case (which have also been shown to be geometrically similar based on the described scenarios). Based on the doppler relationships discussed earlier, the round trip doppler frequency shift, $f_{doppler}$, due to the relative motion of the radar and target is:

$$f_{doppler} = \frac{2v_r}{\lambda} = \frac{-2\Omega_0 R_T R_0 \sin\theta_t}{\lambda\sqrt{(R_T \sin\theta_t)^2 + (R_0 - R_T \cos\theta_t)^2}}$$

where λ is the wavelength of the transmitted frequency.

Since the doppler-only system uses a continuous wave radar transmitting at a constant frequency f_0, the received signal frequency f due to the doppler shift is:

$$f = f_0 + f_{doppler}$$

Due to a single scatterer target, the phase shift of the system will be given by $e^{j2\pi ft}$. For the case of multiple scatterers, it is noted that each scatterer will have a corresponding $R_{T,k}$ and $\theta_{0,k}$, thus contributing to a frequency shift of $f_{dopper,k}$. The combined signal, s_N, that is received by the radar due to the doppler shift of N scatterers is:

$$s_N = \sum_{k=1}^{k=N} A_k e^{j2\pi f_k t}$$

where

$$f_k = f_0 + f_{doppler,k}$$

C. Extracting the Radon Transform of the Target

The SAR scenario described has assumed a circular rotational motion of the radar imaging a fixed target consisting of multiple point scatterers, which can be modelled by delta functions in space. The analysis also applies for the ISAR case with the only difference being an opposite direction of rotation. When the radar moves with a circular rotational motion, the superposition of the target from the different perspectives is mathematically equivalent to a Radon transform of the target. This Radon transform of the target represents the superposition of all the returns due to scatterers with the same relative velocity lying along the isodoppler.

However, the received signal, s_N, in the form described above is not the Radon transform of the target yet. The Radon transform of a group of point scatterers making up the target appears graphically as a number of blurred sine waves with different amplitudes and phases. The Radon transform data is often called sinogram. The sinogram is actually a three-dimensional plot where the *x*- and *y*- axis are of *frequency* and *time*, and the z-axis indicates the relative magnitude of the value of that particular *frequency* at a particular *time*. In order to extract this sinogram from the signal s_N, a Short-Time Fourier Transform (STFT) will be performed on the signal. A short description of the STFT process is given below.

1. Short-Time Fourier Transform

Fourier analysis is not well suited to describing local changes in "frequency content" because the frequency components defined by the Fourier transform are taken over an infinite time, i.e., the Fourier transform assumes the signal is analysed over an infinite time duration. Thus, Fourier transforms do not clearly indicate how the frequency content of a signal changes over time. To analyse the frequency content, one approach is to cut the signal into blocks and compute the spectrum of each block. This process, the "Short-Time Fourier Transform", is a Fourier-related transform used to determine the sinusoidal frequency and phase content of local sections of a signal as it changes over time.[11]

The function to be transformed is multiplied by a window function, which is non-zero for only a short period of time. The Fourier transform (a one-dimensional function) of the resulting section of the signal is taken as the window is slid along the time axis, resulting in a two-dimensional representation of the signal. Mathematically, this is written as:

$$STFT\{s_N[\ ]\} = S_N(\tau, w) = \int_{-\infty}^{\infty} x(t)w(t-\tau)e^{-iwt}dt$$

The function $w(t)$ is the window function, such as a Hamming or Gaussian window, and s_N is the function to be transformed.

In the discrete time case, the data to be transformed are broken up into smaller sets, which usually overlap each other, and each set is Fourier

transformed. Mathematically, this is represented by:

$$STFT\{s_N[\ ]\} = S_N(m,w) = \sum_{n=-\infty}^{\infty} x[n]w[n-m]e^{-jwn}$$

For both the continuous and discrete case, each frequency spectrum will show the frequency content during the short time, and so the successive spectra will show the evolution of frequency content with time.

Some of the parameters involved in setting up a STFT include the block length, the type of window, and the amount of overlap between blocks. In general, the result of the STFT process can be improved by choosing blocks that are overlapping, and multiplying each block by a window that is tapered at its endpoints.

One of the issues of STFT is that it has a fixed resolution. The width of the windowing function relates to the how the signal is represented. This determines whether there is good frequency resolution or good time resolution. A wide window gives better frequency resolution but poor time resolution; a narrower window gives good time resolution but poor frequency resolution.

2. Illustration of STFT with Sinusoidal Signals

A set of data consisting of sinusoidal signals will be used to illustrate the concept of STFT. The signal contains four different frequencies (500, 100, 110, 150 Hz), but in each time only one of the four frequencies are present. The signal is represented by:

$$x(t) = \begin{cases} \sin(2\pi 500t), \text{for } 0 \le t < 1 \\ \sin(2\pi 100t), \text{for } 1 \le t < 2 \\ \sin(2\pi 110t), \text{for } 2 \le t < 3 \\ \sin(2\pi 150t), \text{for } 3 \le t < 4 \end{cases}$$

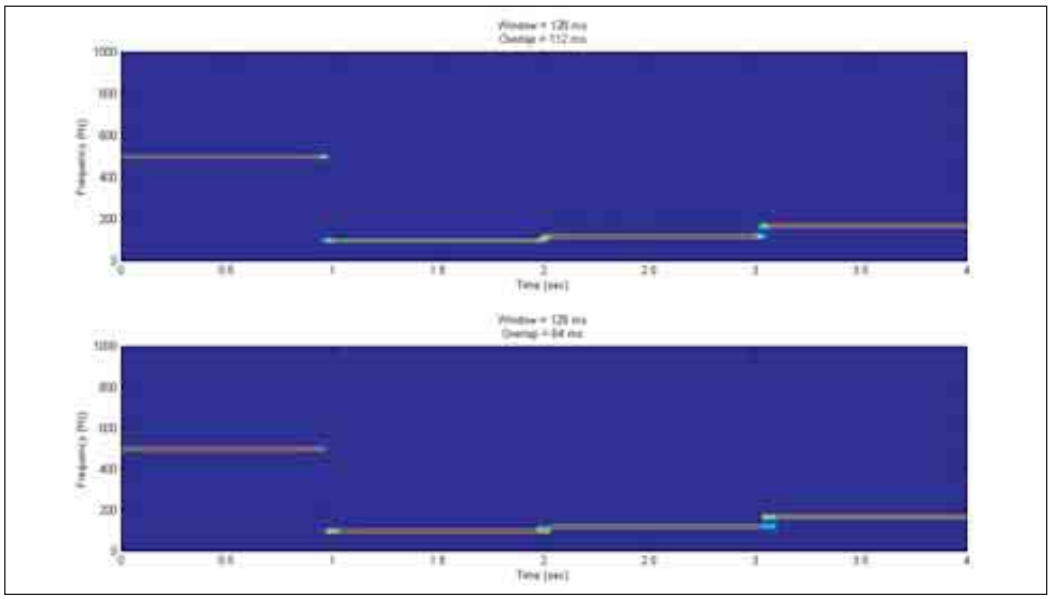

Figure 11. Sinogram of signal x(t) with a wide window and high frequency resolution.

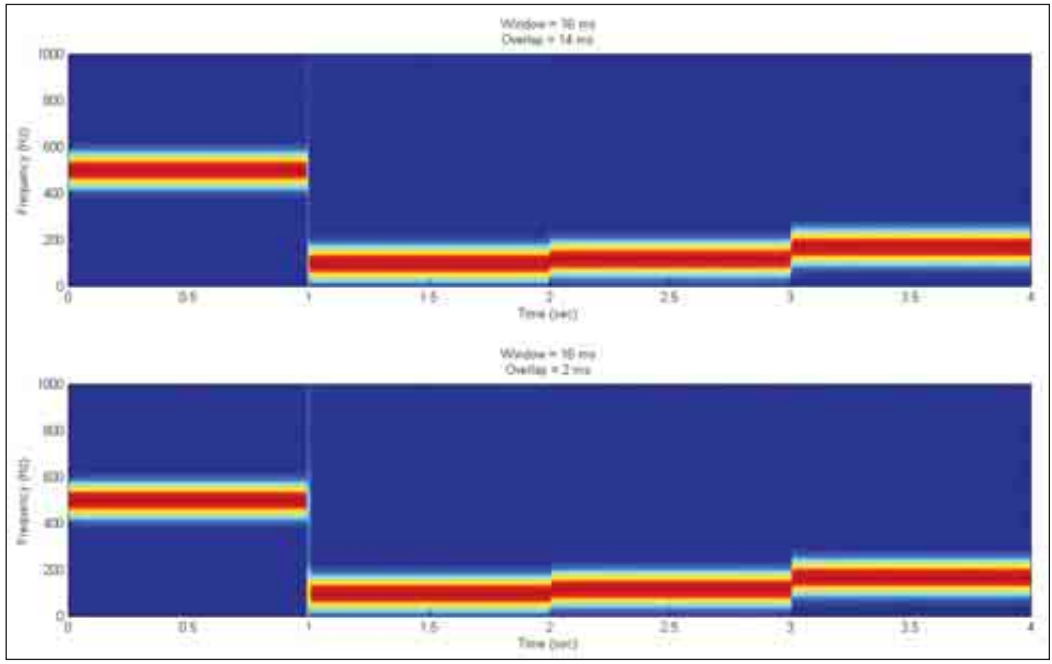

Figure 12. Sinogram of signal x(t) with a narrow window and high time resolution.

