Missile defense and strategic stability: Terminal High Altitude Area Defense (THAAD) in South Korea

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Note to Proof-Reader: **Terminal High Altitude Area Defense** is a weapons system (brand name, like e.g. "Big Mac") and should be capitalized throughout the manuscript.

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ABSTRACT

South Korea is threatened by its troubled relationship with North Korea. North Korea possesses a large cache of missiles as well as chemical/biological weapons, and the future potential to mount nuclear weapons on its missiles. The United States is also challenged because of its defense commitments to Seoul. As a countermeasure, the United States and South Korea decided to deploy Terminal High Altitude Area Defense (THAAD) missile defenses in South Korea. However, China has objected. Chinese scholars believe the THAAD radar would be able to track Chinese intercontinental ballistic missiles, thereby weakening their deterrent. A technical analysis does not support this assertion. However, it is vital for South Korea, given its proximity and economic interdependence, to reassure China. South Korea should highlight that THAAD will be deployed by the United States Forces Korea (USFK) and is not a commitment by Seoul to become part of U.S.-led missile defenses in Asia-Pacific.

KEY WORDS

Ballistic missile defense, Terminal High Altitude Area Defense (THAAD), South Korea, China, strategic stability, extended deterrence

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No conflict of interest has been reported by the authors.

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Among the many facets of American commitment to its allies, including their national defenses' and extended deterrence, one of the most visible aspects is missile defense. Regional missile defenses, in particular, are designed to offer limited protection to the cities and military bases of U.S. allies and the forward-deployed U.S troops. The U.S. has developed and deployed regional missile defenses in both the European and the Asia-Pacific theatre. In the wake of the recent North Korean nuclear test and rocket launch, in July 2016, South Korea and the United States have agreed to deploy the Terminal High Altitude Area Defense (THAAD) missile defense system to the United States Forces Korea (USFK) ("US to Deploy," 2016).

China, however, has objected vehemently to the decision. A recent commentary in the *People's Daily* suggested that "if the United States and South Korea harm the strategic security interests of countries in the region including China, then they are destined to pay the price for this and receive a proper counter-attack" ("US will Pay," 2016).[i] A principal Chinese objection to the deployment of THAAD has been that the radar associated with the system would be able to observe and track Chinese warheads and decoys much earlier and possibility in far greater detail than previously possible (Riqiang, 2013, p. 46). Challenging this argument, this article and the associated technical appendix will demonstrate that a THAAD radar deployed near Seoul would have no significant ability to observe and track warheads and decoys deployed by a Chinese strategic missile.

While Chinese scholars and policy-makers couch the opposition to THAAD in technical details, there are also significant geostrategic calculations behind their reaction. In early 2016, when the United States offered to provide a technical briefing on the issue, Chinese foreign ministry spokesman, Hong Lei, argued that China did not view the matter "as simply a technical one. The THAAD system exceeds the normal defensive needs of the Korean peninsula, threatens China's reasonable national security interests and damages regional strategic stability" (Wroughton, 2016). China fears encirclement by the United States and its allies. In fact, anticipating the possibility of THAAD deployment, Chinese Assistant Minister of Foreign Affairs, Liu Jianchao, suggested in early 2015 that South Korea "….think about Beijing's attention to and concerns over the deployment of THAAD to the peninsula" (Sang-Ho, 2015; Chul, 2015; Huaxia, 2016). Provoked by the Chinese opposition at that time, Kim Min-Seok, spokesman for the South Korean defense ministry announced, "A neighboring country can have its own opinion on the possible deployment of the THAAD system here by the US forces in South Korea […] But it should not try to influence our [South Korean] security policy" (Sang-Hun, 2015). He also said, "We will make a decision if the U.S. government asks for consultations, and we make that decision based upon our national security interests and military benefits" (Sang-Hun, 2015).

The Republic of Korea (ROK) had for a long time publicly maintained a policy of "strategic ambiguity" on the missile defense question. The standard refrain has been the three no's: "on this issue there has been no request from the United States, no negotiations with the United States, and no decision by the Korean government" (Lee, 2015). The ROK has had several good reasons to maintain this ambiguity. South Korea works to sustain close ties with China given that it is ROKs largest trading partner (Chung, 2015, p. 10; Han, 2008, pp. 340-344). Overt cooperation with the United States on missile defense could risk antagonizing China. Also, an integrated Asia-Pacific missile defense could be perceived to include closer military cooperation with Japan, which the South Korean public might be unlikely to support.

On the other hand, the scale of the threat posed by North Korea has increased. Kim Jong Un, the current leader of North Korea, has conducted approximately 50 missile tests and three nuclear weapons test since he took over five years ago (Fitfield, 2016). North Korea is in possession of a large arsenal of missiles that in principle could be used to rapidly disrupt and destroy both South Korean and forward-deployed U.S. forces. North Korea has also continued to engage in provocative military encounters.

In response, South Korea has recently indicated a willingness to react more forcefully to North Korean provocations. For example, in the aftermath of the 2010 shelling of the Yeonpyeong Island by North Korea, South Korea espoused a new "Proactive Deterrence" strategy in its latest defense plan, the Defense Reform Basic Plan 2014-2030 (The National Institute for Defense Studies, 2015, p. 82). The Plan advocates the development of a kill chain that "is intended to detect signs that North Korea has launched nuclear weapons, missiles or long-range artillery and to intercept and destroy them over North Korean territory" (The National Institute for Defense Studies, 2015, pp. 84-85). The Plan also hinted at Seoul's willingness to pre-emptively strike at North Korea if it observes preparations for using missiles (The National Institute for Defense Studies, 2015, pp. 82, 84-85; Sang-Woo, 2010, p. 12; Eun-Jung, 2013). However, for South Korea to be able to exercise such options would require it to deploy THAAD-like missiles defenses that are more capable than the rudimentary system it currently has in place.

