CHARLES UNIVERSITY

FACULTY OF SOCIAL SCIENCES

Institute of Political Studies

Department of Political Science

Bachelor's Thesis

2023 **Jaroslav Maxa**

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David and Goliath: Aspects of Air Warfare in the China-Taiwan Confrontation

Bachelor's Thesis

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Study programme: Political Science and International Relations

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Year defended: 2023

Declaration

1. I hereby declare that I have compiled this thesis using the listed literature and resources only.
2. I hereby declare that my thesis has not been used to gain any other academic title.
3. I fully agree to my work being used for study and scientific purposes.

In Prague on May 1st, 2023 Jaroslav Maxa

References

MAXA, Jaroslav. *David and Goliath Aspects of Air Warfare in the China-Taiwan Confrontation.* Praha, 2023. 61 pages. Bachelor's thesis (Bc). Charles University, Faculty of Social Sciences, Institute of Political Studies. Department of Political Science. Supervisor RNDr. Jan Kofroň Ph.D.

Length of the Thesis: 131 546 characters (with spaces)

Abstract

The prospect of a Chinese invasion of Taiwan and the impact it would have on the region has been a subject of concern for many years. The aim of this thesis is to analyze the potential outcome of air warfare in such an event, focusing on changes in Chinese and Taiwanese military capabilities over time. Drawing on previous RAND Corporation research published over the past two decades, this thesis examined two aspects of a potential Chinese invasion, the possibility of a disarming strike against Taiwanese air defenses and air bases, and the possible outcome of air warfare. To accomplish this, the critical variables from previous studies were examined and the development of their values was assessed through a mixture of quantitative and qualitative analysis. The thesis finds that China currently has the upper hand in military capabilities, making it unlikely that Taiwan could sustain a full-scale air war without U.S. support. The study also discusses possible future developments in the contest for air superiority over Taiwan in the next decade and offers policy implications for Taiwan to maintain close ties with its allies and invest in its military capabilities, especially air defense.

Abstrakt

Možnost čínské invaze na Tchaj-wan a její dopad na region vyvolává obavy již řadu let. Cílem této práce je analyzovat potenciální výsledek letecké války v případě čínské invaze se zaměřením na změny čínských a tchajwanských vojenských schopností v průběhu času. Na základě předchozích výzkumů společnosti RAND Corporation publikovaných v posledních dvou desetiletích tato práce zkoumá dva aspekty potenciální čínské invaze, a to možnost odzbrojujícího úderu proti tchajwanské protivzdušné obraně a leteckým základnám a možný výsledek letecké války. Za tímto účelem byly zkoumány kritické proměnné z předchozích studií a vývoj jejich hodnot byl posuzován prostřednictvím kombinace kvantitativní a kvalitativní analýzy. Práce dochází k závěru, že Čína v současné době disponuje převahou ve vojenských schopnostech, takže je nepravděpodobné, že by Tchaj-wan dokázal obstát v plnohodnotné letecké válce bez podpory USA. Studie se rovněž zabývá možným budoucím vývojem v soupeření o vzdušnou převahu nad Tchaj-wanem v příštím desetiletí a nabízí možné politické implikace pro Tchaj-wan, aby udržoval úzké vazby se svými spojenci a investoval do svých vojenských schopností, zejména do protivzdušné obrany.

Keywords

Taiwan, China, Airforce, Warfare, Asia, Deterrence

Klíčová slova

Tchaj-wan, Čína, letectvo, válčení, Asie, odstrašení

Název práce

David a Goliáš: Letecká válka v Čínsko-Taiwanské konfrontaci

Acknowledgment

First of all, I would like to thank RNDr. Jan Kofroň, Ph.D. for his advice regarding this thesis, for the time he invested in this project and for the endless consultations he had to endure. Without him and his professional guidance, there would be no thesis. I would like to thank my family for their constant support throughout my studies. Finally, I would like to thank my girlfriend for her endless support and valuable advice regarding the intricacies of mathematics.

Contents

Abbreviations

PRC	People's Republic of China
ROC	Republic of China
CASI	China Aerospace Studies Institute
CCP	Chinese Communist Party
BVR	beyond-visual-range
AAM	air-to-air missile
SRBM	short-range ballistic missile
MRBM	medium-range ballistic missile
PGM	precision-guided munition
LACM	land-attack cruise missile
LGB	laser-guided bomb
GPS	Global Positioning System
IDF	Indigenous Defense Fighter
ROCAF	Republic of China Air Force
PLAAF	People's Liberation Army Air Force
AMRAAM	Advanced Medium-Range Air-to-Air Missile
SOF	special operations forces
CVBG	carrier battle group
USAF	United States Air Force
CEP	circular error probable
SAM	surface-to-air missile
JICM	Joint Integrated Contingency Model
MRL	multiple rocket launcher
GLCM	ground-launched cruise missile

ALCM	air-launched cruise missile
IADS	integrated air defense system
CAP	combat air patrol
SEAD	Suppression of Enemy Air Defenses
SHORAD	short-range air defense
MOS	minimum operating strip

Introduction

In recent decades, we have seen the effects of what some call the "power shift to the East" and others call the "Asian Century," the economic rise of Asian countries, and especially the unprecedented economic rise of the People's Republic of China (PRC). The rise of China as a major regional power caused concern in the United States, which feared losing its position as the regional hegemon. This concern led to the adoption of the Barack Obama administration's "Pivot to Asia" foreign policy initiative, which sought to strengthen the U.S. position in the region. Efforts to contain China's growing power and influence in Asia and around the world have continued into the presidencies of Donald Trump and Joe Biden.

Many scholars of international relations in recent decades have argued that the region of Asia is the most likely place for the next international conflict, and it is the possible conflict between the PRC and the Republic of China (ROC) that would pose the greatest danger of escalating into an open conflict between the rising power of China and the established great power of the United States. China has long considered Taiwan to be an integral part of its territory, and Chinese officials often speak of peaceful reunification, but with the deterioration of China-Taiwan relations following the election of President Tsai Ing-wen and the massive opposition of the Taiwanese public to any form of unification, the threat of Chinese military action is increasing. Unification would severely jeopardize the U.S. position in the region, as Taiwan's economic and geographic importance makes it a potential breach point in the so-called first island chain. The U.S. has long maintained a policy of "strategic ambiguity" as a means of deterrence, but President Biden's recent statement that the U.S. would commit military resources to Taiwan in the event of a Chinese attack and House Speaker Nancy Pelosi's recent visit to Taiwan indicate a shift in U.S. rhetoric toward Taiwan and, together with preparations for new arms sales to Taiwan, demonstrate the growing threat of conflict and U.S. understanding of the need for stronger deterrence.

The conflict between China and Taiwan could take many forms. In this thesis, I have focused on the scenario of a full-scale invasion. In recent years, many experts considered such an invasion highly unlikely, assuming that such a large-scale conventional war was a thing of the past, but the recent invasion of Ukraine teaches us that it is still a very real threat and that it is "… much closer to us than most think," according to the head of the U.S. Indo-Pacific Command, Admiral John Aquilino (Lendon 2021). His predecessor, Admiral Phil Davidson, even offered a date, stating that China could invade Taiwan by 2027 (Shelbourne 2021).

Two prerequisites for a successful invasion of Taiwan would be Chinese sea and air supremacy. My thesis builds on reports published by researchers at the RAND Corporation over the past few decades dealing with aspects of a possible air war over Taiwan. I have attempted to answer the question "*How have changes in Chinese and Taiwanese military capabilities influenced the likely outcome of a possible struggle for air superiority over Taiwan, based on previous research?*".

The previous reports published by RAND used their Joint Integrated Contingency Model, a theater simulation system, to model possible outcomes of a fight for air superiority, but since this system is not available to the public and I have been unable to find a suitable replacement, I have attempted to identify the critical variables in their research, that have most influenced the achieved outcomes, and through a mixture of quantitative and qualitative analysis based on available data, assess the most probable values of these variables today, and thus conclude whether the probability of a Chinese victory would now increase or decrease. I decided to try to assess possible future developments of the contest for air supremacy over Taiwan in the next decade, instead of analyzing the possible course of the air war over Taiwan in 2030, as I had originally planned. Based on my findings and on publications predicting possible developments in the region, I have attempted to briefly answer a secondary question: "*How will the likely outcome of a possible struggle for air superiority over Taiwan change in the next decade?*".

Besides the introduction and conclusion, the thesis is divided into several chapters. In the first chapter, I introduced the reports on which my thesis is further built, their methodology, and their achieved outcome. The second chapter discusses the methodology of the research. In the third chapter, I have tried to determine the values of the discussed variables based on the available data and answer my main research question. The chapter is divided into two subsections, the Chinese missile threat, and air combat which also discusses the possible U.S. involvement and Taiwanese air defense systems. The final chapter is divided into three subsections, in the first I have presented how the results of my thesis contribute to the discussion of Taiwan's deterrence, in the second I have discussed the possible future development of the research variables and answered the follow-up research question, and in the third, I have offered policy implications arising from the results of my research.

1. Previous research

The history of the China-Taiwan confrontation dates back to the Chinese Civil War which ended de facto in 1949 with the victorious Chinese Communist Party (CCP) under Mao Zedong founding the People's Republic of China and the defeated Kuomintang forces led by Chiang Kai-shek forced to retreat to Taiwan proclaiming Taipei the new temporal capital of the Republic of China. The conflict continued with escalations in the years 1954 and 1958 called the First and Second Taiwan Strait Crisis, which included the use of artillery, air and naval engagements, and amphibious operations. Despite the gradual thawing of relations since 1979, the third crisis occurred between 1995 and 1996 with the PRC conducting military exercises and missile tests due to fear that the ROC is moving away from the One-China policy.

During the presidency of Ma Ying-jeou in Taiwan (2008-2016), the relations between the PRC and the ROC have probably reached an all-time high, but Chinese leaders never abandoned their aim of China-Taiwan unification. This improvement in relations resulted in increased optimism about the possibility of peaceful unification but was soon thwarted by the election of pro-independence president Tsai Ing-wen.[1] Since then the pro-independence sentiment in Taiwan only increased, making peaceful unification quite unlikely. Chinese leadership reflected this in the speech of the CCP spokesman before its 20th National Party Congress, reassuring that peaceful unification is China's first choice, but stating that "China reserves the right to use force over Taiwan as a last resort in compelling circumstances" (Pollard 2022).

The tensions in the Strait are rising in the last few years, with an extensive increase in both aerial and naval incursions into the Taiwan territory every year (Lee 2021; Ang U-Jin and Suorsa 2022). The visit of Nancy Pelosi, the speaker of the House of Representatives, to Taiwan then resulted in probably the most serious escalation since the Third Taiwan Strait Crisis with China conducting missile tests and extensive military exercises. This escalation raised concern in light of Chinese efforts to acquire the capability to take Taiwan by 2027 leading to the introduction of the Taiwan Policy Act of 2022 in the U.S. Senate, "the most comprehensive restructuring of U.S. policy towards Taiwan since the Taiwan Relations Act of 1979" which is supposed to increase U.S.-Taiwan military cooperation and Taiwanese defense capabilities (LaGrone 2021; Montgomery and Bowman 2022).

[1] For more information about the influence of Ma Ying-jeou's presidency on cross-Strait (in)stability read Yves-Heng Lim, "The Future Instability of Cross-Strait Relations: Prospect Theory and Ma Ying-Jeou's Paradoxical Legacy," *Asian Security*, 14:3, 318-338, 2018, https://doi.org/10.1080/14799855.2017.1355302

Although escalation to a full-scale invasion of Taiwan is relatively unlikely, it is a scenario that needs to be thoroughly researched and analyzed in order to be deterred. For such an invasion China would need to possess sufficient naval and amphibious capabilities but both navies and armies are extremely unlikely to prevail in a battle or a war without enjoying either command of the air or air supremacy (Edmonds 2004, 11). Therefore, in the following pages, I will discuss the issue of air warfare in the China-Taiwan confrontation.

1.1 Air Warfare over Taiwan between 2005 and 2016

My research will primarily build on three reports produced by researchers at the RAND Corporation, an American non-profit organization that helps improve policy and decision-making through research and analysis. These three reports together offer a valuable overview of changes and the development of variables that would shape air warfare in possible China-Taiwan confrontation in the 21st century. In this chapter, I will introduce the methodology, the results, and the findings of these reports. The first report, from 2000, attempts to determine the results of air and naval warfare in a scenario of a possible Chinese invasion of Taiwan in 2005, and serves as an introduction to the topic of this thesis for the general reader; readers of this thesis who are familiar with the topic may skip this section, as my thesis is primarily based on the second and third reports (Shlapak et al. 2000). The second report from the year 2009 builds on the previous one adding a political dimension of a possible invasion, this time in the year 2013, and taking a deeper look into the issue of ballistic missiles and air warfare, abandoning the naval warfare dimension (Shlapak et al. 2009). The third report from the year 2016 then concerned itself more with the question of ballistic missiles and primarily air defense in scenarios of different levels of conflict (Lostumbo et al. 2016).

1.1.1 Air Warfare in 2005

In a 2000 report titled *Dire Strait? Military Aspects of the China-Taiwan Confrontation and Options for U.S. Policy* researchers David A. Shlapak, David T. Orletsky, and Barry Wilson tried to model a scenario of a possible Chinese invasion of Taiwan in the year 2005. They assessed that the first two steps China would undertake almost simultaneously for a successful invasion would be a fight for air superiority and a struggle for maritime control (Shlapak et al. 2000, 10). The authors decided to focus their attention on these two aspects of a possible invasion as they are the prerequisites for a successful amphibious or airborne invasion of such scale that an invasion of Taiwan would represent (Shlapak et al. 2000, 11). Based on a reading of existing literature and discussions with experts the authors formulated initial variables (Shlapak et al. 2000, xv). These variables were then tested in a set of model runs, using Joint

Integrated Contingency Model (JICM), a deterministic theater combat model developed by RAND, which was previously used in numerous other studies (Shlapak et al. 2000, 12). After this, the authors conducted 1,700 model runs using seven key variables (Shlapak et al. 2000, 12-13):

- "The size and composition of the air forces committed to the attack by the PRC.
- Each side's possession of beyond-visual-range (BVR), "fire-and-forget" medium-range air-to-air missiles (AAMs).
- The number and quality of short- and medium-range ballistic missiles (SRBMs and MRBMs) used by the Chinese.
- The number of advanced precision-guided munitions (PGMs), such as laser-guided bombs (LGBs) and Global Positioning System (GPS)-guided weapons in the Chinese inventory.
- The ability of the Republic of China Air Force (ROCAF) to generate combat sorties.
- The quality of the ROCAF's aircrew.
- The extent, if any, of U.S. air forces, both land and sea-based, committed to Taiwan's defense."

The authors used three values for the variable describing the size and composition of the People's Liberation Army Air Force (PLAAF) committed to the attack: The base case that consisted of 679 aircraft which was the estimate of aircraft that could be operated from Chinese air bases in the vicinity of Taiwan; the big force case with 1,039 aircraft represented a scenario where the PRC committed additional aircraft to take place of those lost in combat; the advanced force case then considered possible rapid modernization of the PLAAF with the same number of aircraft as in the base case, but with more than twice the size of fourth-generation fighters (216 versus 96) (Shlapak et al. 2000, 13-14).