The sinogram of x(t) is shown in Figure 11. The parameters used for this were a wide time window of 128 ms, but with two sets of overlap conditions. A second sinogram was also plotted with a narrow time window of 16 ms, and shown in Figure 12.

As expected, a wide time window yielded a better frequency resolution, and a narrow time provided better time resolution. Also, a greater amount of overlap generally provides better resolution in frequency and time, and this is especially evident when comparing the crossover regions of the wide time window sinogram at frequency 100Hz to 110Hz from time 2 to 3 sec.

3. Sinogram of a Delta Function

It is useful to analyse the Radon transform of a delta function. The Radon transform of a function *f(x,y)* is defined as:

$$\Re_\theta(\tau,\theta)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\tau-x\cos\theta-y\sin\theta)dxdy$$

This following analysis is significant as, in the sequel, the target is assumed to be made up of a composition of individual scatterers, and each scatterer is modelled with a delta function.

Consider two delta functions located at *(x1, y1)* and *(x2, y2)*, then ,

$$f(x,y)=\delta(x-x_1)\delta(y-y_1)+\delta(x-x_2)\delta(y-y_2)$$

and:

$$\Re_\theta(\tau,\theta)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}[\delta(x-x_1)\delta(y-y_1)+\delta(x-x_2)\delta(y-y_2)]\delta(\tau-x\cos\theta-y\sin\theta)dxdy$$

$$=\delta(\tau-x_1\cos\theta-y_1\sin\theta)+\delta(\tau-x_2\cos\theta-y_2\sin\theta)$$

$$=\delta(\tau-r_1\sin(\theta-\phi_1))+\delta(\tau-r_2\sin(\theta-\phi_2))$$

where $r_n=\sqrt{x_n^2+y_n^2}$, and $\phi_n=\arctan\left(-\frac{y_n}{x_n}\right), n=1,2$

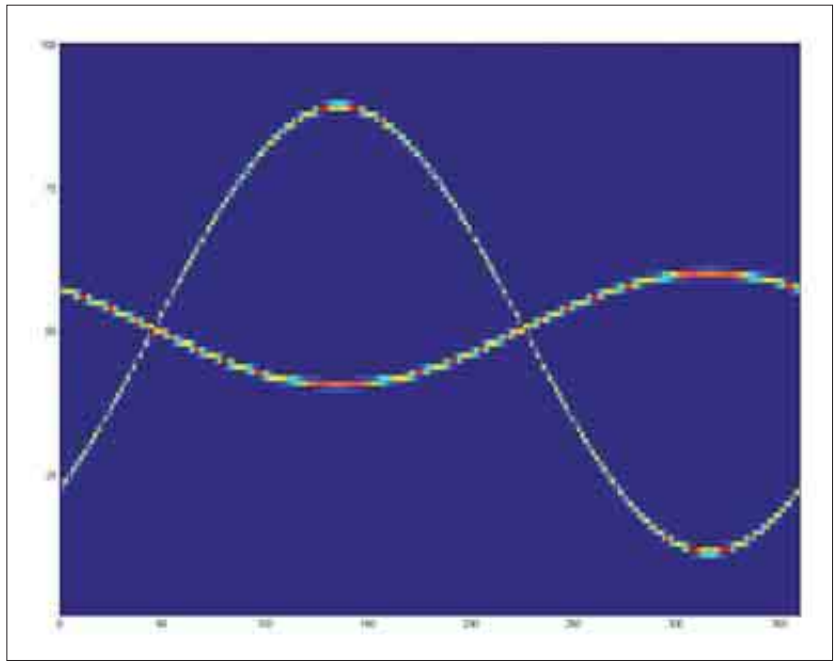

Figure 13. Sinograms of a pair of delta functions at (10,10) and (60,60).

The above shows that the Radon transform of a two point scatterers are a pair of sine curves, and that these curves are distinct from each other, as shown in Figure 13.

It is noted that when a delta function is at the centre of the grid (corresponding to a physical SAR scenario where the circular flight profile is directly centred on the target), the sinogram is a straight line. As the delta function is placed further from the centre of the grid, the amplitude of the sine wave increases. Depending on which side of the grid the delta function is placed (physically, this corresponds to the relative positions between SAR aircraft and the target), the phase of the sine wave is shifted accordingly. Although not immediately apparent from the figures below, the frequency of the sine wave is determined by the linear (or rotational) speed of the aircraft.

In summary, a Short-Time Fourier Transform is performed on the received signal, s_N, to obtain S_N, which corresponds to the Radon transform of the target. Since the Radon transform of a delta function is a sine wave, and if the target is assumed to be made up of discrete scatterers, each modelled by a delta function, then the Radon transform of the target will be a sinogram consisting of a series of sine waves with different phases and amplitudes. An Inverse-Radon transform process, which is the subject of the next section, is then applied to the sinogram in order to reconstruct an image of the target.

D. Inverse-radon Transform

A brief introduction was given earlier on the Inverse-Radon process, implemented via the two-step Filtered Backprojection method, as a means to reconstruct the image of the target from

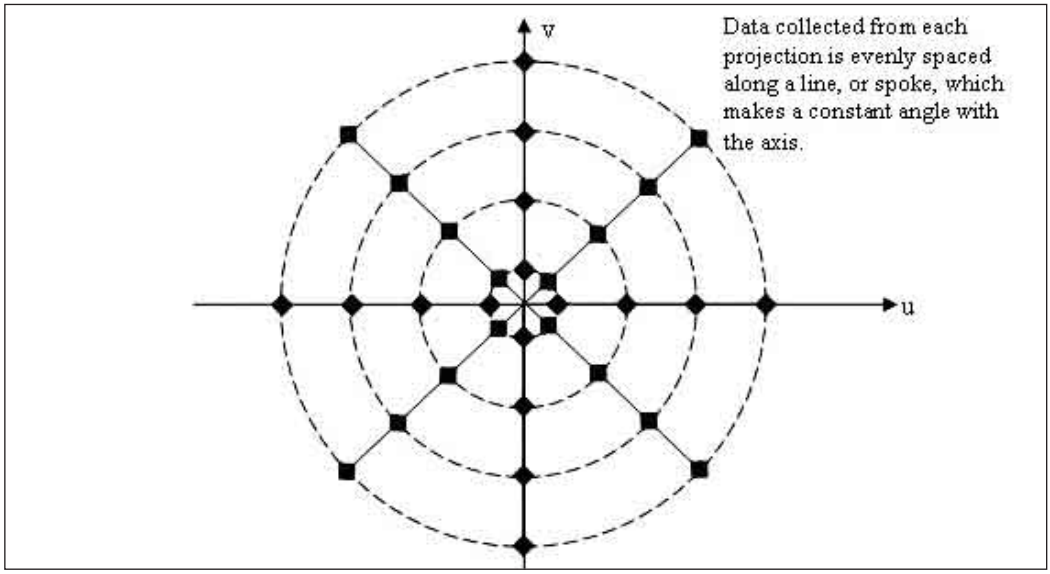

Figure 14. Data points evenly spaced along a spoke result in higher density of points near the centre.

the sinogram. The first step is a filtering process, which can be visualised as a simple weighting of each projection in the frequency domain. The second step is the backprojection process, which is the successive addition of the filtered projections in the appropriate coordinates in the *x*-*y* plane, thereby obtaining a reconstruction of the original image. These two steps will be further elaborated in the following sections.

1. Filtering Process

Recall that the Fourier Slice Theorem relates the projection of the image along a line in the time domain to another line in the Fourier domain via a Fourier transform. Consider a single projection and its Fourier transform. If the values of the Fourier transform of the projection are inserted into their proper place in the object's two-dimensional Fourier domain, then a simple reconstruction (based on only one set of projections) had effectively been performed.