This paper examines the various factors that have influenced South Korean decision to deploy THAAD in its territory. The first section begins with a historical account of South Korean attitude towards missile defense. The second section outlines the scale of the missile threat posed by North Korea. It then provides an indication of the defense THAAD might provide. The third section will discuss in detail some of the concerns raised by China, their validity and various U.S. responses to China concern. The fourth section will examine the complicated relationship between South Korea and China. Finally, the article concludes with potential options for the U.S.-South Korea alliance to consider in the wake of the decision on THAAD deployment.

South Korean policy evolution on theater missile defenses

While the decision on the deployment of THAAD in South Korea is relatively new, the larger debate on theater missile defenses (TMD) has existed for over two decades in differing contexts. As far back as March 1985, U.S. Secretary of Defense Caspar Weinberger requested South Korea to participate in the Strategic Defense Initiative (SDI) program (Kim, 2009, pp. 376-377). Eventually, when Seoul decided to participate in SDI, it apparently did so only to obtain technological and scientific knowledge and not to accrue any additional security benefits (Kim, 2009, pp. 376-377).

In 1993, then U.S. Undersecretary of Defense John Deutch visited South Korea and requested its participation in a regional Theater Missile Defense (TMD) system (Kim, 2009, p. 377). At that time, both the South Korea foreign minister and air force chief indicated that Seoul might consider procuring the Patriot missile defenses for a price of $600 million for seven batteries (Kim, 2009, p. 378). However, later in 1994, Seoul decided against the purchase. Explaining the decision made, South Korean Defense Minister Rhee Byoung-Tae said: "We should be prudent in making the decision in order not to provide North Korea with a pretext on the nuclear issue" (Kiernan, 1994). In the same year, however, USFK were able to independently deploy Patriot Advanced Capability (PAC-2) batteries at Pusan (Myo-ja, 2003; Pine, 1994; "North Korean Nuclear," 2011). The deployment of PAC-2 was primarily seen as a decision made by USFK for the organic defense of its forward-deployed forces and not as a policy change in Seoul on missile defense (Myo-ja, 2003; Pine, 1994; "North Korean Nuclear," 2011).

In 1999, in the face of growing North Korean nuclear and missile capabilities, the issue of TMD was brought up again at various U.S.-South Korea forums. In May 1999, the South Korean President Kim Dae Jung announced "that South Korea would not join the TMD system on the grounds that it would provide little benefit to the defense of South Korea" (Kim, 2009, p. 378). In 2001, South Korea Defense Minister Cho Sung-Tae, pointing to the high costs and questions on the feasibility of missile defenses, expressed South Korea's unwillingness to participate in U.S. TMD plans (Kim, 2009, p. 380). He, however, "admitted that South Korea "needs to build our own missile system that fits our circumstances" (Kim, 2009, p. 380). Beginning in 2006, South Korea started to acquire components for its independent, lower-tier missile defenses, called the Korea Air and Missile Defense (KAMD) system. Its first procurement was the acquisition of 48 U.S. PAC-2 interceptors from Germany in 2008 (Montague, 2014, p. 4). In 2012, it acquired and deployed two Israeli Green Pine radars (Montague, 2014, p. 5). As of late 2013, South Korea had approximately 300 Patriot PAC-2 missiles in its inventory (Montague, 2014, p. 4). In 2013, South Korea also requested the sale of 112 batteries of the more advanced PAC-2 Guidance Enhanced Missile (GEM-T) (Hyun, 2013). There are also ongoing talks with the United States on acquiring the latest PAC-3 models (Shalal, 2015). South Korea has three Navy Cruisers equipped with the U.S.-designed Aegis combat system, SPY-1D radars, and SM-6 missiles. These ships successfully tracked the 2012 launch of the North Korean Unha-3 rocket (Keck, 2013). Finally, the command and control of KAMD rely on early-warning data from U.S. satellites (Eun-Jung, 2013). To sum up, the KAMD is substantially American technology but is operationally South Korean.

While the Patriot missile defenses currently deployed within the KAMD and with the USFK affords some protection against North Korean missiles, U.S. commanders in Korea have persistently suggested that these systems be considered as part of a layered missile defense architecture. Patriot missile defenses have a very small defensive footprint and can defend only a small portion of South Korea. In 2008, at his nomination hearing, USFK Commander General Walter Sharp suggested that development of THAAD could be crucial "to provide the layered, systematic missile defense capability required to protect critical United States facilities in the Republic of Korea" ("Nominations before the," 2008). Similarly, in 2011, General James D. Thurman at his nomination hearings as USFK Commander testified that "the system that would best support the layered defense employment principle is a THAAD system which can engage inbound TBMs at either the terminal or mid-course phase of flight. A THAAD system could be used to provide layered defense and also improve early warning for the Korean Peninsula as well as enhance Ballistic Missile Defense (BMD) early warning in the region" ("Nominations before the," 2011).

