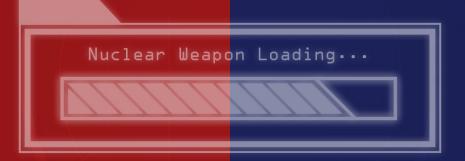
TAIWAN'S FORMER

NUCLEAR WEAPONS PROGRAM



NUCLEAR WEAPONS ON-DEMAND

DAVID ALBRIGHT AND ANDREA STRICKER

TAIWAN'S FORMER NUCLEAR WEAPONS PROGRAM

NUCLEAR WEAPONS ON-DEMAND

DAVID ALBRIGHT AND ANDREA STRICKER

Institute for Science and International Security

The Institute for Science and International Security is a non-profit, non-partisan institution dedicated to informing the public about science and policy issues affecting international security. Its primary focus is on stopping the spread of nuclear weapons and related technology to additional nations and to terrorists, bringing about greater transparency of nuclear activities worldwide, strengthening the international non-proliferation regime, and achieving deep cuts in nuclear arsenals.

Copyright © 2018 by Institute for Science and International Security

Institute for Science and International Security (ISIS) Press

440 1ST Street NW Suite 800 Washington, DC 20001 USA

www.isis-online.org @TheGoodISIS

Library of Congress Control Number: 2018910946

Front cover photograph credits:

Cover design: Stewart A. Williams Design

ISBN-13: 978-1727337334 ISBN-10: 1727337336 Dedicated to all those who worked to ensure Taiwan's nuclear weapons program was stopped.

TABLE OF CONTENTS

Preface, vii

Acknowledgements, xiii

Section I: The Beginnings, 1

Chapter 1: Early History, 3

Chapter 2: The Shock of the 1964 Communist Chinese Test, 9

Section II: The 1970s, 29

Chapter 3: Growing Nuclear Weapons Capability, 31

Chapter 4: Taiwan Crosses the Line, 49

Chapter 5: International Inspectors and the United States Act, 63

Chapter 6: Denuclearizing and Constraining Taiwan's Nuclear Program, 81

Chapter 7: Pushback, 103

Section III: The 1980s, 115

Chapter 8: Normalization and Growing Resurgence, 117

Chapter 9: Going Too Far, 143

Chapter 10: Final Denuclearization, 179

Section IV: Aftermath and Lessons, 205

Chapter 11: Post-1988 Activity, 207

Chapter 12: U.S. Lessons for Today and Tomorrow, 223

PREFACE

Thirty years ago, in 1988, the United States secretly moved to end once and for all Taiwan's nuclear weapons program, just as it was nearing the point of being able to rapidly break out to build nuclear weapons. Taiwan claimed that it would never build nuclear weapons and said its nuclear program was for peaceful uses only, although it often heralded its goal of having the capability to make nuclear weapons, a policy best characterized as one of, "we could but we will not." However, this policy hid active programs aimed at being capable of rapidly making nuclear weapons and maintaining a well-rehearsed nuclear readiness to build them on short notice. Despite Taiwan's efforts to hide these activities, the United States was able to gather incriminating evidence that allowed it to act, effectively denuclearizing a dangerous, destabilizing program, that if left unchecked, could have set up a potentially disastrous confrontation with the People's Republic of China (PRC).

The year 1988 was only the final act in a series of U.S. actions stretching over more than two decades to prevent Taiwan from building nuclear weapons. The United States maintained a multi-decade commitment to stopping Taiwan's sensitive and potentially destabilizing nuclear programs well before it could decide to build nuclear weapons. Worried about a possible war with the PRC, the United States worked to keep Taiwan far from an ability to separate plutonium or enrich uranium and achieve a rapid breakout capability to build nuclear weapons.

The United States obtained in 1977 Taipei's agreement to a series of norms or restrictions against reprocessing, enrichment, heavy water reactors, and nuclear weapons development that went well beyond the constraints found in the Nuclear Non-Proliferation Treaty. However, Taiwan, while seeming to agree, balked at these constraints. While the United States was working to end Taiwan's nuclear weapons efforts, Taipei's relations with the PRC remained strained. Worse, Washington was moving to recognize the PRC as the official representative of China and building a new relationship with it while trying to ensure Taiwan's security. However, Taiwan's military was skeptical about U.S. actions. It was highly motivated to press onward toward developing a full nuclear breakout capability under the guise of a peaceful nuclear program, putting its activities in direct contravention with the norms created in the 1977 agreement.

Seeing through the lies of states secretly seeking nuclear weapons is as difficult today as it was then, and multiple U.S. interventions were necessary. To understand what Taiwan was doing, the United States carefully monitored its nuclear and military programs and engaged in intensive bilateral dialogues with the government and entities responsible for nuclear development. It also developed human sources deep inside the program. The United States carefully watched Taiwan's foreign procurements and partnerships. Spy satellites scanned for new nuclear-related facilities and activities. The International Atomic Energy Agency (IAEA) played a key role in the 1970s in sounding the alarm about suspicious activities and ensuring the secret efforts remained ended after 1988.

Because so much of this story occurred in secret and extended over two decades, the full story of Taiwan's nuclear weapons effort has not been publicly recorded. Now, after many years of work by the Institute for Science and International Security, and in parallel, diligent declassification efforts by the U.S. National Security Archive, and combined with the revelations of a number of former participants of the nuclear weapons program and information about U.S. efforts, a much more complete picture of the Taiwan case has emerged.

At the Institute, work on Taiwan started soon after its founding in 1992. One of its first investigative projects was understanding Taiwan's nuclear weapons program in the 1970s and the role of the IAEA in uncovering secret nuclear activities tied to that program. Since that initial

work, which led to a major report in the *Bulletin of the Atomic Scientists* by David Albright and Corey Hinderstein (Gay), the Institute continued to collect information on the program. It was determined to tell the technical history of Taiwan's nuclear program and the efforts to thwart it in as authoritative of a way as possible.

This work necessarily led to many discussions with those involved in the effort on both sides of the Pacific. These discussions were enriched by the declassification of many U.S. State Department and other government cables dating up to the late 1980s. More recently, former members of Taiwan's nuclear weapons program have decided to tell their stories.

One of the most important of those willing to discuss the case with the authors was Colonel/Dr. Chang Sen-i (known in the media and in public to date by an alternative transliteration, Chang Hsien-yi). In the 1980s, Colonel Chang was a deputy director at the Institute for Nuclear Energy Research (INER), where the nuclear weapons program was centered. After he became increasingly convinced that nuclear weapons were too dangerous for Taiwan to possess, he was recruited by the U.S. Central Intelligence Agency (CIA) in the early 1980s, and served as the United States' personal eyes and ears of the program during this important period. To share the fullest picture of the story that is available to date, and to document how far Taiwan went, the authors obtained an interview with Col. Chang. During a week-long interview in Washington, D.C. in June 2017, Dr. Chang, or "Gray"—the American first name he adopted after moving to the United States, shared an at times emotional journey about his role as an important historical figure in nonproliferation. He provided rich detail about the technical steps of the program, its achievements, and decision making in Taiwan's covert nuclear weapons program, along with information about his controversial actions in ending it. He spoke movingly about his friendships with colleagues at INER and about the impact that leaving Taiwan had on his family. Only recently when he produced a memoir in Chinese about his role did his now adult children begin to truly understand what he had done for his country, and they thanked him. Now in his seventies, he believes that this is the appropriate time to share his story. We sincerely thank him for sharing his story and for allowing us to be a part of this remarkable history. We use information from this and subsequent interviews throughout the book. We also decided, due to the wide use of "Hsien-yi" in public literature, to use this



Figure P.1. Andrea Stricker, Gray Sen-i Chang (Chang Hsien-yi), and David Albright at the Institute office in June 2017.

spelling in the main part of the book. However, we will remind the reader periodically of his own English spelling of his name.

Two decades of interviews by the authors with former U.S. and IAEA officials with direct knowledge of the Taiwan case add importantly to this story. We are able to include more about the role of the IAEA in detecting illicit activities on Taiwan in the 1970s through safeguards inspections. This book also makes use of event-related media reports and draws on important research of other experts. It uses translated Mandarin resources, including the daily diary of Chief of the General Staff General Hau Peitsun, who oversaw Taiwan's nuclear weapons program in the 1980s. The book contains much new technical information about Taiwan's former nuclear programs. We include more information about the secret nuclear sites at the heart of much of this story and present commercial satellite imagery to show several of these sites. The book also characterizes key people and facilities involved in the Taiwanese program.

This report also takes stock of the lessons for today and tomorrow from the story of Taiwan's dynamic and complicated nuclear weapons program. The Taiwan case has significant differences from the case of South Africa's denuclearization, which we also studied in the context of a grant from the Project on Advanced Systems and Concepts for Countering Weapons of Mass Destruction (PASCC), producing a book

on the subject. The most obvious difference is that Taiwan never built nuclear weapons. More intriguing, however, Taiwan did not settle its security issues, as South Africa did before denuclearizing. The Taiwan case contains many valuable lessons for nonproliferation, disarmament, denuclearization processes, safeguards, export controls, and verification. We hope that this book will therefore be regarded as a useful contribution to policy debates and a compendium of information on Taiwan's nuclear program. We also hope that it will contribute to discussions about avoiding nuclear proliferation and achieving denuclearization.

Although not every question could be answered, this book reveals a great deal of new information about Taiwan's nuclear weapons program and the role of the United States in stopping it. For both Taiwan and the United States, ensuring that Taiwan never built nuclear weapons was a priceless achievement.

ACKNOWLEDGEMENTS

This book was made possible in large part by support from the Project on Advanced Systems and Concepts for Countering Weapons of Mass Destruction (PASCC), Center on Contemporary Conflict, Naval Postgraduate School, under Grant Noo244-16-1-0029. PASCC is supported by the Defense Threat Reduction Agency (DTRA). In addition, research for this report was supported over the years by a range of U.S. foundations that have funded Institute for Science and International Security nonproliferation research.

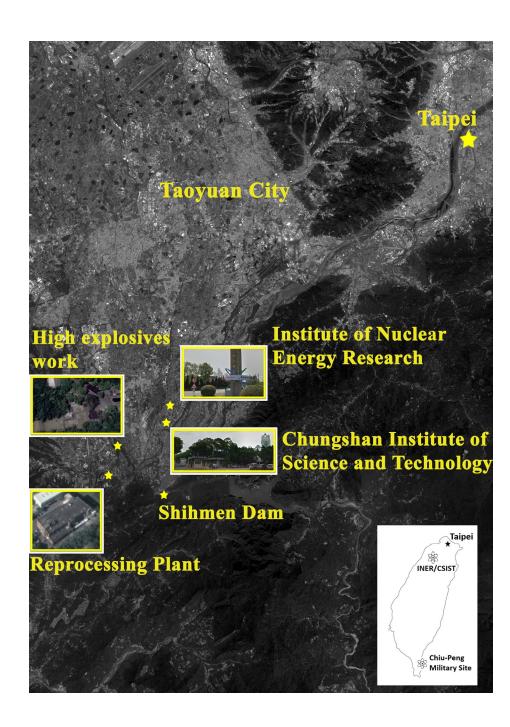
We extend our sincere thanks to Sarah Burkhard, who provided extensive research support for the project and annotated the satellite imagery for the book. We also thank Ivy Yang for her development and translations of Mandarin-language resources.