At the time of this report, neither PRC nor ROC possessed weapons with BVR capabilities, but since both sides were seeking to obtain such weapons, China wanted to buy Russian AA-12/R-77 Adder and Taiwan the U.S. AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM), the authors decided to consider four cases of this variable: case in which neither side possesses such weapons; case in which Taiwan obtained AMRAAMs; case in which China acquired AA-12s; and case in which both sides have such weapons in equipment with stockpile for four days of intensive combat (Shlapak et al. 2000, 14-15).

For the variable assessing the impact of SRBMs and MRBMs, the authors used two values: one case consisted of 310 missiles of various types; the other doubled the number to 620 missiles, representing possible Chinese rapid development; the authors assumed that Taiwan would not have any active missile defense by 2005 (Shlapak et al. 2000, 15).

Due to uncertainties regarding PLAAF capabilities, the authors decided to use two cases of numbers of PGMs in the Chinese inventory: one case with a very limited supply of 300 PGMs; the second case with a much larger stockpile of 3,000 PGMs used by PLAAF (Shlapak et al. 2000, 16).

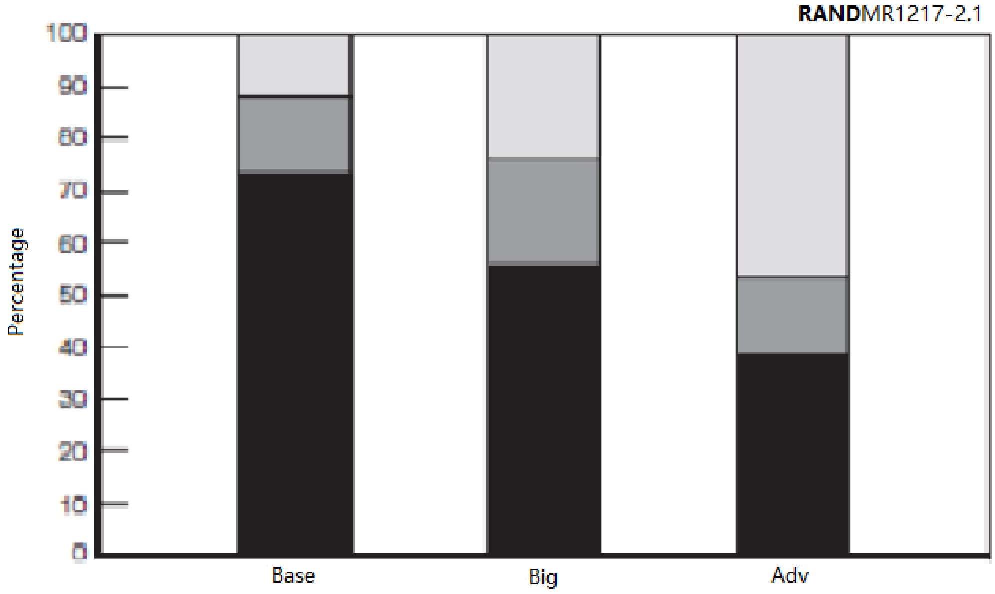
Due to several possible constraints to sortie generation that the ROCAF could experience in a possible invasion, be it air and missile attacks or attacks of Chinese special operations forces (SOF), and due to the inexperience of ROCAF in maintaining sortie generation under wartime conditions, the authors decided to use three values of sortie generation: 100 percent of baseline; 75 percent of baseline; and 50 percent of baseline (Shlapak et al. 2000, 16).

In analyzing the quality of ROCAF aircrew the authors based their research on unclassified estimates of flying hours and on conversations with experts from the U.S. and Taiwan, which led them to the conclusion that a ROCAF pilot is probably about 80 percent as well-trained as a U.S. pilot, while an average PLAAF pilot is probably only about half as good as his U.S. counterpart. But to achieve more representative results on the importance of pilot quality to combat outcomes, the authors decided to use two values for this variable: 80 percent of a U.S. pilot; and a more pessimistic 60 percent of a U.S. pilot (Shlapak et al. 2000, 16).

Due to uncertainties connected to the possible U.S. engagement in the Chinese invasion of Taiwan, the authors decided to consider six different levels of U.S. combat involvement: no engagement of U.S. forces; engagement of a single carrier battle group (CVBG) operating east of Taiwan; engagement of a single wing of United States Air Force (USAF) 72 F-15C fighters at the time stationed at Kadena Air Base on Okinawa; engagement of one CVBG and one fighter wing from Kadena; engagement of two CVBGs; engagement of two CVBGs and one fighter wing (Shlapak et al. 2000, 17).

The authors then scored the air war in each model run using the PRC-ROC exchange ratio, the number of PLAAF aircraft downed for every ROCAF plane lost, as the measure of merit. Then they evaluated every outcome based on the ratio of both sides' committed air forces before combat and the total losses after four days of combat. Cases in which the ROC achieved an exchange ratio 50 percent greater than the opening force ratio the authors scored as "green" (high probability of denying the PRC invasion opportunity), as "yellow" were classified cases in which the final exchange ratio was less than the "green" threshold but greater than the

Figure 1.1 Overall Outcomes



Note: "Green" outcomes are shown as black, "yellow" as dark grey, and "red" as light gray
Source: Shlapak et al. 2000, 26

opening force ratio, and as "red" were labeled all cases in which the exchange ratio dropped below the "yellow" threshold (Shlapak et al. 2000, 25).

The results of the research can be seen in Figure 1.1 categorized into three columns based on the values of the PRC air force composition variable. As we can see, the ROC was able to thwart the Chinese attempt at achieving air superiority in almost 90 percent of the cases (both "green" and "yellow" outcomes can be seen as "victory" for Taiwan) if it stood against the base case PLAAF, and in about 75 percent cases against the big case force. A different result was shown in cases when the ROCAF faced the modernized advanced force. Only in about 50 percent of the outcomes was the ROC able to deny Chinese air superiority.

In Table 1.1 the authors assessed which variables and their values had the biggest impact on "red" outcomes, cases when the Chinese were able to obtain some degree of air superiority. Quite clearly the most impactful variable was "limited U.S. involvement" (defined by the authors as no U.S. involvement, one CVBG, or one fighter wing), which played role in 100 percent of "red" outcomes in the base case, and 81 and 62 percent in big force and advanced force cases (Shlapak et al. 2000, 26). Two other very important variables, involved in 80 percent of the base case and about ¾ of the big force case "red" outcomes, were the PRC BVR superiority and the suppression of the ROC sorties (cases in which the ROC sortie generation reduced to 50 or 75 percent). A less important role played poor ROCAF training, the number of Chinese tactical ballistic missiles, and the number of PRC PGMs which had an impact only

Table 1.1 Impact of Parameter on "Red" Outcomes

Parameter	Base Case	Big Threat	Advanced Threat
Limited U.S. involvement	100%	81%	62%
PRC BVR superiority	80%	71%	51%
ROC sorties suppressed	80%	75%	64%
Poor ROC training	67%	65%	54%
More PRC TBMs	56%	52%	51%
More PRC PGMs	56%	54%	48%

Source: Shlapak et al. 2000, 27

in 67 and 56 percent of the base case "red" outcomes.

From their research, the authors concluded that any Chinese attempt at an invasion would be, at least in the near term, "a very bloody affair with a significant probability of failure" and to keep it that way, they identified key findings that both the ROC and the U.S. should pay very close attention to (Shlapak et al. 2000, xvi). For air warfare, these findings are (Shlapak et al. 2000, xvi-xvii):

- "Taiwan's air bases must remain operable.
- The ROC must maintain at least parity in advanced air-to-air weaponry.
- Pilot quality may be Taiwan's ace in the hole.
- U.S. involvement is important now and will likely grow increasingly vital."

1.1.2 Air Warfare in 2013

In the year 2009 researchers David A. Shlapak, David T. Orletsky, and Barry Wilson decided to build on their previous work, this time joined by Toy I. Reid and Murray Scot Tanner, and published a report titled *A Question of Balance: Political Context and Military Aspects of the China-Taiwan Dispute*. The authors continued with their analysis of air warfare during a scenario of the Chinese invasion of Taiwan, this time in the year 2013, looking more deeply into the importance of ballistic missiles and devoting a whole chapter to this issue, while adding the political dynamics of China-Taiwan relations as a new dimension of analysis.

To properly analyze aspects of air warfare in a scenario of the Chinese invasion of Taiwan, the authors decided to devote a separate chapter to the issue of the potential use of missiles, more precisely SRBMs (not including MRBMs and cruise missiles), in an attack on Taiwanese air bases (Shlapak et al. 2009, 32). In assessing the Chinese force of SRBMs, the authors used as a variable not only the number and range of certain types of missiles but also the weight of their

Table 1.2 Characteristics of Notional SRBM

	Notional SRBM
Range (km)	>280
Warhead (kg)	500
CEP (m)	5, 25, 40, 200, 300
Number of missiles	900
Number of launchers	200

Source: Shlapak et al. 2009, 34

warheads, their circular error probable (CEP), and the number of available launchers (Shlapak et al. 2009, 34).[2] From different values of these variables associated with different types of SRBMs, the authors created a notional SRBM using the lowest values for variables of range, warhead, number of missiles and launchers, and several possible CEPs. To model the impact of a potential Chinese missile attack at Taiwanese air bases, the authors conducted simple Monte Carlo computer simulations of strikes at Taiwanese runways, ROCAF aircraft parked in the open, and hangars and maintenance facilities, using the notional SRBM whose exact characteristics can be seen in Table 1.2 (Shlapak et al. 2009, 45).[3]

The authors argued that possibly the biggest threat to ROCAF's ability to operate and generate combat sorties is a Chinese attempt to cut runways at ROC air bases (Shlapak et al. 2009, 35). The most suitable warhead for such an attack would be a specially designed submunition warhead so the authors decided to create their representative submunition warhead that would be part of their notional SRBM and will be used for further simulation. This representative warhead would have a total payload of 500 kg (warhead weight of notional SRBM) and would consist of 82 bomblets each weighing 4.5 kg (of which the HE charge would weigh 2.25 kg and

[2] CEP is a standard form of measurement for the accuracy of missiles, technically defined as "the radius of the circle within which 50 percent of some number of weapons fired at a specific aimpoint will land" (Shlapak et al. 2009, 32). The smaller the CEP, the better the missile's accuracy.

[3] Monte Carlo simulation is a mathematical technique which can be used to estimate the possible outcome of an uncertain event using random sampling from certain probability distributions with a high number of experiment repetition. For more information see for example Kroese, Dirk P., Tim Brereton, Thomas Taimre and Zdravko I. Botev, "Why the Monte Carlo method is so important today," *WIREs Comput Stat*, 6: 386-392, 2014, https://doi.org/10.1002/wics.1314

Table 1.3 Characteristics of Representative Anti-Runway SRBM Warhead

Characteristic	Value(s)
Delivery CEP (m)	5, 25, 40, 200, 300
Warhead weight (kg)	500
Missile reliability (%)	85
Number of submunitions	82
Submunition weight (kg)	4
Submunition HE weight (kg)	5
Submunition lethal radius (m)	2.5
Submunition reliability (%)	85
Submunition pattern radius (m)	25, 45, 90

Source: Shlapak et al. 2009, 40

would create a 1.5 m long crater) with 25 percent of warhead weight devoted to "structure, packaging, post-boost systems, and a mechanism to dispense the submunition payload" (Shlapak et al. 2009, 38-39). To tackle the issue of possible malfunctions, the authors assumed 85 percent reliability for each missile launched and the same reliability for each submunition contained in a representative warhead meaning that with the overall reliability of 72 percent only about 59 bomblets can be expected to arrive and explode (Shlapak et al. 2009, 39).

The authors further assumed that the submunition dispenser in the warhead would be programmed differently for each missile, based on the missile CEP, so they considered three cases for dispersal radius: 25, 45, and 90m (Shlapak et al. 2009, 39). The parameters of a representative warhead can be seen in Table 1.3. The authors then used these characteristics to determine, employing the Monte Carlo simulation, how many missiles of a given accuracy would be needed to cut all 12 runways on all 10 ROC air bases in a way that there was no undamaged portion that could be used for a fully loaded fighter to take off (Shlapak et al. 2009, 37, 42). Through the simulation, the authors find out that the CEP of a missile has a very large impact on the number of weapons required to cut all runways leading to a conclusion that between 60 and 200 missiles would be needed to cut all runways with more than 90 percent chance of success, using missiles with CEP of 5 to 40 meters (Shlapak et al. 2009, 43).

The next target that the Chinese missiles might strike to disrupt the ROCAF's ability to operate is aircraft parked in the open. All Taiwanese air bases have some number of shelters, which would be able to protect a number of ROC aircraft, but in their study, the authors find out that there are not enough shelters for all aircraft, which they highlighted in the case of Tainan Air

Base that had only 45 shelters for 60 fighters based there (Shlapak et al. 2009, 45-47). For this kind of attack, the PRC would still use warheads with submunition, but this time optimized for use against parked vehicles which would for example emphasize "fragmentation and incendiary effects versus armor penetration" with each warhead being able to carry around 800 bomblets (Shlapak et al. 2009, 48). The authors conducted the same kind of simulation as for the runway case, this time using CEPs ranging from 8 to 90m concluding that only around 30 to 40 SRBMs would be sufficient to destroy or damage all aircraft parked at all bases (Shlapak et al. 2009, 48).

Another target the authors considered for the Chinese attack is hangars and maintenance facilities whose destruction or serious damage could lead to a severe reduction in combat sortie generation. For simulating such an attack, the authors once again used a simple Monte Carlo simulation, this time with a unitary warhead which would be needed for better penetration, requiring the missile to strike the building directly with 85 percent reliability (Shlapak et al. 2009, 45). The value of the CEP was very important in this case with around 20 missiles with a CEP of 15 m needed to destroy hangars and maintenance facilities at one base (Shlapak et al. 2009, 45). If the CEP was increased to 30 m the required number of missiles rose to 40 or 60 SRBMs for a single air base (Shlapak et al. 2009, 45).

The authors concluded that despite the quite disproportional ratio of the cost and the possible weight of explosives carried by SRBMs, the missile attack still poses a serious threat to Taiwan with China continuing to add more missiles to its inventory, improving their accuracy and reducing their cost (Shlapak et al. 2009, 51). With its ability at that time, China could launch a big wave of 60 to 200 submunition-equipped SRBMs aimed at all Taiwanese runways severely reducing their ability to defend themselves and giving China the opportunity of a clear sky, at least for several hours (Shlapak et al. 2009, 51). In the end, the authors offered two final findings (Shlapak et al. 2009, 126-128):

- "Taiwan cannot completely keep China from inflicting heavy damage to them, but can, through future possible improvements in air and missile defense, reduce its vulnerability to small, selected strikes and force the PRC to concentrate a considerable number of missiles even in "limited" attacks.
- Probably the only survival strategy for the ROC air force is to hide them in underground hangars that have been constructed at two ROCAF bases. But for this strategy to have some effect, Taiwan would also need to have a number of fighters ready to fly from dispersed strips and mobile surface-to-air missiles (SAMs) with war reverse stockpiles

of radars, launchers, and missiles and highly redundant or reconstitutable command and control systems."