It is noted, however, that in the *u*-*v* plane, the data points resulting from various one-dimensional transformations lie on diverging spokes of constant θ. When the projections are collected in the *u*-*v* plane, sampling rates (or in the case when numerical simulation is used, the discrete FFT points) result in data points being evenly spaced along that particular spoke. This is illustrated in Figure 14. This results in a high concentration of data points at the centre of the u-v plane. The density of the radial points becomes sparser as the distance from the centre increases.

Therefore, the aim of the filtering process can be thought of as applying appropriate weights to the data collected in order to account for the differing densities at different locations based on their radial distance from the centre. It is expected that the weighting function should have a smaller value when close

to the centre and a relatively larger value when the distance from the centre increases. Keeping in mind that the projections are taken over a frequency w, it turns out that the weighting factor is simply |w|. This will be shown mathematically in the subsequent section, where the factor of |w| actually represents the Jacobian for a change of variable between polar coordinates and the rectangular coordinates required for the Fourier transform.[12] The physical interpretation of the weighting factor is as explained above. The aim of this filtering process is to facilitate a simple reconstruction via the backprojection process, which is explained in the next section.

2. Backprojection Process

The final reconstruction is found by adding together the two-dimensional inverse Fourier transform of each of the weighted projections. Since each projection has been properly weighted, and gives only the values of the Fourier transform along a single line, the image reconstruction is a simple and even smearing of the filtered projection over the corresponding line in the image plane. The weighting process performed previously was to enable each projection to contribute evenly to all the pixels along the appropriate line AB in the x-y plane, as illustrated in Figure 15.

3. Mathematical Implementation of the Filtered Backprojection

The concept of the Filtered Backprojection process to implement an Inverse-Radon transform has been explained, and the mathematical implementation will now be presented.

Recall that for an inverse Fourier transform, the object function, f(x,y), can be expressed as:

$$f(x,y)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}F(u,v)e^{j2\pi(ux+vy)}dudv$$

A change of coordinate system from rectangular to polar is performed in the frequency domain, i.e., from *(u,v)* to *(w,θ)*, by making the coordinate and differential substitutions:

$$u=w\cos\theta$$
$$v=w\sin\theta$$
$$dudv=\frac{\partial(u,v)}{\partial(w,\theta)}dwd\theta=|w|dwd\theta$$

The inverse Fourier transform of a polar function is thus:

$$f(x,y)=\int_{0}^{2\pi}\int_{-\infty}^{\infty}F(w,\theta)e^{j2\pi(x\cos\theta+y\sin\theta)}|w|dwd\theta$$
$$=\int_{0}^{2\pi}\left[\int_{-\infty}^{\infty}|w|F(w,\theta)e^{j2\pi(x\cos\theta+y\sin\theta)}dw\right]d\theta$$

This equation can be applied in the Filtered Backprojection process when the following substitutions for the terms in the square brackets are made:

$\tau=x\cos\theta+y\sin\theta$, the line about which the projection is taken, and

$F(w,\theta)=\Im_{\theta}(w)$, where $\Im_{\theta}(w)$ is the Fourier transform of $\Re_{\theta}(w)$

The resulting equation is:

$$f(x,y)=\int_{0}^{2\pi}\left[\int_{-\infty}^{\infty}|w|\Im_{\theta}(w)e^{j2\pi w\tau}dw\right]d\theta$$
$$=\int_{0}^{2\pi}Q_{\theta}(x\cos\theta+y\sin\theta)d\theta$$

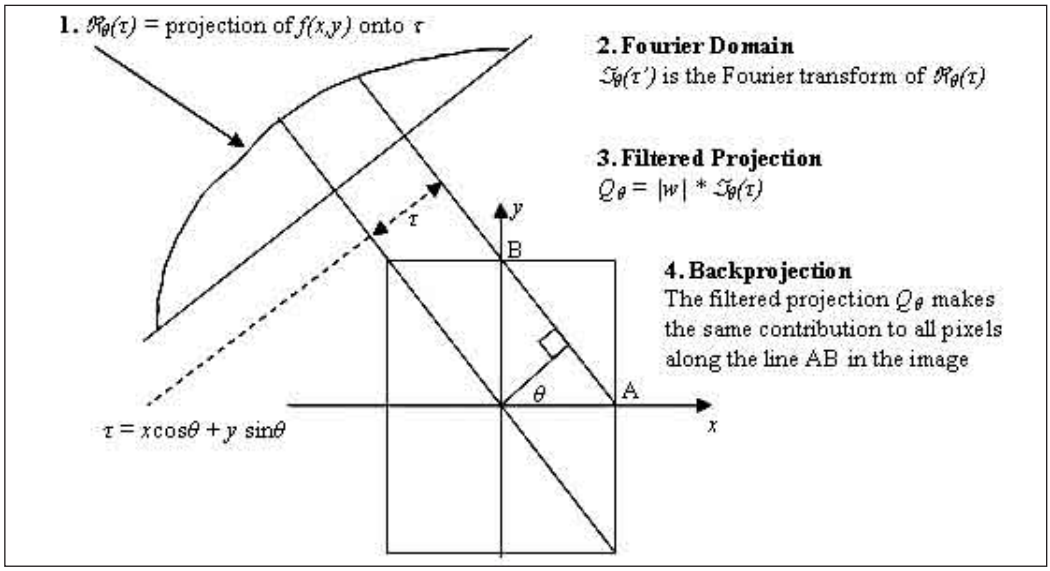

Figure 15. Overview of the reconstruction process.[13]

where

$$Q_\theta(t) = \int_{-\infty}^{\infty} |w| \mathfrak{I}_\theta(w) e^{i2\pi w t} dw,$$

which is the inverse Fourier transform of

$$|w| \mathfrak{I}_\theta(w).$$

$|w| \mathfrak{I}_\theta(w)$ represents the filtered projection, and the physical explanation for multiplication by |w| is the compensation for the decreasing density of data points as the distance from the center increases. The resulting projections for different angles θ are then added to reconstruct an image of $f(x,y)$.

Thus, we have formed an estimation of $f(x,y)$ from the projection data $\mathcal{R}_\theta(\tau)$. The Filtered Backprojection algorithm is summarised as follows, and shown in Figure 15.

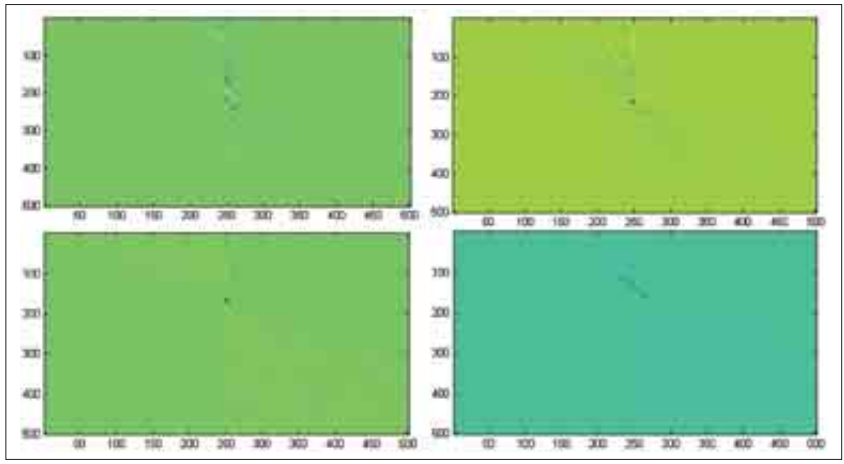

Figure 16. Image reconstruction of three delta functions in a straight line (upper left), and individual images of each of the three delta functions.