Thank you in particular to Dr. Wu Ta-you for sharing his story in 1997. We are also grateful to Dr. Jeremy Bernstein who helped us clarify some aspects of the early history of the program.

We appreciate the vital work of the Dr. William Burr and his colleagues at the U.S. National Security Archive and their invaluable efforts to secure Freedom of Information Act declassifications of historical U.S. government diplomatic cables on Taiwan. Two such sets are available at https://nsarchive2.gwu.edu/nukevault/ebb221/ and https://nsarchive2.gwu.edu/NSAEBB/NSAEBB20/. We also wanted to thank Dr. Burr for making additional declassified cables available to our project.

We especially thank our friend Dr. Gray Chang, who entrusted us with his story and improved through this book all researchers' and historians' knowledge of Taiwan's nuclear weapons program and the events surrounding its closing. We thank the participants of our interview with Dr. Chang during June 2017. We also thank our interpreter and translator, who prefers to remain anonymous, for her wonderful substantive assistance. Thank you to Cindy Sui at the BBC who put us in contact with Dr. Chang. We also want to acknowledge Chen Yi-shen of Taiwan's Academia Sinica, who interviewed Dr. Chang for his memoir. Olli Heinonen provided invaluable comments and assistance in our meetings with Dr. Chang and was kind enough to review the book.

Finally, we thank the hundreds of diplomatic, intelligence, and scientific officials in the United States, Taiwan, and other countries, and inspectors at the International Atomic Energy Agency, who worked over decades to ensure Taiwan's nuclear weapons program was stopped, potentially averting conflict. These actions, to the authors, were a great benefit to maintaining peace. Thank you to those who shared their stories with us but wish to remain anonymous.



SECTION I THE BEGINNINGS

CHAPTER 1 EARLY HISTORY

In 1949, amid mounting losses in the Chinese civil war between the governing Nationalists of the Kuomintang party (KMT) and the Communist party led by Mao Zedong, Generalissimo Chiang Kai-shek ordered the evacuation to Taiwan of what would total around two million members of the KMT including military, political, business, and intellectual elites. The total population on Taiwan then came to number about six million people. At that time, Chiang became President of the Republic of China (ROC)—the government-in-refuge on Taiwan—and was still considered by the international community to be the legitimate government of all of China.1 Meanwhile, Mao declared the establishment of the People's Republic of China (PRC) on the mainland in late 1949, setting off a multidecade conflict between the PRC and the ROC. The United States refused to intervene in the dispute but in 1950 deployed its Seventh Fleet to "neutralize" the Taiwan Straits and prevent an invasion of Taiwan by the PRC.2 Yet, even as the Kuomintang's retreat became permanent, Chiang and the KMT would not accept the loss of the Chinese civil war; they remained determined for many years to return to mainland China as victors. One consequence was that Chiang's government took China's seat on the United Nations Security Council as one its five permanent members.

After President Chiang established the ROC government on Taiwan, he enacted martial law and relied on authoritarian rule to maintain power over the population on the island. Tensions with the Communist regime on the mainland, referred to as CHICOMs at the time, remained high.

Washington and Taipei signed a Mutual Defense pact in 1954, obliging American intervention in the event of an attack by the PRC. But the pact was inadequate to moderate Chiang's goals of securing the island against attack and one day retaking the mainland.³

BURGEONING INTEREST IN NUCLEAR CAPABILITIES

It is difficult to identify exactly when President Chiang took the first concrete steps toward developing the wherewithal to make nuclear weapons to counter the PRC's overwhelming conventional military forces. Signs point to 1953, when the United States launched the Atoms for Peace program, that Chiang decided Taiwan should develop the infrastructure needed to develop a covert nuclear weapons program under the guise of peaceful use.⁴ He must have worried when he learned of Soviet/PRC nuclear cooperation, which started to take off in 1953, and accelerated greatly thereafter throughout the 1950s. Over the next several years, the Soviet Union committed to providing Mao the means to make nuclear weapons, including nuclear reactors, a uranium enrichment plant, and help designing and making the nuclear weapon itself.

Chiang's original interest in obtaining nuclear weapons probably dates to the time when he was still ruling on the mainland at the end of World War II, and established the Nationalist Atomic Energy Commission (AEC) infrastructure, which he abandoned to the Communists in 1949. Chiang purportedly wanted China to be the second in the world to possess nuclear weapons. In 1946, prior to the evacuation to Taiwan, a thenmainland Chinese military officer and physics professor joined a group of colleagues from other U.S. allied countries in attending the U.S. detonation of the atomic bomb at Operation Crossroads in the Marshall Islands, South Pacific. While there, despite tight security over the test, they tried to collect as much technical information about the nuclear explosion test as they could.5 One of Chiang's chief Generals, Yu Ta-wei, claimed that he was even permitted to review a U.S. document regarding the Trinity nuclear test.6 Yu would go on to become Taiwan's defense minister from 1950 to 1951 and again from 1954 to 1965. Chiang later took the opportunity to send five scientists to study nuclear energy in the United States. Among them was Wu Ta-you, who would later become an important science advisor to Chiang regarding the trajectory of a proposed nuclear

weapons program. Of the five scientists, only Wu went to Taiwan following his studies, and in an advisory role in the 1960s.⁷

In 1953, likely as deference to U.S. wishes and as a way to motivate the United States to provide a nuclear umbrella and civilian nuclear capabilities, Chiang publicly announced that China (Taiwan) would not develop its own nuclear weapons and risk killing its own people in a conflict with the PRC. It was a hollow commitment that would not interfere with the ROC developing a nuclear program under a civilian cover. In December 1954, amid fighting, the United States deployed the nuclear-armed U.S.S. Midway aircraft carrier to the Taiwan Straits and nuclear weapons to Okinawa to deter China from attacking the Quemoy and Matsu Islands. Tensions remained high until 1955.

In January 1958, fighting renewed and the mainland Chinese shelled the Quemoy Islands. The United States deployed nuclear-capable missiles to Taiwan to deter the PRC from attacking it, but without nuclear weapons. U.S. Matador missiles were publicly paraded on Taiwan. In December 1958, Washington dismissed a request among a set of proposals from President Chiang that included a suggestion to arm Taiwan with U.S. nuclear weapons. U.S. President Dwight D. Eisenhower even considered whether to use nuclear weapons against the PRC to stop its attack but decided to wait until necessary. The crisis abated that year.

The United States had increasingly come to see Taiwan as a front-line ally in the struggle against communism and finally agreed in January 1960 to deploy nuclear weapons on its territory. 11 By the end of the Eisenhower administration, the United States had stationed about a dozen nuclear weapons on Taiwan. The number increased afterward under President John F. Kennedy, peaking at an estimated 200 or more nuclear weapons under President Lyndon B. Johnson in 1967. 12 The nuclear weapons would remain on Taiwan until the United States withdrew them in 1974 following the Richard M. Nixon administration's rapprochement with the PRC.

NUCLEAR COOPERATION

Despite the tensions, in 1955, the United States and ROC reached an Agreement for Cooperation concerning civil uses of atomic energy which laid the basis for Taiwan's development of civilian nuclear infrastructure including nuclear facilities and technical expertise. In 1956, National Tsing-hua University, formerly of the Chinese mainland, was

re-established on Taiwan in Hsinchu city, along with an Institute on Nuclear Science.¹³

Taiwan's military, which would play the key role in the development of a nuclear weapons program, began acquiring training for personnel in nuclear science-related applications. It encouraged officers to apply for scientific degrees and to study abroad in the United States and Europe. In fact, about two-thirds of the Institute on Nuclear Science's students were military officers. ¹⁴ Hundreds of students subsequently enrolled in nuclear engineering and other scientific training programs in the United States under Atoms for Peace. Many went to Western European nuclear institutes for training.

According to Dr. Chang Hsien-yi (Chang Sen-i, according to his own English spelling), a former deputy director of a key institution in the Taiwanese nuclear program who later informed on behalf of the U.S. Central Intelligence Agency (CIA), there were mainland Chinese who had immigrated to the United States and were trained there, including working at U.S. national laboratories, and they came to Taiwan to give talks at the Ordinance School at Tsing-hua University about sensitive nuclear weapons design topics. One such lecture, in 1964, was given by Zheng Hou-qun on both implosion and gun-type fission nuclear weapons. The view on Taiwan was that someone educated at Tsing-hua University in Beijing was an "alumni" of Tsing-hua University in Taiwan and could attend alumni events and other social gatherings. The bonds of the former countrymen were difficult to sever, and safeguards against information transfer were apparently not a high priority.

In 1958, under Atoms for Peace, Taipei started building a U.S.-supplied nuclear research reactor at Tsing-hua University. The Tsing-hua one megawatt-thermal (MWth) Open-Pool Reactor (THOR), which achieved criticality in early 1962, was used for "education and training purposes, research and development, and practical applications, especially radioisotope production and irradiation services." The reactor enabled students to gain practical training in reactor science and technology. President Chiang came to visit the reactor on multiple occasions. The military encouraged people to apply to the university's atomic research center, and in the early years, most of the students studying nuclear energy and engineering were military officers. In reality, Taiwan was taking the initial steps toward establishing what would eventually become a vast, covert nuclear weapons program.

NOTES

- 1 In some declassified U.S. government cables, Government of the Republic of China (GRC) is used instead of ROC.
- 2 Bruce A. Elleman, "High Seas Buffer: The Taiwan Patrol Force, 1950-1979" (Newport, Rhode Island: Naval War College Press, 2012), *Naval War College Newport Papers 38*, http://www.dtic.mil/dtic/tr/fulltext/u2/a565881.pdf
- 3 Historical Stories of Taiwan: The Mystery of Taiwan's Nuclear Weapons, Mandarin language documentary, April 21, 2013 (Translated by the Institute for Science and International Security, 2017).
- 4 Historical Stories of Taiwan documentary.
- 5 As described in a biography of Yu Ta-wei by Lee Yuan-ping, *The Biography of Yu Ta-wei* (Taipei: Taiwan Daily, 1994), p. 61, as translated by Alan K. Chang in *Crisis Avoided: The Past, Present and Future of Taiwan's Nuclear Weapons Program* (Honolulu: Hawaii Pacific University, Fall 2011), Masters thesis, p. 6.
- 6 Ibid.7 Ibid.
- 8 Robert S. Norris, William M. Arkin, and William Burr, "Where They Were," *Bulletin of the Atomic Scientists*, November/December 1999, p. 30, http://www-personal.umich.edu/~sanders/214/other/news/nd99norris.pdf
- 9 Department of State, Office of the Historian, Foreign Relations of the United States, *State Department Memorandum*, December 30, 1958 in 1958-1960, China, Vol. XIX, pp. 509-510.
- 10 Department of State, Office of the Historian, Foreign Relations of the United States, *Memorandum of Meeting in the President's Office by Robert C. Cutler*, *National Security Adviser* in 1955-1957, The China Area, Vol. II, pp. 357-359.
- 11 Hans M. Kristensen, "Nukes in the Taiwan Crisis" (Washington, D.C.: Federation of American Scientists, May 13, 2008), https://fas.org/blogs/security/2008/05/nukes-in-the-taiwan-crisis/
- 12 Norris, Arkin, and Burr, "Where They Were," p. 34.
- 13 Cheng Chen-Hwa and Yang Chio-Min, *Report on the Status and Functions of the Tsing-hua Open-Pool Reactor*, National Tsing-hua University, Hsinchu, Taiwan, Republic of China, undated, http://www.iaea.org/inis/collection/NCLCollectionStore/Public/04/059/4059277.pdf
- 14 Historical Stories of Taiwan documentary.