North Korean missile threat and the missile defense response

The primary factor impelling South Korea's missile defense choices is the persistent and growing North Korean threat. The missile arsenal of North Korea has grown, with some qualifiers, at a constant pace in both quantity and quality. While it is very difficult to obtain an accurate count of North Korea missiles, it is possible to develop a rough estimate based on various publicly available sources. A report by the International Crisis Group (2009, p. 8) lists that North Korea has probably deployed over 600 SCUD missile variants and around 320 Nodong missiles. The 2010 USFK *Strategic Digest,* states that North Korea "with as many as 800 missiles in its active inventory…intends to increase its offensive capabilities" (Cordesman & Linn, 2015, p. 184; "Statement of General," 2007, p. 7; United States Forces Korea, 2010, p. 11). Very recent estimates by the U.S. Air Force have suggested that North Korea could have a total 1,000 missiles with around 100 SCUD launchers and 50 Nodong launchers (National Air and Space Intelligence Center, 2013; Schilling & Kan, 2015, p. 10). Table 1 below summarizes an estimate of the North Korean missile inventory collated from multiple sources. A more conservative estimate of North Korea missile inventory and capabilities is provided in Schiller (2012, p. 66).[ii]

	Toksa (Viper /KN-02)	SCUD-B (Hwaseong-5)	SCUD-C (Hwaseong-6)	SCUD-ER	Nodong	Musudan (BM-25, Nodong-B, Taepodong-X, Mirim)	Taepodong-1 (Paektusan-1)	Taepodong-2 (Paektusan-2/Unha-2)	KN-08 (Hwaseong-13) (Road mobile ICBM)
Range (km)	120	300	500	700-1000	1,300	> 3,000	1,500 to ~2,000	6,000 to ~10,000	~10,000
No. of Missiles		600-800			200-300	30 to ~50	20-30	~5	
No. of Launchers	~100	~40 to ~100			30 to ~50	25 to ~50		~6 (Road mobile version)	
Warhead Weight (kg)		1,000	770		700	650	500	650 to ~1,000	500 to 700
Status		Operational	Operational		Operational	Operational	Test Launch	Under Development	

Table 1: North Korean Missile Specifications

Source: Office of the Secretary of Defense,2013, p. 19; Ministry of Unification, 2014, p. 193; Ministry of Defense, 2015, pp. 20-22; Ministry of National Defense, 2014, p. 32; International Crisis Group, 2009; Cordesman & Linn, 2015, pp. 184, 187; National Air and Space Intelligence Center, 2013.

While North Korea has an ambitious missile development program, its various missile capabilities are not equal. For example, its ability to successfully use an Inter-Continental Ballistic Missile (range greater than 5,500 kilometers) or even an Intermediate Range Ballistic Missile (range from 1,000 kilometers to 5,500 kilometers) is highly questionable (Mayer, 2015). However, recent successful space launches by North Korea suggest it is becoming increasingly capable (Landler, 2016). A U.S. Defense Department (2013) Annual Report on North Korea, for example, points out that "ICBMs are extremely complex systems that require multiple fight tests to identify and correct design or manufacturing defects, and the Hwasong-13 has not been flight-tested. Without flight tests, its current reliability as a weapon system would be low" (p. 10). The report also says that "a space launch does not test a reentry vehicle (RV). Without an RV capable of surviving atmospheric reentry, North Korea cannot deliver a weapon to target from an ICBM" (Office of the Secretary of Defense, 2013, pp. 10-11).

However, North Korea's shorter range missiles, including various types of SCUDs and some Nodong missiles are more tested and presumed to have a higher likelihood of operational effectiveness. One of the largest worries for the U.S.-South Korean alliance is the concerns regarding the North's potential ability to use these missiles coupled with a nuclear weapon. The South Korean 2014 Defense White Paper, for example, speculates that "North Korea possesses about 40 kg of plutonium that can be used to produce nuclear weapons and it also assessed that a highly enriched uranium (HEU) program is underway. North Korea's ability to miniaturize nuclear weapons also seems to have reached a considerable level" (Ministry of Defense, 2014, p. 32).[iii] North Korea is also feared to have an arsenal of biological and chemical weaponry that could be delivered using its missiles. Its chemical weapons stockpile was estimated in 2005 to be between 2,500 and 5,000 tons (Ministry of National Defense, 2014, p. 32; J5 Strategic Communications Division, 2005, p. 14). Finally, even with mildly inaccurate conventional warheads, North Korean missiles could, in principle, substantially disrupt military operations and impede logistics at U.S. bases in the region.

Conceivably, the deterrence of the American nuclear umbrella might dissuade North Korean use of nuclear force (O'Neil, 2005, pp. 327-338). However, the North Korean missile threat outlined above must be taken seriously and a credible defense against such threats is needed. In a major military contingency for the U.S.-ROK alliance, North Korea could potentially launch hundreds of SCUDs into South Korean cities and military bases simultaneously. The North Koreans have recently demonstrated another worrisome capability. On March 26, 2014, North Korea test fired two medium-range Nodong missiles, one day after a trilateral South Korea-Japan-U.S. meeting

("NK's March missile," 2014). Particularly worrisome about this test were the launch tactics. Instead of flying a nominal trajectory with a range of 1500 kilometers, the Nodong flew a modified trajectory for a distance of only about 650 kilometers ("NK's March missile," 2014). It was apparently launched at a steeper (i.e., lofted) angle, rose to an altitude higher than usual and fell back down with a much higher speed. Such a missile trajectory would likely be quite difficult to defend using the Patriot PAC-2/3 point defense batteries already in place. As reported, according to an anonymous senior South Korea military source, "by carrying out such a test, North Korea appears to have come up with a way not to be caught by either the South Korean or American missile interception system when launching an attack against South Korea with its midrange missiles" ("NK's March missile," 2014). A THAAD system would likely have a better chance of handling missile trajectories when "launched at high trajectories (i.e., arcing at a high angle and reaching a high altitude relative to the ground distance traveled)" (Grisafi, 2015). With a presumed capability to have an intercept range of 200 kilometers with a maximum altitude ceiling of approximately 150 kilometers, THAAD would, in principle, be able to execute intercepts earlier when the North Korean Nodong missile would be more vulnerable (Kasper & Balle, 2014).