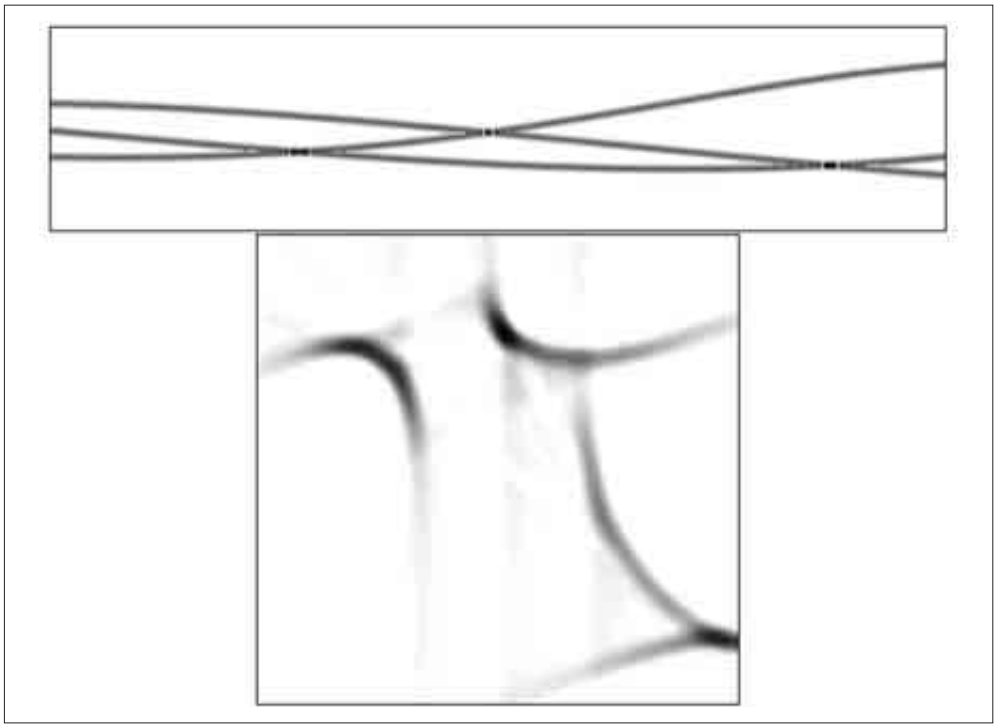

Figure 17. Sinogram (top) and reconstructed image of three point-scatterers.

- The collected data from the change in doppler frequency is $\mathcal{R}_\theta(\tau)$.
- $\mathcal{R}_\theta(\tau)$ is Fourier transformed to obtain $\mathcal{I}_\theta(\tau)$.
- The filtered projection is multiplied by the weighting factor $|w|$, which behaves like a smoothing filter to compensate for the decreasing density of data points as the distance from the centre increases.
- This weighted, filtered projection is backprojected evenly over the image plane along the appropriate line.

IV. Results and Conclusion

A. Results

The image reconstruction scheme using high-doppler resolution data, as described in the previous sections, had been implemented based on the ISAR scenario shown in Figure 10. Using a simple target modelled by various sets of delta functions, the following reconstructed images were obtained.

1. Basic Reconstruction Results

A simple target modelled by three delta functions in a straight line used to check for generic accuracy of the implementation scheme. This is shown in Figure 16. The picture in the upper left corner is the reconstructed image of the original three delta functions. The other three remaining pictures show the locations of the individual delta functions if the original image had consisted of only one single delta function. A comparison of the images will indicate that the implementation scheme is able to distinguish each individual delta function and reproduce the correct image.

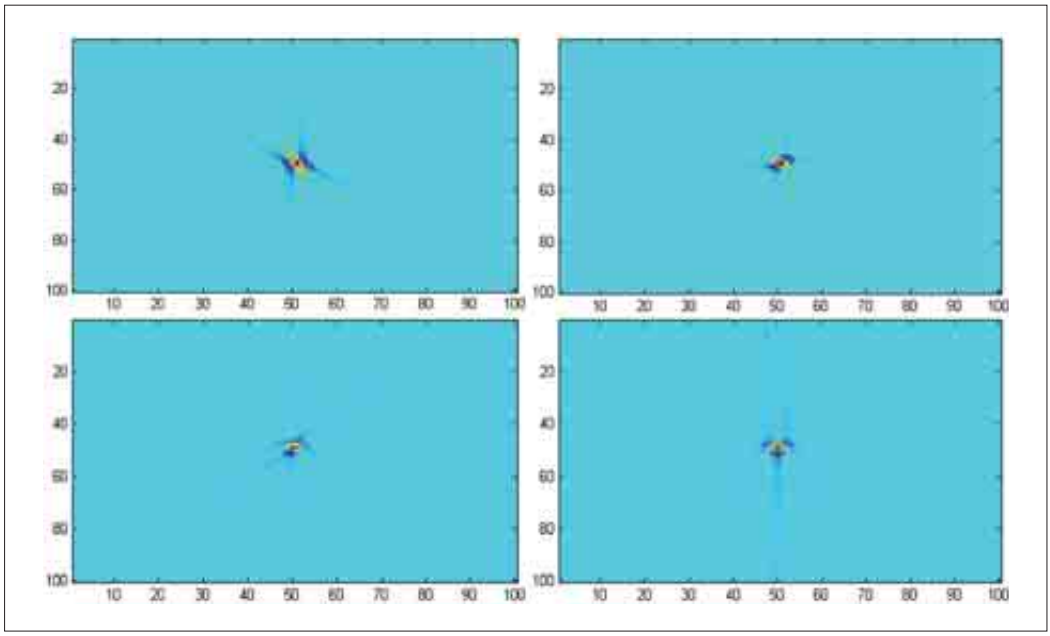

Figure 18. Image reconstruction based on 45°, 90°, 135° and 180° (starting clockwise from top-left picture) views of the target.

The sinogram and reconstructed image of a set of three delta functions is shown in Figure 17. It is also noted that the reconstructed image of each delta function is not a point image, but rather an area of finite size, and that there are "lines" of relatively smaller amplitude extending radially outwards from this point.

The next set of figures show the effects on quality of the image when a different number of "views" is taken of the target. Consider the simple case when the image is a single delta function at the centre of the circular flight path taken by the aircraft and radar in a SAR configuration. The reconstructed image when the aircraft flies 45°, 90°, 135° and 180° around the target are shown respectively (starting clockwise from top-left) in Figure 18. Examining the image when the aircraft flies 45° around the target, it can be seen that there are interference lines radiating from the centre of the target. Similar lines are found in each of the other three pictures such that it can be roughly estimated how much of a perspective the aircraft had taken of the target.

Another analysis on the effects of taking a different number of perspectives of the target can be seen in Figure 19. When more perspectives are taken of the target, a clearer and better resolution image can be obtained.

2. Discussion of Results

The following were noted when analysing the reconstructed images based on high-doppler resolution data.

Firstly, the reconstructed image produced a proportionately scaled representation of the image. The scaling

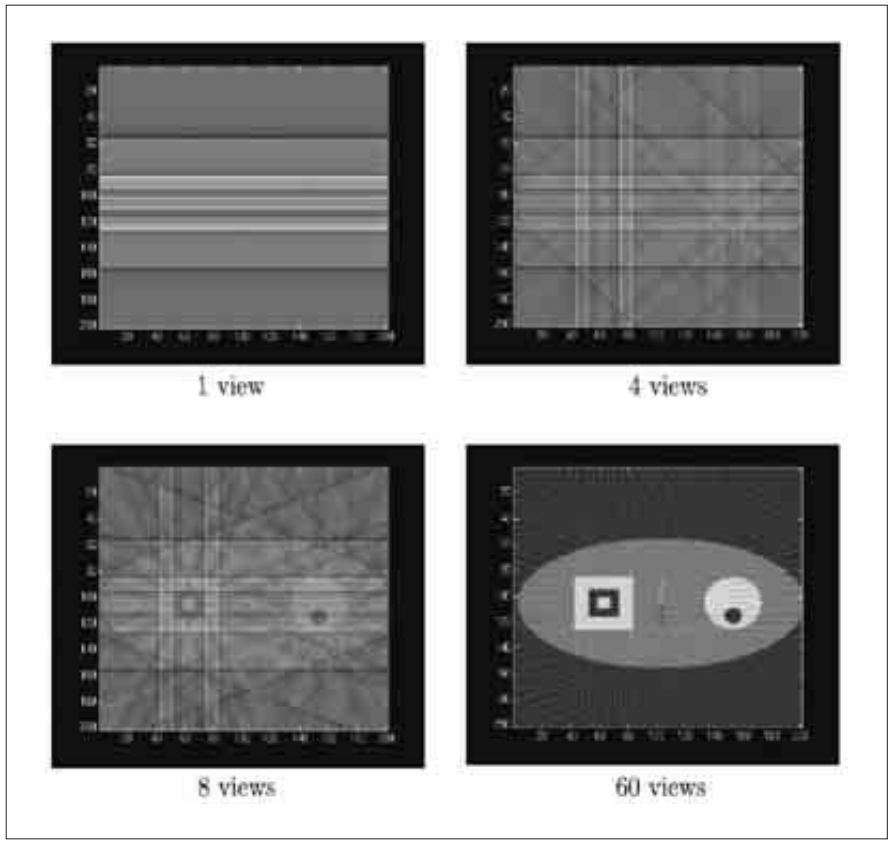

Figure 19. Effect of taking different number of perspectives of the target.

factor depends on a variety of factors such as how the computational Fast Fourier Transform (FFT) was performed to evaluate Fourier transforms and inverse Fourier transforms, window and step sizes for the Short-Time Fourier Transform, and image size output parameters for the Filtered Backprojection algorithm. Thus, some reference on the length scale of the original image is necessary in order to correlate the scaled image with the real image.