CHAPTER 1

15 Cheng and Yang, Report on the Status and Functions of the Tsing-hua Open-Pool Reactor.

16 Historical Stories of Taiwan documentary.

17 Ibid.

CHAPTER 2 THE SHOCK OF THE 1964 COMMUNIST CHINESE TEST

In October 1964, the People's Republic of China shocked the world when it conducted its first nuclear test. Taiwan's political establishment went into a state of emergency. The United States and likely Taiwan had thought that the PRC was years away from testing a nuclear weapon, although they were well aware that it was advancing its nuclear facilities. Part of the reason for the failure to anticipate the test was the fact that the PRC had a falling out with the Soviet Union, which abruptly ended all nuclear assistance in 1960. Many did not believe the PRC could finish the needed facilities and build nuclear weapons so quickly on its own. President Chiang was particularly rattled by the nuclear test; he had thought a test was not possible for three more years.¹

Although the United States had pledged to defend Taiwan against a Chinese invasion and had stationed U.S. nuclear weapons on its territory, Taipei's sense of security was badly shaken by China's first test. Declassified government cables sent to Washington, D.C. from the U.S. embassy in Taipei reflect the near panic. In meetings with senior U.S. embassy officials, top leaders on Taiwan, including President Chiang Kaishek, pressed for U.S. support for a Nationalist Chinese military strike to destroy China's nuclear installations. They also urged the formation of an Asian anti-communist defense organization and possibly the creation of

a common defense force.² One cable reported Chiang's fear that Taiwan might be wiped out in a single attack, with U.S. retaliation coming too late to prevent destruction.³ Taipei was also worried about the political fallout from the test, which was expected to boost China's international stature at Taiwan's expense. One cable reports that then-Foreign Minister Shen Chang-huan was seriously concerned about the reaction and morale of Taiwan's armed forces.⁴ In this state of panic, the ROC government quickly formed plans for accelerating the development of its own nuclear deterrent.

PLAN HSIN CHU AND RESISTANCE FROM THE UNITED STATES

The PRC had warned the ROC government early on that it would resort to military action against Taiwan—even forcefully claiming it—if it were ever to develop nuclear weapons. Even so, around 1966, President Chiang directed Taiwan's Chungshan Science Research Institute (or Chungshan Institute), under the Ministry of Defense, to draw up a specific plan for nuclear weapons development, which was titled "Plan Hsin Chu" or "Hsinchu Project." The proposal included a five- to seven-year plan to procure a heavy water-moderated reactor, heavy water production facility, and plutonium separation plant, or "reprocessing" plant, and prepare them for use in a nuclear weapons effort, all while professing that these facilities were strictly for peaceful purposes. The schematic for the three proposed facilities appeared to be a near replica of Israel's Dimona nuclear weapons complex near Beersheva (see also the sidebar on the role of Ernst David Bergmann of the Israeli nuclear program in advising Taiwan's nuclear program).⁶ At the time, Israel was just developing its own nuclear weapons capabilities and was close to building its first nuclear weapon.

A Cambridge University-trained mathematician and close advisor to President Chiang, Lieutenant General Tang Jun-po, would oversee material and equipment procurements and technology development for Plan Hsin Chu. In addition, Tang would oversee soliciting and recruiting domestic and foreign expertise for running the facilities. Some in Taiwan with scientific training were anxious to put their expertise to what they believed was an honorable use. Yet, the ROC apparently had difficulty attracting back a great number of people who had left Taiwan to live or study abroad. Moreover, not all who participated agreed with the government's plans.

Earlier, in 1965, President Chiang put his son, then deputy defense minister, Chiang Ching-kuo, in charge of developing the nuclear plan. The plan would focus on a dual track of civil and military nuclear development, with the military side carefully hidden from view.⁹

In March 1965, the United States became concerned when during a nuclear-related visit under the auspices of the International Atomic Energy Agency (IAEA), U.S. officials who were consulting with Taiwan's nuclear power company, the Taiwan Power Company or Taipower, about siting for two nuclear power plants, were asked by Taipower's representative about the best location for a 200-megawatt pilot reactor. The Taipower official envisioned the reactor as being completed by 1968 or 1969 and operated by a consortium of interests. Notably, one of the potential sites would put the facility under the control of the Chungshan Institute and the military. The Taipower representative inquired about where Taiwan could purchase such a reactor. The lead IAEA official, an American, stated that he did not think the United States or Canada would be willing to sell a reactor.

In mid-1966, Taiwan and the West German company Siemens neared finalization of a deal for the purchase of a single, multipurpose, 50-megawatt, natural uranium oxide-fueled, heavy water-moderated nuclear reactor. The proposed cost for the reactor was \$50 million. Reactor would be similar to the 200 megawatt-thermal (57 megawatt-electric) Multipurpose Research Reactor (MZFR) that had recently gone critical in West Germany. Taipei's stated intention for the facility was for research on the feasibility of using this type of reactor as a commercial electric power source. According to a cable originating from the U.S. embassy in Taipei, it was becoming apparent GRC [Government of the Republic of China] may well have decided launch program of nuclear weapons research and is seeking means by which necessary wherewithal can be obtained, hopefully with IAEA approval and under guise of power generation.

In March 1965, Washington found out about the Siemens deal. For at least a year subsequently, the United States and West Germany deliberated about the political sensitivities, safeguards requirements, and proliferation potential of the facility. The West German federal science ministry was in favor of the sale, but the foreign ministry was cautious about the political ramifications regarding relations with the Soviet Union and

China. The United States, for its part, considered that European countries more broadly might view its intervention in a sale to be based on a motive to take the sale away from European commercial companies, then an oft-stated European misconception about U.S. nonproliferation policy. The United States also wanted to maintain its strong ties to allies West Germany and Taiwan, while at the same time, prevent Taiwan from creating a security crisis with China. It notified West Germany of the need to ensure that the transaction, if it went through, was not viewed as secretive or suspicious to the PRC. Washington also considered the reactor to be "uneconomic." 16

Moreover, the United States did not want to undermine international faith in the IAEA's ability to safeguard nuclear facilities on Taiwan if it tried to prevent the sale. In April 1966, the German science ministry pressed its foreign ministry to authorize the export of the reactor if the ROC and IAEA concluded a bilateral safeguards agreement for safeguarding the facility.¹⁷ Washington wanted any such arrangement to be heavily publicized to quell inevitable concerns from the PRC. In February 1967, the first secretary of the U.S. embassy in Taipei approached Victor Cheng, the Secretary-General of Taiwan's Atomic Energy Council (AEC), for assurances about the purpose of Taipei's interest in a nuclear reactor. Cheng stated that "he saw no relationship between the proposed purchase of the reactor and nuclear weapons research." 18 Cheng also noted that the United States would likely need to provide heavy water for the reactor, allowing it the opportunity to establish safeguards over it. He suggested Canada as a possible heavy water supplier. Ultimately, West Germany awaited guidance from the United States about whether it should go forward with the sale

Despite the ROC's secrecy about its true intentions, by 1966 the U.S. intelligence community had become increasingly suspicious that Taipei was embarking on a path to acquire nuclear weapons. A January 1966 *National Intelligence Estimate* by the CIA found:

There is some evidence that one of [Chungshan Science Research Institute's] purposes is to study the possibility of Nationalist China's acquiring its own nuclear weapons. Although there are a number of U.S.-educated Nationalist Chinese scientists with a high degree of competence in the nuclear field, the Chinese Nationalists do not have the capability to produce such weapons domestically. They would have to

import unsafeguarded uranium, a suitable reactor, and almost all other necessary equipment. For the next few years at least, we believe that Nationalist China would have great difficulty in obtaining such unsafeguarded materials and equipment.¹⁹

The United States developed an informant close to a key individual in Taiwan's atomic energy establishment who confirmed its suspicions, according to a declassified diplomatic cable. The information came from Dr. Hsu Cho-yun, Chairman of the History Department of National Tsinghua University, who was a protégé of Dr. Wang Shih-chieh, a member of the Chungshan Institute's Council. Wang had been Minister of Foreign Affairs of mainland China in 1948 but fled to Taiwan. Hsu was in touch with a reporting officer at the U.S. embassy. The April 1966 assessment, titled, "Indications GRC Continues to Pursue Atomic Weaponry," sent to the State Department, stated, "... At the direction of President Chiang, the GRC Defense Ministry continues to try to develop an atomic weapon and delivery system, according to a source close to the effort." The embassy reported, "The President has overridden the advice of Lt. General Tang Chun-po"..."Tang believes the attempt impractical and beyond ROC resources. Thus far the GRC has been frustrated in its efforts to procure the necessary nuclear materials and has been similarly unsuccessful in its attempts to hire scientists from abroad to work on the project."20

The April 1966 assessment mentioned that Taiwan "tried Israel" after the United States refused to provide Taipei with additional nuclear technology or facilities, but that the ROC's support of Arab votes at the United Nations contributed to the deal being unsuccessful. Taiwan then approached West Germany and Japan, but no deals were made in the latter case due to Japan's concern about proliferation. According to the cable, the Chungshan Institute, which was at the time also working on missile development under a sensitive military division, was encountering "difficulty in developing its missile capability."

MOVING AHEAD ON NUCLEAR WEAPONS DEVELOPMENT

Dr. Chang confirmed to the authors that a nuclear weapons effort was then starting in the military, despite the government's public pledges not to develop them. In 1967, Chang formally started working at the military's Chungshan Institute as a First Associate and Army captain. He had

just graduated from the military's Chung Cheng Institute of Technology and Science (later renamed the National Defense University 22) with a Bachelor of Science in Physics.23 His training included two years at Tsing-hua University, where he studied physics and nuclear science and engineering. He was part of a group of about 20 military officers enrolled at Chung Cheng who were sent to Tsing-hua because it had the only nuclear engineering program on the island.24 The military sought to accelerate the group's training in the nuclear area. The military expected that this group would achieve careers in Taiwan's nuclear program. Sending them to Tsing-hua as undergraduates was viewed as fast-tracking their nuclear careers, which would be devoted to development of both peaceful and non-peaceful applications of nuclear energy. Chang said that the students knew that the underlying purpose was aimed at developing nuclear weapons, even though they were told to state that they were interested in only peaceful nuclear energy. He said the students used to joke that "nuclear weapons are to keep the peace."25

When Chang arrived at the Chungshan Institute, he joined a small effort just starting to develop computer codes for understanding the initiation and detonation of nuclear weapons. He spent the next year or two working on the first steps in code development. He reported that he used open literature from the U.S. Plowshares peaceful nuclear explosion project and literature on reactor safety. Looking at certain transient phenomena in reactor accidents, in particular when a reactor core undergoes a rapid rise in power and then disassembles, e.g. "the reactor runs away," was an unclassified doorway to studying the dynamic simulation of a nuclear explosion. Chang modified unclassified reactor transient codes, including a U.S. unclassified reactor safety code called AX1, which he received from his director, who had obtained it from a friend in the United States. The circuitous procurement process may have reflected that the code was covered by U.S. export controls, which would have likely blocked its legitimate transfer to Taiwan. With the code in hand, Chang proceeded to modify it for nuclear explosions. He first needed to get the program to work, namely debug it, which was not simple. He concentrated on modifying the code for calculating the dynamics of an implosion system, in particular the simulation of nuclear weapon assembly explosion sequences and the estimation of the explosive yield.