Right after or simultaneously with their initial missile strike the PRC would mount an air attack in an effort to achieve air superiority. The authors tried to answer the question of who would win the air war in their next chapter, building on their report from the year 2000. As their simulating tool, they once again decided to use JICM, but this time they updated and extended their scenario variables to correspond to issues that would be connected to a possible Chinese invasion in the year 2013 (Shlapak et al. 2009, 53, 56). The updated variables were (Shlapak et al. 2009, 57):

- "The size and composition of the air forces committed to the attack by the PRC.
- The relative quality of the PLAAF's aircrew.
- The ability of the PLAAF to coordinate massed air raids and generate multiple sorties per day with its advanced aircraft.
- The presence or absence at Taiwan and U.S. air bases of defenses against PGMs and cruise missiles.
- The size and composition of Taiwan's air force.
- The ability of both the ROCAF and the United States on Okinawa to generate combat sorties from air bases under heavy attack.
- The survivability of Taiwan's SAMs.
- The number of shelters at ROCAF and U.S. air bases.
- The extent, if any, of U.S. air forces, both land- and sea-based, committed to Taiwan's defense."

To assess possible Chinese air force size and composition in the year 2013, the authors created two projections, a base case force consisting of 967 aircraft (631 fighter/multi-role and 336 attack/bomber aircraft) and an advanced case force composed of 770 aircraft (630 fighter/multi-role and 140 attack/bomber aircraft) equipped with an unlimited number of PGMs and 200 cruise missiles (Shlapak et al. 2009, 54-55). These numbers are limited by the number of operational Chinese air bases within the unrefueled fighter range of Taiwan to around 600 aircraft that can be kept in action at any one time with the rest held in reserve and used as a replacement for combat losses (Shlapak et al. 2009, 54-55).

The training of Chinese aircrew was historically evaluated as not very good in comparison to the training of ROCAF or USAF, but due to actions taken by PLAAF to improve the quality of their pilots, the authors decided to look at broad possibilities of quality of Chinese training assessing the value of the variable at 40, 60 and 80 percent of their U.S. counterparts (Shlapak et al. 2009, 58).

Since the PLAAF has never conducted an operation of such magnitude as would full-fledged air war over the Taiwan Strait be, the authors decided to create a variable that would represent possible command-and-control or logistics problems that China could experience: the first case of low-intensity of operations limits PLAAF's sortie generation on the first day to 900 and also limits their ability to conduct large raids by spreading the sorties evenly over daylight hours; the high-intensity case increases the sortie generation of Chinese aircraft to 1200, their full potential, with the majority of sorties concentrated in two massive daylight strike packages (Shlapak et al. 2009, 58-59).

In both cases of the PRC aircraft size and composition China possess a very high number of modern aircraft capable of delivering PGMs which is why the authors decided to not use the number of PGMs as a variable (giving the Chinese unlimited supply of PGMs) and instead, they shifted their attention towards possible short-range defenses against these missiles like local GPS jammers, laser-guided bomb blinders, quick-reacting short-range SAMs, rapid-fire radar-guided guns, and decoys (Shlapak et al. 2009, 59). In one case the ROC does not field such defenses leading to 100 percent effectivity of Chinese PGMs, in the other case anti-PGM defenses are placed at all ROCAF bases and U.S. Kadena and Iwakuni bases on Okinawa, leading to a reduction of PGMs effectiveness by 75 percent (Shlapak et al. 2009, 59).

To offer projections of possible ROCAF size and composition, the authors created again two cases: the base case force consisting of 317 fighters and the advanced case force that increases the number of fighters to 383 (Shlapak et al. 2009, 56).

As the authors concluded in the previous chapter, the Chinese SRBM force has the potential to greatly impact ROCAF's sortie generation through sustained strikes at Taiwanese runways and parking areas. The authors accounted for this by estimating three cases of 20, 40, and 60 sorties (one-sixth, one-quarter, and one-half of fully operational base) generated each day from each ROCAF base and USAF bases on Okinawa (Shlapak et al. 2009, 60).

Because the ROC medium- and long-range SAMs were mainly dependent on fixed radars and launcher installations that could be quite an easy target for attacks involving jamming, anti-radiation drones (China for example possess Harpy drones supplied by Israel), air-launched anti-radiation missiles, and ballistic missiles, the authors decided to model three possible cases of ROC SAM effectiveness reduction based on different types of improvements Taiwan could adopt to preserve SAM effectiveness: base case assumes 50 percent effectiveness reduction each day with 0 percent effectiveness achieved on the second day of combat; the second case assumes 25 percent effectiveness reduction per day, reaching 0 percent effectiveness on the fourth day; the third case considers a scenario of 10 percent effectiveness reduction each day while maintaining a 60 percent SAM efficiency on the fourth day. (Shlapak et al. 2009, 60-61).

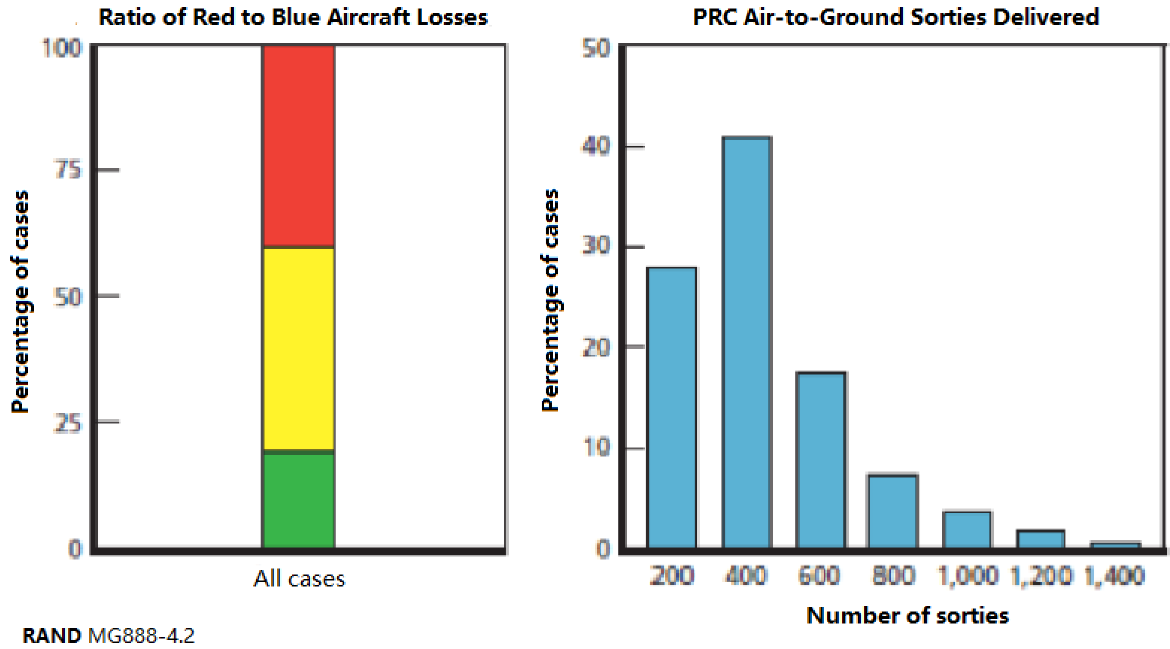
Since the PRC could conduct precise SRBM attacks targeted at any aircraft parked in the open, but lacks such efficiency when targeting planes inside shelters, as the authors have previously concluded, the number of shelters represents an important variable. The authors, as was previously also stated, assumed that China possesses an inventory of 200 cruise missiles that could be capable of destroying up to 70 shelters, according to the authors' assumptions (Shlapak et al. 2009, 61). Against this, the authors through analysis of open sources and unclassified imagery created a base case of 50 shelters at each ROCAF air base (except Hualien and Taitung which have been credited with large underground shelters), 15 shelters at Kadena, and no shelters at Iwakuni (Shlapak et al. 2009, 62). To consider possible modernization the authors also estimated a "high-shelter" case that increases the number of shelters to 66 at each ROCAF air base, 73 shelters at Kadena, and 36 shelters at Iwakuni (enough to shelter all deployed fighters), and "super-shelter" case that represents a possible scenario where the U.S. hardens their shelters at Kadena and Iwakuni and makes them indestructible even by very accurate cruise missiles (Shlapak et al. 2009, 62).

In answering the question of possible U.S. involvement, the authors first assessed possible cases of CVBG involvement amounting to none, one, or two CVBGs, and then calculated possible fighter involvement at Okinawa, assuming cases where no fighters were involved, a wing of 72 F-15Cs or a wing of 72 F-22s from Kadena helped in the fight over Taiwan, in both cases joined by 36 USMC F/A-18C/Ds from Iwakuni Air Base in Japan, and a case where the U.S. relocated its fighters from Kadena to Andersen Air Force Base on Guam and flew one wing of F-22s to Taiwan from there (Shlapak et al. 2009, 62).

Combining these variables resulted in a total of over 31,000 separate cases that were run through the JICM (Shlapak et al. 2009, 63). The achieved outcomes of the simulation were then evaluated, this time according to two measures of merit, the first being the ratio of Red (China) to Blue (Taiwan + the U.S.) losses compared with the initial force ratio between the two sides with the cases being scored as "green" (Blue "win") when the loss ratio was at least 1.5 times the original force ratio, as "yellow" (Blue "marginal win") were categorized all cases where the exchange ratio was at least equal to the opening force ratio, and as "red" (Blue "loss") the authors scored cases with exchange ratio less than the initial force ratio (Shlapak et al. 2009, 67-68). Taking into account the change in the character of the possible air war over Taiwan, the authors decided to add a new measure that would count the number of PLAAF air-to-ground sorties delivered calculated by looking at the total number of the PRC air-to-ground sorties that JICM reported as "successfully penetrating Taiwan's defenses in each attack" and subtracting from it attack devoted to suppressing air bases leaving the number of sorties set to attack other targets as part of an invasion-preparation campaign (Shlapak et al. 2009, 68). Figure 1.2 shows the outcomes of all mentioned cases categorized according to the measures of merit. While in the previous study, the result of the base case ratio of Red to Blue aircraft losses showed almost 90 percent "win" for the Blue side with 40 to 70 percent of cases scored as "green", based on the PRC force used, outcomes of this study showed Blue "win" in only less than 60 percent of cases with only about 20 percent "green" outcomes (Shlapak et al. 2009, 69). The number of air-to-ground sorties delivered varies widely across cases, but overall, about 90 percent of all cases showed 600 or fewer sorties delivered over the four days, with 400 being the most likely number for more than 40% of cases.

In Table 1.4 the authors showed the weight of all used variables in achieving the "green" outcome. The authors highlighted in gray variables that had at least a 3:1 spread in outcomes across their range of values (Shlapak et al. 2009, 70). These variables then can be considered, to some degree, as key variables since their different values lead to the biggest variance in outcomes. These key variables would then be the PRC aircrew quality which could increase the

Figure 1.2 Outcomes of All Cases



Source: Shlapak et al. 2009, 70

number of “red” results from 15 to 60 percent with the quality of training increasing from 40 to 80 percent (Shlapak et al. 2009, 72-73). ROC SAM survivability which led to the Chinese winning 70 percent of cases when 50 percent of SAM effectiveness was reduced each day and to only 25 percent of “red” cases when there was a 10 percent effectiveness reduction per day (Shlapak et al. 2009, 79). The number of Blue shelters then also greatly influenced the outcome with the “low” case leading to a “red” win in over 50 percent of cases in comparison to 25 percent of cases being classified as Chinese win when the “super shelter” value was used (Shlapak et al. 2009, 80). The last variable that could be considered a key variable was the level

Table 1.4 Impacts of Scenario Variables on Outcomes

Variable	Value	% Green
PRC forces	Base	70
	Advanced	30
PRC aircrew quality	40	68
	60	25
	80	7
PRC air operations	Low	43
	High	57
ROC/U.S. PGM defenses	No	27
	Yes	73
ROC forces	Base	46
	Advanced	54
Blue sortie generation	20	43
	40	30
	60	27
ROC SAM survivability	10	55
	25	30
	50	15
U.S./ROC shelters	Low	12
	High	34
	Super	54
U.S. CVBGs available	0	20
	1	32
	2	48
Fighters at Kadena	None	10
	F-15	21
	F-22	27
	Guam	42

Notes: Variables highlighted in gray show at least a 3:1 spread in outcomes across their range of values.

Source: Shlapak et al. 2009, 71

of U.S. contribution which can vary quite significantly, but as the authors surprisingly concluded, it was the "F-22s from Guam" case that allow the Chinese to "win" only about 10 to 30 percent of cases, depending on the possible engagement of U.S. CVBGs (Shlapak et al. 2009, 81-84). Other variables, for example, the size and composition of PRC forces or the existence of Blue PGM defenses had also a very significant influence on the total outcomes, definitely in comparison to the ROC forces or quality of PRC air operations which were surprisingly insignificant.

Since the Nationalists retreated to Taiwan air power was always seen as an advantage for the ROC (Shlapak et al. 2009, 84). This was true also in the year 2000, but with the PRC's progress in creating a stockpile of very accurate SRBMs and rampant modernization of the PLAAF that has led, aside to massive quantitative advantage, to also qualitative parity, the authors concluded that in the year 2009, "a credible case can be made that the air war for Taiwan could essentially be over before much of the Blue air force has even fired a shot" (Shlapak et al. 2009, xvi, 89). This statement the authors supported with the fact that three values of scenario variables that had a very important impact on Blue successes – survivable ROC SAMs, successful Blue defense against PGMs, and a high number of hardened shelters at all ROCAF and USAF bases – are also the most unrealistic values for these variables (Shlapak et al. 2009, 89).

In the end, the authors offered these findings regarding the PRC missile threat and possible war of air superiority (Shlapak et al. 2009, xviii-xix):

- "China's ability to suppress Taiwan and local U.S. air bases with ballistic and cruise missiles seriously threatens the defense's ability to maintain control of the air over the strait.
- Restructuring Taiwan's air defenses to "ride out" heavy strikes on its bases and other installations can complicate Chinese planning and reduce the leverage that Beijing can derive from its offensive forces.
- Regaining the initiative in the air may require that the United States and/or Taiwan field a new, expensive, and politically problematic suite of strike capabilities (e.g., hundreds of medium-range ballistic missiles) aimed at China's own air base infrastructure.
- Making clear to Beijing the consequences of attacking U.S. bases and forces in East Asia in terms of counterstrikes on the Chinese mainland has the potential to enhance deterrence."

1.1.3 Air Warfare in 2016

In 2016 RAND researchers Michael J. Lostumbo, David R. Frelinger, James Williams, and Barry Wilson published a report titled *Air Defense Options for Taiwan: An Assessment of Relative Costs and Operational Benefits*. This report assesses different possible air defense investments that Taiwan could make and analyzes them against the current PLAAF threat in three vignettes that estimate possible levels of conflict ranging from quite limited coercive uses of force to a full invasion while also taking into account the threat of PRC missiles strikes against ROC air bases and SAMs (Lostumbo et al. 2016, iii, xii).

In their research concerning the threat of PRC missiles, the authors build on previous research from the year 2009, using the same methodology, but this time taking into account not only SRBMs but also MRBMs (1,000-1,200 ballistic missiles in total), long-range multiple rocket launchers (MRLs) and both ground- and air-launched cruise missiles (GLCMs and ALCMs) (Lostumbo et al. 2016, 6). The authors revisited the issue of the PRC attack on Taiwanese runways. This time the PRC used a firing doctrine of shooting three missiles at each cut point (with approximately a 70 percent chance of successful cut) and reshooting when needed, which led to a reduction of needed missiles to between 41 and 155 (based on the missile CEP between 5 and 40 m) with a possibility of even further reduction of this number due to four ROC air bases being within the range of PRC MRL systems (Lostumbo et al. 2016, 16-17).

