

Early Warning in the Taiwan Strait



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Cover Image: Aerial view of military radar and asphalt road in Kenting National Park, Hengchun Town, Southern Taiwan at sunrise. (*Source: "PNK Photo."*)

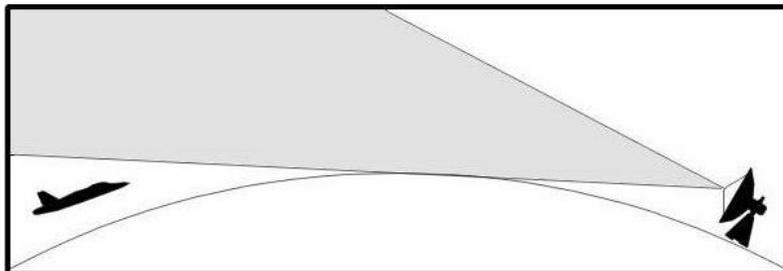
Introduction

Air sovereignty is a nation's exercise of absolute control and authority over the airspace above its territory. Political and military leaders demonstrate authority over territorial airspace through surveillance and control. Territorial airspace is the domain above a country's land areas, internal waters, and territorial waters out to no more than 12 nautical miles. The U.S. Department of Defense defines air sovereignty as "a nation's inherent right to exercise absolute control and authority over the airspace above its territory."¹

Taiwan, under its current Republic of China (ROC) constitution, exists as an independent sovereign state. From Beijing's perspective, there is one China, Taiwan is part of China, and the People's Republic of China (PRC) is the sole legitimate government of China in the international community. PRC claims over Taiwan represent a border dispute in which one side claims the entire territory of the other.

Early warning systems are critical at each point along the peace-war continuum. Early warning generally includes intelligence, space-based infrared sensors, and long-range radars. Various sources of intelligence, such as human resource intelligence, signals intelligence, and satellite imagery may provide strategic warning pending military action. U.S. Space Command provides warning through satellite-based infrared sensors that are able to detect heat signatures created by ballistic missiles upon launch. Alerts are shared with allies and partners, including Taiwan.

Taiwan relies mostly on radar for early warning.² Ground-based and airborne radars and other sensors search the air, space, maritime, land, cyber, and electromagnetic domains for indications and warnings of potential threats, including a full-scale invasion. Radar intelligence can be produced through monitoring and cataloging air activity over time, which helps discern patterns and unusual activity. Radar is correlated with identification friend or foe (IFF) equipment and passive sensors to determine the nature of flight activity. It scans within a defined geographic area well beyond territorial airspace, known commonly as an air defense identification zone (ADIZ). Air surveillance radar works in tandem with civilian air traffic control to deconflict the use of airspace and enable vectoring of fighters to visually identify flight activity within an ADIZ.³ Upon detecting large-scale raids, long-range radars enable the dispersal of aircraft and cueing of ground- and sea-based air defenses. Early warning thus offers Taiwan's national command authority an essential window of time to implement contingency plans for civil defense, mobilization, and counterstrikes.



(Figure 1: At very long ranges the curvature of the Earth limits the so-called "radar horizon.")

Source: "Ogier Electronics."

Ground-based early warning radars are typically characterized by large antennae and low frequencies that can detect and track PLA flight activity hundreds of kilometers away. Line of sight limits a radar's detection range. The higher the radar, the greater the range, placing a premium on mountaintop real estate. Taiwan is blessed with some of the highest elevations in the Indo-Pacific region, giving its radars an advantage. In addition to conventional long range radar systems, Taiwan has invested in early warning radar systems capable of detecting potentially catastrophic ballistic and land attack cruise missile strikes.

A powerful ground-based early warning radar, similar in appearance to the U.S. Precision Acquisition Vehicle Entry Phased Array Warning System (PAVE PAWS) radar, detects PLA ballistic missile launches upon breaking the horizon thousands of kilometers away. The single ground-based radar is also capable of detecting airbreathing flight vehicles and maritime traffic transiting the Taiwan Strait. However, any ground-based system will have limitations on the ability to provide early warning against cruise missiles and other low flying, low observable flight vehicles. Powerful radars constructed on airborne early warning aircraft fill such critical gaps.⁴

For Taiwan, early warning is a critical requirement at the strategic, operational, and tactical levels of warfare. The Taiwan Relations Act (TRA) states that the United States shall “maintain the capacity of the United States to resist any resort to force or other forms of coercion that would jeopardize the security, or the social or economic system, of the people on Taiwan.”⁵ Furthermore, the U.S. shall make available “such defense articles and defense services in such quantity as may be necessary to enable Taiwan to maintain a sufficient self-defense capability.” However, since 2007, U.S. defense policy towards Taiwan appears to have adopted an increasingly restrictive definition of self-defense. This shift most recently manifested itself in a new State Department security assistance policy toward Taiwan that enshrines an arbitrary distinction between “asymmetric defense” and “conventional” defense articles and services. While details remain unclear, the new policy allegedly includes a strong presumption of denial of requests for defense articles and services judged to be “conventional” in nature.⁶

Early warning, and the air sovereignty mission more broadly, is an example of a capability that defies the simple “asymmetric” versus conventional dichotomy. This brief examines the role of early warning in Taiwan's national security and defense and within the context of the broader U.S.-Taiwan relationship.

Air Sovereignty, PLA Use of Force, and the Conflict Continuum

Chinese use of military force takes place along a continuum from peace to war. Coercive courses of action, known in contemporary lexicon as “gray-zone” operations, are directed military activities designed by the Central Military Commission (CMC) to advance the Chinese Communist Party (CCP) Politburo’s political goals with minimal cost. The CMC Political Work Department likely plays a critical role in planning and executing coercive military campaigns.⁷

Coercion succeeds when Taiwan’s political leadership concedes to Beijing’s demands under armed duress, despite retaining the power to resist.⁸ Coercive uses of force augment propaganda, military liaison, diplomatic, United Front Work, and economic instruments. Graduated escalation increases the risk of continued resistance, instilling in an enemy fear of future loss by slowly raising the risk of greater damage. Coercion also requires the ability to retain control over each step on the escalation ladder. A coercive campaign may seek to sow fear and uncertainty, or inflict pain and destruction, to generate popular support to compel Taiwan’s leadership to the negotiating table on unfavorable terms.

At the low end of the spectrum, the CMC routinely calibrates shows of force for strategic effect. Shows of force are a form of subtle cross-Strait signaling, demonstrating potential consequences of a particular policy decision in Washington or Taipei. Military actions are amplified through PLA propaganda and liaison channels for audiences around the world. Courses of action in the middle part of the continuum include an air and/or maritime blockade, an island grab, and a strategic paralysis campaign.