Missile defense, however, cannot provide 100% guaranteed defense against every incoming missile. Rather, missile defense is expected to intercept a significant fraction of an early salvo of missiles, thereby giving the U.S.-ROK forces sufficient time to respond. The presence of THAAD will not eliminate the missile threat that U.S.-ROK forces might face from North Korea. Specifically, a single THAAD battery[iv] is likely sufficient to defeat a barrage of a small number of threat missiles. North Korea, on the other hand, is believed to possess 250-300 Nodong missiles that can be launched in a short time window (The National Institute for Defense Studies, 2015, p. 64). Even with an idealized ratio of one interceptor for every missile, one or two THAAD batteries would only be able to provide only limited protection to critical civilian and military assets. A large North Korean attack salvo of hundred(s) of missiles could still cause severe damage to alliance forces or civilian populations. Nevertheless, THAAD along with the Patriot systems could offer a valuable capability to preserve important military assets thereby strengthening overall deterrence.

China's opposition to the Asia-Pacific missile defense deployments

China has had an innate suspicion regarding U.S. missile defense deployments in the Asia-Pacific region. A recent Chinese military text, *The Science of Military Strategy,* has, for example, asserted that U.S. missile defense in Asia is "creating increasingly serious effects on the reliability and effectiveness of a Chinese retaliatory nuclear attack" (Kulacki, 2015, p. 5). Chinese personnel argues that missile defense deployments in their neighborhood would fundamentally alter the strategic balance and stability between the United States and China and, in turn, could force China to increase its nuclear arsenal or adopt other countermeasures (Cunningham & Fravel, 2015, pp. 7-8). China and Russia have consistently argued that any missile threats from North Korea are a pretext to deploy missile defenses targeting them ("Joint Statement by," 2000).

Although Washington, DC is undertaking a missile defense plan that it clearly states is driven by legitimate U.S. and allies' security considerations, China and Russia apparently have found it difficult to accept this U.S. articulation. Conceivably "in dealing with the US, prudent states are necessarily going to assume that its intentions are at best ambiguous, and more likely adversarial" (Steff and Khoo, 2014, p. 233). China and Russia tend to argue that even mild U.S. missile defense postures will over time accumulate increasing capabilities; and can therefore quickly convert such capability to a larger threatening posture in the region (Rinehart, Hildreth, & Lawrence, 2015, pp. 15-18, Haynes, 2016, p. 49; Christensen, 1999, pp. 51, 54 & 62).

Such logic can be observed directly in Chinese opposition to the deployment of THAAD. Riqiang (2013) from China's Renmin University, for example, suggests that "Beijing's biggest concern is that such radars will be deployed close enough to China to register the decoy-deployment process of strategic missiles […] this prevents missile defense systems from being susceptible to mid-course decoy countermeasures, and should be seen as China's red line" (p. 46). It is worthwhile to remember that U.S. early-warning satellites have had the ability for a long time to track missiles launched from any location in the world, including from China, during the boost-phase by tracking their infrared radiations. Any significant additional benefits to U.S. missile defense mission from the THAAD radar would lie in its ability to track the warhead and decoys after the missile's rocket motors have burnt out and not in its ability to track the missile while they are still in powered flight.

One Chinese writer has said that "the highly advanced AN/TPY-2 radars, a core component of THAAD, US surveillance will be greatly expanded, effectively covering the entire Chinese mainland" (Rui, 2015).[v] Even with modest analysis, it is evident that THAAD radar simply cannot cover the entire or even a substantial portion of Chinese mainland (see appendix for a complete technical analysis). Such coverage would require the radar to operate at distances more than 4,500 kilometers, which is far beyond the capabilities of the THAAD radar. U.S. defense officials point out that the AN/TPY-2 radar operates in an "engagement mode" with a much shorter effective radar range (Rinehart, Hildreth, & Lawrence, 2015, p. 12). The frequently cited range for the THAAD radar is about 1,000 kilometers, depending on the quality of data needed (Lewis & Postol, 2012). In fact, it is possible that in some situations the ranges are, in fact, much lower and do not possess the ability to track Chinese strategic missile warheads/decoys (see appendix).

Additionally, the United States has repeatedly pointed out that these systems do not and are not meant to alter the strategic stability. For example, the recent U.S. Ballistic Missile Defense Review stated that "Engaging China in discussions of U.S. missile defense plans is also an important part of our international efforts […] maintaining strategic stability in the U.S.-China relationship is as important to the administration as maintaining strategic stability with other major powers" (U.S. Department of Defense, 2010a, p. 34). The 2010 Nuclear Posture Review also made similar commitments (U.S. Department of Defense, 2010b, pp. 4 & 29).

Of course, in theory, U.S. missile defense systems in the Asia-Pacific could be reconfigured to offer limited defenses against Chinese short- and medium-range missiles. However, such a reconfiguration would be of limited effectiveness given that China's deployed missile arsenal is one of the most extensive in the world (Cordesman & Linn, 2015, pp. 467-472). China continues to modernize its missile arsenal and is also developing newer and more capable offensive missiles (Office of the Secretary of Defense, 2010, p. I). China is believed to have around 1,200 short-range missiles. Its medium-range missile inventory could include as many as 400 CSS-6 missiles (with a range of 600 kilometers) and around 85 CSS-5 missiles (with a range of 1,750 kilometers) (Office of the Secretary of Defense, 2010, p. 66). China also possesses a significant number of other medium- and intermediate-range ballistic missiles (Office of the Secretary of Defense, 2010, p. 66). These missiles could be targeted against U.S. forward-deployed forces, allied forces and bases in the region. Succinctly capturing this aspect of the tensions between the United States and China on missile defense, former Secretary of Defense William Perry (2000) states that:

> I share the Chinese concern over the deleterious effect of an arms race in the region, but I believe that if an arms race does get underway it will have been stimulated by the extensive deployment of missiles, not the deployment of missile defenses […] I am today more pessimistic about the future of United States-China relations than I have been for several decades.