The authors then assumed that before attacking Taiwanese air bases the PRC would first try to deal a knockout punch to their air defense systems (Lostumbo et al. 2016 12). In 2016, when their report was published, the ROC air defenses were in a transitional period with 31 long- and medium-range SAM batteries, but the authors decided to evaluate the survivability of Taiwanese SAMs for a projected future force of 9 Patriot batteries (mobile U.S. SAM with anti-missile capabilities), 6 TK I/II batteries (fixed older Taiwanese SAM without anti-missile capabilities), and 12 TK III batteries (mobile Taiwanese SAM based on the Patriot with anti-missile capabilities) (Lostumbo et al. 2016, 4). Using the same methodology as in the 2009 report and looking at the maximum number of SRBM interceptors the Patriot and TK III can control, the authors determined that between 5 and 15 ballistic missiles arriving simultaneously would overwhelm and kill the Patriot radar (Lostumbo et al. 2016, 13). Based on the number of missiles launched at each radar the total number of needed missiles would range between 124 and 370 with a possibility of reduction if the PRC would decide to use MRLs to attack radars within their range (Lostumbo et al. 2016, 14). After the destruction of the ROC SAMs with anti-missile capabilities the PRC would be able to eliminate the remaining SAMs using ballistic or cruise missiles (Lostumbo et al. 2016, 13).

The authors concluded that if Taiwan wants to increase the survivability of its SAMs it needs to completely change its perception of the purpose of its integrated air defense systems (IADS). In their view, the ROC could take inspiration from the air war over Serbia, where the Serb adopted a strategy of conserving their ground-based SAMs, keeping them dispersed and concealed in rugged terrain and using them only under favorable conditions to increase the costs of enemy air operations or to offer support to other military operations, reducing air threat for a limited time (Lostumbo et al. 2016, 19-20).

In the core research of their work, the authors conducted a cost-benefit analysis of several possible air defense and fighter force structures. They estimated that Taiwan would spend about US$22 billion in the next 20 years to maintain its current fighter force and an additional US$3.3 billion for modernization investments (Lostumbo et al. 2016, xv). The authors then created four possible ROC force structures including the projected baseline force and three alternatives maintaining the same budget. The Baseline force included 328 fighters that Taiwan operates with investments into retrofitting all 144 F-16s and no additional SAMs; the Mixed force also consisted of 144 retrofitted F-16s but it retired the rest of the fighters to invest into 4 additional Patriot batteries and the creation of 21 air defense platoons[4]; JSF-Only force considered a possibility when Taiwan would decide to acquire and U.S. to authorize the acquisition of 57 JSF STOVL (F-35B) fighters while retiring all other fighters; SAM-Dominant force described a case when the ROC would retire all its fighter fleet keeping only 50 retrofitted F-16s and acquiring instead 13 additional Patriot batteries and creating 40 air defense platoons (Lostumbo et al. 2016, 31). These force structure options were then tested in three vignettes simulating different levels of possible conflict.

The first vignette is called the Air Sovereignty vignette. This vignette established a scenario where the PRC decided to conduct a maritime blockade of Taiwan, deterring commercial ships in hopes to reduce maritime commerce and force Taiwan to accede to PRC demands (Lostumbo et al. 2016, 34). The ROC decided not to capitulate and instead answered with a

[4] The authors introduce the concept of "air defense platoon" that is created after U.S. IFPC-2 which is under development. It consists of four multi-missile launcher trucks, each with 15 launch tubes, command elements, Sentinel radar, and a command-and-control Integrated Air and Missile Defense Battle Command System that is shared with the Patriot system. This "air defense platoon" can be used as a part of short-range air defense using the AIM-9X missile or medium-range air defense when equipped with the AIM-120 missile (Lostumbo et al. 2016, 27-28).

counterblockade, keeping open sea lines of communications and escorting convoys of ships with vital supplies using maximum restraint, while the ROCAF was trying to support escort operations of the navy and secure airspace over Taiwan by conducting combat air patrols (CAPs) (Lostumbo et al. 2016, 34-35). The authors assumed that while the ROC would try to keep any conflict to the bare minimum the risk-tolerant attitude of the PRC pilots would lead to combat encounters, which they simulated as combat of 2 ROC fighters in risk-averse defensive posture versus 4 PRC fighters in risk-tolerant offensive posture clashing in low- (one CAP engaged per day), medium- (three CAPs engaged per day), and high-intensity conflict (seven CAPs engaged per day) (Lostumbo et al. 2016, 35-42). The authors then looked at how the different forces fare against PRC's current threat (in the year 2016) and possible future threat (including upgraded J-11B fighter armed with new PL-15 missiles) based on how long they were able to maintain CAPs (Lostumbo et al. 2016, xviii). Against the current threat with high intensity of conflict, the baseline force, the mixed force, and the JSF force were able to maintain operations for one to more than four months and against future threat for about two to four weeks (SAM dominant force was not able to sustain operations for not even two weeks) (Lostumbo et al. 2016, xviii).

The second vignette called Disarming Strikes was trying to assess a scenario where the PRC conducts an initial missile and air strike at Taiwanese military targets, including air defense systems, in a try to incapacitate ROC defenses to force both the population and the administration into submission and to deter any third side from joining the conflict (Lostumbo et al. 2016, 48-49). The PRC attack would begin with missile strikes at SAMs and air bases, as the authors previously assessed, and would be followed by air-to-ground attacks that will destroy any aircraft which will not be hidden in Taiwanese underground facilities (Lostumbo et al. 2016, 49-50). The authors assumed that the ROC would try to hide their Patriot/TKIIIs and would initially engage enemy aircraft using short-range air defense (SHORAD), later joined by thoroughly dispersed, highly mobile medium-range air defense platoons to cause severe attrition of PRC aircraft (Lostumbo et al. 2016, 50-51). The authors further assumed that the ROC would need to cause approximately 10 percent attrition from the total number of PRC aircraft (about 200 aircraft) to force China to stop flying over Taiwan (Lostumbo et al. 2016, 55-56). To achieve this the ROC would need between 5 and 20 Sentinel radars (with a 5 or 10 percent radar loss rate) and about 600 AIM-120 missiles (with 3 missiles needed to kill an aircraft) (Lostumbo et al. 2016, 56).

In the third vignette called Invasion Air Defense, the PRC had launched the same initial attack as in Disarming Strike vignette, but this time followed by a full-scale invasion. To counter PRC air attacks Taiwan this time fielded all of its air defenses, but this time not to cause attrition to the attacker, but to support its ground forces by offering periods of time when the unrestricted Chinese air superiority would be broken, and ROC forces could conduct operations under the clear sky – windows of operation (Lostumbo et al. 2016, 56-57). The authors calculated three cases of how many Patriot/TK III and Sentinel radars would be needed (with Patriot/TK III radar attrition per engagement of 50 and 75 percent and Sentinel radar attrition of 5 and 10 percent per engagement) to open 12 two-hour windows facing 100 fighters, 25 attack helicopters, and 25 UAVs every two hours; to open 12 two-hour windows facing 50 percent more enemies every two hours; to open 18 two-hour windows using the former number of enemies (Lostumbo et al. 2016, 63-65). The authors then concluded that only the Mixed force and SAM-Dominant force would be able to supply 100 percent or more of needed Patriot/TK III and Sentinel radars, with JSF-Only and Baseline force possessing only about 60 to 70 percent and less than 50 percent, respectively, of the required Patriot/TK III radars (Lostumbo et al. 2016, 66).

In the end, the authors concluded that despite ROC's focus on maintaining a sizable fighter fleet it will be SAM systems that will play the dominant role in the potential fight for air superiority (Lostumbo et al. 2016, 84). According to the results of vignettes, two and three Taiwan needs about 21 air defense platoons and between 5 and 12 additional Patriot batteries (Lostumbo et al. 2016, 80). With these results in mind, the authors adjusted possible force structure options and created a force that would be able to contest Chinese provocations in the air for 22 days against the current force and for 10 days against the future force and that would be able to achieve positive results in vignettes two and three. This force consisted of 85 retrofitted F-16s, 12 additional Patriot batteries with 900 interceptors, and 21 air defense platoons with additional 2,440 AIM-120 missiles (Lostumbo et al. 2016 87). The authors wanted to show that despite the incredible difficulty Taiwan's air defense problem presents, it is not hopeless, but to find and achieve an appropriate solution Taiwan needs to rethink its air defense strategy and investments before it will be too late (Lostumbo et al. 2016, 88).

1.1.4 Conclusion

The RAND report from the year 2000 identified seven key variables and four findings: "Taiwan's air bases must remain operable; the ROC must maintain at least parity in advanced air-to-air weaponry; pilot quality may be Taiwan's ace in the hole; U.S. involvement is important now and will likely grow increasingly vital" (Shlapak et al. 2000, xvi). The subsequent report from 2009, using the same simulation model, updated and extended the variables and divided them into ballistic missiles and air war categories, concluding that the sustainability of three out of four findings from the 2000 report is quite questionable. The report also identified key variables that played the biggest part in Taiwan's victory or defeat in the air war: PRC aircrew quality, ROC SAM survivability, U.S./ROC shelters, and Fighters at Kadena. The 2016 report then updates the values of ballistic missile variables and mentions the possible use of MRLs and takes a closer look at possible ROC SAM survivability. To summarize, the reports have concluded that one of the most important factors in the China-Taiwan confrontation will be the use of PRC ballistic missiles (their number, their CEPs, and the number of launchers), that the U.S. will continue to play a critical role in such a confrontation, for which it will need to revise its deterrence strategy in East Asia, and finally that Taiwan will need to substantially rethink and restructure its air defenses in order to successfully withstand and repel a possible Chinese attack.

The authors of all three reports offer a very thorough and convincing analysis. However, there is still room for some criticism. One may be the methodological approach to the ROC SAM survivability variable in the 2009 report, which is plausible, but a little bit too simple in contrast to how important this variable ended up being. However, this issue is addressed in the 2016 report, the main focus of which is the survivability of Taiwan's SAMs. Another minor criticism would be that the authors view the U.S. base on Guam as a sort of safe haven, which was probably true at the time, but it is quite likely that nowadays the PRC possesses the means to seriously threaten the U.S. position on Guam. The final critique would be the issue of loitering munition. The authors mention loitering munition in their works when they briefly comment on the possible use of Israeli Harpy drones in PLA's inventory against the ROC radars, but the recent conflict in Ukraine highlighted the importance of this weapon system which will probably only grow in the future and so it would deserve more detailed elaboration.

2. Methodology

This work will be a mixture of quantitative and qualitative analysis and will be based on previous RAND research introduced in the previous chapter. To achieve their results the authors of previous studies used mainly the Joint Integrated Contingency Model (JICM). This model is not publicly available, and I was not able to find a suitable publicly available substitute. Due to this, I will try to update the values of the most important variables the authors used in their studies and thus conclude whether the chances of Chinese aerial victory over Taiwan increased or decreased.

In the first part of my work, I will look into the issue of ballistic missiles, more precisely SRBMs and MRBMs. I will summarize their types, ranges, CEPs, number of missiles, and number of launchers from various sources including Military Balance (2022, 2023), Department of Defense (DoD) Report to Congress (2022), or reports by the Center for Strategic and International Studies or China Aerospace Studies Institute (CASI). Then I will compare these numbers to those in RAND studies and I will conclude how these figures developed and what are the ballistic strike capabilities based on calculations done by RAND researchers. Calculations of the results presented in this part of the paper will be available in an external appendix.

In the next part, I will analyze the key variables from the 2009 RAND study with some changes. The key variables are PRC aircrew quality, ROC SAM survivability, U.S./ROC shelters, and Fighters at Kadena. I decided to include in my analysis the variables PRC forces and ROC forces despite the fact they were not evaluated as key variables because the qualitative advantage of the ROC air force was for a long time considered a key factor for a successful defense of Taiwanese airspace, but such an advantage may be a history in face of Chinese rapid modernization. On the other hand, I decided to exclude the variable U.S./ROC shelters due to a lack of proper data and due to the increase of shelter-busting capabilities of various missiles in the last 20 years (Lostumbo et al. 2016, xiii).

I will approach the variables of PRC and ROC forces by researching their numbers and compositions based for example on Military Balance (2022, 2023) and DoD Report to Congress (2022) and then by comparing them to figures from previous RAND research.

To analyze PRC aircrew quality, I will compare the number of flying hours of PLAAF pilots to U.S. Air Force (USAF) pilots based on various sources such as China Aerospace Studies

Institute reports and DoD Report to Congress (2022) and I will discuss the development of the quality of PLAAF training.

To assess the Fighters at Kadena variable I will research the size and composition of U.S. fighter forces inside the First Island Chain area and on Guam and I will try to assess how their engagement in a possible conflict over the Taiwan strait would be impacted by Chinese increasing anti-access/area denial capabilities (A2/AD).

To determine the development of the ROC SAM survivability variable, I will use calculations from the Air Defense Options for Taiwan (2016) RAND study that analyzed the survivability of radars of both medium- and long-range SAMs.

In the last chapter, I will first discuss how the results of my research contribute to debates about Taiwanese deterrence. I will then attempt to assess possible future developments of my research variables over the next decade. Finally, I will offer some policy implications that can be drawn from the results of my research.

Table 2.1 Importance of research variables

Variables	Definition	Importance
Ballistic missiles	Analysis of PRC disarming strike capabilities against Taiwan based on calculations from previous RAND studies.	High
Range	Development of the range of Chinese SRBMs and MRBMs.	Low
Number of missiles	Development of the number of Chinese SRBMs and MRBMs.	Medium
Number of launchers	Development of the number of Chinese SRBMs and MRBMs launchers.	High
CEP	Development of the circular error probable of Chinese SRBMs and MRBMs.	Very High
PRC forces	Size and composition of PLAAF in comparison with projections of previous studies.	Medium
ROC forces	Size and composition of ROCAF in comparison with projections of previous studies.	Low
PRC aircrew quality	Comparison of PLAAF and USAF pilots flying hours (expressed as a percentage) and analysis of the development of PLAAF training quality.	Very High
Fighters at Kadena	Size and composition of USAF forces that could take part in conflict over the Taiwan Strait.	High
ROC SAM survivability	Survivability of ROC SAM radars against PRC ballistic missiles, MRLs, and Suppression of Enemy Air Defenses (SEAD) weapons launched from aircraft.	Very High

3. Conflict over Taiwan in 2022

After the summary of the existing literature on the issue of possible air warfare over Taiwan in various years, I will now try to explore the aspects of such a conflict in the year 2022. I will start with the development of the possible Chinese disarming strike, exploring possible outcomes of attack on Taiwanese air bases and the viability of overwhelming the ROC missile defenses, and then I will look at the changes in variables influencing the air warfare itself assessing the development of both Chinese and Taiwanese air forces, the quality of Chinese aircrews, possible involvement of U.S. airplanes and the development and operational capabilities of Taiwanese current air defenses.

3.1 Disarming strike

Before mounting a full-fledged air attack on Taiwan with hundreds of aircraft, the PRC will probably try first to conduct a disarming strike against ROC air bases and SAMs using ballistic missiles, cruise missiles, and MRLs. To find out how could this disarming strike look in 2022 it is needed first to look at the development of PRC's ballistic missile inventory, then I will determine how the number of missiles needed to cut runways and taxiways and destroy all aircraft parked in the open on all ROC and close U.S. air bases changed. Finally, I will add the number of missiles needed to destroy all SAMs with anti-ballistic missile capabilities and conclude with an evaluation of the PRC's capability to conduct such a disarming strike.