Chang left for the United States in 1969 as a scientific exchange visitor to Oak Ridge National Laboratory (ORNL) in Tennessee and graduate student in nuclear engineering at the University of Tennessee at Knoxville. The exchange was both encouraged and arranged by the military and nuclear establishment on Taiwan. While at ORNL, he focused on studying reactor safety transients in a nuclear accident, a clearly peaceful application but one that was not far from the simulation of nuclear weapons. However, Chang knew he would work on nuclear weapons when he returned to his nuclear research on Taiwan, and the visit was an opportunity to hone the skills he would use in developing nuclear weapons—in particular anything that would contribute to better understanding of the dynamics of an implosion device design.²⁶

DISSENT OF WU TA-YOU

It was well known that General Tang, who had been named Taiwan's Vice Minister of Defense and director of the Chungshan Institute's Preparatory Committee, was skeptical of the Hsin Chu Plan. The plan to procure a heavy water-moderated reactor, heavy water production facility, and plutonium separation plant and for use in a secret nuclear weapons effort would entail enormous costs and personnel requirements, and Tang worried about the ability of Taiwan to carry out the project.

In 1967, President Chiang asked Wu Ta-you, a well-respected Chinese physicist and professor living in the United States, to become director of the newly formed Committee for Science Development of the National Security Council.²⁷ The position was that of science advisor to the president. Chiang personally asked Wu to review a proposal for the allocation of \$140 million to the defense ministry for the Hsin Chu program.²⁸ The West German company Siemens had provided Taiwan an estimate of \$120 million for the construction of the three facilities requested for the program.

On July 26, 1967, Wu Ta-you officially dissented over the government's nuclear plans to a Scientific Advisory Committee meeting attended by General Tang, Chen Wen-kao, the director of Taipower, and other officials. Wu titled his dissent document *My July 1967 Evaluation Report on the Proposed Nuclear Energy Development Plan of Our Country.*²⁹ Wu foresaw that the Hsin Chu project would be exorbitantly expensive, especially

with the development of a missile delivery capability. The government's reserve at the time contained just half the cost of the entire project, he said. The plan did not contain anything about how to build a nuclear explosive or test a device. Taiwan was too small to host an underground nuclear test, or for that matter, to deploy a nuclear arsenal capable of surviving a first strike by the PRC. Although the PRC's nuclear arsenal was relatively modest, it was still going to be far larger than one envisioned by the ROC. A Taiwanese bomb would also increase the risk of a preemptive PRC nuclear strike. He determined that Taiwan did not possess adequate scientific expertise for a nuclear program, even though numerous scientists from Taiwan were then receiving nuclear technology training under Atoms for Peace programs internationally.³⁰ Wu felt that Taiwan required years to develop the expertise needed to support even a basic nuclear energy program.

If Taiwan went forward, Wu suggested that it first acquire a reactor and then map out a three-year plan to develop the other projects. It would also need to grapple with the problem of dependence on outside provisions of uranium and heavy water. In addition, Wu believed that placing the Hsin Chu program under the Ministry of Defense would arouse international suspicion and that it needed to be a separate civilian program from the military.³¹ He thought above all that Washington would find out about any such covert effort, putting the U.S.-ROC relationship in jeopardy.

President Chiang ultimately opted not to buy the nuclear facilities being offered by Siemens, respectful of Wu's advice and in consideration of U.S. opposition. In addition, Taiwan temporarily put on hold plans for reprocessing domestically-produced plutonium obtained from a reactor.

Amid the internal controversy, Taiwan became one of the first signatories of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) when it opened for signature in 1968. However, Dr. Chang believes that one of the purposes for Taipei signing the NPT was to continue the policy of using a civilian cover to obtain access to nuclear technology and training.

By 1969, the Executive Yuan (Taiwan's executive branch) and Chungshan Institute reached a compromise for the purchase of light water reactors to be run by Taipower, and for the purchase of a smaller, heavy water-moderated research reactor from Canada that would effectively be

controlled by the military. Chiang also planned to allocate \$30 million per year to scientific research and development and nuclear energy development, a figure that was subsequently reduced by two thirds in 1969, and then settled at about \$15 million per year after 1970.³²

In 1968, to create a devoted research institution with specific programs as suggested by Wu, Taiwan formally established the Institute for Nuclear Energy Research, or INER. Also that year, according to Wu's recommendation, Chiang allowed the civilian-run Taiwan AEC, which was under the authority of Taiwan's Executive Yuan, to assume jurisdictional control of INER. INER formally changed its name to AEC INER. The shift removed, at least in appearance, all of the nuclear establishment from an explicitly military organization and made it the sole organization responsible for Taiwan's nuclear research and development programs. However, most of the staff at INER were military, and its budget came from the military. General Tang maintained the military's presence by acting as a "standing committee member" of the AEC. Tang relinquished his post as director of Chungshan Institute's Preparatory Committee for the time being.

In 1969, Taiwan created a new scientific establishment under the Ministry of Defense, the Chungshan Institute of Science and Technology (CSIST). It was established as the ROC's leading institution for research, development, and design of defense technology and advanced weapons. Figure 2.1, a declassified 1969 U.S. spy satellite Corona image, shows the beginning structure of what became the main CSIST site, which would in effect control key sections of the military nuclear program, including the new nuclear research reactor at INER.

Both CSIST and INER were created out of the military's Chungshan Science Research Institute. That many of INER's personnel initially came from this military institute helps explain why INER was dominated by the military, despite nominally being under the Atomic Energy Council. Although INER was under the jurisdictional control of the AEC, it was placed under the administrative control of CSIST, which treated it as one of its divisions.³³

Years later, an AEC Secretary-General would characterize INER as a daughter of the AEC that had been married to CSIST.³⁴ By being under a CSIST umbrella, INER could operate under a great deal of secrecy. This secrecy would have a special benefit to INER staff, namely it "permitted"

payment of salary supplements to nuclear technicians at INER without public scrutiny."35

Later in 1969, construction started at INER on the Canadian-supplied, 40-megawatt-thermal, natural uranium-fueled, heavy water-moderated research reactor, called the Taiwan Research Reactor (TRR). It went critical in January 1973, giving Taiwan for the first time a source of weapon-grade plutonium. Canada supplied the TRR's first 25 metric tonnes of natural uranium fuel elements and provided U.S.-origin heavy water.³⁶ The \$35 million reactor would fall under IAEA safeguards once in operation.

CSIST and INER effectively shared one large site in Lungtan, Taoyuan county. Figure 2.2 is a declassified U.S. Corona image from early 1969 that shows the emerging CSIST site and where construction of the TRR and INER would start later that year. The image also shows the close proximity

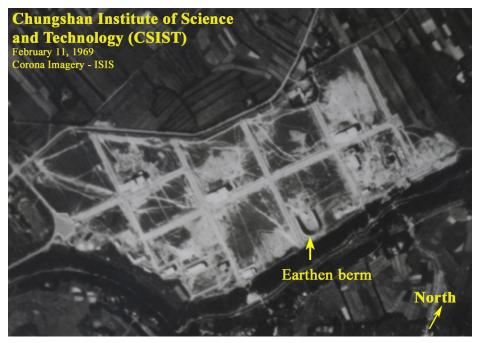


Figure 2.1. A 1969 declassified Corona image shows the beginnings of CSIST's main site, which was a successor of the Chungshan Science Research Institute. At the time, only about a dozen buildings could be seen in the complex, which would eventually expand and turn into an Institute hosting hundreds of buildings and thousands of employees. Many of its employees would play a major role in developing Taiwan's nuclear weapons capabilities. According to Dr. Chang, one of the larger buildings already hosted a Van de Graaff accelerator at the time that image was taken.

of a campus of the Chung Cheng Institute of Technology and Science. CSIST and INER were within a common security fence, with no physical boundary and constant traffic between them. Many U.S. and IAEA officials commented in the 1970s on the oddity and suspicious nature of the place. In addition to not being physically separated, the facilities shared many common capabilities including leadership and a computer center. The only physical separation was an internal checkpoint which allowed passage between the two. One typically had to transit through INER to access CSIST facilities as it continued to expand over the years.³⁷ Eventually, CSIST essentially wrapped around INER.

For many of those working at the site in the late 1960s and early 1970s, they did not see two separate organizations, but a unified one dedicated to making nuclear weapons. They referred to CSIST as an organization composed of four primary divisions, all united to build deliverable nuclear

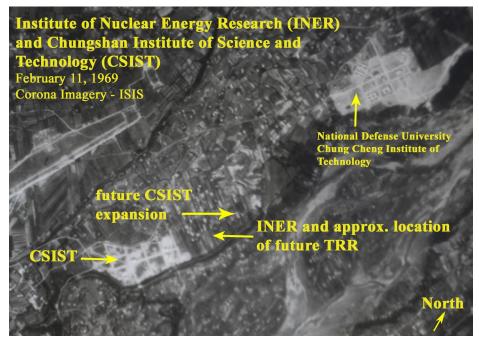


Figure 2.2. A 1969 declassified Corona image shows the soon-to-be location of INER, strategically located next to CSIST. Chang graduated from the CSIST-affiliated nearby university, which was first called Chung Cheng Institute of Technology and Science, then the Army Institute of Technology, and is today part of the National Defense University.³⁸ Chang obtained a Bachelor of Science in Physics from this university in 1967.

weapons. The first division was INER and was responsible for the nuclear weapons program. The second division was a mechanical research institute and was responsible for missile development. The third division was for electronics and was in charge of missile guidance, among other tasks. Some claim that the fourth division, for chemistry, was responsible for the development of chemical weapons and missile fuel.

Wu Ta-you was instrumental in temporarily slowing the trajectory of the program by influencing the decisions of Taiwan's top leadership. He later learned that then-Chungshan Institute scientists had denounced him as a traitor for his role in halting the much-anticipated development of nuclear weapons. In September 1967, Wu returned to the United States to teach. He maintained his advisory role to the program after 1967, and returned to CSIST for a visit in 1970, where he provided an evaluation to President Chiang about the need for more leadership of the nuclear program and a reduction in the length of military tenure for those pursuing scientific degrees. Wu also advised Chiang that Taipei should focus on improving collaboration between academic institutions and industry.³⁹ He was still considered for advice by Taiwan's nuclear establishment leaders well into the 1980s. Wu lamented in 1988 that he was not able to affect later events that led to so much trouble with the United States over proliferation.