Presently, ranges of Chinese missiles extend to U.S. bases as far away as Guam. Any debate on U.S. missile defense reductions in the region should, therefore, also involve a discussion of China's missile arsenal.[vi]

South Korean relations with China

South Korea has often characterized itself as a nation caught between two major powers: China and the United States (Kim, 2014). The popular caricature has been: "When Whales [U.S. & China] fight, the shrimp's [South Korea's] back is broken" (Ratner, 2014). South Korean foreign policy elites have attempted to strike a balanced relationship between the United States and China, and the decision on THAAD (and North Korea) falls in the middle of that balancing act.

South Korea has a substantial trade relationship with China. In 1992, when South Korea and China established formal diplomatic relations their bilateral trade stood at 4.4 billion dollars (Allen et al., 2000, p. 35). In 2014, South Korea had roughly 235 billion dollars of trade with China, which is higher than South Korea's combined trade with both the United States and Japan at about 200 billion dollars. South Korean trade with China constitutes over 21 percent of its global trade (Chung, 2015, p. 10; Han, 2008, pp. 340-344). There have been concerns in South Korea that China might use non-tariff barriers, tighter customs inspections, and other means to punish it for agreeing to the deployment of THAAD (Lee, J., 2016). Additionally, there is a large infusion of Chinese culture into South Korea with many South Koreans learning Chinese, visiting China, and enrolling in universities throughout China (Han, 2008, p. 336).

China has also responded positively to some South Korean concerns. In a shift from its standard protocol, China did not veto the passage of United Nations Security Council (UNSC) Resolutions 2087 and 2094 tightening sanctions over North Korea (Ministry of Defense, 2015, p. 27). Some senior Chinese officials also came out and spoke against North Korean actions. First Vice-Premier of the State Council, Li Keqiang, has "cautioned Pyongyang" on "its provocative and troublesome behavior" (The National Institute for Defense Studies, 2014, p. 89). Wang Jiarui, director of the International Department of the Central Committee of the Communist Party of China (CCP) stated that "both countries [China and North Korea] merely had 'normal relations between states' and not a 'special relationship,' implying that in Beijing's view the two neighbors no longer shared the blood ties that they had held since the Korean War" (The National Institute for Defense Studies, 2014, p. 89).

The diplomatic norm for a long time has been for the Chinese president to visit North Korea before visiting South Korea. However, breaking away from this pattern, President Xi Jinping made an unprecedented state visit in July 2014 to South Korea without going to the North (The National Institute for Defense Studies, 2015, p. 66). The visit ended with a *joint communique* on political and security matters as well as economic and cultural issues. On the security front, the *joint communique* stated: "both countries firmly opposed nuclear weapons development in the Korean Peninsula" (The National Institute for Defense Studies, 2015, p. 77). The use of such strong language like "firmly" was interpreted in South Korea as a significant departure from past Chinese practices and as a meaningful change in Chinese positions concerning North Korea. The communique also mentioned that both nations would start formal discussions on fixing their ocean boundaries; an issue of importance to South Korea (The National Institute for Defense Studies, 2015, pp. 66, 76-77).

Nevertheless, there remain significant points of contention between South Korea and China. For example, soon after China declared an expansion of the East China Air Defense Identification Zone, which overlapped with South Korea's own air defense zones, the Park Geun-Hye administration rejected the Chinese declaration (The National Institute for Defense Studies, 2014, p.

100). China disappointedly also did not take a public stance after a North Korean submarine torpedoed a South Korean navy ship, the Cheonan, in March 2010 that resulted in the death of 46 sailors. At the end of an internationally conducted investigation, there was strong forensic evidence that North Korean was the perpetrator (Snyder & Byun, 2011, pp. 74-81).[vii] The United States and South Korea were attempting to marshal international condemnation against North Korea for an unprovoked attack. China, however, took weeks to acknowledge the incident. China nonchalantly called for a "flip over the page" of the incident and resumption of six-party talks ("China Calls for," 2010). President Obama commenting on the Chinese position has said that "They have a security interest in not seeing complete chaos on the Korean peninsula […] But there is a difference between restraint and willful blindness to consistent problems" ("Remarks by President," 2010). Similarly, China again did not admonish North Korea when it engaged in the unprovoked shelling of the Yeonpyeong Island in November 2010. The incident resulted in the death of two South Korean marines and two civilians residing in the Island. As a consequence, tensions between the two Koreas escalated to a level not seen since the 1953 armistice (McDonald, 2010a). Beijing's response was a generic statement saying "related parties do things conducive to peace and stability in the Korean Peninsula" ("China Expresses Concern," 2010; McDonald, 2010b). In the wake of the North Korean nuclear test in January 2016 China seemed initially reticent to support additional U.N. sanctions (Ellis, Kwon, & Ap, 2016; Snyder, 2016). China had apparently also refused to engage in direct communication at the level of defense ministers with Seoul regarding North Korean provocations ("Who's to Blame," 2016).

In essence, while South Korea retains a very productive economic partnership and cultural exchanges with China, on the matter of North Korea there are measurable differences. Chinese actions are primarily driven by a desire to avoid political instability in North Korea. China also aims to minimize American influence in the region. South Korea, on the other hand, is dependent on the United States for its national security needs. As the threat from North Korea grows, Seoul will increasingly rely on the United States to counterbalance that threat.

Conclusion

This paper examined the various factors that have influenced South Korea policy preferences on missile defense cooperation with the United States to understand the recent decision to deploy THAAD near Seoul. The decision was motivated by increased North Korean belligerence and a growing missile arsenal that might pose a major threat in a military contingency. China, however, has strenuously objected to the decision arguing that the THAAD radar would pose a threat to its nuclear deterrent against the United States. A technical analysis does not support this assertion. It is more likely that geopolitical considerations drive China. China remains very skeptical of any major military expansion of the U.S. alliance with South Korea.