3.1.1 PRC ballistic missile inventory

When trying to ascertain how the PRC disarming strike capabilities have changed over time it is first important to look at the development of the PRC ballistic missile inventory. In Table 3.1 I have compared the PRC SRBM inventory that the authors of the 2009 RAND study used to create their notional SRBM with contemporary PRC SRBM and MRBM inventory.

In 2009 China used several different versions of DF-11 and DF-15 missiles with different characteristics. The oldest DF-11 variant had a small range of 280-350 km and an enormous CEP of 600 m. The modern variant of this missile DF-11A then had an increased range of 350-530 km and CEP of only 20-30 m. China then possessed between 675 and 715 missiles of these types which could have been fired from 120-140 launchers. All variants of the DF-15 missile had a range of 600 km. The default DF-15 had a CEP of 300 m, DF-15A had improved this number to 30-45 m and the newest DF-15B achieved a CEP of only around 5 m. To fire 315-355 missiles of various DF-15 variants, PRC possessed 90-110 launchers.

In 2022, according to the Military Balance, China uses only DF-11A and DF-15B in their three SRBM brigades (IISS 2022, 255). These missiles have increased range of 400-600 km and 725-800 km respectively and the same CEP as in 2009. Around 432 DF-11A and 324 DF-15B missiles can be fired from 108 DF-11A and 81 DF-15B launchers. The development of these numbers can be explained through an increased PRC focus on modernization instead of inventory expansion of SRBMs. In 2015 China first publicly displayed its new DF-16 missile that is due to its increased range of 800-1,000 km classified by different sources as either SRBM or MRBM and believed to be, with its 5 m CEP, a replacement for older DF-11 and DF-15 variants (Missile Defense Project 2021). PRC at the moment fields two DF-16 brigades of 36 launchers in total and approximately 108 missiles. When it comes to conventional land-attack MRBMs the PRC also fields around 72 DF-21C missiles with a range of 2,150 km and CEP of 30-40 m that can be fired from 24 launchers.

Table 3.1 Comparison of PRC ballistic missile inventory over time

Year	**2009**					**2022**			
	CSS-7		**CSS-6**			**CSS-7**	**CSS-6**	**CSS-11**	**CSS-5**
Characteristic	**DF-11**	**DF-11A**	**DF-15**	**DF-15A**	**DF-15B**	**DF-11A**	**DF-15B**	**DF-16**	**DF-21C**
Range (km)	280-350	350-530	600	600	600	400-600	725-800	800-1,000	2,150
CEP (m)	600	20-30	300	30-45	5	20-30	5	5	30-40
Number of missiles	675-715		315-355			432	324	108	72
Number of launchers	120-140		90-110			108	81	36	24

Note: To estimate the number of missiles in 2022 4 reloads for SRBMs and 3 for MRBMs were assumed.
Source: Shlapak et al. 2009, 34; IISS 2022, 255; Sankaran 2021, 29; Wood and Stone 2021, 64; Missile Defense Project 2021; Missile Defense Advocacy Alliance 2023

3.1.2 Attacking air bases

To disrupt and limit adversary air operations the PRC might consider two main targets at ROC and U.S. air bases, the runways and taxiways, and aircraft parked in the open. To cut a runway or a taxiway, it is needed to limit the usable surface under 1,525 x 15 m which is called the minimum operating strip (MOS) for fighter airplanes by the USAF planning documents (Shlapak et al. 2009, 37; Heginbotham et al. 2015, 56). This means that every runway and taxiway under 3,050 m in length must be cut at least once and every surface above this figure must be cut at least at two points. The authors of the 2009 RAND study modeled an attack at all 12 runways on 10 ROC air bases, with 19 cut points needed to prevent any ROCAF fighter to take off at least for several hours (Shlapak et al. 2009, 42). In the 2016 RAND study, the authors again modeled this attack, this time with only 18 runway cut points needed and with 12

Table 3.2 Military air bases and runways in Taiwan and Okinawa

		Runway	
State	Base	Length (m)	Width (m)
ROC	Chiashan	2,438	46
		2,438	46
ROC	Chiayi	3,050	45
ROC	Taitung	3,370	45
ROC	Ching Chuan Kang	3,658	45
ROC	Hsinchu	3,644	45
ROC	Hualien	2,750	45
ROC	Penghu/Makong	3,000	45
ROC	Pingtung North	2,438	46
ROC	Pingtung South	2,386	45
ROC	Tainan	3,050	45
		3,050	45
US	Kadena	3,658	61
		3,658	91
US	Futenma	2,800	46

Source: Shlapak et al. 2009, 42; Heginbotham et al. 2015, 56; Examination using Google Earth

cuts to taxiways, to disrupt any possible takeoffs from ROC bases (Lostumbo et al. 2016, 15). Another target the PRC might want to destroy in their disarming strike is aircraft parked in the open.

Using the Tainan Air Base as an example, the authors of the 2009 RAND study concluded from an analysis of unclassified imagery that a typical Taiwanese air base has three rectangular parking areas measuring approximately 105 x 305 m, 215 x 380 m, and 245 x 245 m. (Shlapak et al. 2009, 47).

Cutting runways and taxiways

To model an attack on Blue runways and taxiways it is first needed to determine the number of cut points. Table 3.2 shows the overview of all runways on all ROC air bases together with runways on the U.S. Kadena Air Base and Marine Corps Air Station Futenma on Okinawa. I decided to add these two bases because they are the only U.S. air bases within the unrefueled combat radius of 1,000 km to the Taiwan Strait, making them a strategic target for the Chinese disarming strike. (Heginbotham et al. 2015, 54-55). Every runway with a length of 3,050 m and

Table 3.3 Number of ballistic missiles required to cut all runways and taxiways

Missile CEP (m)	Total Missiles Required
5	54
25	123
40	187

Source: Calculations done by the author, can be seen in the appendix

more needs to be cut twice, resulting in 23 runway cuts and additional 14 taxiway cuts needed.[5]

In the 2009 RAND study, its authors modeled an attack on runways using a representative anti-runway SRBM warhead which I introduced in the chapter summarizing previous research. In my research, I also worked with this representative warhead, but to model the attack itself I could not use the 2009 methodology which assumed one massive strike that would achieve all cuts, due to the unclear calculation procedure. Instead, I used the 2016 RAND methodology, which assumed that the PRC would adopt a limited first-strike doctrine followed by damage assessment and follow-on reshooting where needed (Lostumbo et al. 2016, 16). To successfully cut all runways and taxiways using this strategy the PRC would need to fire between 54 and 187 missiles depending on their accuracy (as shown in Table 3.3). It should be noted that the actual number of missiles required would likely be lower due to several factors, firstly this methodology assumes that the missile was either a hit or a miss, without taking into account that a missile classified as a miss may still cause serious damage to the runway or taxiway, secondly, some ROC air bases may be empty at the time of the PRC attack as the aircraft will be relocated to underground facilities, and finally, some air bases closer to the Chinese coast could be targeted by PLA MRLs (Lostumbo et al. 2016, 16).

Destroying aircraft parked in the open

Each ROC and U.S. air base possesses a number of hardened shelters for its aircraft that are hard to penetrate, but the authors of the 2009 RAND study, using once more the Tainan Air Base as an example, observed that there are only about 45 shelters for 60 fighters fielded there (Shlapak et al. 2009, 47). The remaining aircraft thus need to be parked in the open and the

[5] 12 taxiway cuts on ROC air bases from Lostumbo et al. 2016 (15), additional taxiway cuts on U.S. air bases assumed through an examination using Google Earth.

authors identified three rectangular areas that could be used for this purpose. The authors assumed through imagery analysis that such parking areas can be found on all 10 ROC air bases, and I will assume for my research that such parking areas can be found also on the two U.S. air bases.

To model an attack on these parking areas the authors of the study used a missile warhead similar to the representative anti-runway warhead optimized for use against parked aircraft with an emphasis on fragmentation and incendiary effects (Shlapak et al. 2009, 48). Through their calculations, the authors concluded that one or two ballistic missiles, regardless of their accuracy, are enough to destroy most or all parked aircraft with the probability of 80 % or 90 % respectively, resulting in between 30 and 40 missiles needed to destroy most of the aircraft parked in the open on all ROC air bases (Shlapak et al. 2009, 49-50). Since the exact calculations the authors conducted are not clear, I was not able to expand the results to include the additional parking areas on the U.S. bases, but it can be assumed that the results would not change dramatically.[6]

3.1.3 Countering ballistic missile defense

The ROC fields a variety of anti-air systems spanning from short- to medium- to long-range systems with anti-ballistic missile capabilities. These systems can be employed as a so-called stalwart defense, protecting critical infrastructure and facilities, for example air bases, or in a more mobile manner, concealed at first and used carefully to create windows of operation (Lostumbo et al. 2016, xiv). In this subchapter, I will focus on the PRC's capacity to counter ROC anti-air systems with anti-ballistic missile capabilities employed as a defense of fixed assets.

The ROC Air Defense and Missile Command deploy two main systems that can be considered ballistic missile defense, the U.S.-made Patriot system with PAC-2 and newer PAC-3 interceptors and Tien Kung III (TK-III), an indigenous system with very similar parameters to the U.S. Patriot. The ROC has 9 Patriot batteries upgraded to modern PAC-3 standard but is still using both PAC-3 and PAC-2 GEM missiles, due to a shortage of modern interceptors (Thim and Liao 2017; IISS 2022, 310). The number of fielded TK-III batteries is unclear, but

[6] While it can be argued that adding the U.S. air bases and not increasing the number of missiles needed to destroy aircraft parked in the open is generous to the Chinese side, I would argue that it is better to overestimate the capabilities of the attacker than the defender and taking into account the PRC ballistic missile modernization, the overestimation will probably not be severe.

Table 3.4 Number of ballistic missiles needed to counter ROC ballistic missile defense

Number of Simultaneously Arriving Missiles at Each Patriot/TK III	Total Missiles Needed
5	124
10	247
15	370

Note: Total number of missiles assumes 85 % missile reliability.
Source: Lostumbo et al. 2016, 14

the ROC plans to operate 12 TK-III batteries in the year 2024 to completely replace medium-range MIM-23 Hawk systems (Thim and Liao 2017). As the ROC still fields Hawk systems, it can be assumed that it does not have all 12 TK-III batteries available at the moment, but given the insufficient information, I will assume that Taiwan possesses all 12 batteries (IISS 2022, 310).

To assess the PRC's ability to counter ROC's ballistic missile defense I will work with methodology from the 2016 RAND study. The authors of the study assumed that to suppress a Patriot or TK-III battery it is necessary to destroy its radar. The best way to achieve it is to overwhelm it, since the Patriot radar, for example, can control only 9 PAC-3 interceptors in the final moments of an engagement (Lostumbo et al. 2016, 12). The exact number of missiles needed to overwhelm such radar depends on a multitude of factors such as the number of objects being engaged, their speed, or possible usage of warhead decoys, but since the doctrine of engagement for the PAC-3 is to fire two interceptors to increase the probability of kill to an acceptable level of 90 %, the authors assumed that between 5 and 15 ballistic missiles will be enough to overwhelm a radar of one Patriot or TK-III battery (Lostumbo et al. 2016, 12-13; Thim and Liao 2017).

The number of ballistic missiles needed to overwhelm and destroy the radars of all 9 Patriot and 12 TK-III batteries is between 124 and 370, as can be seen in Table 3.4. The number of missiles is the same as in the 2016 RAND study since the number of ROC air defense systems with anti-ballistic missile capabilities did not change. It can be argued that ballistic missile defense systems protecting Kadena Air Base and Marine Corps Air Station Futenma should have been added to the calculation. Nevertheless, I decided against it, even though it is almost certain that there are ballistic missile defenses on Okinawa, any number of Patriot batteries would be a mere guess since information on the movements and deployments of U.S.-operated Patriot systems in Japan is not publicly available (Reif 2019).

3.1.4 Concluding observations

In this chapter, I have attempted to analyze what a Chinese attack on Taiwan's air bases and ballistic missile defenses would look like. It is now necessary to conclude what the PRC's capabilities are to execute such a disarming strike. To achieve this, I have created several possible scenarios which can be seen in Table 3.5. Best Case and Worst Case scenarios were calculated using the most favorable and most unfavorable results for the PRC respectively. Since these are extreme scenarios, I decided to create also the Most-probable Case which I will explain further.

For the attack against all runways and taxiways, the PRC would need to launch between 54 and 187 missiles from 37 to 111 launchers. This number is based on the accuracy of used missiles and since the PRC has more than enough of the most accurate missiles it seems that 54 missiles fired in several salvos from 37 launchers (maybe even less as mentioned before) will most probably be enough to cut all runways and taxiways.

To destroy most or all Blue aircraft parked in the open I assumed, as the authors of the 2009 RAND study, that between 30 and 40 missiles of any accuracy fired from the same number of launchers will be enough. Since I was not able to expand this number to include also the destruction of aircraft on the U.S. air bases, I assumed that the use of the upper boundary of 40 missiles and launchers in modeled attack is most probable.

In analyzing the number of missiles needed to counter Blue ballistic missile defenses, I concluded, as did the authors of the 2016 RAND study, that 124 to 370 missiles launched from the same number of launchers would be needed. This number is based on the number of missiles

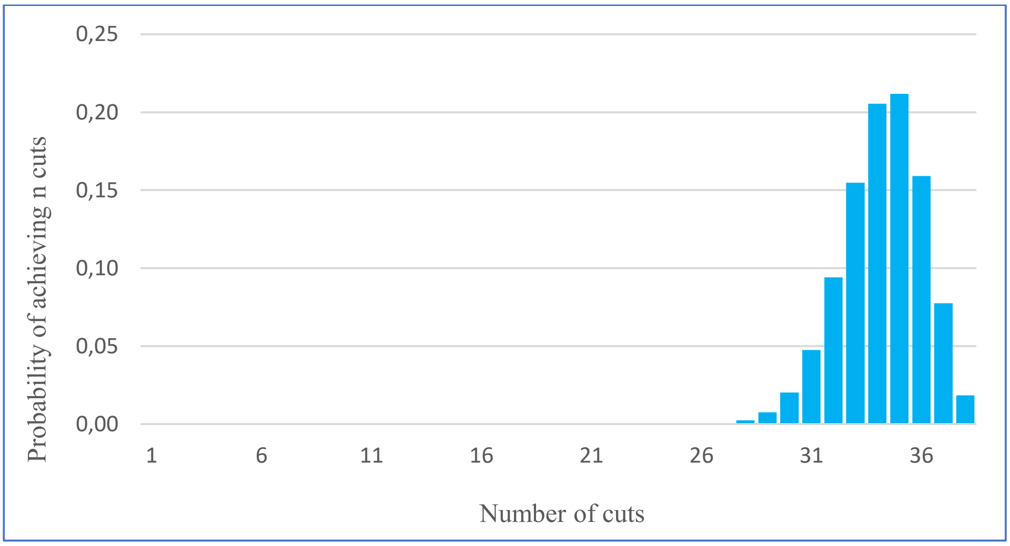
Table 3.5 PRC's capability to execute a disarming strike

	Best Case	**Worst Case**	**Most-probable Case**
Number of missiles available	936	936	936
Number of missiles needed	208	597	341
Percentage left	78 %	36 %	64 %
Number of launchers available	249	249	249
Number of launchers needed	191	521	324
Number of salvos needed	1	3	2

Source: Shlapak et al. 2009, 34; IISS 2022, 255; Sankaran 2021, 29; Wood and Stone 2021, 64; Missile Defense Project 2021; Missile Defense Advocacy Alliance 2023 needed to overwhelm the radar of one SAM battery. Since the lower threshold of missiles needed is based on the absolute minimum number of missiles that could overwhelm a Patriot radar, I concluded that a middle figure of 247 missiles was the most probable number that would with reasonable probability overwhelm all SAM radars.