ROLE OF ERNST DAVID BERGMANN

The head of the Israeli Atomic Energy Commission (IAEC) and "father" of its nuclear weapons program, Ernst David Bergmann, allegedly played a major advisory role to the development of Taiwan's nuclear, missile, and chemical weapons programs in the 1960s. This was a time when Israel's nuclear weapons aspirations were at an early stage and it was developing its own nuclear weapons capabilities at the Dimona complex not far from Beersheva in the Negev desert.

Research on Bergmann's role has been carried out by Yitzhak Shichor, using translated Mandarin sources and declassified Israeli government documents. However, the full extent of what Bergmann offered Taiwan during his visits and consultations on the nuclear program remains unclear. Moreover, the Israeli government was notably cautious about upsetting the United States and China and appeared to have tried to limit technology assistance mainly to missile and chemical weapons-related development.

What is known is that Bergmann believed that Taiwan needed a nuclear weapons deterrent and felt that the Israeli method of carrying out a covert program was best suited to do it. President Chiang followed Bergmann's recommendations about the development and trajectory of Taipei's nascent nuclear weapons program. Moreover, since Bergmann headed Israeli procurement efforts for its covert nuclear weapons program, he may have lent valuable guidance regarding such procurements for Taiwan—such as advising on countries and suppliers that would make sales of sensitive goods that could be used in the program.

Dr. Chang stated that Bergmann assisted with chemistry applications relevant to chemical weapons, because this area was not as scrutinized as nuclear research. Shichor also found that Taiwan's missile leadership was constantly in touch with Bergmann, who advised on the development of anti-ship missiles, anti-aircraft missiles, and nuclear-capable ballistic missiles.⁴¹ Chang corroborated that Bergmann was "instructed not to do much

on nuclear with Taiwan," and only offered recommendations about the direction and goals of a program.

This collaboration was evidently started by Taiwan. In 1961, a ROC delegation to the IAEA's fifth annual general conference made first contact with Bergmann. The delegation included Dr. Li Shih-mou, the executive secretary of Taiwan's AEC. A 1962 ROC delegation to the sixth conference included Victor Cheng, who was at that time the director of the Institute for Nuclear Science, and would later become Secretary-General of the AEC.⁴² In 1963, Chiang directed his close adviser, General Tang Jun-po, to attend the IAEA conference and personally invite Bergmann to Taiwan.

In early 1965, Bergmann came to Taiwan to meet with President Chiang at a remote lakeside hotel. During the two-day meeting, Bergmann recommended to Chiang that Taiwan develop nuclear weapons, yet not surprisingly, and disingenuously, he referred to Israel's efforts as entirely peaceful. In the fashion that Israel had, however, he recommended that Taiwan first establish an institute to oversee a broader effort with individual nuclear, missile, and electronic research focuses. It should also establish institutes for biological and chemical warfare research in case the nuclear program was ever closed by the United States.⁴³ Bergmann was resentful of U.S. efforts to inspect Israeli nuclear facilities.⁴⁴

In December 1965, two scientists from Taiwan visited Israel to meet with nuclear officials. The visit prompted both a news story in *Ha'aretz* and a now-declassified diplomatic cable from the U.S. embassy in Tel Aviv that noted with concern the visit by the scientists to the Nahal Shoreq nuclear reactor, a safeguarded reactor located south of Tel Aviv.⁴⁵ A follow-up cable about the meeting between the U.S. embassy's acting scientific attaché and the administrative director of the reactor, Mordecai Morahg, indicated that Victor Cheng was one of the visiting scientists, along with an assistant. Morahg revealed that Bergmann himself had personally escorted the two visitors. Bergmann refused to acknowledge to the U.S. officials whether they had come at his invitation.⁴⁶

In 1968, General Tang accompanied a delegation to Israel and met with high-level Israeli defense officials including the defense minister.⁴⁷ The Israelis perceived that Taiwan wanted to become more independent of the United States' scientific and military assistance and saw Israel as an alternative, particularly in the nuclear and missile fields.

Chiang apparently followed Bergmann's recommendations regarding the structure of INER and CSIST; it is outside the scope of this report whether Taiwan proceeded with chemical and biological weapons. Although Bergmann resigned from the IAEC in 1966, he periodically visited Taiwan over subsequent years as both an official and unofficial consultant, and Dr. Chang stated that his visits were always arranged by General Tang. Taiwan's scientists also visited Israel although the extent of cooperation and study was limited.⁴⁸ Amid impending political recognition changes by the international community toward Taiwan, Bergmann spent a month there from July to August 1968.⁴⁹ He met with President Chiang, among others, under the coordination of the Israeli Ministry of Defense. In an Israeli government report of a conversation with Bergmann, a senior foreign ministry official noted that Bergmann "had been consulted about research and development and about a 'very big' scientific institute that they were about to set up, as well as about a 'plutonium nuclear reactor." 50 Some Israeli officials worried that the cooperation extended too far.

Taiwan and Israel never held formal diplomatic relations. Israel joined most of the world in officially recognizing the PRC government on the issue of governance of China in 1969.

Taiwan maintained its advisory relationship with Bergmann until at least 1970. During a meeting in 1970, Bergmann suggested that Taipei acquire three more nuclear reactors and seek to reprocess the resulting plutonium. According to Shichor, a picture of Bergmann hung at Taiwan's military academy until as late as 1988.

NOTES

- 1 Cable from American Embassy in Taipei to Secretary of State, Washington, D.C., *Regarding Briefing of President on Special Subject*, October 24, 1964. All diplomatic cables cited can be located in the U.S. National Security Archive's electronic files. See briefing books on Taiwan's nuclear weapons program: William Burr, ed., "U.S. Opposed Taiwanese Bomb during 1970s," U.S. National Security Archive, Electronic Briefing Book No. 221, Posted June 15, 2007, https://nsarchive2.gwu.edu/nukevault/ebb221/ and William Burr, ed., "New Archival Evidence on Taiwanese 'Nuclear Intentions,' 1966-1976," U.S. National Security Archive, Electronic Briefing Book No. 20, Published October 13, 1999, https://nsarchive2.gwu.edu/NSAEBB/NSAEBB20/
- 2 Regarding Briefing of President on Special Subject, October 24, 1964; Cable from American Embassy in Taipei to Department of State, Views of Former Foreign Minister Wang Shih-chieh, Concerning the CCNE and GRC Prospects in the UNGA, October 28, 1964.
- 3 Regarding Briefing of President on Special Subject, October 24, 1964.
- 4 Cable from American Embassy in Taipei to Secretary of State, *CHICOM Atomic Detonation*, October 17, 1964.
- 5 Chang Hsien-yi (Sen-i), "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points," undated (Translated by Institute for Science and International Security, 2017).
- 6 Yitzhak Shichor, "The Importance of Being Ernst: Ernst David Bergmann's Role in Taiwan's Defense" (Qatar: Georgetown School of Foreign Service, Center for International and Regional Studies), *The Asia Papers*, No. 2, 2016, p. 13.
- 7 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 8 Cable from State Department to American Embassy in Taipei, *Indications GRC Continues to Pursue Atomic Weaponry*, April 8, 1966.
- 9 See Chapter 3 of Chang Hsien-yi's account in Chen Yishen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi* (Taiwan, Walkers (Yuan Zu Wen Hua), 2016) (Translated by the Institute for Science and International Security, 2017).
- 10 Cable from American Embassy in Taipei to State Department, GRC [Government of Republic of China] Request to IAEA Team for Advice on Location of Reactor for Possible Use by Military Research Institute, March 30, 1966.

- 11 Cable from American Embassy in Bonn [West Germany] to Secretary of State et al., *German Nuclear Reactor for Taiwan*, April 15, 1966.
- 12 Cable from American Embassy in Bonn to Secretary of State, *German Nuclear Reactor for Taiwan*, March 25, 1966.
- 13 Cable from American Embassy in Taipei to State Department, *GRC Plans for Purchase of 50 Megawatt Heavy Water Nuclear Power Plant*, February 16, 1967.
- 14 Cable from American Embassy in Taipei to State Department, *German Nuclear Reactor for Taiwan*, April 6, 1966.
- 15 Cable from American Embassy in Brussels to Secretary of State et al., *Possible German Nuclear Reactor Export to Taiwan*, April 7, 1966.
- 16 Cable from State Department to American Embassies in Bonn and Taipei et al., *Untitled*, April 29, 1966.
- 17 Cable from American Embassy in Bonn to Secretary of State et al., *German Nuclear Reactor for Taiwan*, April 15, 1966.
- 18 Cable from American Embassy in Taipei to State Department, *GRC Plans for Purchase of 50 Megawatt Heavy Water Nuclear Power Plant*, February 21, 1967.
- 19 CIA, National Intelligence Estimate: The Likelihood of Further Nuclear Proliferation, Number 4-66, January 20, 1966.
- 20 Cable from State Department to American Embassy in Taipei, *Indications GRC Continues to Pursue Atomic Weaponry*, April 8, 1966.
- 21 Ibid.
- 22 Chung Cheng Institute of Technology, "History," http://eweb.ccit.ndu.edu. tw/files/11-1001-641.php
- 23 *Professional Resume of Gray S. Chang, Consulting Engineer/Scientist (ret.)*, Provided to the authors, 2017.
- 24 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 25 Ibid.
- 26 Ibid.
- 27 Curriculum Vitae of Wu Ta-you and "Brief History of Wu's Administrative Work in Taiwan," both supplied by Dr. Wu Ta-you to one of the authors on October 29, 1997 via facsimile.

- 28 "Taiwan Considered Developing Nuclear Weapons in 1960s," *Sing Tao Jih Pao*, September 22, 1997, p. A10 (Translated by Foreign Broadcast Information Service, or FBIS); Author interviews with Professor Wu Ta-you on October 20, 1997 and November 18, 1997.
- 29 Details about the Hsin Chu program are relayed in: Dr. Wu Ta-you, "A Historical Document—A Footnote to the History of Our Country's 'Nuclear Energy' Policies," *Biographical Literature*, Vol. 52, No. 5, May 1988 (Translated by the Institute for Science and International Security), http://isis-online.org/isis-reports/detail/a-footnote-to-the-history-of-our-countrys-nuclear-energy-policies/15; Author interviews with Professor Wu Ta-you, 1997.
- 30 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 31 Wu, "A Historical Document—A Footnote to the History of Our Country's 'Nuclear Energy' Policies;" Author interviews with Professor Wu Ta-you, 1997. 32 Ibid.
- 33 See for example, Cable from American Institute of Taiwan (AIT), Taipei, to AIT, Washington, *Taiwan Press Reports INER to Be Absorbed by Industrial Technology Research Institute*, May 1988 but day of the month is illegible.
- 34 Cable from American Institute in Taiwan, Washington, DC, to American Institute in Taiwan, Taipei, Conversations in the Margins on Meeting of AIT-CCNAA Joint Standing Committee on Civil Nuclear Cooperation, May 31, 1988.
- 35 Ibid.
- 36 David Albright and Corey Hinderstein (Gay), "Taiwan: Nuclear Nightmare Averted," *Bulletin of the Atomic Scientists*, Vol. 54, No. 1, 1998, p. 57.
- 37 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 38 Chung Cheng Institute of Technology, "History," http://eweb.ccit.ndu.edu. tw/files/11-1001-641.php
- 39 Chang, "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points."
- 40 Shichor, "The Importance of being Ernst," p. 5.
- 41 Ibid, pp. 13, 15, 19-23.
- 42 Ibid, p. 2.