A maritime blockade would seek to isolate Taiwan by attacking its sea lines of communication into and out of ports. An air blockade could forcibly bring the Taipei Flight Information Region (FIR) under Shanghai or establish and enforce a no-fly zone over Taiwan. An air blockade also could support a broader campaign to attain information dominance. Judicious application of firepower, combined with electromagnetic spectrum operations, cyber, operations security, and deception presumably would seek to paralyze Taiwan’s command and control system and its ability to mount an organized resistance. Strategic-level targets likely would include early warning radar systems, national and operational-level command and control centers, communications nodes, critical infrastructure, and any deep interdiction assets. PLA writings suggest heavy reliance upon surprise and pre-emption to shock leaders in Taiwan, paralyze the ability to conduct operations, and to force a political solution soon after initiation of hostilities.

At the upper end of the conflict continuum, Beijing could seek the destruction of the ROC central government, physical occupation, and imposition of will upon a vanquished population. Planning for annihilation takes political considerations off the table and assumes the ROC armed forces are the center of gravity. PLA mobilization for an invasion would be difficult to mask. However, China’s leaders may believe that ordering large-scale surprise missile strikes could decisively destabilize Taiwan, compelling it to acknowledge PRC sovereignty over the island before U.S. intervention. Theater-range hypersonic glide vehicles, land attack cruise missiles, and ballistic missiles pose the most significant threats to Taiwan’s strategic and operational-level command and control system.

The Chinese Airspace Challenge

Chinese Communist Party statecraft has adopted extraordinary means to control Taiwan's interactions with the international community since establishing the PRC in 1949. Such measures include blocking Taiwan's meaningful participation in United Nations-affiliated agencies, such as the International Civil Aviation Organization (ICAO). The United Nations calls upon members to refrain from "the threat or use of force against the territorial integrity or political independence of any state."⁹ The PRC has ensured that Taiwan is excluded from such criteria.

The CCP has outlined seven triggers for employment of non-peaceful means to advance its political goals: 1) actions resulting in Taiwan's permanent separation from China; 2) sustained refusal to engage in cross-Strait negotiations; 3) internal chaos in Taiwan; 4) a drastic deterioration of Taiwan's armed forces and operational readiness; 5) permanent basing of U.S. or other foreign military forces on Taiwan; 6) Taiwan's deployment of nuclear weapons; and 7) subverting CCP legitimacy through direct promotion of democracy or other measures.¹⁰

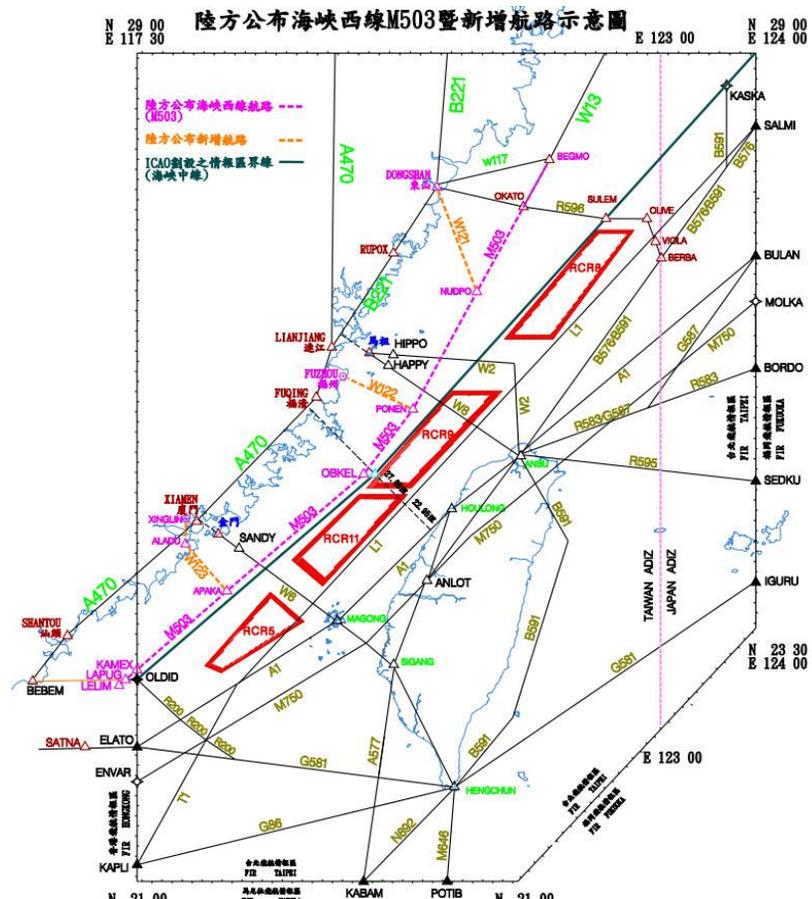
Military courses of action available to the Politburo Standing Committee and CMC can generally be categorized as coercive or annihilative. Annihilation seeks the destruction of the ROC state and imposition of will on a vanquished population. Annihilative courses of action set aside the political context, including conditions and demands. Coercive courses of action are calibrated for political effect and intended to fall below the threshold to justify direct U.S. military intervention. Targets of a coercive campaign may include Taiwan's public, the United States, or coalition partners. The CMC may seek an explicit policy change, shift in public opinion, or change in the economy. A single air or missile strike, activation of a jammer targeting early warning radar, or crossing of the Taiwan Strait centerline may produce a strategic or political effect. The mechanism for how a military action will directly result in the desired political effect is unknown, but could entail punishment, denial, and strategic paralysis.¹¹ Examples of coercive courses of action include low intensity shows of force or an air campaign to achieve strategic paralysis. The CMC prioritizes escalation dominance.¹²

PLA displays of force could aim to deter or compel political leaders in Taipei and the international community to concede to Beijing's political agenda. Limited uses of force could challenge Taiwan's authority over its territorial airspace. Over the past few years, for instance, the PLA has crossed the Taiwan Strait's centerline, conducted circumnavigational flights around Taiwan, and made deliberate incursions into Taiwan's ADIZ. The centerline has been tacitly acknowledged as a border by both sides of the Taiwan Strait. While Taiwan's ADIZ extends well over mainland China for alert purposes, the centerline marks the boundary of the Taipei and Shanghai FIRs. ROC Air Force (ROCAF) training areas are also to the east of the centerline. PLA military flights that cross the centerline can thus be interpreted as deliberately calibrated forms of coercion.