Secondly, the number of "perspectives" or "views" of the target from the radar is an important factor is determining the quality of the reconstructed image. An analogy can be drawn with the process of triangulation. When the baselines for triangulation are large, an object location can be triangulated to a higher degree of accuracy. Similarly, when a larger number of perspectives are taken of the target, a better resolution of the image can be obtained.

Thirdly, it is noted that the reconstructed image of a delta function has another point of finite size, and that there are radial lines of comparatively smaller amplitude extending from that point. These lines represent some form of second-order interference patterns originating from the finite implementation (e.g., computational Fourier transforms) of

high frequency components associated with delta functions. By themselves, these interference patterns are seen to be clearly of lower amplitude than the signal forming the image itself. However, when a more complex image consisting of multiple scatterers is analysed, the interference lines from multiple scatterers may begin to form constructive interference and certain points, thereby giving rise to additional peaks in the reconstructed image. This phenomenon can be visualised by examining the above mentioned effects in Figure 16. Nevertheless, when an increasing number of views of the target are taken, the amplitude of the interference lines become progressively smaller so that any apparent images from points of constructive interference are not of significant amplitude, which can be as seen in Figure 18.

B. Conclusion

SAR has traditionally been performed using high-range resolution data. This thesis is a proof-of-concept that the imaging process can be performed using high-doppler resolution data. The system requires a simple continuous wave transmitter, and the signal returns are confined to a narrow band.

High-doppler resolution data is collected along an isodoppler line for different perspectives of the target. This data, a sinogram, is equivalent to taking the Radon transform of the target. The Fourier transform of the sinogram from each perspective (at an angle θ) gives a slice of the two-dimensional transform subtending an angle θ with the axis, with equally distributed points along the line. This results in a higher density of points near the centre. Some form of weighting is necessary. This weighting is part of the Filtered Backprojection algorithm to determine the Inverse Radon transform of the sinogram. The backprojection portion is a simple redistribution of data back along the original projection line.

Images were modelled by delta functions to test the above algorithm. The main points noted were that the reconstructed image was a scaled version of the original image, and that the quality of the image improved when more perspectives of the target were taken.

Acknowledgments

The author would like to express his gratitude to Professor Brett Borden and Professor Donald Walters for their guidance, patience and direction throughout this journey. He would also like to appreciate his wife and confidante, Valerie, for her support and understanding during the period of research.

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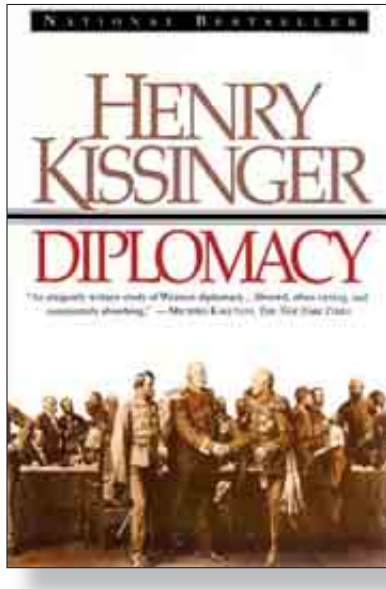
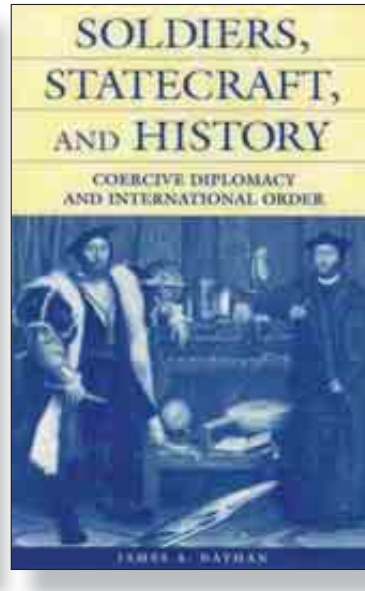
BOOK REVIEW

Diplomacy Revisited

by MAJ Teo Cheng Hang





Henry A. Kissinger, *Diplomacy*

James A. Nathan,
Soldiers, Statecraft and History: Coercive Diplomacy and International Order

Both Kissinger and Nathan examine history with an eye on international affairs, drawing insights from significant historical events, though their objectives vary. This article looks at the objectives and main arguments of each work, and seeks to compare and contrast them in terms of style and structure, strengths and weaknesses, as well as commonalities and idiosyncrasies. Ultimately, each work in its own way contributes in no small measure to the existing body of knowledge in the subject realm.

Nowhere in Kissinger's voluminous book does he explicitly state its objective. However, his introductory chapter on the "New World Order" yields clues. Published in 1994, *Diplomacy* is clearly attempting to make sense of the post-Cold War world only five years after the end of the war and three years after the fall of the Soviet Union. The one statement I most attribute the objective of his book is this:

"Yet the rise and fall of previous world orders based on many states – from the Peace of Westphalia to our time – is the only experience on which one can draw in trying to understand the challenges facing contemporary statesmen."

Indeed, in *Diplomacy*, Kissinger does exactly this; painstakingly relating the sequence of world events from the period just prior to the peace of Westphalia in 1648 to the time of writing. In doing so, he draws various parallels between the behaviours of states and statesmen – more the latter than the former it seems – from different periods in history. These parallels are frequent as they are insightful. One example is the comparison made between Tsarist Russia in the 18th century and Soviet Union two hundred years later. Kissinger shows that the same Russia under both regimes undertook continuous expansion in Central Asia in an effort to preserve its security.[1] He also draws the parallel that Russia in both times needed to expand or else would "implode and collapse".[2] It is remarkable that the prognosis remained the same for the same country despite the polar opposites of the regime in power. The parallels that Kissinger draws in *Diplomacy* suggest a kind of constancy about the affairs of state. Such parallels seem to suggest that different individuals, when put in the same situation, would act in the same way – perhaps a triumph of interests over culture and ideology.

One could sense that there are two parts to this book. In the very first chapter, Kissinger makes the comparison between the intellectual and the statesman, claiming that "there is a vast difference between the perspective of an analyst and that of a statesman".[3] He then goes on to list the myriad constraints and pressures that statesmen work under, none of which the analyst ever has to contend with. Kissinger would know. It is apparent that this man wears both analyst and statesman hats at various points of *Diplomacy*. He starts off his account of international history undoubtedly as a detached analyst, occasionally putting on the statesman hat when he makes a comparison with a contemporary event. The former White House insider makes the transition from analyst to statesman – mere observer to active player – when describing the events in which he himself was the National Security Advisor, and subsequently Secretary of State to President Richard Nixon. Whether it is as analyst or statesman, Kissinger writes with such authority; as though he was physically present throughout the events described in the book. However, the fact that he was indeed an active participant in the latter sections of the book, does take away a certain level of authenticity from those very sections – an accusation that a few have levelled against the book.

To some extent, Nathan – very much both an observer and player in his own right – could be included amongst the said group of accusers. Though he rightly compliments *Diplomacy* as "engaging and magisterial", Nathan calls those "statesman" chapters in the book "exculpatory".[4] The lead-in paragraph to those disastrous Vietnam years said it all, commencing with "it all began with the best of intentions", and ending with a highly suspect sweeping statement: "The countries under the American umbrella were enjoying peace, prosperity, and stability".[5] Nathan's remark could virtually be vindicated just from this opening paragraph.

As for his own publication, Nathan devotes *Soldiers* to what he calls "the essence of diplomacy and statecraft".[6]

In his introductory chapter, he makes two propositions: that "limited force has enduring utility"; and that force "needs to be informed by more than a narrow definition of the national purpose".[7] He goes on to argue that "the successful management of foreign policy requires the conscious integration of force and diplomacy".[8] At first read, this argument evokes the legendary Clausewitzian dictum of war – the use of military force – being an instrument of policy.[9] Indeed, Carl von Clausewitz is quoted in this book with such frequency, it is hard to think the author did not have the greatest Western military theorist constantly at the back of his mind throughout the construction of this work. Clausewitz would agree with Nathan's argument for the amalgamation of force and diplomacy. If, according to Clausewitz, the use of force is the practice of policy by other means, then surely the combination of diplomacy and the use of force – the two major components in the conduct of foreign relations – comprehensively constitutes foreign policy in practice.