Finally, I concluded, as Table 3.5 shows, that to cut all runways and taxiways, destroy aircraft parked in the open, and suppress ballistic missile defenses in the Most-probable case, the PRC would have to fire 341 missiles out of 936 missiles in their inventory, leaving them with 64 % of the stockpile. To fire these missiles, 324 launchers would be needed, but since the PRC fields only about 249 launchers, at least two salvos would be needed to execute the disarming strike. This means that in the first attack, the PRC would be able to only strike the ballistic missile defenses, which is needed for the other attacks to be successful, giving the ROCAF time to get their fighters in the air before they reload to attack the air bases. This, of course, takes into consideration only the use of ballistic missiles, but as I already mentioned, the PRC will probably use a combination of ballistic missiles, cruise missiles, and MRLs. To calculate such a joint attack is beyond the scope of this thesis. However, if the PRC were successful in overwhelming and eliminating the ROC's ballistic missile defenses, the subsequent attack on runways and taxiways would result in the destruction of more than 75 % of cut points with more than a 99 % probability of success, as shown in Figure 3.1. Since the execution of a ballistic missile disarming strike that would completely prevent Taiwan from confronting China in the air is then rather improbable, it is necessary to look at what air warfare over Taiwan would look like, which I will attempt to do in the next chapter.

Figure 3.1 Probability of achieving n cuts with 5m CEP - 2nd Strike



Source: Calculations done by the author, can be seen in the appendix

3.2 Air Warfare

In the previous chapter, I concluded that it is rather improbable that China would be able to conduct a disarming strike that would completely prevent ROCAF from taking off. This means that in a possible China-Taiwan confrontation some degree of air warfare between ROCAF and PLAAF is probably inevitable. In this chapter, I will try to look at aspects of such air warfare through an analysis of the development of variables that were evaluated as crucial in previous research. Those variables are the PRC and ROC air force structures, the PRC aircrew quality, the size and composition of USAF forces in the vicinity of Taiwan referred to as "Fighters at Kadena", and the survivability of ROC SAMs.

3.2.1 PRC forces

In the 2009 RAND study, the authors modeled a possible Chinese air attack on Taiwan and concluded that the size and composition of the PRC air force is one of the most important variables (Shlapak et al. 2009, 71). In their analysis of the air warfare in the year 2013, they used two possible projections of the PRC forces that would be allocated to the attack on Taiwan, Base case and Advanced case, as can be seen in Table 3.6. In their projections, the authors expected an increase in the size of PLAAF's fourth-generation fighter fleet of between 90 and 300+ %, an addition of generation 3½ advanced J-8 aircraft at the expense of older J-8 airframes and an addition of advanced H-6 bombers capable of launching modern land-attack cruise missiles (LACMs) (Shlapak et al. 2009, 53-54). When trying to analyze the impacts of used variables on analysis outcomes, the authors observed that the Base case force was used in 70 percent of Taiwan's winning outcomes, while the Advanced case force was used only in 30 percent (Shlapak et al. 2009, 71). At the same time, the authors observed that when the Base case force was used the PRC won decisively only in about 30 percent of the outcomes, while when the Advanced case was used the number of victorious outcomes has risen to 50 percent (Shlapak et al. 2009, 72).

In Table 3.6 I offered a comparison of the 2013 projections with contemporary PRC forces. To make these numbers as real as possible I included both the total inventory of PRC aircraft and forces stationed at bases in Eastern and Southern Theaters from which an attack on Taiwan would likely be conducted. The number of aircraft at bases in Eastern and Southern Theaters is not precise because the number of aircraft in a Chinese air brigade can vary between 30 and 50 aircraft, I decided to work with 40 aircraft per brigade and 25 per bomber regiment (Li 2022). The most important developments in the PLAAF include the introduction of generation 4½ J-16 fighters and fifth-generation J-20, which are the most modern and capable Chinese aircraft that can, at least to some degree, be compared to modern U.S. fighters (China Power Team 2017). The precise number of these aircraft in the PRC inventory is unclear, but it is rapidly growing. The Military Balance from February 2022 claimed that China possesses more than 170 J-16s and about 50 J-20s, while the Defense News published in November 2022 an article about Zhuhai Airshow, claiming based on the construction numbers seen on displayed fighters, that China fields more than 240 J-16s and 200 J-20s (IISS 2022, 261; Yeo 2022). The newest Military Balance from February 2023 then claimed that China has 250 J-16s and more than 140 J-20s in its inventory (IISS 2023, 242).

Table 3.6 Comparison of PRC air forces over time

Year	**2013 Projection**		**2022**	
Aircraft Type	**Base**	**Advanced**	**Total**	**Eastern and Southern Theater**
5th Generation				
J-20A	0	0	140+	80
4th Generation				
Su-35	0	0	24	24
Su-30MKK/J-16	73	150	323	160
Su-27UBK/J-11	116	130	257	40
J-10	100	250	565	200
3rd Generation				
J-8 (advanced)	62	100	30	0
J-8	280	0	0	0
Total fighter/multirole	631	630	1339+	504
JH-7	40	40	120	80
Q-5	200	0	0	0
H-6 (advanced)	46	60	160	125
H-6	50	40	0	0
Total attack/bomber	336	140	280	205
Grand total	967	770	1619+	709

Note: The comparison includes only aircraft of the PRC air force, not PRC naval aviation.
Source: IISS 2022, 260-262; IISS 2023, 242-244; Li 2022

3.2.2 ROC forces

In contrast to the rapid modernization of the PRC Air Force, the inventory of ROC fighter aircraft remained virtually unchanged. In the 2009 RAND study, the authors also created a Base case and Advanced case projections for ROC forces in 2013, as can be seen in Table 3.7. Their Base case projection consisted of various fourth-generation fighter aircraft like U.S. F-16, French Mirage-2000, or Taiwanese F-CK-1 Ching-Kuo commonly known as the Indigenous Defense Fighter (IDF). In their projected Advanced case, the authors added 66 new F-16 fighters to the ROC arsenal, the acquisition of which Taiwan had been planning since 2006 (US-Taiwan Business Council 2012).

When looking at the ROC fighter jets inventory in 2022, we can see that not much has changed. Taiwan still possesses the same arsenal of Mirage 2000s and IDFs, with the only small change being the upgrade of a number of F-16s to an advanced version. In 2017 Taiwan began upgrading its 140 F-16A/B fighters to the most modern F-16V variant and received its first upgraded fighter wing in 2021 (Gady 2017; Yeo 2021). In 2019 Taiwan also asked for permission to purchase 66 more advanced F-16V fighter jets, which was very quickly granted (Stewart, Ali, and Lee 2022). This delivery was scheduled to occur in 2026, but recent security concerns have led to so-far unsuccessful efforts to seriously accelerate this delivery (Stewart, Ali, and Lee 2022).

Table 3.7 Comparison of ROC air forces over time

Year	**2013 Projection**		**2022**
Aircraft Type	**Base**	**Advanced**	
F-16 (advanced)	0	0	63 (+66)
F-16	132	198	77
Mirage 2000	57	57	54
IDF	128	128	127
Total	317	383	321 (387)

Source: IISS 2022, 310; IISS 2023, 293

3.2.3 PRC aircrew quality

As another highly important variable, the authors of the 2009 RAND study identified the quality of PLAAF pilots. To measure their quality the authors compared the average number of flying hours and the quality of practiced training of PLAAF personnel with their counterparts in the USAF and looked at possibilities when Chinese aircrew were 40, 60, and 80 percent as good as

U.S. pilots (Shlapak et al. 2009, 58). As the authors themselves acknowledge, the quality of aircrews is very difficult to comprehensively measure but deserves close attention as the percentage of cases in which the PRC achieved a decisive victory in the air drops from around 60 percent to just 15 percent as the quality of aircrews drops from 80 percent to 40 percent (Shlapak et al. 2009, 73).

To compare the number of flying hours of PLAAF pilots it is first needed to assess the number of flying hours of USAF personnel. While in 2008, the average USAF fighter pilot flew approximately 200 hours each year, in 2021 this number decreased to 120.6 hours (Haynes 2008; Venable 2022). The number of flying hours started declining after budget cuts in 2013 and has not increased to its former figure since, despite the USAF goal of achieving once more 20 flying hours per month on average (Odell 2022; Pawlyk 2018). Instead, the USAF is now trying to compensate for this decline through the extended use of simulators, due to a surge in modern aircraft sustainment costs (Pawlyk 2021).

The number of flying hours of PRC aircrew cannot be so easily obtained as it is not publicly available information. In 2009 and 2011 a total of flying hours of several elite Chinese pilots were published in China Air Force Magazine from which scholars Kenneth W. Allen and Cristina L. Garafola assessed that their annual flying hours varied greatly between 100 and 325 (Allen and Garafola 2021, 259). The average number of flying hours per year for PRC aircrew is hard to assess also because the annual flying quotas in the PLAAF are assigned to each air division and brigade, which then further assigns them to subordinate regiments and they then divide them between the unit's pilots (Allen and Garafola 2021, 257). This system leads to unequal distribution of flying hours among different units and pilots, with commanders favoring prospective pilots who can excel in various PLAAF competitions, such as the most prestigious Golden Helmet. (Allen and Garafola 2021, 257). Nevertheless, in 2018 the state-sponsored online news agency Sina reported that PLAAF pilots must fly at least 200 hours per year, and in the same year, the PLA published a report which mentioned that a certain regiment, which included the Golden Helmet winner, flew in the previous year 150 hours of normal flight training time and emphasized that with confrontation exercises and combat duty missions a pilot of this regiment could meet and even exceed 200 hours per year (Allen and Garafola 2021, 259). These numbers are probably exaggerated to some degree, but around 150 hours of training flying per year seems like a realistic estimate (Odell 2022).

PLAAF training was often characterized as very rigid and old-fashioned, which was reflected, for example, in intercept training, which was conducted primarily as a test of various prescribed combat methods and tactics, with the commander in the control tower giving precise instructions to the pilot during the actual training (Allen and Garafola 2021, 233). This started to change in 2003 when pilots got permission to recommend changes to specific combat methods when they found out during training sorties that this method or tactic did not work (Allen and Garafola 2021, 233). However, an evaluation process of such a recommendation lasted for about two years and the first real change did not occur until 2011 when the terms "pilot autonomy" and "free-air combat" were introduced and which gave pilots autonomy to conduct combat training with their own flight plan in mind (Allen and Garafola 2021, 233-234). In 2016 an updated version of the main PLAAF training guidance document, called *Outline of Military Training and Evaluation*, was published. This version once again emphasized the importance of pilot autonomy and free-air combat and prioritized the importance of mission execution over strict adherence to prescribed maneuvers, which meant, for example, giving pilots more freedom to follow any route and use any means to successfully complete the mission. (Allen and Garafola 2021, 236). These changes then allegedly led to "a 17 percent increase in the number of sorties, a 46 percent increase in the length of simulated training, and an increase in the proportion of tactical basic training by nearly four times" (Allen and Garafola 2021, 237). The question that is unlikely to be answered until we see the PRC Air Force in action is how these changes have been able to translate into the quality of the current PRC aircrew, given that it takes 7 to 10 years for a cadet to become an experienced operational pilot in the PLAAF (Allen and Garafola 2021, 245). But it is quite clear that the PLAAF leadership is aware of its problems and is actively working on solving them as quickly as possible, as can be seen in the recently discovered case of up to 30 former UK military pilots that were employed to train PRC aircrews (Corera, 2022).

3.2.4 Forces at Kadena

When the authors of the 2009 RAND study were evaluating the effects of the U.S. contribution to the air warfare over Taiwan, they have taken into account both the involvement of a number of U.S. CVBGs and fighter jets from U.S. bases in Okinawa, specifically from Kadena Air Base and Marine Corps Air Station Iwakuni (Shlapak et al. 2009, 62). But after they concluded the outcomes analysis it was only the U.S. involvement from air bases in Okinawa named "Forces at Kadena" that was evaluated as a key variable (Shlapak et al. 2009, 71). The values of this variable were "None", "F-15", F-22", or "Guam". "None" meant no U.S. involvement from Okinawa, "F-15" the involvement of one wing of 72 F-15 fighter jets on Kadena accompanied by 36 USMC F/A-18 fighters from Iwakuni, "F-22" accounted for a case when the wing of F-

15s on Kadena was replaced by the same number of F-22 fifth-generation fighter aircraft with the same number and type of aircraft flying from Iwakuni and the "Guam" value represented a case when the U.S. command decides that flying from the proximity of Chinese mainland is too dangerous and instead from Kadena one wing of F-22s fly from Andersen Air Base in Guam (Shlapak et al. 2009, 71). Unsurprisingly no U.S. involvement led to a mere 10 percent of simulated runs that could be classified as Blue victories. The involvement of F-15s increased the percentage of victorious runs to 21 percent while the replacement of F-15s with F-22s led only to a small additional increase to 27 percent. Cases in which F-22s flew from Guam were judged to be most favorable to the Blue side; despite a significant drop in the number of generated sorties, cases in which the aircraft were safe from attack while on the ground led to an increase in the number of victorious runs for the Blue to 42 percent (Shlapak et al. 2009, 71, 83-84).

When estimating how this variable could look today, I decided to give some attention to distance. As I mentioned in the previous chapter, the most immediate threat to the PRC is posed by the U.S. bases within the 1,000 km unrefueled combat radius from Taiwan, within which falls the Kadena Air Base and the Marine Corps Air Station Futenma, which despite being a helicopter base has a well-functioning runway and thus cannot be ignored. Kadena Air Base and two squadrons of about 48 F-15s stationed there in 2022 then remained basically the only U.S. air base within a reasonable distance that could generate more than one sortie per plane a day (Losey 2022). But in October 2022 the U.S. Department of Defense released a statement that on November 1st the retirement of F-15 squadrons on Kadena will begin and that while the DoD will be devising a long-term plan for the air base a force of modern fourth and fifth generation fighter aircraft will rotate on Kadena, beginning with an undisclosed number of F-22s from Alaska (Losey 2022).

This decision received some critique because on one hand the DoD continuously points to China as the greatest threat to the U.S. and as its most dangerous rival, calling for a bigger presence of U.S. forces in Asia to deter Chinese aggression, and on the other hand, it removes 48 fighter jets from Kadena and replaces them temporarily with fighters from Alaska that are designated to the same Pacific Theater, ultimately lowering the total number of planes dedicated to counter China, and at a higher cost since rotational force is more expensive than a permanent one (Eaglen, Sayers, and Walker 2022).

On the other hand, there are also supporters of this decision that are arguing that although Kadena should not be permanently abandoned, since it can be eventually very useful in a conflict with China, the rotational force is more suitable for it for several reasons. First, the purpose of a permanent force in Kadena was to work as a deterrence against China, but since the PRC possesses the ability to conduct a serious missile strike against Kadena and severely hinder any combat abilities of fighters based there, as was argued both in the 2009 RAND study and this thesis, the deterrence does not really work. Second, the rotational force gives an opportunity to more USAF pilots to get acquainted with the region where they might wage future war. And third, it allows the U.S. to focus more on resilience and survivability, and to move towards distributed operations as a part of the USAF agile combat employment concept (Pettyjohn, Metrick, and Wasser 2022). The emphasis on resilience and survivability goes in line with the findings of the 2009 RAND study, with operations from a greater distance, but from a relative safety providing significantly better results. But this relative safety obtained by distance is nowadays getting more and more relative with new PRC cruise and intermediate ballistic missiles developed in recent years (Heginbotham et al. 2015, 55; Missile Defense Project 2021).