- 43 Liwei He (David Ho), *Nuclear Bomb MIT:* "A" Bomb Made in Taiwan (Taipei: Women Chubanshe, 2015), p. 95; *Historical Stories of Taiwan: The Mystery of Taiwan's Nuclear Weapons*, Mandarin language documentary, April 21, 2013 (Translated by the Institute for Science and International Security, 2017); Shichor, "The Importance of Being Ernst," p. 4.
- 44 Shichor, "The Importance of Being Ernst," p. 4.
- 45 Cable from American Embassy in Tel Aviv to State Department, *Nationalist Chinese Atomic Experts Visit Israel*, March 19, 1966.
- 46 Cable from American Embassy in Tel Aviv to State Department, *More on Nationalist Chinese Atomic Experts' Visit to Israel*, March 24, 1966.
- 47 Shichor, "The Importance of Being Ernst," citing an Israeli Bureau of Scientific Relations document from May 6, 1968; Moshe Yegar, *The Long Journey to Asia: A Chapter in Israel's Diplomacy* (Haifa: Haifa University Press, 2004 [in Hebrew]), p. 288.
- 48 Shichor, "The Importance of Being Ernst."
- 49 Ibid, p. 19.
- 50 Ibid, pp. 11-12.

SECTION II The 1970s

CHAPTER 3 GROWING NUCLEAR WEAPONS CAPABILITY

Although President Chiang Kai-shek's advisor on nuclear development, Wu Ta-you, may have seen nuclear weapons as counterproductive, after a brief pause, Chiang re-committed to developing the capability to make nuclear weapons under a peaceful guise. However, he realized that achieving that goal would take longer and require more investment into a range of smaller-scale projects and the education of far more nuclear scientists and engineers. As a result, Taiwan's nuclear program began sending more students abroad to Western countries to obtain information and expertise that would ultimately further the nuclear weapons program, even if their overseas education was in strictly peaceful nuclear energy. They had ample opportunities, however, to use their access to gather nuclear weapons-relevant information.

The Institute of Nuclear Energy Research (INER) and the Chungshan Institute of Science and Technology (CSIST) remained the center of nuclear weapons work, but off-site facilities started to play a role in developing nuclear weapons. The authors could not identify all of these reported facilities, but the existence of some of them could be confirmed.

In addition, as it continued to seek "turn-key," or complete reprocessing plants from abroad, Taiwan also started to seek the capability to conduct small scale plutonium separation and processing at pilot facilities that it built using imported equipment and know-how. The United States continued to closely watch Taiwan's nuclear programs and often

intervened to stop sensitive purchases. President Chiang's interest in attaining a nuclear weapons capability led to several controversial efforts to obtain a reprocessing facility from abroad. Taipei at various times in the 1970s tried to acquire a large-scale plutonium reprocessing facility from U.S., German, French, and Belgian/Dutch suppliers, and even started negotiating off-shore reprocessing contracts with a British firm. When Washington found out about the efforts to acquire a reprocessing facility, backed by shared intelligence internationally, it made high-level demarches to shut down each attempt.

While successful in discovering the larger reprocessing projects early in the process, the United States during the first half of the 1970s missed small-scale plutonium separation and processing activities. U.S. officials started the decade by overly downplaying INER and CSIST's nuclear weapons prowess. For example, an April 1971 State Department letter, with an enclosed memorandum on the subject of Taiwan's nuclear weapons program, concluded that Taiwan did indeed have a nuclear weapons program, but it represented a "waste of talent and resources" and the author believed "we can all take comfort in the GRC's inefficiency in this direction." The memorandum associated with this finding, which also disparaged General Tang's qualifications, estimated that Taiwan was at least five years away from a nuclear weapons capability, and "with the present research program, it is likely that the time required would be substantially in excess of five years." The authors of this letter and memorandum appeared to have been largely oblivious of the true state of Taiwan's nuclear weapons program and underestimated the risk of its long term approach of slowly acquiring facilities and capabilities.

In addition, INER had started to develop methods to defeat IAEA safeguards, a strategy which ultimately did not work, despite the inadequacy of safeguards equipment and techniques. In the end, the most important inspection tool was the human brain in thwarting Taiwan's proliferation-sensitive activities in the 1970s.

A TROUBLING, ON-GOING INTEREST IN ACQUIRING A TURN-KEY REPROCESSING PLANT

On October 25, 1971, Taiwan lost its seat in the United Nations and its IAEA membership when the PRC gained international recognition as the sole, legal government of China. President Chiang was deeply shaken by the loss. Chiang judged that pushing along with developing a latent nuclear deterrent against China would be Taipei's best bet. He decided to hedge his options by pursuing a longer-term plan than the Hsin Chu Plan had envisaged. This plan would develop the nuclear material needed for nuclear weapons within seven to fifteen years, a more realistic timetable than the earlier estimates. The effort was called Plan Tao Yuan. Plan Tao Yuan aimed to acquire the capability to produce indigenous weapongrade plutonium by separation, using irradiated Taiwan Research Reactor fuel. The plan commenced in full force when the TRR went critical in January 1973.³ But Taiwan still lacked a means to separate the plutonium.

Although in 1967, Taiwan had deferred buying a reprocessing plant from Siemens, by the late 1960s, it started to try again to acquire one. Taiwan's efforts to acquire a reprocessing plant from the United States were unproductive, leading Washington to firmly oppose Taiwan obtaining such a plant, even though at the time, the United States was committed to its own domestic civilian reprocessing programs. A reprocessing facility was just too dangerous in the case of Taiwan.

Taiwan reached out to the United States in 1969 for the purchase of a relatively large-scale reprocessing facility. The idea was vetoed by President Richard Nixon due to the risk for proliferation.⁴ There was little chance to revive any reprocessing assistance from the United States, and Washington was becoming increasingly vigilant about any attempts to acquire foreign reprocessing assistance by Taiwan (and other countries, as well).

Around 1971 or 1972, Taiwan secretly turned again to Europe as a potential supplier of a reprocessing plant. European countries in the early 1970s were deeply committed to reprocessing their own nuclear fuel, and several countries were engaged in building domestic reprocessing plants.⁵ Moreover, to reduce their own costs, several countries welcomed the chance to export reprocessing plants with less concern about the proliferation risks than the United States.

In late 1972, the U.S Mission to the European Commission in Brussels learned from a confidential source that Taiwan was seeking a reprocessing plant from a number of contractors in France, Belgium, and Germany.⁶ The source, who was an employee of one of the potential suppliers located in nearby Antwerp, had inside knowledge of Taiwan's efforts. The source told the United States that AEC Secretary-General Victor Cheng had just visited several potential European contractors, including Saint Gobain Techniques Nouvelles in France, UHDE-Lurgi Group in Germany, the Belgian subsidiary of the Dutch Comprimo in Antwerp (the employer of the confidential source), and British Nuclear Fuels Limited (BNFL) in Britain.7 The source also told the United States that some of the prospective contractors had sent teams to Taiwan as part of the bidding process for a reprocessing plant. At the time, Taiwan had reduced the list of potential contractors to Germany and Belgium, with the former being the favored candidate.8 According to the U.S. source in Antwerp, as of late 1972, only the German bidder had a governmental guarantee for the delivery of the necessary equipment and materials.

The United States already knew of some of Taiwan's efforts. In November 1972, the West German government informed the United States that Taiwan had secretly approached an unidentified West German company, possibly UHDE-Lurgi, based on the above information, for the purchase of a reprocessing facility. The facility would have "small capacity designed to process fuel from the two research reactors (US and Canadian supplied) on Taiwan plus the two US-origin nuclear power plants, Chinshan 1 and 2, now under construction." The German firm assumed that since all the fuel in those four facilities was under IAEA safeguards, no issues would be expected. Washington pressured both the West German and ROC governments not to go through with the sale, explaining that there were complexities in safeguards on Taiwan due to the special political considerations.

A few months later, in January 1973, the United States learned from the West German government that the German company UHDE-Lurgi had secretly signed an agreement with Taiwan to both construct and provide parts for a reprocessing facility. AEC Secretary-General, Victor Cheng, told U.S. officials at a meeting in Washington that the proposed plant was specifically intended for small-scale use. But according to West Germany, the facility would have been capable of processing 50 tons of

irradiated fuel each year, consistent with the processing level described above, directly contradicting Cheng's statement. This size of plant was large enough to separate a few tens of kilograms of weapon-grade plutonium a year and to handle all of the TRR's irradiated fuel.¹²

It appears from declassified U.S. government cables that the French government recognized the need to stop any officially sanctioned participation in reprocessing projects on Taiwan. Although the reason was not given, it appears to have centered on the general political question of exporting to Taiwan.¹³ Nonetheless, this decision apparently made it impossible for Saint Gobain to directly bid on building a reprocessing plant in Taiwan.

At some unknown time in 1973, perhaps as U.S. pressure built on Germany not to sell a reprocessing plant to Taiwan, Comprimo learned that Taiwan's AEC was interested in it building the reprocessing plant but wanted the French company, Saint Gobain Techniques Nouvelles, as the architect engineer for the construction of this facility.¹⁴ According to French governmental documents dated February 5, 1973 and obtained by the authors of *The Islamic Bomb*, the facility could have processed 100 tons of spent fuel a year.¹⁵ It was the same size as the Chashma reprocessing plant that French companies started to sell to Pakistan but stopped under U.S. pressure. It is unknown if Saint Gobain dropped out of this particular bid as a result of the French government's position. Later, however, the United States would learn that the indirect support of Saint Gobain continued despite the French government's stance, when the IAEA discovered a Saint Gobain employee on a leave of absence in Taiwan who was helping to set up a small reprocessing facility (see Chapter 5). Moreover, Taiwan's negotiations with Comprimo continued in secret.

The Comprimo source in Antwerp was unclear about whether BNFL was bidding to sell a reprocessing plant to Taiwan. However, Washington found out by as early as 1972 of a "preliminary agreement" between Taiwan and BNFL for "reprocessing services." Such services were commercial arrangements being offered at the time by Britain and France. In the case of Britain, irradiated fuel from Taipower nuclear power reactors would be sent to a large reprocessing plant to be built at Sellafield, Britain. After reprocessing, the plutonium in separated form or in unirradiated, or fresh, plutonium/uranium oxide nuclear fuel (mixed oxide fuel) would be delivered to the customer. In the case of Taiwan, the AEC

proposed to Washington that it would send the separated plutonium to the United States for storage or fabrication into mixed oxide fuel.¹⁸ The mixed oxide fuel could be used in lieu of enriched uranium fuel in nuclear power reactors.