PLA circumnavigational flights, referred to as "island encirclement patrols," began in 2016. Long distance overwater training flights have transited the Bashi Channel, proceeded northeast of Taiwan, and returned to China through the Miyako Strait. PLA propaganda outlets noted the flights were intended to "maintain national sovereignty and territorial integrity."¹³

Beijing made veiled threats to declare an ADIZ covering the Taipei FIR as early as 2007. Five years later, the CMC established an ADIZ over the East China Sea. In 2018, China unilaterally announced and implemented a new air route (M503) running northbound along the western side of the centerline of the Taiwan Strait. Also announced were three spurs from M503 to Xiamen, Fuzhou, and Dongshan that parallel military and civilian flights to Kinmen and Matsu.¹⁴

The unilaterally announced routes deepened Taiwan’s suspicions of Chinese intent. As a matter of principle, Beijing has long viewed the Taiwan Strait as internal waters, along with the airspace above it. Furthermore, Beijing has used diplomatic coercion across international organizations to deny Taiwan’s meaningful participation in ICAO. ICAO is responsible for global air navigation, including the conciliation of jurisdictional flight information regions. The Taipei FIR is one of the busiest in the world.¹⁵



(Figure 2: Diagram of newly declared M503 flight by mainland China down western line of the Taiwan Strait. Source: “Civic Aeronautics Administration, ROC Ministry of Transportation and Communications.”)

The PLA Kinetic Challenge

The PLA Rocket Force (PLARF) presents the most significant kinetic challenge to Taiwan's early warning and command and control system.¹⁶ Under direct control of the CMC, the PLARF has traditionally been responsible for nuclear operations. Planning for a conventionally capable ballistic and cruise missile capability since after conclusion of the U.S.-Soviet Intermediate Nuclear Forces (INF) Treaty in 1987. The INF Treaty restricted U.S. and Soviet deployment of ballistic and land attack cruise missiles with ranges between 500 and 5,500 kilometers. Unbound by the treaty, the PLA's first brigade equipped with a conventionally capable ballistic missile was established in 1993. The brigade launched dummy rounds into announced closure areas off the coast of Keelung and Kaohsiung during exercises in 1995 and 1996.¹⁷

By 2007, the PLA's corps-level missile command opposite Taiwan completed its planned structure of five conventional ballistic missile brigades under a corps-level missile command opposite Taiwan. Initial units were equipped with the 600-kilometer range DF-15 or DF-11A short range ballistic missile (SRBM). A typical ballistic missile with a 300-kilometer range has a flight time of approximately five minutes.¹⁸ Therefore, since 2007, any unhardened structure on Taiwan has been within seven minutes of destruction.

Ballistic Missile Flight Data			
<i>Missile Range (km)</i>	<i>Highest Altitude (km)</i>	<i>Angle of Reentry at 70km</i>	<i>Total Flight Time in seconds (minutes)</i>
300	84.4	25	331 (5.51)
600	164	39	443 (7.38)
1,000	257	40	562 (9.37)
1,500	391	42.1	677 (11.20)
2,000	490	40	789 (13.15)
3,000	700	38.6	989 (16.48)

(Figure 3: Ballistic Missile Flight Data. *Source: "Project 2049 Institute."*)

Today, the PLARF's conventional missile forces include an 800-kilometer range variant of the DF-15; DF-11A SRBM; 700-kilometer range DF-16 SRBM; 1,500-kilometer range variant of the DF-21 medium-range ballistic missile (MRBM); the DF-17 MRBM equipped with a hypersonic glide vehicle; and the 3,000-kilometer range DF-26 intermediate-range ballistic missile.¹⁹ The PLARF diversified its strike options through deployment of a first-generation ground launched cruise missile in 2005. Systems such as the 1,500-kilometer range DH-10 and 2,000-kilometer range DF-100 ground-launched cruise missile are deployed to at least two PLARF brigades.²⁰

In a crisis, the CMC could assign selected PLARF brigades to a Taiwan-focused joint task force. A combination of airbreathing flight vehicles, such as the DH-10, and ballistic missiles launched from multiple axes of attack would present significant challenges for any defender. Use of decoys, military deception, and penetration aids would further complicate defenses.

A missile campaign would be followed by conventional PLA Air Force (PLAAF) strikes to ensure air defenses remain suppressed. If the PLA is successful in operating in the skies over Taiwan with

impunity, conditions are created for a maritime blockade or an amphibious invasion. Together, the PLAAF and Navy Aviation are equipped with approximately 2,250 combat aircraft, making it the largest aviation force in the region and the third largest in the world. In 2020, the Party announced objectives to move towards “intelligitized” warfare that could offer Beijing an even broader range of military options by 2027.

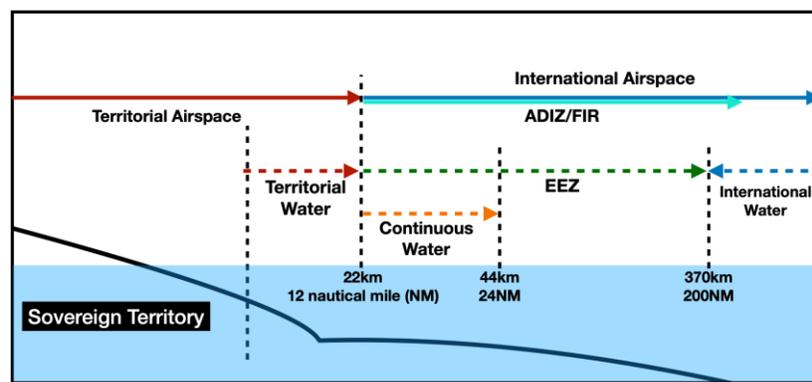
The PLA Non-Kinetic Challenge to Early Warning

The PLA is increasing investments into non-kinetic force options as well. The PLA understands that electromagnetic spectrum superiority is a prerequisite for dominance in air, sea, ground, space, and cyber domains. Therefore, it is investing significant resources into non-kinetic means of disrupting, deceiving, and destroying single points of failure in an adversary’s early warning and control systems. Priorities include artificial intelligence and microelectronics.²¹

Electromagnetic spectrum operations would be central to a PLA coercive campaign directed against Taiwan. Electromagnetic attack assets would reduce Taiwan’s warning time through covering the takeoff, formation into strike packages, and transit. Radar countermeasures directed against early warning are intended to reduce time available to organize an effective response. PLA strategists note that employment of electromagnetic attacks can be a deterrent in and of itself.²² A notional PLA electromagnetic attack would employ stand-off jamming to saturate or deceive early warning systems by injecting noise through sidelobes to mask flight formations penetrating Taiwan’s ADIZ and territorial airspace. The Southwest Institute of Electronic Equipment (SWIEE) is the PLA’s most significant supplier of radar countermeasure systems.²³

Early Warning in the Taiwan Strait

Early warning provides Taiwan’s national-level decision makers with the information needed to make timely and accurate decisions throughout the conflict continuum. Air sovereignty is the exercise of control and authority over national territorial airspace. Air sovereignty missions – surveillance and control – demonstrate authority over territorial airspace. Ground-based and AEW radar systems search well beyond sovereign airspace to identify threats. Once detected and identified, necessary actions can be taken to respond.