3.2.5 ROC SAM survivability

One of the most important variables that could offer a substantial advantage to the ROC is the survivability of surface-to-air missiles (Shlapak et al. 2009, 80). It is problematic to properly model the survivability of air defense systems, so the authors of the 2009 RAND study decided to measure the SAM survivability by the degradation of SAMs per day (Shlapak et al. 2009, 61). They created three values of degradation: 50 percent per day, 25 percent per day, and 10 percent per day (Shlapak et al. 2009, 61). Changes in these values led to big differences in outcomes, while the 50 percent degradation per day led to almost 70 percent of modeled cases being labeled as Chinese victories, a decrease to 25 percent degradation per day led to about half of the runs being PRC victories, and further decrease to 10 percent degradation per day ended with China winning only 25 percent of the time (Shlapak et al. 2009, 79).

To offer an assessment of how the ROC SAM survivability might look nowadays I decided to follow the methodology from the 2016 RAND study *Air Defense Options for Taiwan*. In this study, the authors argue that there are two main approaches to surface-to-air missile deployment that Taiwan might consider: One can be characterized as a stalwart defense, in which SAMs would be used to defend fixed assets such as air bases, critical infrastructure, or command and control facilities; The other can be described as a method of concealment and dispersion, in which SAMs would remain dormant and hidden in the early stages of the conflict, used either to inflict attrition on PRC air forces in rapid mobile hit-and-run operations or, in the event of a full-scale invasion, to provide a series of windows of opportunity, periods of clear skies, for the ROC Army to conduct defensive maneuvers or counterattacks. (Lostumbo et al. 2016, xiv). Possible outcomes of the first approach I already described in the chapter "Disarming Strike" of this thesis, now I will try to analyze the second approach. If the ROC would try to adopt this approach to air defense, it would need to conceal and disperse all its SAMs. For successful concealment and dispersion, the anti-air systems must be mobile, which leaves fixed systems such as ROC's TK I/II very vulnerable. Even though these systems are based in underground silos and are thus hard to destroy, their above-ground radars are much easier targets and as such will be fairly quickly and easily destroyed (Lostumbo et al. 2016, 13-14). Another air defense system that the ROC possesses is a semi-mobile medium-range MIM 23 Hawk. This is a fairly old system and while Military Balance 2023 claims that ROC still fields around 50 Hawk launchers other sources claim that the ROC is quickly retiring all these systems and is replacing them with TK III SAMs since Hawk missiles have passed their expiration date and are now dangerous both to shoot and storage and thus need to be destroyed (IISS 2023, 293; Chen 2023; Strong 2022). Ignoring short-range SAMs that are incapable to engage targets in higher altitudes, the only ROC's mobile systems left to consider in this analysis are long-range Patriot and TK III systems of which, can be assumed, ROC fields 9 and 12 batteries respectively (Lostumbo et al. 2016, 13).

Using this approach, the ROC can choose to either attempt to inflict enough attrition on PRC aircraft to force them to withdraw from the ROC airspace and reconsider any further air operations or to use its SAMs to support the rest of the ROC army in defensive operations against a full-scale Chinese invasion and to open several windows of opportunity during which the PRC aircraft would suffer from air denial (Lostumbo et al. 2016, xvii-xviii). But to enact high-enough attrition of PRC air forces the used SAMs would need to be able to conduct fast hit-and-run operations and thus would have to be able to be movable very quickly which is a condition that is not met either by Patriot battery which takes 60 minutes from firing to moving or by TK III battery which needs 30 minutes (Lostumbo et al. 2016, 4). Such operations would have to be thus conducted by highly mobile medium-range SAMs that Taiwan at the moment does not possess. Taiwan can try to use its Patriot and TK III systems to open a number of windows of opportunity. In case of an invasion RAND researchers claim that the PRC would need two six-hour long windows of air control to transport their troops to the Taiwanese shore and on the other hand, the ROC would need, in case of successful halting of PRC attack, 12 hours or 6 two-hour long windows of clear sky to conduct a counterattack (Lostumbo et al.

2016, 63). To provide support both during the ongoing Chinese invasion and subsequent ROC counterattack SAMs assigned to this task would in total need to provide 12 two-hour long windows. According to calculations done by the authors of the 2016 RAND study, 21 Patriot or TK III radars, which is arguably the exact number ROC possesses, would be needed to provide these 12 two-hour long windows with 50 percent radar attrition per engagement with the additional support of a high number of medium-range SAMs that Taiwan at the moment does not possess, as was argued before (Lostumbo et al. 2016, 63). If Taiwan would want to provide these windows of opportunity with its actual arsenal, it would take 42 Patriot or TK III radars with an enormous attrition of 90 percent per engagement (Lostumbo et al. 2016, 65).

3.2.6 Concluding observations

In this chapter, I tried to highlight the development of variables evaluated in previous research as crucial to the outcome of a possible air war over the Taiwan Strait. To offer some sort of a conclusion, I created a very simplistic assessment of the air power of the Red and Blue sides by multiplying the number of fighter aircraft likely to be deployed by either side, based on previous research, by the quality of the aircrew, measured as a percentage of USAF pilot quality, which can be seen in Table 3.8. Now I will try to briefly explain the numbers.

When trying to assess the number and composition of Red forces that would take part in a battle over Taiwan I decided to follow the methodology of a previous study conducted by RAND researchers in 2015. They argued that for the air campaign over the Taiwan Strait, the PRC could allocate approximately 1,000 aircraft, or about 80% of its air force, with the more modern

Table 3.8 Comparison of Airpower of Red and Blue Forces over the Taiwan Strait

	Red forces		Blue forces	
	PRC		ROC	U.S.
5th Generation	100		0	48
4th Generation	547		321	108
Total	*647*		*321*	*156*
Aircrew Quality	0.8	1.2	1.0	1.0
Airpower	518	776	321	156
Total	*518-776*		*477*	

Source: IISS 2022, 260-262, 310; IISS 2023, 242-244, 293; Li 2022 and capable aircraft being prioritized for the Taiwan theater, while the older aircraft would be responsible for defending the rest of Chinese airspace (Heginbotham et al. 2015, 75). They further assumed that of this number 400 aircraft would be needed to deploy in defensive operations over Chinese territory in the vicinity of the Taiwan Strait (Heginbotham et al. 2015, 75). Using these calculations, I concluded that 647 fighter aircraft, 100 5th generation, and 547 4th generation, could be used by the PRC to achieve air superiority and potentially air control, which is in line with previous research that concluded that the PLAAF could keep in action at one time up to around 600 aircraft (Shlapak et al. 2009, 54).

To assess the number and composition of Blue side forces it is needed to look at ROC and U.S. forces separately. When it comes to ROC forces, I decided to work with all 321 4th generation fighters that the ROCAF possesses. While it is almost a certainty that the PRC would destroy a considerable number of these aircraft on the ground, or at least prevent them from taking off, it can be also argued, based on the conclusion of the previous chapter, that the ROC air bases will probably not be the first target of a Chinese disarming strike, and thus the ROCAF will be able to generate a number of sorties at the onset of a conflict. Nevertheless, a calculation of changes in sortie generation based on possible disarming strike outcomes is beyond the scope of this thesis, and the use of all ROCAF fighter aircraft, while significantly favoring the Blue side, is therefore a logical decision.

There are several options for how to look at possible U.S. presence in the air war over Taiwan ranging from no presence at all to hundreds of aircraft from all bases in the West Pacific. I decided to stick with the methodology of the 2009 RAND study and work with a case when the U.S. contributes after the outbreak of war 72 4th generation fighter aircraft from 2 CVBGs, 36 4th generation fighters from a Marine Corps Air Station (be it Futenma or Iwakuni) and 72 5th generation aircraft (from either Kadena or Guam) (Shlapak et al. 2009, 62).

To show how the differences in aircrew quality could influence the projected airpower over the strait I multiplied the number of Red and Blue forces by the assessed aircrew quality. I measured aircrew quality as a percentage compared to the USAF pilot, so I evaluated the quality of the USAF aircrew at 100%. Since the quality of the ROC crews is not the subject of this thesis, I have simplistically assigned them 100% as well. For the PRC force, I decided to create two possible cases given the significant difference between the number of training hours, according to which PRC fighter pilots could be rated as 125% as good as their USAF counterparts, and the quality of the training itself, which is still lacking in comparison to Western standards, in which case I worked with the assumption that PRC pilots are 80% as good as USAF pilots.

From these calculations can be concluded that PRC forces are currently in a much stronger position than in past decades. Both in the number of aircraft and projected airpower in all cases, the PRC is in an advantageous position against allied Blue forces, and without U.S. 5th generation aircraft, the PRC would have both qualitative and quantitative superiority. Taiwan possesses a lot of very modern SAMs but is currently lacking in any mobile medium-range systems that should form the backbone of its integrated air defense system. It can be then said that without the high-scale involvement of modern U.S. fighters and acquisition of mobile medium-range SAMs and the creation of comprehensive layered air defenses the chances of Taiwanese victory in case of full-scale Chinese invasion are getting slim.

4. Discussion and Future Development

In this chapter, I will begin with a discussion of conventional deterrence and the relationship of my work to this theory as it relates to Taiwan. I will then discuss possible future developments of the variables I worked with in the main body of my thesis. Finally, I will conclude with some policy implications that arise from the findings of my thesis.

4.1 Deterrence

Deterrence in its broadest sense means “persuading an opponent not to initiate a specific action because the perceived benefits do not justify the estimated costs and risks” (Mearsheimer 1985, 14). To attain this goal there are two main possible ways, deterrence based on punishment, which threatens the enemy with the destruction of large parts of its civilian population and industry and is generally associated with nuclear capabilities, and deterrence based on denial, which relies on convincing the opponent that he cannot achieve his goals on the battlefield, and which usually relies on conventional forces (Mearsheimer 1985, 14-15).

For Taiwan, the discussion of deterrence is a matter of survival, and this thesis has the ambition to contribute to this debate. The ROC possesses neither nuclear weapons nor long-range missile strike capabilities to threaten the Chinese mainland, so the only option for Taiwan is a proper conventional deterrence based on denial. There are two main variables for assessing the quality of a state's deterrence capabilities, namely, the cost to the enemy if it decides to attack and the probability of success of such an attack. (Mearsheimer 1985, 23-24). There are then two approaches to testing these variables, a holistic approach, which looks at deterrence as a whole, and an approach that looks at specific deterrence capabilities and analyzes them individually. My paper takes the latter approach and builds on previous research assessing the ROC's ability to successfully deter China in the air.

In the year 2000 researchers from RAND Corporation published an analysis of possible air warfare over Taiwan in a scenario of Chinese invasion, concluding that “the PLA cannot be confident of its ability to win the air-to-air war,” and that “any near-term Chinese attempt to invade Taiwan would likely be a very bloody affair with a significant probability of failure” (Shlapak et al. 2000, xvi). Thus, it can be concluded that in 2000 Taiwan had sufficient deterrent capabilities to inflict serious costs on China in the event of an attack and that such an attack would have had little chance of success.

A decade later the researchers expanded on their study and this time concluded that “China’s ability to suppress Taiwan and local U.S. air bases with ballistic and cruise missiles seriously threatens the defense's ability to maintain control of the air over the strait," and that "… the United States and Taiwan can no longer be confident of winning the battle for the air in the air" (Shlapak et al. 2009, xviii, 131). This can be seen as one of the first signs that the Taiwanese approach to deterrence in the air is starting to become unsustainable.

In 2016, another RAND report analyzing Taiwanese capabilities in the air was published. This time, the authors tested ROC air forces and air defenses in several scenarios and concluded that Taiwan's approach to deterrence in the air used to date is definitely unsustainable and that a new approach based on mobility, dispersion, concealment, and other asymmetric capabilities must be adopted as soon as possible (Lostumbo et al. 2016, xxi-xxiv).

The 2016 report was not the first work to reach this conclusion. In 2014, John Mearsheimer wrote that without U.S. support, which cannot be guaranteed, the ROC will not be able to deter China as the costs of a possible Chinese invasion will decrease and the chances of success of such an operation will increase (Mearsheimer 2014, 36-38). The only possible way for Taiwan to deter China, according to Mearsheimer, is to obtain nuclear weapons, which he writes is highly unlikely; to acquire such capabilities that the ROC will be able to "make China pay too huge a price to achieve a victory"; or to surrender and negotiate a status for Taiwan similar to that of Hong Kong. (Mearsheimer 2014, 38).

These conclusions did not go unheeded and in 2017 the new Chief of the General Staff of the ROC Admiral Lee Hsi-min introduced the Overall Defense Concept, a holistically integrated concept that is trying to present a new possible approach to Taiwanese deterrence based on asymmetric capabilities (Lee and Lee 2020). This new approach received much praise and recognition from U.S. strategists and academics, but unfortunately did not impress the ROC Ministry of National Defense and was abandoned when Lee retired (Hunzeker 2021).

In my thesis, I tried to build on the above-presented research and analyze how would the confrontation between the ROC and the PRC in the air over Taiwan look in 2022 and consequently thus assess how the ROC's capabilities to deter China in the air developed. The results are not positive for Taiwan.

Looking at the possibility of a disarming strike, which played a large role in the conclusions of the 2009 study, I concluded that the number of ballistic missile launchers limits China's ability to conduct a disarming strike because it will need almost all of its launchers to overwhelm and eliminate ROC ballistic missile defenses in a first strike, but when the use of cruise missiles and MRLs is taken into account, China will still be able to conduct a devastating first strike even if it will not be a disarming strike.

In assessing the balance of power over the Strait in terms of aircraft, I found that China has massively increased the strength of its air power over the last decade, not only in terms of quantity, where it has long maintained superiority over the ROCAF but also in terms of quality, where it used to lag behind but now clearly dominates with the only possible challengers to its new 5th generation fighters being modern U.S. fighter jets.

When it comes to the quality of aircrews, a variable in which Taiwan has long had the upper hand, China no longer seems to be too far behind, and it could be argued that it is China that is now ahead.

Finally, when it comes to the ROC air defenses it must be acknowledged that Taiwan possesses a massive inventory of long-range mobile SAMs that quite a bit increases its deterrence capabilities, but without a similar force of short- and medium-range mobile SAMs able to counter Chinese aircraft conducting suppression of enemy air defenses operations, the survivability of such air defenses is not very high.

Thus, it can be concluded that Taiwanese deterrence capabilities in the last two decades greatly deteriorated. The variable on which the entire current ROC air deterrence depends is the possible involvement of US forces, which should not be taken for granted. Taiwan today is the most vulnerable it has been in decades.

4.2 Future Development

In Chapter 3, I attempted to assess how the conflict over Taiwan might have looked and ended in 2022, examining a possible Chinese disarmament strike and subsequent air war. In this chapter, I will attempt to offer a brief analysis of the future development of the previously examined variables.