While the need to limit provoking China will continue to influence South Korea defense decisions, China should not possess a veto over South Korean defense choices. It is worthwhile to note that "it is highly possible that China considers [South] Korea as the weakest link among the Northeast Asian allies of the United States and, in this context, believes it could weaken the U.S.-South Korea alliances" (Jung-Yeop & Block, 2015). If China were able to influence the security decisions of South Korea unduly, it could set an unfortunate precedent. Such a precedent could effectively demonstrate China's influence in political-military decisions to other regional players, giving it significant leverage. It is not in South Korea's (or the United States') interest to provide such leverage to China.

In fact, in the near term, recurrent North Korean provocations will likely shift South Korean preferences towards a more assertive defensive posture. Daniel Russel, U.S. Assistant Secretary of State for East Asia recently pointed out at a congressional hearing that the "two nuclear tests and an unprecedented series of ballistic missile launches this year flagrantly violate United Nations Security Council Resolutions (UNSCRs). Moreover, North Korea has repeatedly threatened to attack the United States and our allies with nuclear weapons" ("The Persistent Threat," 2016). Unless some of form of arms control agreement is negotiated with North Korea, it would be politically impossible for South Korea not to pursue such defensive options. However, South Korea could pursue its options without overtly disregarding Chinese concerns. Some have argued that the impending deployment of THAAD would imply that South Korea has consented to become a part of the integrated U.S.-Japanese Asian missile defense structure (Yoon, 2015). South Korea should stress that it has not agreed to become part of a broader regional missile defense architecture. Seoul should indicate that it continues to operate its Korea Air and Missile Defense (KAMD) system independent of the United States. South Korea could also provide some reassurance to China by pointing out that USFK will be independently deploying very limited numbers of THAAD interceptors primarily for the defense of U.S. troops in the region.

However, policy makers in South Korea and the United States should not eliminate the future possibility of having Seoul participate in a regional Asian missile defense architecture. They should retain the option of pursuing at least some interoperability during a crisis. The oft-cited worry of U.S. allies, including South Korea, is that adversaries might succeed in decoupling their defense from American interests (Roberts, 2014; Frühling & O'Neil, 2017, pp. 15-17). The chief mechanism by which adversaries such as North Korea could pursue that such a tactic is to target U.S. forward-deployed forces, U.S. aircraft carriers groups operating in the region, and major U.S. bases from which military operations are conducted. Integrated missile defenses could, in principle, be better equipped to foil such a strategy (Yun-Hyung, 2016).

Appendix: Range of THAAD AN/TPY-2 Radar

The maximum range of a tracking radar is determined by the equation (Skolnik, 2001, p. 88):

$$R^4_{max} = \frac{P_{av} G A \rho_a \sigma \, n \, E_i(n) \, F^4 \, e^{-2\alpha R max}}{(4\pi)^2 \, k T_0 F_n \, (B\tau) f_p (\frac{S}{N})_1 L_f L_s}$$

where

R_{max}= Maximum radar range, m
P_{av}= Average transmitted power, W
G= Antenna gain
A= Antenna area, m2
Antenna aperture efficiency
σ= Radar cross section of the target, m2
n= Number of pulses integrated
$E_i(n)$= Integration efficiency
F^4= Propagation factor
α= Attenuation coefficient, nepers per unit distance

k= Boltzmann's constant = 1.38 x 10-23 J/deg.
T_0= Standard temperature = 290 K
F_n= Receiver noise figure
B= Receiver bandwidth, Hz
τ= Pulse width, s
f_p= Pulse repetition frequency, Hz
$(\frac{S}{N})_1$= Signal-to-noise ratio required as if detection were based on only a single pulse
L_f= Fluctuation loss (for a Swerling target model)
L_s= System loss

This equation inherently maximizes the range of the THAAD radar by assuming operations in tracking mode, as opposed to surveillance mode. A radar in tracking mode already knows where the target missile is located in space and can direct energy at the target. In reality, though, the radar must search a certain volume of solid angle in space (Delaney, 2015, pp. 190-191).

Simplifying the equation listed above:

$$R_{max}^4 = \frac{P_{av} G A \rho_a \sigma\, n}{(4\pi)^2\ k T_0 F_n\ f_p (\frac{S}{N})_1 L_s}$$

To solve this equation, the various parameters of the THAAD radar were collated from multiple sources and listed in Table 2 below (American Physical Society, 2003, p. 177; Lewis and Postol, 2012). Most of the information listed below was chosen to maximize the range of the THAAD radar. For example, the average transmitted power was presumed to be 81,000 Watts. However, other sources have used 76,000 Watts. Similarly, in the calculations below, an optimistic antenna aperture efficiency (ρ_a) of 0.8 was chosen. However, it may be that antenna aperture efficiency would be lower, as low as 0.65 (American Physical Society, 2003, p. 177).

Furthermore, the values for radar cross are varied parametrically between 0.001 m^2 and 0.025 m^2. Warheads and decoys might have radar cross section values close to 0.01 m^2 (Lewis and Postol, 2012). In fact, at certain aspect angles between the radar and the warheads/decoys it might be even lower (Sessler et al., 2000, p. 131).[viii] Similarly, the values for signal-to-noise ratio $(\frac{S}{N})$ is varied parametrically between 20 and 100. For the THAAD radar to be able to effectively delineate the process of decoy deployment and be able to differentiate decoys from actual warheads would likely require signal-to-noise ratios in the higher end of this range.