U.S. REACTIONS

The United States apparently decided soon after obtaining the information from the Comprimo source to formally object to Taiwan's foreign ministry about its efforts to purchase a reprocessing plant. In January 1973, the United States made a presentation to Taiwan's foreign ministry in Taipei expressing that the acquisition of a reprocessing plant would risk Taiwan's development of nuclear energy and threaten IAEA safeguards.¹⁹ In response, it appears that Taiwan told the United States that it would not proceed with its bidding process for acquiring a reprocessing plant.20 However, Taiwan attempted to downplay and hide what it had done from the United States. Not knowing that the United States had learned from its confidential Comprimo source that Secretary-General Cheng had led the effort to obtain a reprocessing plant in Europe, Cheng tried to mislead senior State Department officials in March 1973 and state that he did not know about this effort until December 1972 when he learned about it from U.S. officials on a visit to Washington. He compounded his misstatements by adding that after returning to Taiwan he learned that a laboratory director interested in the entire fuel cycle "had priced a reprocessing pilot plant in Europe in order to include cost estimate in budget proposal."21 The United States had little incentive to risk its source by correcting Cheng. His misleading comments presaged more deception to come.

Faced with staunch U.S. opposition to buying a reprocessing plant in Europe, Taiwan's senior nuclear and foreign ministry officials shifted tactics, and in August 1973, presented Washington with a draft nuclear fuel management proposal that sought to legitimize domestic reprocessing as a long term goal. The justification for reprocessing was couched in a civilian rationale for reprocessing that had then gained currency in the West. These officials argued that the eventual acquisition of a domestic reprocessing capability was the "most reasonable and most economic" manner to address then expected worldwide shortages in uranium supplies. If the United States approved the plan, AEC Secretary-General Victor Cheng

said that Taipower would start sending personnel to Europe for training in reprocessing. Cheng estimated that four or five years would be needed to obtain the "necessary know-how." Only at that point would the ROC be in a "position to determine the advisability of constructing a reprocessing plant and would then request an amendment [to the U.S./ROC peaceful nuclear cooperation agreement] permitting equipment purchase and the eventual construction and operation of the plant."²²

As an interim step, Taiwan wanted U.S. approval to send Taipower irradiated nuclear fuel to BNFL for reprocessing. According to Cheng, BNFL "would be [the] most economical source of reprocessing since it [is] equipped to handle all stages of the cycle including shipping." The plan also called for modification of the U.S./ROC peaceful nuclear cooperation agreement to include fuel for eight anticipated Taipower reactors (instead of the two in operation).

The United States was unimpressed and deeply suspicious. In a declassified cable titled, *ROC Declares Need for Nuclear Reprocessing Capability: Probable Second Try at Acquiring Weapons Grade Material Capability,* then Deputy Chief of Mission in Taipei, William H. Gleysteen, Jr., recommended that the United States turn down the "well-orchestrated ROC attempt" and any other efforts to acquire a reprocessing facility. ²⁴ He also noted that some of the statements and forecasts appeared questionable. For example, qualified chemical engineers should require "two years study" to design a reprocessing plant, not four to five, and the United States believed it could "satisfy Taipower's enriched uranium fuel needs, both now and in the eighties." ²⁵ He also pointed out that although the concept of in-country reprocessing was presented as originating with Taipower, its "company officials in the past have expressed serious doubts as to the economic feasibility of such a program." ²⁶

Washington agreed with its embassy in Taipei that this backdoor request for domestic reprocessing be firmly denied and presented another demarche that same August, which was similar to the one presented in January.²⁷ It did indicate that it would be willing to modify the joint nuclear agreement to cover eight Taipower reactors, ambitiously scheduled for operation before 1986.²⁸ Surprisingly, Washington also said it would have no objection in principle to the foreign reprocessing of irradiated ROC nuclear fuel.²⁹ This U.S. view coalesced as a policy of potentially not objecting to overseas reprocessing in Britain or to the development of an

Asian regional reprocessing plant, as long as any separated plutonium was put into mixed oxide fuel outside Taiwan.³⁰ But even with eight power reactors in operation, to the United States, a domestic ROC reprocessing plant would be uneconomic, "let alone more economical that having the fuel reprocessed elsewhere."³¹

These attempts, and revelations that Taiwan's negotiations for a reprocessing plant may have continued after the August demarche, added to U.S. suspicions that Taiwan's true reason to both obtain the TRR and a reprocessing plant was to develop a nuclear weapons capability. The CIA was asked to issue an estimate on Taiwan's nuclear capabilities and intentions. The CIA concluded that Taipei could potentially fabricate a "weaponized nuclear device" by 1976 if its research and experimentation efforts continued on the current track.³² Missing from the analysis was the dismissive attitude about CSIST and INER's technical capabilities found in the 1971 State Department memo.

In addition, some senior U.S. officials worried in the fall of 1973 that some of their key colleagues were not firm enough in expressing disapproval to the ROC about reprocessing and pressed them to take stronger positions.³³ Evidently, part of the motivation was concern over U.S. officials giving mixed messages to the ROC. According to a senior State Department official, "We are not yet persuaded that the Chinese are really hearing us, let alone taking us seriously" on the reprocessing issue.³⁴

The episode also raised another concerning issue, namely that during the contract discussions, Taiwan had received from experts at UHDE-Lurgi, Saint Gobain, or Comprimo, designs or other know-how, and perhaps some sensitive equipment relevant to building a reprocessing plant. For example, German reprocessing companies in the 1970s and 1980s were relatively relaxed and focused more on exports than preventing proliferation. Evidence for this laxness was found during the IAEA inspections of the Libyan nuclear weapons program in the mid-2000s. The IAEA found a substantial number of German pilot reprocessing plant documents, which had gone through another country to Libya. With such items, Taiwan would be in a stronger position to build its own reprocessing plant in the future.

INER's fuel cycle facilities were still rudimentary in 1972 and 1973. However, the State Department's Intelligence and Research Bureau expressed suspicion that Taiwan's reason for seeking the TRR might have

truly been for the development of a "modest" domestic plutonium production capability.³⁶ This meant that Taiwan would likely persist in its efforts to acquire a plutonium separation capability, albeit under the guise of seeking one as part of Taipower's long-term fuel management plans, because without it, the TRR plutonium remained locked away in the irradiated fuel and unusable in nuclear weapons.

U.S. NUCLEAR TEAM VISIT

U.S. officials realized that Taipei would not abandon its chemical reprocessing ambitions unless serious disincentives were put forth. The United States decided to display a stronger willingness to delay or cancel vital shipments of military equipment, or even threaten to end its military relationship with Taiwan and put a halt to nuclear energy supplies. It asked to visit Taiwan's nuclear facilities and Taipei agreed.³⁷ It dispatched a team of technical nuclear and policy experts during November 15 to 20, 1973 to investigate the issue and deliver a new demarche.³⁸

A five-person team comprised of U.S. Atomic Energy Commission scientists and State Department officials toured the Atomic Energy Council's head office, INER, CSIST, National Tsing-hua University (which housed the THOR), and Taipower's nuclear energy facilities.³⁹ The delegation met with Taiwan's Foreign Minister, Shen Chang-huan, AEC Secretary-General Cheng, and several Taipower officials.

The team presented the U.S. demarche over efforts to procure a reprocessing facility to Foreign Minister Shen and assembled heads of the nuclear establishment. The team specified that the U.S.-Taiwan military and economic relationship would be jeopardized, in addition to future IAEA safeguards and nuclear fuel assurances, if attempts to develop the full nuclear fuel cycle continued.⁴⁰ A termination of IAEA safeguards and U.S. nuclear supplies would have certain significance because China would assume that Taiwan had been conducting illicit activities. The U.S. team cautioned the foreign minister that they "had the impression that some individuals and segments of government viewed full [domestic] fuel cycle and chemical reprocessing plant as a way to keep open the military option."⁴¹ Ambassador to Taiwan, Walter P. McConaughy, noted in a report back to Washington that the "rationale for reprocessing capability does not represent consensus within ROC. Taipower, for example, remains cool

if not opposed to scheme which military/scientific community portrayed as long term key to ensure successful nuclear power program."⁴² The team also noted from the visit that "INER seemingly has unlimited funds at its disposal" in terms of the sophistication of equipment present and apparent waste, which "often seemed purchased without clear cut program for utilization." One unanswered question is whether some of this equipment could have been intended for undeclared nuclear activities.

Foreign Minister Shen "reaffirmed ROC's intent to limit nuclear program to peaceful uses. He emphasized ROC would not jeopardize U.S. nuclear cooperation on which Taiwan critically depends."⁴³ The U.S. nuclear team left Taiwan strongly assured that the officials understood the purchase of a reprocessing facility was a red line not to be crossed. McConaughy's report stated, "Although we expect continued pulling and hauling which may nudge ROC further toward military program, study team has at least exposed more key people on Taiwan to what cost would be."⁴⁴ Importantly, however, General Tang, CSIST's Director, failed to attend an important dinner at the U.S. ambassador's residence and was absent when the U.S. team visited CSIST.⁴⁵ He was unlikely to have been convinced to stop Taiwan's slow pursuit of a nuclear weapons capability.

The team's visit was ultimately not very satisfying in terms of convincing Taiwan not to proceed to develop a nuclear weapons capability, according to a knowledgeable, former U.S. official. American intelligence also remained skeptical about Taiwan's intentions. With the assistance of its European allies, it continued to maintain a vigilant eye.

U.S. intelligence agencies were becoming more alarmed about Taiwan's growing capabilities. The CIA estimated in 1976 that it would take just two years for Taiwan to fabricate a small enough nuclear device to be "carried externally on a tactical aircraft" once it produced a crude nuclear weapon.⁴⁶

That alarm was also being raised because Washington had apparently penetrated Taiwan's nuclear program and continued to receive disturbing reports about on-going activities. According to the 1996 Congressional testimony of Ambassador James R. Lilley, a National Intelligence Officer in Taiwan during the late 1970s and director of the American Institute in Taiwan in the 1980s, the United States "knew [Taiwan was] conducting a clandestined (sic) nuclear program." But the spy or spies active in the 1970s do not appear to have been Colonel Chang, based on his

description of when his involvement with the CIA began (in 1982 and fully as an informant in 1984), in what is a common mischaracterization of his activities. There were apparently other spies before him.

Former Congressman Rob Simmons, who had an earlier life in the CIA from 1975 to 1978 in Taiwan, stated that he inherited a secret operation involving a few individuals active in obtaining information about Taiwan's nuclear weapons program.⁴⁸ This would likely account for the United States' growing insight into Taiwan's nuclear weapons efforts throughout the 1970s.

SAFEGUARDS AND THE NPT

Compounding the problem of monitoring Taiwan were the then-weak IAEA inspections. Although Taiwan signed the Nuclear Non-Proliferation Treaty in 1968, it never brought a NPT-type safeguards agreement into force. Negotiations on the standard comprehensive safeguards agreement, called INFCIRC/153, were finalized in 1971. But in October 1971, when Taiwan lost its seat in the United Nations, it was no longer considered a sovereign state but a province of China, and unable to sign nonproliferation agreements or treaties. In December 1971, the IAEA Board of Governors, as a UN organization, removed Taiwan as the representative of China. As a result, the IAEA broke off its negotiations with Taiwan on the freshly minted comprehensive safeguards agreement.