Clausewitz aside, Nathan goes about substantiating his thesis by relating specific chosen events in history. He first points to the Thirty Years War that culminated in the Peace of Westphalia, which Nathan claims brought about "a more constrained kind of warfare and international politics".[10] Subsequent portions of the book see the author raise other events in international politics in an episodic fashion – in contrast to *Diplomacy's* chronological, systematically sequential account of history. *Soldiers*, however, is not confined by monumental world events but instead is free to pick and choose those that suit the author's purpose. Certain historical events related in the book may even be seen as relatively obscure – Nathan uses Britain's approach to the competing colonial powers of the United States in Venezuela and Germany in South Africa in the late 19th century as a parallel to what the US could possibly do with a rising power like China today.[11]

Unlike many political science works today, technical jargon and scientific analysis are totally absent from *Diplomacy* and *Soldiers*. Both works look at events from a purely historical perspective – to borrow from the words of Allison and Zelikow, an "artist" view, as opposed to the "scientist" angle.[12] Nathan even manages a dig at what he thought was an over-scientific approach to international relations in some quarters, writing that most disciples of the subject think that it is "closer to geometry and calculus than the real stuff of conflict or the nature of epoch-changing ideas".[13] However, Allison and Zelikow prove a welcome arbiter to the two opposing camps, saying "if a common ground exists between the artists and the scientists, that ground is explanation…central to both enterprises is an attempt to understand and explain why events occurred."[14]

Kissinger in his writings seems to suggest that good diplomacy and the proper conduct of international affairs is not for the mediocre – he does it almost with an elitist bent. Nowhere is this more apparent than in his comparative description of Emperor Napoleon III and Otto von Bismarck. On Napoleon III, Kissinger had virtually nothing good to say, preferring to focus on his

mistakes and bad decisions. Juxtaposed against Napoleon III, Bismarck looked good indeed. Perhaps it was because Bismarck and Kissinger shared an allegiance to the practice of *Realpolitik*. Kissinger contrasted the greatness of the great with the mediocrity of the mediocre almost to the point of caricature – almost everything the great did was right, and virtually everything the mediocre did was not. To Kissinger, it seemed as though only the truly great statesmen men made great foreign policy, and the rest made bad foreign policy. The conduct of international affairs, it seems with Kissinger, is clearly for great statesmen – ordinary mortals could not hope to aspire to such heights.

The comparison between Bismarck and Napoleon III – as well as detailed descriptions and analyses of various political personalities in the rest of this book – is indicative of the importance in international affairs that Kissinger places on the individual. For much of his account of world history, it was about Richelieu in the pre-Westphalian period, Frederick the Great in the 18th century, Bismarck in the pre-World War I period, and the various personalities that make up 20th century history. In Chapter 24, the actions of France as a state was almost completely attributed to Charles de Gaulle: his thoughts, background and actions – there was virtually no mention of the French government as a collective, nor were there any reference to any other personalities in the French government of the time. Clearly, in heavily focusing on individuals throughout his book, Kissinger sees the individual as a critical factor, if not the critical factor, in the way history proceeds.

Nathan, in contrast to Kissinger's descriptive characterisation of each protagonist and his actions, uses a highly narrative style to relate history and substantiate his thesis. While the weight of Kissinger's account is on the characters, Nathan's focus is very much on the events themselves. Most of his words are directed towards the narrative, and much less than Kissinger does Nathan emphasise the role and nature of the individual and his actions. Where Kissinger would incisively probe the person's actions to great detail – as he did at the onset to President Woodrow Wilson and Wilsonianism in Chapter 1 – Nathan's focus would mostly fall on the narration of the actions of the players, letting the reader perform the character judgment and analysis.[15]

Kissinger could sometimes be guilty of oversimplification – the feeling is that, at certain points in *Diplomacy*, he relates history in a way that allows him to bypass the vexing complexities involved, enabling him to draw a line on events by pronouncing crisp and simple verdicts on them. An example was a generalisation of the events leading to World War I, when he wrote "historically, alliances had been formed to augment a nation's strength in case of war; as World War I approached, the primary motive of war was to strengthen the alliances".[16] Knowledge of the explanations presented in other eminent historical works takes some shine away from Kissinger's seemingly profound pronouncement.

Much as these two texts provide an authoritative and comprehensive view of international politics, there is just one criticism of both – the lack of

a non-Western perspective. The angle taken in these works has been decidedly and monolithically Western. That they represent probably the best of the existing body of knowledge reflects the paucity of writings in the English language covering the two other major civilisations – Asian, to include China, Japan and India; and Muslim, to include all of the Middle East. Coverage of these two major groups among these books is limited and insufficiently recent. China and Japan were mostly introduced around the end of the 19th century, while the Middle East was properly discussed only after the First World War was done and dusted. Kissinger in his "New World Order" rightly mentions China, India and Japan as the new powers.[17] The Middle East has been a troubled but significant region for some time and looks to be so in the foreseeable future. There exists, in my opinion, an urgency to extend the collective study, exemplified by the works of Kissinger and Nathan, to include the history of these two civilisations. Such an extension would do well to inform the current students of international affairs, and in turn, the future administrators of foreign policy.

All in all, the criticisms do not detract from the achievements of both pieces of work. In my opinion, each book has exceeded what its respective author set out to achieve. In doing so, each has also, in its own unique way, contributed immensely to the existing body of knowledge. Their contrasting styles and perspectives provide the necessary diversity that is required of a well-rounded education in the subject of international politics.

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FEATURED AUTHOR

Henry Kissinger

Henry Alfred Kissinger is arguably the most famous American diplomat of the 20th century. Born in Germany in 1923, Dr. Kissinger escaped Nazi persecution and moved to New York in 1938. While in military training in 1943, he was naturalised a US citizen. He received his B.A. degree *summa cum laude* at Harvard College in 1950 and received M.A. and Ph.D. degrees from Harvard University in 1952 and 1954 respectively. In the period from 1954 to 1969, he was a member of the faculty of Harvard University, in both the Department of Government and the Center for International Affairs. He was also Director of the Harvard International Seminar from 1952 to 1969. From 1973 to 1977, he served as the US Secretary of State. In addition, he was Assistant to the President for National Security Affairs from 1969 to 1975. At different periods in his life, he became a consultant to several governmental boards and agencies, some of which include the Department of State, US Arms Control and Disarmament Agency and National Security Council. Presently, he holds the position of Chairman at Kissinger Associates Inc.

During his illustrious career, Dr. Kissinger received several awards, notably the Nobel Peace Prize in 1973, the US Presidential Medal of Freedom (the highest civilian award in the US) in 1977 and the US Medal of Liberty (one-time award for twelve outstanding individuals chosen as representatives of the most distinguished naturalised citizens of US) in 1986. He has also written many books and articles on the foreign policy of the US, international relations and diplomatic history. With his first hand account of the international incidents, he is able to depict the many scenarios with clarity and conviction. Moreover, his critical analysis provides the depth to make his books intellectually engaging.

One of Dr. Kissinger's earlier and better known books, *Nuclear Weapons and Foreign Policy* (1957) highlights the challenges, the dilemmas and the impact of the impending nuclear age. This book won the Woodrow Wilson Prize in 1958 for being the best in the fields of government, politics and international affairs. In the foreword to the abridged edition of 1969, Gordon Dean, Chairman of the United States Atomic Energy Commission from 1950 to 1953, described it as having "an immediate and profound impact on American thinking about the political world" in which they lived with "such terrible insecurity" when it was first published. He also feels that it is "the most profound and constructive study that has yet been made of one of the toughest problems" faced by the US. Penned in the period of a intense nuclear arms race between the two superpowers, *Nuclear Weapons and Foreign Policy* primarily discusses about the changes to the global situation with the advent of nuclear weapons. It examines the notions of both an all-out war and limited war and also reflects on global politics, particularly US relationships with the Communist nations, China and the Soviet Union. Understanding the mindsets of these two countries were crucial to ensuring peace and stability and Dr. Kissinger freely voices his insightful opinions in this book. His work is concerned with not just the potential adversaries, but also the relationships forged with other democratic countries and non-aligned nations and how America's stance on nuclear weapons undoubtedly affects these important ties. The book concludes with a chapter on the need for a new strategic doctrine to tackle the nuclear issue and also highlights the importance of several improvements to the US military organisation at the time. These include a closer interaction and cooperation between the different Services to deal with new technologies and threats and also new forces – Strategic and Tactical – to handle all-out and limited warfare. Though some of his propositions did not materialise or were proven incorrect, this book is still worth a read as it displays the maturity of thought that had propelled Dr. Kissinger onto the world stage.