Finally, we use two sets of values are used for the number of pulses integrated (n) and the pulse repetition frequency (f_p). The first set of optimistic values in case 1 chose parameters that maximize the range for the THAAD radar. The second set, case 2, uses more realistic values to show how the range of the THAAD radar decreases. The two sets of parameters lead to different dwell times.

Parameter	Value	
P_{av}	81,000 W	
A	9.2 m^2	
ρ_a	0.8	
F_n	400^{0}K	
L_s	8dB=6.3	
σ	Varied parametrically between 0.001m^2 and 0.025m^2	
$\left(\frac{S}{N}\right)_1$ or SNR	Value of SNR is varied parametrically from 20 to 100. 13dBsm 20 (Prob. of detection=0.9; Prob. of false alarm=10^{-6}).	
	Case 1	*Case 2*
N	20	2
f_p	200 Hz	75 Hz

Table 2: THAAD Radar Parameters

SOURCE: By author(s)

Using these different combinations of parameters, we calculated ranges of the THAAD radar as displayed below in figure 1. For the idealized case 1, in which the values for the number of pulses integrated (n) and the pulse repetition frequency (f_p) was selected to maximize radar range, the maximum range of the radar is around 1,000 kilometers (at a radar cross section of 0.025 m^2 and a signal-to-noise ratio of 20). However, if a more likely lower radar cross section and/or signal-to-noise ratio is chosen, the range is significantly reduced. For example, at a radar cross section of 0.01 m^2 the range drops to around 800 kilometers (see the dark black dot in figure 1(a) below).

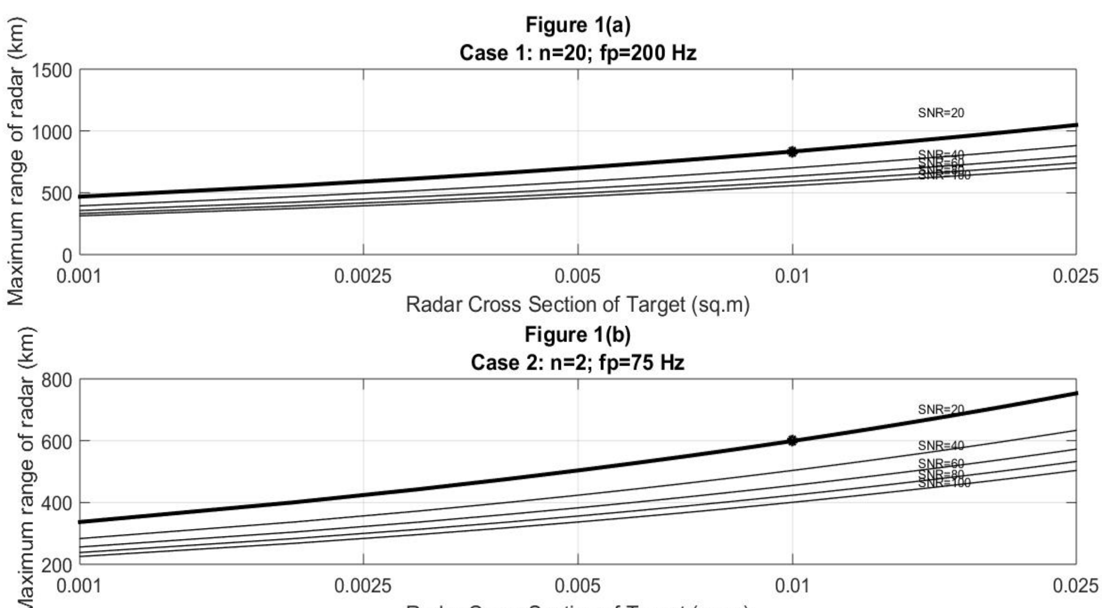

Figure 1: Parametric Evaluation of the Range of the THAAD Radar.
SOURCE: By author(s)

Note: The x-axis represents various possible values of radar cross section of target warheads and decoys. The y-axis represents the corresponding maximum possible ranges of the radar. The dark black dots indicate the nominal range of a THAAD radar. In case 1, it reveals that the maximum range of a THAAD radar is approximately 800 kilometers when the radar cross section is 0.01 m^2 and the SNR is 20.

At a range of 800 kilometers, a hypothetical THAAD radar deployed in the city of Pyeongtaek (Shim, 2016), near Seoul would, for example, have no ability to observe and track warheads and decoys deployed by a Chinese strategic missile. As figure 2 below clearly shows, most trajectories from a variety of known Chinese missile launch sites (Patton, Podvig, & Schell, 2013, pp. 6-9) are clearly beyond the tracking capability of the radar. Even the one trajectory that is momentarily observable could be lofted to avoid the radar detection entirely.