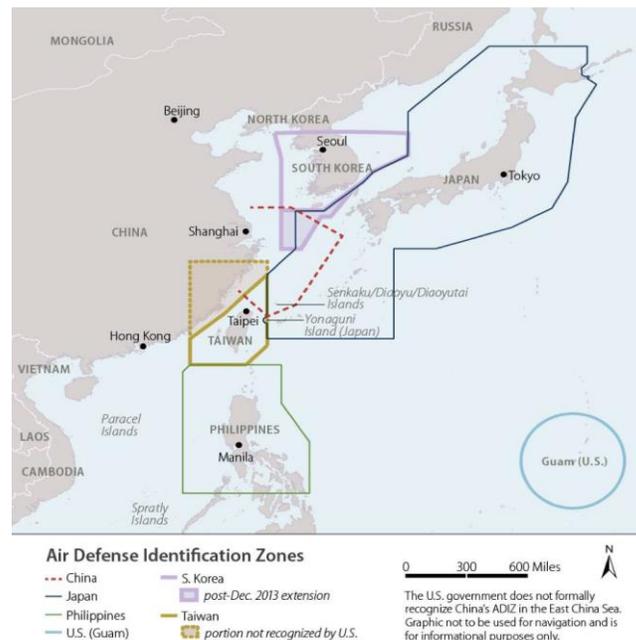
(Figure 4: Taiwan’s Concept of Air Sovereignty. Source: “Steven Wang / Song Wen-shih.”)

Early warning allows national-level command authorities to forecast, monitor, and assess national security threats, and determine appropriate countermeasures. Early warning also enables civil defense. Taiwan's early warning system is tested through *Wan'an* air raid drills, which are carried out annually around Taiwan to exercise civil defense plans. Conducted since 1978, *Wan'an* drills increase operational readiness and civil awareness of possible threats.²⁴

Taiwan's ADIZ is a declared geographic area extending beyond its territorial airspace. It is a designated airspace within which aircraft are required to comply with special identification procedures.²⁵ Flight activity within the area is monitored and assessed for its potential threat to national security. Taiwan's ADIZ was established in 1953 in the lead-up to the U.S.-ROC Mutual Defense Treaty.²⁶

An ADIZ supports the air sovereignty mission. Former Taiwan President Ma Ying-jeou emphasized that "ADIZs are established to provide early warning and identification."²⁷ In coordination with air traffic control authorities, ROCAF air surveillance operators track cooperative and non-cooperative aircraft within Taiwan's ADIZ using radar and passive sensors. Cooperative aircraft, such as commercial flights, file a flight plan and use a transponder to identify themselves to civilian and military air traffic managers. An aircraft flying in an ADIZ may be identified as a possible threat, potentially leading to interception by ROCAF fighters.²⁸

The boundaries of Taiwan's ADIZ extend west into China. In a practical sense, the western boundary is the centerline of the Taiwan Strait, also known as the "Davis Line." Taiwan's Ministry of National Defense (MND) and Ministry of Transportation and Communications specify areas within the ADIZ where flight activity is restricted.²⁹ The MND is responsible for identifying, monitoring, intercepting, following, and engaging all aircraft in Taiwan's ADIZ.³⁰



(Figure 5: Air Defense Identification Zones in East Asia. *Source: "Congressional Research Service."*)

Taiwan's Early Warning Infrastructure

Early warning enables Taiwan's national-level decision makers to make timely and accurate decisions. Sources of early warning include intelligence, space-based infrared sensors, and long-range radars. Intelligence includes intercept of selected military and civilian communications channels, commercial space-based imagery, and traditional human assets.³¹ Taiwan also is one of nine international partners of the U.S. Space Command for Shared Early Warning.³²

Taiwan's highest value assets include six AEW platforms, a large ultra-high frequency (UHF) phased array early warning radar, and radars forward deployed on offshore islands. Both search a large swath of airspace for flight vehicles, including airborne targets and ballistic missiles. Secondary missions may include tracking ships at sea and electromagnetic support measures. AEW platforms overcome inherent limitations of ground-based radars due to elevation. Looking down over the Taiwan Strait at 10,000 meters, and over the mainland beyond, AEW searches vast volumes of airspace for potential threats flying "under the radar," so to speak, such as land attack cruise missiles. AEW is an essential component of the air sovereignty mission.

The ROCAF operates one of the most advanced air surveillance systems in the world. Barring the Himalayas, Taiwan has the highest elevations in the Indo-Pacific region: more than 156 mountain peaks surpass 3,000 meters (10,000 feet). Early warning radar installations are maintained on selected peaks.

Taiwan's air sovereignty infrastructure is rooted in the U.S.-ROC Mutual Defense Treaty. The United States developed and installed an initial early warning network in the 1950s. The system, designed to detect Soviet bomber raids against North America, hinged upon a network of radars across Alaska to the Arctic regions of Canada and Iceland. Distant Early Warning Line (DEW Line) radar tracks were correlated via computers within the Semi-Automatic Ground Environment (SAGE) in the 1960s and 1970s. As the Soviets diversified nuclear delivery options, a parallel ballistic missile early warning system (BMEWS) network was designed to detect Soviet and Chinese intercontinental ballistic missile (ICBM) launches against North America.³³

The United States worked closely with allies, including Taiwan. The U.S. Taiwan Defense Command's air component was established adjacent to the ROCAF Air Operations Center (AOC) in Taipei's Gongguan area and connected via tunnel.³⁴ The AOC reported to the Combined Operations Center (COC) in Hengshan, an underground facility in Taipei's northern suburbs. The AOC has traditionally relied heavily on a network of early warning radar stations constructed on the offshore islands - Pescadores (Penghu Islands) - along Taiwan's coastline, and on mountains in the central part of the island.