Dr. Kissinger resumed his prolific writing career after his public service and penned down his experience in the White House. The result was an epic memoir consisting of three volumes – *The White House Years* (1979), *Years of Upheaval* (1982) and *Years of Renewal* (1999). The first volume begins with his rise to the post of National Security Advisor to Richard Nixon in 1969 and ends with the Paris Peace Accords for the Vietnam War in 1973. The second resumes the story with Nixon successfully winning his second term in office while the third and final instalment starts with the premature end of Nixon's term and follows through with Dr. Kissinger's final days in office. Throughout this massive trilogy, Dr. Kissinger gives much valuable first-hand accounts of many momentous events. These include the Strategic Arms Limitation Talks (SALT) which helped to calm the tensions arising from new technologies and weapons. The Vietnam War was another ground-shaking incident which created the many question marks hovering over America's future military involvements. During this time, Dr. Kissinger also

oversaw Détente – the thawing of Soviet-US relations. The incidents of the Cold War during his term were captured by his keen eye for details, analytical mind and masterful description. In the works, he is able to guide the reader step-for-step through the decision-making process his administration undertook before each action. Another delightful aspect of this memoir is his vivid sketches of the contemporary leaders which supplement his story with a personal touch. A brilliant and seminal masterpiece, his three-volume memoir will form an important chronicle of American diplomacy during the 1970s. It is therefore an essential read for political scientists, especially students of international relations.

Another of Dr. Kissinger's works, *Does America Need a Foreign Policy?: Toward a Diplomacy for the 21st Century* (2001) puts more focus on the recent events across the globe. *Amazon* describes it as "brief and comprehensive – (an) excellent introduction to international relations and diplomacy". In *Does America Need a Foreign Policy?*, Dr. Kissinger travels from continent to continent, setting the stage for America's involvement by identifying the historical and cultural characteristics of each continent. Through this, he highlights the underlying factors which make each place special. He advocates the policy of *Realpolitik*, using diplomacy and military might to maintain the peace and stability for global economic growth. This example is evident in his career when he decided to engage the Communists through Détente. He also explores the growing and evident trends such as globalisation and humanitarian intervention, tackling the former's attendant promises and disruptions. By putting them into the context of how they will affect US national interests, he gives a sublime perspective on these issues. In a not-so-subtle manner, he also pushes for a more active role by the US in key areas around the world, such as the Middle East, in order to regain the credibility and respect it needs to function as a superpower. On the whole, Dr. Kissinger showcases his forte and wealth of experience on traditional security topics and balancing international powers. It is hence without a doubt that he favours an affirmative answer to his book title.

One of Dr. Kissinger's latest books, *Ending the Vietnam War: A History of America's Involvement in and Extrication from the Vietnam War* (2003) tracks the course of the Vietnam War. The book was written through the eyes of a relatively unknown Harvard Professor who later rose to the apex of American government as Nixon's principle foreign policy advisor and Secretary of State. He has carefully selected several chapters from four previous books, and rearranged and rewrote them to give a better picture of the events in this "black hole of America historical memory". As a major player in US foreign policy, Dr. Kissinger is able to provide a behind-the-scenes look into the whole situation which makes this historical account indispensable. Besides its enriching account of the desperate war situation in Vietnam, it also details the war on the home front – the fierce antiwar movements and disagreements within Congress. During this tumultuous period, the conflict between US idealism and the urge to remain grounded in the

pragmatic world of international power-play is cast into the spotlight in this book. Hence, *Ending the Vietnam War* is a good source of knowledge on American politics during the Vietnam War. In addition to its colourful content, Dr. Kissinger's gifted prose makes the sections documenting his day-to-day, face-to-face skirmishes with the North Vietnamese in Paris especially thrilling.

Henry Kissinger is, unquestionably, an authority on international relations. He possesses plenty of experience in this area and is a scholar of the first rank. Having braved through several watershed events in recent American history, he is well-respected as an elder statesman as well as a visionary. Not many can claim to have had such an impact on the world as he did in the last century. With his influential works and speeches, he provides the world with an incisive perspective into global politics and relations. *POINTER* is indeed pleased to do a write-up on this exceptional individual.

World War I – Against the Odds
Major-General Paul von Lettow-Vorbeck

To commemorate the 90th anniversary of Armistice Day, which ended active operations for World War One, *POINTER* is proud to present a new four-part series under the theme of "Against the Odds". Under this series of Personality Profiles, we will feature four remarkable commanders who overcame great adversity to achieve victory. For this issue, the focus is on Major-General Paul von Lettow-Vorbeck, Commander of German forces in East Africa.

Introduction

One of the most successful asymmetric campaigns of the modern era took place in East Africa during World War I. This campaign was waged by German forces or *Schutztruppe* under Major-General Paul Emil von Lettow-Vorbeck who was the only undefeated German commander in World War I. When the First World War broke out in 1914, few gave the isolated and hopelessly outnumbered German forces in East Africa any chance of surviving attacks by British troops. Major-General Paul Emil von Lettow-Vorbeck proved his detractors wrong by remaining undefeated as he was able to convert his tactical advantages such as familiarity with the terrain and quality of troop training into strategically significant factors. His force, which never exceeded 15,200 at any time managed to hold down a quarter of a million enemy troops.[1]

Background

Lieutenant-Colonel von Lettow-Vorbeck, a veteran of the Boxer Rebellion in China and the Hottentot and Herero Rebellions in German West Africa arrived to take command only six months before the outbreak of WWI. German East Africa (modern Tanzania) was surrounded by potentially hostile territories on all sides. Its barely 3,000-strong garrison was mostly equipped with the Model 71 Mauser, a loud early breech-loader which gave off a lot of smoke with every shot. This greatly inhibited stealth, a vital factor in bush warfare.[2] The colonial Governor, Dr Heinrich Schnee impeded military preparations, hoping to keep the colony out of the War by diplomatic means. With British naval supremacy all but guaranteed and no chance of substantial reinforcement, von Lettow concluded that his mission was to draw enemy attention and resources away from the main theatre in Europe for as long as possible.[3]

Tanga: A Resounding Initial Victory

Surveying the lie of the land (mostly on foot), von Lettow concluded that he had to concentrate his field companies near the border with British East Africa (modern Kenya) in the north. This was the main corridor of invasion the British were likely to use. Unfortunately, by late October 1914, the British had assembled enough forces from India to launch two strong attacks, one through the northern corridor (Force "C" 4,000 men) and another by amphibious assault in the south at Tanga (Force "B" 8,000 men). Either force was larger and much stronger than von Lettow's small mostly *askari* (African soldiers) command. German East Africa was expected to be easily overwhelmed by the giant pincer movement.

Von Lettow decided to leave a small detachment to delay Force "C" while he re-deployed his scattered field units to take on Force "B". Meanwhile, the 17th Field Company in the port of Tanga held a two-brigade British force at bay, inflicting 300 casualties on a two-battalion initial attack with the help of some police *askaris*. British overconfidence and dithering allowed von Lettow to arrive two days after the battle began. With four *Schutztruppe* and three weaker companies and no artillery, the Germans faced a cruiser and howitzer-supported force more than eight times their number. Von Lettow nonetheless decided to risk it all as his supply situation did not permit a purely guerrilla campaign at this point. As the British forces concentrated on attacking his weak right flank, von Lettow seized the initiative by throwing his reserves against the enemy's exposed 101st Grenadier Battalion. This precipitated a rout amongst the less experienced British units which eventually resulted in a humiliating evacuation by sea. On top of an immeasurable boost to morale, von Lettow solved his immediate supply problems by capturing enough modern rifles for three field companies, sixteen machine-guns, half a million rounds of "smokeless" ammunition and all of Force "B's" field telephones. The *Schutztruppe* received further supplies and converted naval guns from the *Konigsberg* and *Kronberg*, two German ships which were sunk after inspired

resistance against overwhelming odds. Force "C" also suffered a stinging defeat at the hands of the small German northern force. These victories cowed the British into staying on the defensive, giving von Lettow a whole year to recruit more troops and prepare the colony for prolonged resistance.[4]

The 1916 British Offensive: Von Lettow Tears the Heart Out of Two Enemy Contingents

Von Lettow was even more elated when 20,000 South Africans and the famous former Boer leader Jan Smuts were added to the British forces. British East Africa also became the first British territory to adopt conscription. Smuts brought air support and armoured cars along with his expertise and some big names in manouevre warfare and bushcraft.[5] The Germans now commanded the serious enemy attention he sought.

"Jannie" Smuts did not intend to let von Lettow fight a prolonged campaign by falling back at will. The youngest Lieutenant General in the British Army intended to manoeuvre his much larger forces to encircle the Germans whenever they tried to make a stand. Von Lettow read his moves like a grandmaster. Familiarity with the terrain gave him the tactical edge he needed to defeat the theoretically sound British strategy. Encircling manoeuvres entailed splitting up one's forces, making them liable to defeat in detail if they could not support one another. The *Schutztruppe's* mobile field companies alternated between hit-and-run tactics and large-scale pitched battles on well-prepared ground of their choosing, inflicting heavy casualties on their eager but less well-trained opponents.