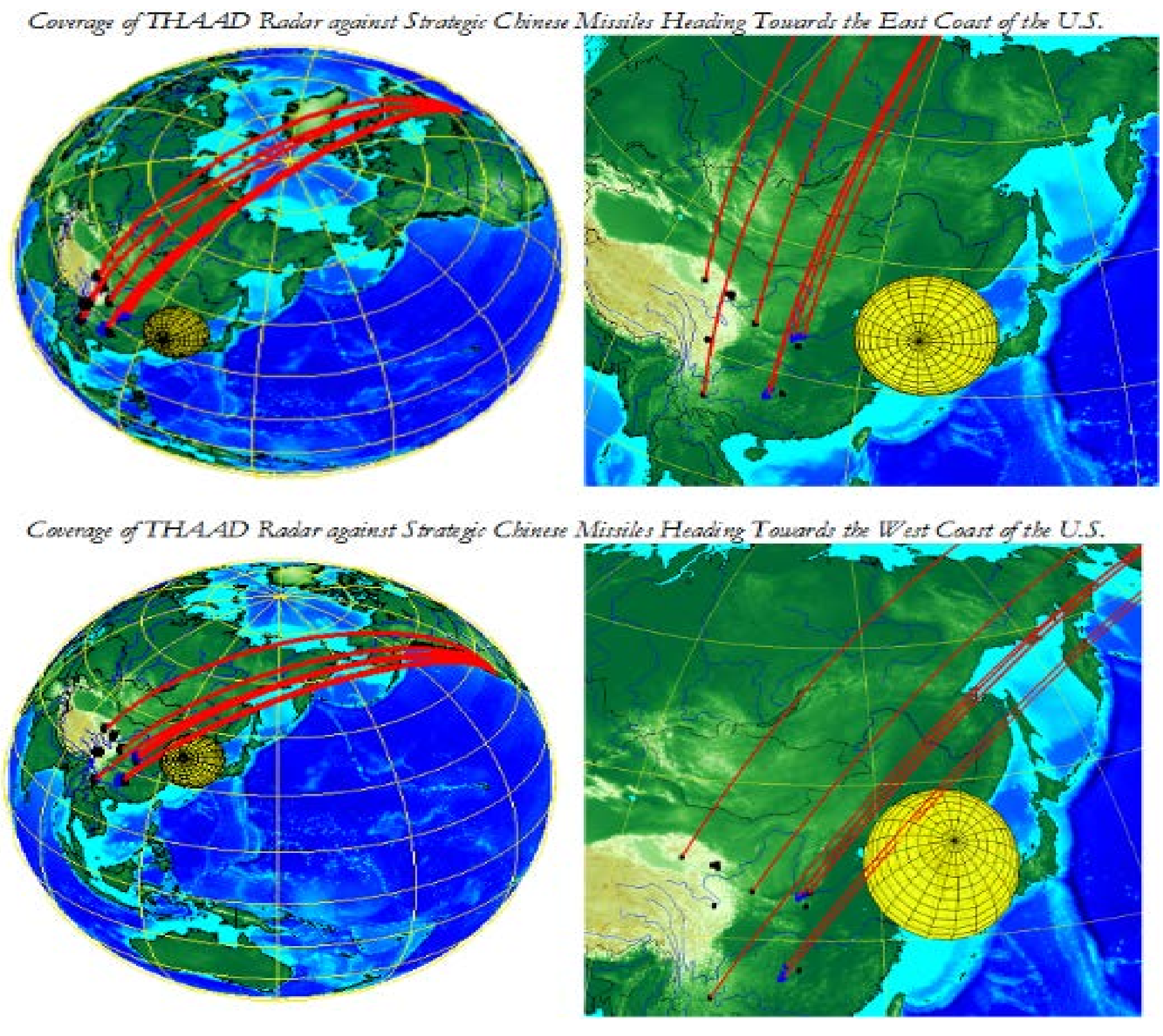

Figure 2: Coverage of THAAD Radar (with 800 Kilometer Range) against Strategic Chinese Missiles
SOURCE: By author(s)
Note: The dots represent the locations of Chinese mobile and silo-based ICBM units. The lines on the map represent the trajectories of Chinese missiles. Finally, the dome on the map represents the extent of an 800-kilometer range THAAD radar located in Pyeongtaek, near Seoul.

It is worth stressing that even a range of 800 kilometers is highly optimistic. In reality, the actual operational range of the THAAD radar would likely be much lower. For example, in the more realistic case 2, the ranges decrease dramatically. For case 2 shown in figure 1(b), the maximum range of the radar is around 750 kilometers (at a radar cross section of 0.025 m^2 and a signal-to-noise ratio of 20). However, at a radar cross section of 0.01 m^2 the range drops even further to only around 600 kilometers. All of these calculations and graphs discussed above show that a THAAD radar in South Korea would not pose a threat to the Chinese deterrent.

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Notes

[i] The source ("US will Pay," 2016) points out that the commentary was posted under the name Zhong Sheng which translates to "voice of China", apparently a nom de plume that is often used to give the Communist Party's view on foreign affairs.

[ii] Schiller while acknowledging some level of speculation, he suggests that there are only hundreds of SCUD B models, around 100 SCUD C models, a few dozen SCUD D/ER models, a few dozens of Nodong, around two Taepodong-II, small number of Musudan missiles in North Korean inventory. Furthermore, he argues that "only a small number of [North Korea] launch crews can be well trained…the lack of crew training will result in moderate results at best, with handling failures and low accuracy. If missile are produced in North Korea, they are not of excellent reliability and accuracy because of the lack of firing table creation and lot acceptance tests" (Schiller, 2012, p. 66).

[iii] For a study on how North Korea might use its nuclear weapons and damages such a use might cause, see: Bruce W. Bennett (2010).

[iv] A single THAAD battery consists of six to nine launchers, 48 to 54 missiles and a fire control including an Army Navy/Transportable Radar Surveillance and control Model 2 (AN/TPY-2 radar) (O'Neill, 2011, p. 8; "Strategic Weapons: China," 2015; "THAAD Battery to," 2015).

[v] Similarly, Hyun (2015) suggests that THAAD could have a range of 3,000 km.

[vi] On China's conventional missile capabilities, see: Chase, Erickson & Yeaw, 2009, pp. 72-73. For some preliminary discussions on Chinese conventional missile doctrine, see: Lewis, 2014, p. 112.

[vii] For a skeptical view point on the conclusions of the international investigation, see: Lee & Suh (2010).

[viii] According to Sessler et al. (2000): "A sharply pointed cone-sphere [approximation to a warhead] will have a nose-on RCS…about 0.00009 m^2 for an X-band radar." However, it is conceivable that for very few and specific trajectories that emerge from the South-eastern part of China, the RCS might be quite high momentarily. That possibility does not weaken the broad conclusions made above.