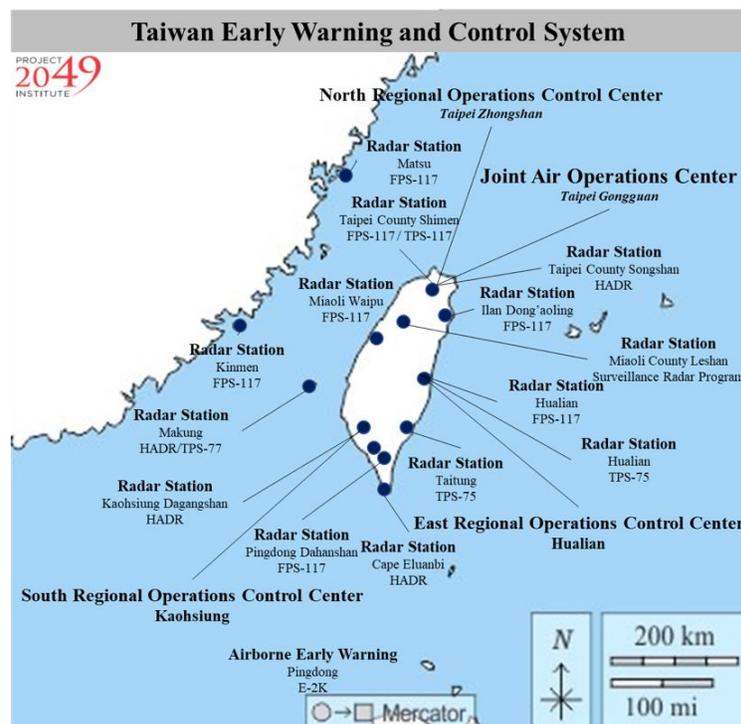
Radar reporting units passed tracks up the chain for manual plotting on boards. Sites on Matsu and Kinmen offered the deepest look over the mainland. Others were constructed at the southernmost tip of Taiwan (Eluanbi), the west coast of Miaoli (Waipu), the northeast coast (Sandiaojiao), the central east coast (Hualien), and Huoyanshan. Selected units were designated as control and reporting centers (CRCs) and granted authority to scramble and control fighter reactions to unidentified flight activity within Taiwan's ADIZ. CRCs were located on Penghu (Magong), at

the northern tip of Taiwan (Shimen), and on Leshan, a 2,600-meter peak in central Taiwan. USAF weapons control officers were assigned to at least five of these early warning radar stations.³⁵

In the years prior to the 1979 derecognition of the ROC, the U.S. supported an overhaul of Taiwan's early warning and control network. The Sky Net (*Tianwang*) system was conceptually based on the U.S. SAGE system.³⁶ With the assistance of the U.S. Air Force, Taiwan acquired FPS-43 early warning radar systems and constructed new installations on Leshan and a 1,000-meter tall mountain north of Taipei near Yangmingshan (Songshan). The ROCAF also rearranged CRC responsibilities. The Department of Defense Rome Air Development Center assisted in upgrading four existing FPS-88 radars to the FPS-110. *Tianwang* reportedly began operations in 1979.³⁷

With the initial deployment of conventional ballistic and land attack cruise missiles and introduction of advanced fighters, the ROCAF began planning in 1994 for a next-generation automated air defense system, known as the *Chiangwang* system. *Chiangwang* integrated tracks downlinked from six E-2T AEW aircraft equipped with a powerful UHF radar.

The introduction of advanced tactical data links further modernized Taiwan's air sovereignty system. Regional battle management centers under the AOC are responsible for northern, southern, and eastern sectors. In the event that the AOC is lost, Regional Operations Control Centers (ROCCs) are able to assume the AOC's national air sovereignty mission should the latter fail.³⁸ As follow-on to *Chiangwang*, the *Huanwang* system leverages Link-16 and sophisticated computing to fuse tracking data from individual early warning radars into a single integrated air picture that is shared among participants in the network.³⁹ Participants include Hengshan, JOAC, ROCCs, selected fighters, long-range air defenses, and ROC Army and Navy platforms.⁴⁰ A common tactical picture also shares friendly position data.⁴¹



(Figure 6: Taiwan Early Warning and Control System. Source: "Project 2049 Institute.")

A large, UHF long-range early warning radar, known today as the Surveillance Radar Program (SRP), is a pillar of Taiwan's air sovereignty system. In 1998, the MND, with the support of President Lee Teng-hui and Chief of the General Staff GEN Tang Fei, formally requested U.S. assistance in the design, development, and construction of a new early warning radar system similar to the U.S. PAVE PAWS. During this period, the PLA began a massive buildup of its conventional ballistic and land attack missile infrastructure opposite Taiwan. At the time, U.S. media reporting suggested policy concerns over Chinese reactions to the sale. Operational-level concerns focused on the radar's survivability in the face of a missile attack.⁴² Ultimately, the Clinton and Bush administrations supported the SRP to increase warning time and undercut the coercive utility of the PLA's growing arsenal of increasingly accurate and lethal ballistic missiles deployed across the Taiwan Strait.⁴³



(Figure 7: Long-range UHF early warning radar in Leshan. *Source: "Up Media."*)

The SRP was constructed at an established site on Leshan at an elevation of over 2,600 meters (8,000 feet). The system is designed to detect ballistic missile launches upon breaking the horizon out to at least 3,000 kilometers, or further upon receipt of an alert from the U.S. Shared Early Warning system. The system's missile warning center is able to generate alerts. Unlike PAVE PAWS, the SRP is able to detect and track airbreathing threats. Low radar cross section targets, such as cruise missiles, unmanned aerial systems, and helicopters, can be detected at 200 kilometers. The radar has a latent space situational awareness and maritime surface tracking capability. The SRP is collocated with a missile warning center.⁴⁴ Taiwan ultimately opted for a single radar but has kept the door open for a possible second.⁴⁵

Ground- and sea-based radar systems are inherently limited in their ability to detect flight activity below the horizon. Airborne platforms equipped with high power early warning radars can detect airbreathing targets at all altitudes and out to extended ranges. Taiwan formally requested the acquisition of four E-2C Hawkeye early warning aircraft in 1992. The Clinton administration

released a specially configured version designated as E-2T in 1993 with initial deliveries taking place five years later. Taiwan acquired two E-2C Hawkeye 2000 aircraft (also known as E-2K) in 2004 and brought the original four E-2Ts up to E-2K configuration by 2013. Within the Indo-Pacific region, Japan and Singapore also are equipped with E-2s.⁴⁶