Disease, thirst and hunger also took a heavy toll on British columns overly reliant on animal and motorised transport in unfamiliar territory. The Germans knew better, relying on porters who were just as adept as *Askari* soldiers at infiltrating British block positions. They also maintained control of the Central Railway system for most of 1916, allowing for rapid re-deployment of troops and the massive *Konigsberg* 4.1 Inch guns, which wreaked havoc on large British concentrations easily sighted from a distance. While the Germans were losing territory, they avoided losing numbers and the ability to carry on the fight. As British General Jacobius Van Deventer lamented, "On paper, our opponents were encircled. In practice, it worked out differently, for the cordon we had established was full of loopholes...through which men with knowledge of woodcraft could escape."[6]

Smuts captured the lightly defended coastal ports by amphibious landing and forced von Lettow into the southern half of German East Africa. However, the beginning of 1917 saw record rain which completely stalled the offensive. Troops from the Caribbean, Nigeria and the Gold Coast began to replace Indian and white South African units, which were invalidated out of the war in large numbers. Smuts compounded the situation by declaring that the campaign had passed into a mopping up phase when he was promoted to the Imperial War Cabinet in London.

His successor General Hoskins knew better. He was rebuilding a shattered force nearly from scratch, sucking in resources badly needed in other theatres as von Lettow intended. The Germans were just as miserable with their greatly reduced rations but improvisation allowed them to avert starvation. The now 8,400-strong *Schutztruppe* were fulfilling their mission, the estimated 15,000 British forces still in the field were failing theirs.[7]

1917: Stand or Surrender, or so the British Assumed

Hoskins learned quickly, expanding the Kings African Rifles (KAR), the highly capable Sudanese contingent of his army to make up for the shortage left by Indian and South African invalidations. He also increased the ratio of porters to soldiers from about 1:3 to 4:1 in preparation for fighting in a region with few roads. Inexplicably, General Deventer was promoted to take his place when the offensive began in May 1917. Von Lettow was also promoted to Major-General.

Deventer planned on using the same encirclement strategy Smuts had employed by moving his blocking force inland from the captured port of Lindi. He intended to avoid the debacles of the past by pressing far more aggressively along the landward front, accepting the need to take casualties in the process. With von Lettow running out of space in German East Africa, Deventer believed that he could end the campaign before the winter rains arrived.

Von Lettow did eventually decide to take on the landward attack in a full-scale set-piece battle at Mahiwa, in part because he believed that the British force commander Brigadier Beves would throw "his men into action regardless of loss of life" as he had done at Latema-Raeta in early 1916. More than half the 4,900-man British force became casualties, while the *Schutztruppe* loss a fifth of that number. On paper, the Germans could ill afford even such a favourable attrition rate since it was now cut off from all sources of recruitment. But von Lettow knew that the long fighting retreat was coming to an end anyway. He just chose to inflict the maximum amount of damage he could before he was forced to abandon all heavy equipment. However, the Germans were far from defeated. They trimmed their forces to 2,000 men and decided to emulate Smut's Boer exploits by marauding in enemy territory. The *Schutztruppe* would tie down far more enemy forces in this final stage of the East African Campaign than ever before.[8]

The Guerrilla Phase

The Schutztruppe marches into Portuguese territory.

Portuguese East Africa (modern Mozambique) was by nature far less hospitable to human habitation than its German counterpart. The Portuguese

however, made von Lettow's mission an easy one, leaving isolated stores in the hands of inadequate garrisons. The capture of Namacurra allowed the Germans to discard most of their outdated Model 71 Mausers. They now had more ammunition than they could carry, three hundred tons of food and plenty of liquor as well! British and Portuguese forces rushed to stop the Germans from rampaging further south but von Lettow turned back and marched toward the northeast, nimbly dodging past the two main forces sent to capture him. The Germans then routed a two-battalion force sent to cut them off from the port of Mozambique at the Namirrue River. Such hasty actions were punished severely. As Deventer re-deployed his forces to trap von Lettow in Mozambique, the Germans headed west for British Nyasaland. In this manner, the *Schutztruppe* retained the initiative, tying down many times its number to static defences.

After another supply bonanza at Numarroe, von Lettow was poised to invade Nyasaland. Instead, he opted to return to German East Africa, hoping to force Deventer to redeploy his main forces by sea. He could then strike in a different direction with his pursuers badly wrong-footed. Meanwhile, a worthy opponent emerged in *Kartucol*, the KAR's elite column nipping at the *Schutztruppe's* heels. Its commander, Lieutenant-Colonel George Giffard did not try to outmanoeuvre its quarry in bush country when he managed to locate them. Instead, his *askaris* would immediately assault the Germans in strength since the latter could no longer afford significant casualties. This whittled von Lettow's force down to two hundred Germans and one thousand four hundred *askaris* by the end of September 1918. Three epidemics, including the dreaded smallpox, also ravaged the Germans at this time. The *Schutztruppe* barely escaped annihilation at the battles of Lioma and the Pere Hills.[9]

Upon reaching German East Africa however, von Lettow's forces began to recover in better climate and renewed access to vast food supplies. Many of his porters deserted to return to their families but the Germans obtained enough live cattle to create a walking ration train. As Deventer deployed his main forces to block the *Schutztruppe's* path, von Lettow moved southwest and invaded lightly-guarded Northern Rhodesia. As he contemplated his options, either attacking Belgian copper mines in the Congo or driving toward Portuguese West Africa (modern Angola) and the Atlantic, the capture of an enemy messenger informed him of the signing of the Armistice. Von Lettow's efforts outlasted the War itself.[10]

Von Lettow's celebrated return to Germany

Conclusion

General von Lettow-Vorbeck knew everything military manuals taught about asymmetric warfare and much more. Though his opponents opened up the possibility of a protracted campaign through poor co-ordination and overconfidence, ultimate credit must go to the courage and foresight of the amazing German commander. Von Lettow constantly sought to invite trouble – he could not help the main War effort unless he irritated and threatened his enemies out of all proportion to his physical resources. This meant raiding across the border to force the British to come at him in strength while small detachments and the inland waterways German "fleet" kept secondary enemy columns at bay. Taking full advantage of local knowledge, he then eroded his attacker's ability to sustain the fight by wearing down selected columns, leaving nature to ravage whatever remained. Von Lettow broke the back of the South African and the early Indian contingents this way, drawing in more enemy forces from further afield. His adversaries also made the mistake of assuming that the *Schutztruppe* could only fight well on its own territory simply because it had chosen to stay there for as long as practicable. This left them completely unprepared for the last "commando" phase of the campaign even though their Commander-in-Chief was a past master of such operations. There is no telling how much longer von Lettow could have "twisted the lion's tail", but the prospects of stopping him were remote when the Armistice brought hostilities to an end.[11]

Endnotes

1. Accounts range from under 200,000 to more than 500,000 but 250,000 is the most widely accepted figure. See Edwin P. Hoyt, *Colonel Von Lettow-Vorbeck and Germany's East African Empire,* (NY: Macmillan Publishing House Co., Inc. 1981), p203; Charles Miller, *Battle for the Bundu: The First World War in East Africa,* (NY:Macmillan Publishing Co., Inc.1974), front jacket.
2. Miller, *Battle for the Bundu,* p39.
3. JR Sibley, *Tanganyikan Guerrilla: East African Campaign 1914-18,* (London: Pan Books Ltd. 1971), p6.
4. Miller, *Battle for the Bundu,* pp55-72.
5. Jacobius Van Deventer was Smuts right-hand man in the famous Cape raid during the Boer Wars. Pieter Pretorious was a legendary Tarzan-like bushman who was instrumental in bringing the celebrated resistance of the *Konigsberg* party to an end. 64 year-old Lieutenant Frederick Courtney Selous was a well-known big game hunter and naturalist who gave his name to post-war Rhodesia's famous Selous Scouts. Von Lettow lost Tom von Prince, his legendary *Schutztruppe* predecessor early in the campaign at Tanga.
6. Miller, *Battle for the Bundu,* p248.
7. Ibid, pp250-260.
8. Ibid, pp283-291; Hoyt, *Colonel Von Lettow-Vorbeck,* pp163-8.
9. Miller, *Battle for the Bundu,* pp316-8.
10. Hoyt, *Colonel Von Lettow-Vorbeck,* pp169-200.
11. Miller, *Battle for the Bundu,* p321.

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