Ballistic Missiles

In the past decades, the Chinese ballistic missile industry has undergone massive development due to the expansion of production and the use of better manufacturing techniques (Wood and Stone 2021, 57). This development was initially focused on the extensive production of SRBMs, but now the focus is more and more shifting in the direction of longer-range modern missiles. It could be then expected that in the future decade, the PRC will continue on the road it embarked on in the past few years. This will mean a reduction of older SRBMs (as are DF-11s) that are despite their modernization getting obsolete due to their limited range and vulnerability to missile defenses, replacement of these SRBMs by missiles of longer-range and greater payload (as is the DF-16) or missile defense penetrating hypersonic missiles (as is the DF-17) and production of more medium- and intermediate-range missiles with naval strike capabilities that can strike targets in the Second Island Chain (as are DF-21s or DF-26s) (IISS 2023, 224; Biddle and Oelrich 2016, 20-21; DoD 2022, 64-65).

PRC forces

Modernization efforts of the PRC air force in the last decades have definitely yielded results. It now fields one of the biggest fleets of 4th generation fighters and in recent years massively increased its inventory of modern 5th generation fighters. PLAAF is thus rapidly catching up with the Western powers and is slowly, but surely catching up with the U.S. and its qualitative technological advantage (DoD 2022, 59). It can therefore be expected that the PLAAF will continue to upgrade its inventory in the coming decade. The modernized two-seat version of the 5th generation J-20 aircraft called J-20S is now being developed (CASI 2022, 25; IISS 2023, 223). When it comes to bombers, China nowadays field modernized H-6K bomber capable of attacking targets in the Second Island Chain from bases in mainland China and is now allegedly developing a new H-20 long-range stealth bomber as a response to new U.S. B-21 *Raider* (CASI 2022, 26; DoD 2022, 60; IISS 2023, 223). It is also speculated that the PRC might be developing a new fighter bomber design that could be revealed in the next few years (IISS 2023, 223).

ROC forces

When it comes to the development of new air forces for Taiwan there is a clash between the U.S. and Taiwanese leadership about how much the ROC should focus on asymmetric capabilities procurement over conventional assets (IISS 2023, 212-213). While Taiwan is increasing its asymmetric capabilities, under which we can categorize for example its purchase of AGM-84 SLAM-ER missiles or four MQ-9 Reaper drones, it is still putting an emphasis on strong conventional air and naval forces which is supported by procurement of 66 new F-16V fighter planes and a plan of development of new indigenous aircraft that was mentioned in a speech of ROC president Tsai Ing-wen (DoD 2022, 131-132; IISS 2023 212). The ROC currently has an impressive fighter force and plans to increase it even more in the next decade, but even after the delivery of new fighters, the ROCAF will still lag massively behind China in both quantity and quality.

PRC aircrew quality

It can be assessed that in the 2020s a new *Outline of Military Training and Evaluation* will be published that will continue the PRC vision of making PLAAF a "world-class airforce" (Allen and Garafola 2021, 341). The PLAAF will then probably continue to put more emphasis on their training on offensive air operations, joint training, and training over water and in difficult weather conditions which will help them with potential operations in the Taiwan Strait or the South China Sea (Allen and Garafola 2021, 342, 347). It can be expected that the outline will include also more free air combat and pilot autonomy training with dissimilar aircraft that can be useful in a potential confrontation with modern U.S. fighters (Allen and Garafola 2021, 348). Allen and Garafola in their predictions of future development of PRC aircrew quality also argue that the introduction of more advanced aircraft will lead to an increase in annual flying hours which is a somewhat questionable argument since the introduction of a more advanced aircraft follows a surge of flying hour cost which with the introduction of modern simulators can be expected to lead to a decrease and not an increase of annual flying hours (Allan and Garafola 2021, 348). Assessing a possible future development in aircrew quality is a very difficult task that depends on a lot of various factors, but it can be argued that in the next decade, the PRC aircrew quality will either improve or remain relatively the same.

Forces at Kadena

In the previous chapter, I concluded that extensive U.S. support for Taiwan and direct involvement in any conflict over the Taiwan Strait is nowadays imperative for ROC victory and it will be only more important in the future. But to be able to defend Taiwan in the future decade the U.S. needs to and is at the moment developing new capabilities such as the new B-21 long-range stealth bomber capable of penetrating modern air defenses or a new anti-radiation missile capable of destroying Chinese air defenses, which will replace aging AGM-88 HARM and is currently being developed under the Stand-in Attack Weapons program (Gunzinger 2020, 38; Losey 2023).[7] To properly deploy its new long-range strike capabilities the U.S. is investing in defenses of bases further away from the vicinity of a future possible conflict center as is for example Guam which is supposed to receive the first round of new anti-missile defenses in 2024 (Judson 2023). The U.S. is also starting to show interest in acquiring new bases in the Philippines to increase its presence in Asia and to disperse its troops to better defend them from

[7] For a critique of the development of the new U.S. long-range stealth bomber for the Western Pacific see Biddle and Oelrich, "Future Warfare in the Western Pacific: Chinese Antiaccess/Area Denial, U.S. AirSea Battle, and Command of the Commons in East Asia," *International Security*, 2016, https://doi.org/10.1162/ISEC_a_00249.

a possible Chinese missile attack (Acosta 2023; Morales 2023). It can be concluded that China is growing stronger every year and it now holds a clear edge over Taiwan when it comes to air power, and the U.S. will thus need to and is currently increasing its presence in Asia together with the development of new capabilities to maintain its technological superiority over China.

ROC SAM survivability

It is not clear how will the ROC SAM survivability develop in the future decade. From the conclusion of the previous chapter can be argued that the development of ROC air defenses and the acquisition of modern mobile medium-range SAMs is a vital task for a successful defense against Chinese threats. It seems that Taiwan is aware of this and thus last year negotiated a future purchase of “more than four” NASAMS medium-range air defense systems that should take place in 2024 (MDAA 2022; Panasovskyi 2022). While this is certainly a step in the right direction, it seems too small a step to completely fill the hole in the ROC's integrated air defense system. ROC SAM survivability will thus probably not significantly change in the future decade.

Conclusion

In the last decade, we could have seen substantial development in Chinese military capabilities which has led to a state of affairs where the PRC holds a significant edge over Taiwan when it comes to quantity and now even in the quality of air forces. It can then be concluded that in the future decade with the development of better ballistic missiles with greater payload, the massive production of new 5th generation fighter aircraft, an increasing emphasis on modern training, and the ROC's continued focus on expanding its 4th generation fighter fleet, the balance of power between the PRC and the ROC appears to continue to shift toward China. However, given the U.S. increasing focus on Asia in recent years and with its plans to increase its presence in the vicinity of Taiwan, the overall situation is unlikely to change significantly over the next decade from today as long as the U.S. continues its support for Taiwan. It can thus be concluded that the balance of power over Taiwan and Taiwan's deterrence in the next decade will depend primarily on the U.S., a view that is consistent with the pessimistic predictions of scholars such as the aforementioned John J. Mearsheimer.

4.3 Policy Implications

Although Taiwan is seen as one of the most dangerous flashpoints today and its air defense situation is by some characterized as “perhaps the most difficult in the world,” it does not mean its hopeless (Mearsheimer 2014, 36; Lostumbo et al. 2016, 88). Through the results of my research, I identified three main implications, the adoption of which could significantly improve

Taiwan's deterrence in the air.[8] These implications are consistent with previous research and recommendations, such as those published in RANDs *Air Defense Options for Taiwan* in 2016 or in *A Question of Time* by the Center for Security Policy Studies at George Mason University in 2018.

Change of SAM deployment strategy

Taiwan needs to change its SAM deployment strategy from the defense of fixed assets to an asymmetric strategy of dispersion and concealment. The ROC at the moment is using its modern and mobile Patriot and TK III SAMs as a stalwart defense to protect fixed assets such as air bases, command and control facilities, or critical infrastructure (Lostumbo et al. 2016, xiv). Such a strategy would be effective against an adversary with limited missile strike capabilities. This is not the case with China, which currently possesses thousands of ballistic missiles and is capable of overwhelming and destroying all ROC SAMs. To preserve its expensive SAMs the ROC should instead employ concealment and dispersion to conserve its air defenses in the PRC's first strike and use them only under favorable conditions, employing "shoot-and-move" maneuvers to inflict costs on Chinese air operations and open windows of opportunity in the event of an amphibious invasion to stop and repel the enemy (Lostumbo et al. 2016, xiv, 19, 68; Hunzeker et al. 2018, 28, 84).

Aircraft reduction

Taiwan should considerably reduce its sizable fleet of 4th generation fighter jets. If the ROC leadership decides to accept the previous recommendation and change the SAM deployment strategy, there will be nothing to limit the scope of the PRC's disarmament strike. It can be expected that most or all runways and taxiways on ROC air bases will be cut and all aircraft parked in the open destroyed. Taiwan, therefore, needs to seriously reduce its fighter fleet, which for years has consumed too much of the ROC's defense budget for very little benefit, and use those funds to strengthen and modernize its inadequate integrated air defense system. Despite recent modernizations and new acquisitions, the ROC fighter fleet is still getting more and more obsolete in comparison to the PRC force, and while there is a need for a certain number of fighters to respond to China's gray zone operations (such as increasing incursions into Taiwan's air defense zone), a fleet of 85 upgraded F-16Vs, less than one-third of the current

[8] In this chapter I am looking only at possible policy implications for Taiwan. For some policy recommendations to the U.S. see for example Eaglen and Ferrari, "Conventional Deterrence and Taiwan's Independence, Necessary Investments," *Æther: A Journal of Strategic Airpower & Spacepower*, 2022, https://www.jstor.org/stable/48668553.

ROCAF force, can accomplish this task, according to calculations by RAND researchers. (Lostumbo et al. 2016, 87)

Increase of SAMs

The ROC should acquire new mobile short- and medium-range SAMs to create an efficient layered integrated air defense system. As I already mentioned Taiwan has in its inventory a great number of modern mobile long-range SAMs capable of firing missiles with anti-ballistic missile capabilities, but it is severely lacking in short- and medium-range SAMs. In my research, based on the aforementioned RAND study, I concluded that without a properly layered air defense consisting of short-, medium-, and long-range SAMs capable of countering ballistic and cruise missiles, PGMs, anti-radiation loitering munitions, drones, and without the ability to impose serious costs on Chinese air operations conducted by both manned and unmanned aircraft, the capability and survivability of ROC SAMs will approach zero.

Conclusion

This thesis builds on research conducted over the past two decades on the potential outcome of air warfare in the event of a Chinese invasion of Taiwan to answer the main research question: "*How have changes in Chinese and Taiwanese military capabilities influenced the likely outcome of a possible struggle for air superiority over Taiwan, based on previous research?*".

After examining the critical variables identified in previous research, it can be concluded that China currently holds the upper hand in terms of military capabilities across the Taiwan Strait. In comparison to the earliest study mentioned in this thesis, which asserted that the balance of power in the Strait heavily favored Taiwan 20 years ago, Taiwan today would not be able to sustain a full-scale air war against the PLAAF without the support of the United States. This assertion is supported by the development of several key variables, such as Chinese ballistic missile CEP, PRC aircrew quality, and ROC SAM survivability, all of which have developed in China's favor. These variables were assessed as having "Very High" importance, making their development particularly significant.

Notably, this conclusion is consistent with previous research that concluded that "none of the cross-strait military trends are in Taiwan's favor" (Shlapak et al. 2009, 123). As such, the evidence suggests that Taiwan would face a significant disadvantage in the event of an air war with China, absent U.S. support.

To assess the possible future developments this thesis also aimed to briefly answer a secondary research question "*How will the likely outcome of a possible struggle for air superiority over Taiwan change in the next decade?*". Confronting the results of my research with publications predicting possible developments in the region and official plans and strategies to be implemented over the next decade, I have concluded that we can expect either a continued buildup of Chinese military capabilities and thus an increase in the PLAAF's chances of achieving air superiority in the event of a conflict, or a continuation of the status quo currently observed across the Strait.

Admittedly, my research suffers from several limitations, which can be divided into two categories: those resulting from previous research and those resulting from my own research. The first category involves the stockpile of Chinese runway-busting warheads for ballistic missiles. As suggested by previous research, my study assumed that the PRC possesses a sufficient number of warheads in its inventory to repeatedly target the runways of all ROC air bases. Additionally, in analyzing the effects of possible foreign involvement in the air war, I followed previous research and assumed only limited U.S. involvement and no direct Japanese involvement over the Strait.

Regarding the limitations of my own research, I must note that in assessing the possibility and effectiveness of a Chinese disarming strike, my calculations considered only ballistic missiles. Although cruise missiles and MRLs were mentioned, their effects were not calculated due to the scope of this thesis. Furthermore, in attempting to analyze the outcome of the air war itself, I used very simple calculations due to the unavailability of a suitable simulation system. Because of this limitation, I evaluated the likely outcome of the air war over the Strait as a comparison of air power rather than a simulation of the war itself. My research was also hampered by the limited availability of data, as much of the information necessary to assess the possible outcome of the air war over the Strait is classified. One variable that was severely limited by this restriction is the PRC aircrew quality, one of the most important variables, which is very difficult to assess using only open-source information.

Recommendations for future research can then be derived from the limitations of my research. Future researchers may wish to focus more thoroughly on the issue of Chinese ballistic missiles and the possibility of a disarming strike, and answer questions such as: "How will the possibility of a Chinese disarming strike against Taiwan change in the event of a comprehensive attack using ballistic missiles, cruise missiles, and MRLs?" or "Does China have enough runway-busting ballistic missile warheads to strike the runways and taxiways at all ROC air bases?" Future research should also focus on crucial variables that would significantly affect air warfare over the Strait in the event of a conflict. For example, more attention should be paid to researching the quality of PLAAF aircrew training, an extremely difficult yet extremely important issue that would arguably be one of the variables that would decide the battle in the air. Another key variable in the case of an air war between the PRC and the ROC would be the level of involvement of the U.S. and other countries such as Japan. Thus, future research should continue to address one of the most important questions regarding the threat of a potential Chinese attack on Taiwan: "Will the U.S. and (or) Japan support Taiwan in the event of a Chinese attack, and if so, what would and should such support look like?"

Summary

The potential for conflict between China and Taiwan has long been of interest to scholars and policymakers alike. This thesis takes a closer look at the issue by focusing specifically on a full-scale invasion scenario and examining the likely outcome of a struggle for air superiority over Taiwan.

The research presented in this thesis draws on previous studies published by RAND Corporation researchers over the past two decades. These studies are presented in the first chapter of this thesis. From these reports, the key variables are identified and described in the methodology.

Two main components of an air war over Taiwan were analyzed in this thesis. First, the feasibility of a Chinese disarming strike was assessed. Second, the outcome of the air war itself was examined. The research concludes that China currently has the upper hand in terms of military capabilities across the Taiwan Strait. Without the support of the United States, Taiwan would not be able to sustain a full-scale air war against the People's Liberation Army Air Force.

The thesis also evaluates possible future developments in the Taiwan Strait. The research suggests that we can expect either a continued buildup of Chinese military capabilities, which would increase the PLAAF's chances of achieving air superiority in the event of a conflict, or a continuation of the status quo currently observed across the Strait.

Finally, the thesis concludes that the assessment of the future of Taiwan's deterrence is consistent with Mearsheimer's view. Without the guarantee of U.S. support, Taiwan will not be able to deter China. As the costs of a potential Chinese invasion decrease and the chances of success increase, Taiwan's ability to deter China without U.S. support is unlikely.

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List of External Appendixes

An external appendix with the name “Appendix” can be accessed at: https://www.academia.edu/100808400/Appendix.

This appendix includes calculations carried out in both Excel and R, the results of which can be seen in the "Disarming Strike" chapter.