Taiwan's E-2K AEW fleet is equipped with the APS-145 active electronically scanned array (AESA) radar, a passive detection system, and IFF. Link-16 terminals feed track data into the *Huanwang* system. The E-2K radar incorporates sidelobe suppression and other electronic counter-countermeasure capabilities. With a service ceiling of more than 10,000 meters, Taiwan's AEW aircraft should be able to detect targets around Taiwan at ranges greater than 500 kilometers.⁴⁷ AEW radar data is shared within the ROCAF Air Combat Command and to selected Army and Navy participants through advanced tactical data links. It is unknown if Cooperative Engagement Capability has been released. After over 20 years of operation, however, the E-2K aircraft are reaching the end of their service life.⁴⁸

Taiwan's conventional radar systems augment the SRP and E-2K for air sovereignty and early warning missions. Most belong to the FPS-117 family of three-dimensional long-range search radar. The USAF invested in, developed, and deployed the first generation of FPS-117s to the DEW Line in the 1980s to provide advance warning of Soviet bomber attacks. Fixed and mobile variants operate in the L-Band (1 to 2-GHz) and employ sophisticated counter-jamming technology. The FPS-117 and its mobile variants (TPS-59, GE-592, and TPS-77) extended the range of Taiwan's early warning and control system. The system reportedly has a maximum detection range of more than 300 kilometers and altitude of 30 kilometers. Taiwan fielded initial FPS-117 derivatives in the 1980s.⁴⁹



(Figure 8: Yilan Dong'aoling Radar Station. Source: "Makato Lin / Wikimedia Commons.")

Taiwan began the process of acquiring seven fixed FPS-117 radar systems and an additional four mobile variants in 2002.⁵⁰ With ballistic missile target tracking capability, the radar is reportedly able to determine accurate launch and impact prediction points, discriminate debris from the missile, and offer cueing quality data to air and missile defense fire units. It is reportedly one of the few currently fielded ground-based sensors that can detect and track long-range airbreathing targets and tactical ballistic missiles.⁵¹ The ROCAF is modernizing its fixed and mobile TPS-117 family of radars.⁵²

Taiwan has acquired other radars to augment the FPS-117. In addition to installing two Hughes Air Defense Radar (HADR or HR-3000) systems in 1993, Taiwan also acquired four TPS-43 radar systems that were subsequently upgraded to the TPS-75, a mobile passive electronically scanned array system operating in the S-band (2.9 to 3.1-GHz). TPS-75s are reportedly deployed to Taitung, Hualian, and Pingdong radar stations.⁵³ The HADR, a three-dimensional phased array air surveillance radar operating in the S-band (2 to 4-GHz), is allegedly deployed to Songshan and Dagangshan radar stations.⁵⁴ The TPS-59 was constructed on Leshan.⁵⁵

Conclusion

The CCP poses an existential threat to the Republic of China (Taiwan). Beijing challenges Taiwan's authority over its territory and the airspace above it. A number of coercive measures are available to the CCP Politburo short of a full-scale amphibious invasion. At the low end of the peace-war continuum, the PLA uses shows of force. The PRC has a long history of leveraging aerospace power as an instrument of coercive persuasion against Taiwan. The PLA could carry out a coercive campaign to attain strategic paralysis and implement a blockade of the skies above Taiwan. A strategic paralysis campaign envisions the physical destruction of Taiwan's command and control system, strategic warning, and communications nodes through integrated air and missile strikes. In a worst-case scenario, the PLA could attempt an amphibious invasion.⁵⁶

Since 2007, U.S. policy has shifted its focus toward the high end of this peace-war continuum. Perspectives assume Chinese coercion will fail and that annihilation, defined as the eradication of the ROC and total political control over its people, is the only course of action that assures Beijing's success. Assessments cast early warning radars, advanced fighters, submarines, long-range air defenses, and main battle tanks as prestige-enhancing platforms with little operational or tactical value. Asymmetric defense, defined for Taiwan as smaller, dispersed, cost-effective, and highly mobile weapon systems, is intended to prevent a *fait accompli* and hold out for U.S. intervention. With an emphasis on a decisive battle in the littoral, counterstrikes against selected targets on the mainland are deemed offensive, provocative, and unlikely to be effective.⁵⁷

Early warning, whether derived from intelligence, satellites, or radars, is critical in responding to all Chinese courses of action. In February 2022, Taiwan's President Tsai Ing-wen called on the armed forces to "ramp up efforts to provide early warning and surveillance of military developments in the Taiwan Strait and surrounding areas."⁵⁸ At the strategic level, early warning enables a national command authority to create a window of time to organize an effective response to existential threats. Early warning also complements operational and tactical level asymmetric approaches outlined in the Overall Defense Concept (ODC).⁵⁹ In the absence of a Mutual Defense Treaty with the United States, Taiwan's armed forces invest in capabilities to counter all possible PLA courses of action along the peace-war continuum.

Taiwan and the United States share a long history of cooperation on air surveillance and control. Taiwan's use of U.S.-supplied systems also provides the potential for interoperability with the U.S. military, and potentially other military forces in the region. The large UHF long-range early warning radar and E-2K airborne early warning aircraft have been strategic pillars of Taiwan's air sovereignty system for over 25 years. Other fixed and mobile early warning radar systems augment the SRP and AEW. Early warning systems, as well as associated networks and communications, are critical for Taiwan's national security and defense. Should Taiwan request additional or new early warning systems, the Biden administration should support it.⁶⁰ U.S. and Taiwan interlocutors should also consider a common operational picture that includes the sharing of radar surveillance among the U.S. and coalition partners in the Indo-Pacific region. For more effective and efficient investments in Taiwan's national security, the United States and Taiwan would do well to begin establishing roles and missions for critical scenarios across the spectrum of coercion and annihilation.

Endnotes

¹ See “DOD Dictionary of Military and Associated Terms,” *U.S. Department of Defense*, updated November 2021, at <https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf>; and “Continental Air Defense: A Dedicated Force Is No Longer Needed,” *U.S. General Accounting Office*, May 1994, at <https://www.gao.gov/assets/nsiad-94-76.pdf>. The North American Aerospace Defense Command (NORAD) describes air sovereignty as “providing surveillance and control of the territorial airspace.”

² Britain deployed the world’s first early warning radar network (CHAIN HOME), prior to the Second World War. CHAIN HOME, along with the Dowding ground controlled intercept, contributed toward the defeat of Nazi Germany’s Luftwaffe. Royal Air Force fighters did not have to invest significant time searching large volumes of airspace for targets, but were guided to within visual range by air controllers on the ground.

³ An ADIZ serves as a buffer between territorial and international airspace. Airspace control authorities may direct fighters on alert to intercept, identify, and escort aircraft within an ADIZ. Selected early warning radar stations are often assigned tactical control.

⁴ A radar’s capability depends on several factors. These include elevation of the radar and altitude of target, portion of the frequency spectrum within which it operates, power and size of the antenna (power aperture). A radar also is judged by its ability to filter returns caused by clutter, such as the sea, ground, birds, rain, and other conditions. Electromagnetic (EM) attack would seek to deliberately reduce the effectiveness of a radar system. EM attack could include noise jamming, generation of false targets, chaff, decoys, and anti-radiation missiles. Fire control radars, organic to air defense units equipped with surface to air missile (SAM) systems, such as the U.S. PATRIOT, Taiwan’s TIANKUNG, or Chinese SA-10/20, generally operate at higher frequencies with reduced range yet better target discrimination.

⁵ “Taiwan Relations Act (Public Law 96-8, 22 U.S.C. 3301 et seq.),” *U.S. Congress*, January 1, 1979, available online at <https://www.ait.org.tw/our-relationship/policy-history/key-u-s-foreign-policy-documents-region/taiwan-relations-act/>.

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⁸ Randall Schriver and Mark Stokes, “Evolving Capabilities of the People’s Liberation Army: Consequences of Coercive Aerospace Power for U.S. Conventional Deterrence,” *Project 2049 Institute*, August 20, 2008, at <https://project2049.net/2008/08/20/evolving-capabilities-of-the-peoples-liberation-army-consequences-of-coercive-aerospace-power-for-u-s-conventional-deterrence/>.

⁹ The International Civil Aviation Organization (ICAO), a specialized agency of the United Nations, defines air sovereignty as the “exclusive competence of a State to exercise its legislative, administrative and judicial powers within its national airspace.” The ROC was a founding member of ICAO at the Chicago Convention of 1944, when it was established that “every State has complete and exclusive sovereignty over the airspace above its territory.” See “Convention on International Civil Aviation,” *International Civil Aviation Organization*, December 7, 1944, at https://www.icao.int/publications/documents/7300_orig.pdf; and “Airspace Sovereignty (Presented by the Civil Air Navigation Services Organization (CANSO)),” *International Civil Aviation Organization*, April 3, 2013, at <https://www.icao.int/Meetings/atconf6/Documents/WorkingPapers/ATConf.6.WP.080.1.en.pdf>. Also see Russell Hsiao, “Cross-Strait Aviation and Beijing’s Hybrid Warfare,” *Taiwan Insight*, February 21, 2018, at <https://taiwaninsight.org/2018/02/21/the-politics-of-cross-strait-aviation-and-beijings-hybrid-warfare/>; and “A Primer on M503 and Civil Aviation in Asia,” *CSIS*, March 14, 2018, at <https://amti.csis.org/primer-m503-civil-aviation-asia/>.

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⁴⁸ The E-2s also include the ARC-158 UHF datalink and ARQ-34 Dual HF Communications Set. See “Taiwan Receives Upgraded E-2K Early Warning Aircraft From US,” *Airforce Technology*, March 10, 2013, at <https://www.airforce-technology.com/news/newstaiwan-e-2k-early-warning-aircraft-us/>.

⁴⁹ The system is reportedly able to counter anti-radiation missiles and counter jamming attempts by randomly hopping among 18 channels in the 1.215 to 1.4-GHz band and using pencil beams for targets with low radar cross sections. “FPS-117,” *Missile Defense Advocacy Alliance*, May 1, 2018, at <https://missiledefenseadvocacy.org/defense-systems/an-fps-117/>.

⁵⁰ “Taiwan To Receive Early-Warning Radars From US: Jane’s,” *Space Daily*, June 13, 2002, at <https://www.spacedaily.com/news/bmdo-02o.html>; and Chu Ming, “Combatant Command radar cannot detect drones and cruise missiles, 3D radar on offshore wind turbines become crucial (戰管雷達無法偵測無人機與巡弋飛彈 離岸發電風機預警的 3D 雷達成利器),” *Up Media*, November 6, 2019, at https://www.upmedia.mg/news_info.php?Type=1&SerialNo=74835.

⁵¹ “AN/TPS-59 Long-range Air Surveillance Radars,” *Lockheed Martin*, at <https://www.lockheedmartin.com/content/dam/lockheed-martin/rms/documents/ground-based-air-surveillance-radars/TPS-59%20Fact%20Sheet.pdf>; and “AN/TPS-59,” *Missile Defense Advocacy Alliance*, May 22, 2018, at <https://missiledefenseadvocacy.org/defense-systems/an-tps-59/>.

⁵² Hung Che-cheng, “Responding to PLA J-20, ROCAF Upgrading FPS-117 Capabilities (因應殲 20 威脅 空軍全面提升 FPS-117 雷達性能),” *United Daily News*, September 1, 2021, at <https://city.udn.com/60321/7124407#ixzz7MC62tAkg>. Taiwan also operates a number of ship-based air search and SAM acquisition radars, such as the ADAR-1 (*Chang Bai*). The *Chang Bai* radar system is reported to be based on Lockheed Martin’s ADAR-HP (Air Defense Array Radar-High Power) design and operates in the 2 to 4-GHz range (S-band). Developed for the TIANKUNG SAM system, the system reportedly has a 120-degree field of view and maximum range of 450 kilometers. Among various sources, see “Medium Range Air Defense Radar,” *Taiwan Defense Review*, June 19, 2006. At least seven systems are said to be currently in service. The system performance specifications remain classified, but its reported effective detection

range against 1m² targets is around 400 kilometers. Reportedly, it is resistant to electronic countermeasures and can detect fixed and rotary-wing aircraft, cruise missiles and UAVs. See “3D Rotating Phased Array Radar System,” *National Chun-shan Institute of Science and Technology*, at https://www.ncsist.org.tw/eng/csistdup/products/product.aspx?product_id=278&catalog=41.

⁵³ “AN/TPS-75 Radar System,” *Federation of American Scientists*, at <https://man.fas.org/dod-101/sys/ac/equip/an-tps-75.htm>; “Military Exercise ‘destroy radar’! J-10 test-fired YJ-91 anti-radiation missile (軍演「摧毀雷達」！殲-10試射鷹擊-91反輻射導彈),” *ETToday*, November 18, 2016, at <https://www.ettoday.net/news/20161118/813607.htm>; and “Transmittal No. 00-22,” *U.S. Department of Defense*, March 16, 2000, at <https://www.govinfo.gov/content/pkg/FR-2000-03-16/pdf/00-6433.pdf>.

⁵⁴ See “Electronic Warfare Handbook 2008,” *Shephard*, 2008, at <https://citeserx.ist.psu.edu/viewdoc/download?doi=10.1.1.174.4209&rep=rep1&type=pdf>. The Songshan radar station, where the HR-3000 system was deployed, reportedly suffered a serious explosion in 1998 that killed nine people.

⁵⁵ The TPS-59 is a mobile variant of the FPS-117 developed for the U.S. Marine Corps. Four TPS-77 (GE-592) air surveillance radars were acquired in 1984 and a fifth in 1992. Data was acquired from Stockholm International Peace Research Institute (SIPRI) trade register database.

⁵⁶ Ian Easton, “China’s Top Five War Plans,” *Project 2049 Institute*, January 6, 2019, at <https://project2049.net/2019/01/06/chinas-top-five-war-plans/>.

⁵⁷ Among various sources, see For background on Taiwan’s counter-strike capability, see Denny Roy, “Taiwan Perilously Ponders Its Strategic Missile Force,” *China Brief* (Vol 6, Issue 20), May 9, 2007, at <https://jamestown.org/program/taiwan-perilously-ponders-its-strategic-missile-force/>; William Murray, “Revisiting Taiwan’s Defense Strategy,” *Naval War College Review*, 61, No. 3 (Summer 2008): 12–38; Jim Thomas, John Stillion, and Iskander Rehman, *Hard ROC 2.0: Taiwan and Deterrence through Protraction* (Washington, DC: Center for Strategic and Budgetary Assessments, 2014), at <https://csbaonline.org/research/publications/hard-roc-2-0-taiwan-and-deterrence-through-protraction/publication/1>; Michael J. Lostumbo, David R. Frelinger, James Williams, and Barry Wilson, *Air Defense Options for Taiwan: An Assessment of Relative Costs and Operational Benefits* (Santa Monica, CA: RAND Corporation, 2016); Michael A. Hunzeker and Alexander Lanoszka, *A Question of Time: Enhancing Taiwan’s Conventional Deterrence Posture* (Fairfax, VA: November 2018), at <https://csps.gmu.edu/wp-content/uploads/2018/11/A-Question-of-Time.pdf>; Drew Thompson, *Hope On The Horizon: Taiwan’s Radical New Defense Concept*, at <https://warontherocks.com/2018/10/hope-on-the-horizon-taiwans-radical-new-defense-concept/>; Tanner Greer, “Taiwan’s Defense Strategy Doesn’t Make Military Sense But It Does Make Political Sense,” *Foreign Affairs*, September 17, 2019, at <https://www.foreignaffairs.com/articles/taiwan/2019-09-17/taiwans-defense-strategy-doesnt-make-military-sense>; and James Timbie, Adm. James O. Ellis Jr., “A Large Number of Small Things: A Porcupine Strategy for Taiwan,” *Texas National Security Review*, December 2021, at <https://tnsr.org/2021/12/a-large-number-of-small-things-a-porcupine-strategy-for-taiwan/>.

⁵⁸ “President Tsai Responds to Ukraine Developments (聽取「烏克蘭情勢因應小組」簡報總統四項指示：呼籲和平理性、確保國家安全、確保民心安定、維持經濟穩定),” *Office of the President of the Republic of China (Taiwan)*, February 23, 2022, at <https://www.president.gov.tw/News/26560>.

⁵⁹ Lee Hsi-min and Eric Lee, “Taiwan’s Overall Defense Concept, Explained,” *The Diplomat*, November 3, 2020, at <https://thediplomat.com/2020/11/taiwans-overall-defense-concept-explained/>; “2021 Quadrennial Defense Review (2021 年日年期國防總檢討),” *ROC Ministry of National Defense*, 2021, at [https://www.mnd.gov.tw/NewUpload/%e6%ad%b7%e5%b9%b4%e5%9c%8b%e9%98%b2%e5%a0%b1%e5%91%8a%e7%b8%bd%e6%aa%a2%e8%a8%8e\(QDR\)/%e6%ad%b7%e5%b9%b4%e5%9c%8b%e9%98%b2%e5%a0%b1%e5%91%8a%e7%b8%bd%e6%aa%a2%e8%a8%8e\(QDR\).files/%e6%ad%b7%e5%b9%b4%e5%9c%8b%e9%98%b2%e5%a0%b1%e5%91%8a%e7%b8%bd%e6%aa%a2%e8%a8%8e\(QDR\)-110/110%20QDR\(%e4%b8%ad%e6%96%87%e6%ad%a3%e5%bc%8f%e7%89%88\).pdf](https://www.mnd.gov.tw/NewUpload/%e6%ad%b7%e5%b9%b4%e5%9c%8b%e9%98%b2%e5%a0%b1%e5%91%8a%e7%b8%bd%e6%aa%a2%e8%a8%8e(QDR)/%e6%ad%b7%e5%b9%b4%e5%9c%8b%e9%98%b2%e5%a0%b1%e5%91%8a%e7%b8%bd%e6%aa%a2%e8%a8%8e(QDR).files/%e6%ad%b7%e5%b9%b4%e5%9c%8b%e9%98%b2%e5%a0%b1%e5%91%8a%e7%b8%bd%e6%aa%a2%e8%a8%8e(QDR)-110/110%20QDR(%e4%b8%ad%e6%96%87%e6%ad%a3%e5%bc%8f%e7%89%88).pdf); and “ROC National Defense Report 2021 (中華民國 110 年國防報告書),” *ROC Ministry of National Defense*, 2021, at <https://www.mnd.gov.tw/NewUpload/%E6%AD%B7%E5%B9%B4%E5%9C%8B%E9%98%B2%E5%A0%B1%E5%91%8A%E6%9B%B8%E7%B6%B2%E9%A0%81%E5%B0%88%E5%8D%80/%E6%AD%B7%E5%B9%B4%E5%9C%8B%E9%98%B2%E5%A0%B1%E5%91%8A%E6%9B%B8%E5%B0%88%E5%8D%80.files/%E5%9C%8B%E9%98%B2%E5%A0%B1%E5%91%8A%E6%9B%B8-110/%E5%9C%8B%E9%98%B2%E5%A0%B1%E5%91%8A%E6%9B%B8-110-%E4%B8%AD%E6%96%87.pdf>.

⁶⁰ Hung Che-cheng, “Taiwan Constructs High-Altitude Air Defense Network with the U.S. Military (我將與美軍建構高高空防禦網),” *United Daily News*, March 15, 2021, at <https://udn.com/news/story/10930/5317999>.