Canada quickly recognized China and ended its diplomatic relations with Taiwan, effectively ending any involvement with the TRR and its uranium fuel. Thus, Canada was no longer in a position to assume safeguarding responsibilities for the TRR, although the Canadian government remained very responsive to the United States and the IAEA if they asked for any assistance, as long as it could be given in a neutral context.⁴⁹ According to a senior Canadian foreign ministry official, China never would have accepted Canada developing the same relationship with Taiwan as the United States did after recognizing China.⁵⁰

The IAEA and Taiwan agreed that inspections would continue, and their existing safeguards agreement would remain in place. This agreement was far weaker than the new comprehensive safeguards agreement being negotiated in the early 1970s. The weak inspection coverage included only two inspections per year of the TRR, and other nuclear facilities at

INER were not inspected. Taiwan did not have to declare uranium it received from non-parties to the Nuclear Non-Proliferation Treaty, under its old-style safeguards agreement with the IAEA, an INFCIRC/66 type, better called a "transfer agreement," and given the name INFCIRC/133.⁵¹ Nonetheless, once the nuclear material was in the reactor, it was safeguarded from that point onward, as was any plutonium produced from the material. Of course, a non-party to the NPT could insist that its exports, e.g. uranium metal, be subject to IAEA safeguards, but it was not under any obligation to do so or report such exports to the IAEA.

In 1972, Taiwan, the United States, and the IAEA reached a tripartite safeguards agreement known as INFCIRC/158, to serve as the basis for safeguarding the island's nuclear facilities, but this agreement too was based on a relatively weak safeguards model.⁵² That same year, the safeguards agreement was strengthened through the renegotiation of the U.S./ROC Agreement on Nuclear Cooperation of 1955 to prohibit unauthorized use of U.S.-provided nuclear technology. The United States then became the sole provider of safeguarded nuclear fuel, heavy water, and nuclear-related equipment to Taiwan. However, other countries could provide nuclear material and equipment without applying IAEA safeguards to them. Importantly, the agreement for cooperation granted the United States the right to conduct snap inspections of nuclear material under its control, a custodial measure that was added in case the IAEA ever became politically unable to safeguard Taiwan's nuclear facilities.

In 1971, Taiwan also signed the Seabed Arms Control Treaty, or Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil thereof. It ratified the Partial Test Ban Treaty banning atmospheric nuclear explosions. These treaties theoretically limited Taiwan to conducting nuclear explosions underground on its own territory, which was too small and population-dense to conduct underground nuclear tests in any case.

CHANG AND THE ROLE OF STUDENTS STUDYING ABROAD

After spending about a year or two working at Chungshan Science Research Institute and then INER, in 1969, Dr. Chang Hsien-yi (Chang Sen-i) embarked on his two-year scientific exchange program in the United States at Oak Ridge National Laboratory, which was encouraged and arranged by the military and INER. In his Mandarin language biography, Chang recounted how the president's son, Chiang Ching-kuo, who had recently been appointed defense minister, met with him and two fellow students being sent abroad. Chang described his reactor related study plans. After hearing about their research, Chiang Ching-kuo insisted that the students take different flights to the United States for safety reasons.⁵³

At ORNL, Chang studied molten salt reactor experiments and the thorium cycle and received reactor safety training under Dr. Alvin Weinberg. Chang received a Master of Science in Nuclear Engineering in 1970.

On his first tour at Oak Ridge, Chang was interested in the ratio of plutonium isotopes in a nuclear explosive. He understood from his work at INER that implosion designs used high purity plutonium, namely material with a relatively small fraction of plutonium-240. He took it upon himself to learn more about the isotopic composition of U.S. nuclear weapons. ORNL had an extensive unclassified microfiche collection containing the operational records of the Hanford nuclear reactors, which produced plutonium for U.S. nuclear weapons. The information in the collection about the operation of the reactors was sufficient for him to calculate the plutonium isotope fractions of U.S. weapon-grade plutonium produced at Hanford. During this time, Chang did not explicitly work on estimating the effect of changing the plutonium-240 fraction, since he did not bring the codes he had developed at INER, but he started to think about the fraction of plutonium-240 that would work in Taiwan's nuclear weapon design. Does the plutonium-240 fraction have to be just a few percent with an emphasis on achieving high confidence that the predicted explosive yield will be achieved, say more than 90 percent of the time? Or could a fraction of 10 percent plutonium-240 suffice, if lower confidence was accepted? If so, what would the impact be on the implosion system's pre-detonation probability and explosive yield? Chang intensively studied those questions.

Students sent abroad from Taiwan to study nuclear engineering and related applications knew their other mission was to further their skills needed in a nuclear weapons program and collect sensitive information when possible. They were told that if they were caught, however, the ROC government would disavow them. Dr. Chang described in interviews how students were sometimes sent abroad with a "minder," or another student whose job it was to monitor their activities. The government had limited resources to pay for expensive study abroad efforts; it expected results.

During 1971, Chang returned briefly to Taiwan to work at INER's Reactor Physics Department. From 1972 to 1976, he went back to the United States to complete his Ph.D. in Nuclear Engineering at the University of Tennessee at Knoxville. Following completion of his studies, Chang returned to Taiwan and became the leader of the Reactor Control Dynamic Simulation Group at INER. Upon returning, he applied his acquired knowledge on reactor safety and runaway chain reactions, or an uncontrolled nuclear accident, to inform INER's nuclear weapons design efforts. He was also promoted to Lieutenant Colonel.⁵⁴ In 1984, he became one of the Deputy Directors of INER.

NOTES

1 Cover letter from Thomas P. Shoesmith, Country Director, to William W. Thomas, Jr., Esquire, Counselor for Political Affairs, American Embassy, Taipei, April 8, 1981, with attached memorandum by William W. Thomas, Jr., pursuant to a conversation with Bruce Billings, State Department, GRC's Atomic Weapons Program, March 11, 1971.

2 Ibid.

- 3 Chang Hsien-yi, "Taiwan Nuclear Weapons R&D Chronology of Events/ Talking Points," undated (Translated by Institute for Science and International Security, 2017); Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 4 Leonard S. Spector, *Nuclear Proliferation Today* (New York: Random House, 1984).
- 5 Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium 1996* (Oxford: Oxford University Press, 1997).
- 6 Cable from US Mission in Brussels to Secretary of State and several American Embassies, *Proposed Reprocessing Plant for Republic of China*, December 21, 1972.
- 7 Ibid.
- 8 Ibid.
- 9 Cable from Secretary of State to AEC Germantown and American Embassies in Bonn, Ottawa, and Taipei, *Nuclear Safeguards in ROC*, November 22, 1972. 10 Ibid.
- 11 Ibid, and see declassified cables from November 1972-January 1973 in U.S. National Security Archive, "New Archival Evidence on Taiwanese 'Nuclear Intentions,' 1966-1976," particularly Cable from American Embassy in Taipei cable to Department of State, *Proposed Reprocessing Plant for Republic of China*, January 20, 1973.
- 12 Proposed Reprocessing Plant for Republic of China, January 20, 1973, p. 1.
- 13 Memorandum from Roger Sullivan to Assistant Secretary of State for Far East and Pacific Affairs Arthur W. Hummel, Jr.: Nuclear Study Group Visit to Taiwan, October 29, 1973; and Informal letter from Dwight J. Porter, Resident Representative to the International Atomic Energy Agency, to H. Daniel Brewster, Department of State, January 12, 1973.
- 14 Memorandum from Sullivan to Hummel, Jr.: Nuclear Study Group Visit to Taiwan, October 29, 1973.

- 15 Steven R. Weisman and Herbert Krosney, *The Islamic Bomb* (New York: Times Books, 1981), pp. 152-153.
- 16 Proposed Reprocessing Plant for Republic of China, December 21, 1972; Cable from American Embassy in Taipei to Secretary of State, Current Status of Nuclear R&D in the Republic of China, August 6, 1976.
- 17 For background on BNFL and its overseas reprocessing contracts see, *Plutonium and Highly Enriched Uranium 1996*.
- 18 Memorandum from Sullivan to Hummel, Jr.: Nuclear Study Group Visit to Taiwan, October 29, 1973.
- 19 Cable from American Embassy in Taipei to Secretary of State et al., *ROC Declares Need for Nuclear Reprocessing Capability: Probable Second Try at Acquiring Weapons Grade Material Capability,* August 11, 1973; Cable from Secretary of State to American Embassy in Taipei et al., *ROC Nuclear Reprocessing Plant,* August 22, 1973.
- 20 Cable from Secretary of State, Washington, to American Embassy, Taipei, *ROC Nuclear Research*, March 21, 1973.
- 21 Ibid.
- 22 Cable from American Embassy in Taipei to Secretary of State et al., ROC Declares Need for Nuclear Reprocessing Capability: Probable Second Try at Acquiring Weapons Grade Material Capability, August 11, 1973.
- 23 Ibid.
- 24 Ibid.
- 25 Ibid.
- 26 Ibid.
- 27 Memorandum from Sullivan to Hummel, Jr.: Nuclear Study Group Visit to Taiwan, October 29, 1973.
- 28 By 1986, Taipower had built and brought into operation six nuclear power reactors.
- 29 Cable from Secretary of State to American Embassy in Taipei et al., *ROC Nuclear Reprocessing Plant*, August 22, 1973.
- 30 See for example, *Memorandum from Sullivan to Hummel, Jr.: Nuclear Study Group Visit to Taiwan*, October 29, 1973.
- 31 Ibid.

- 32 Director of Central Intelligence, *Special National Intelligence Estimate on Taipei's Capabilities and Intentions Regarding Nuclear Weapons Development*, November 16, 1972, p. 2.
- 33 Memorandum from Sullivan to Hummel, Jr.: Nuclear Study Group Visit to Taiwan, October 29, 1973.
- 34 Ibid.
- 35 Interview by one of the authors with a former senior IAEA official, August 2018.
- 36 Department of State Bureau of Intelligence and Research Report, *Nuclear Weapons Intentions of the Republic of China* (Officially dated March 30, 1973, in circulation February 1973), p. 1.
- 37 See for example, Cable from Secretary of State to American Embassy in Taipei, *ROC Nuclear Research*, March 21, 1973.
- 38 Cable from American Embassy in Taipei to Secretary of State, *FONMIN Reaffirms Decision to Refrain from Acquiring Nuclear Reprocessing Plant*, November 23, 1973.
- 39 Shortly before the visit, the team was slated to be comprised of Bill Gleysteen, American Embassy in Taipei; Abraham Friedman, Atomic Energy Commission; Nelson Sievering, State Department; Frank Hauck, Arms Control and Disarmament Agency; and Gerald Helfrich, Atomic Energy Commission. *Memorandum from Sullivan to Hummel, Jr.: Nuclear Study Group Visit to Taiwan*, October 29, 1973.
- 40 Ibid.
- 41 Cable from American Embassy in Taipei to Secretary of State et al., *Atomic Energy Group Study Team Visit to Taiwan*, November 23, 1973.
- 42 Ibid.
- 43 Ibid.
- 44 Ibid.
- 45 Ibid.
- 46 Central Intelligence Agency, Defense Intelligence Agency, and Bureau of Intelligence and Research, Department of State, *Interagency Intelligence Memorandum: Prospects for Arms Production and Development in the Republic of China*, May 1, 1976, p. 8.

47 Hearing of the Commission on the Roles and Capabilities of the United States Intelligence Agency, *Testimony of Ambassador James R. Lilley*, 104th Congress, 2nd Session, January 19, 1996. Available at: http://www.fas.org/irp/commission/testlill.htm

48 Bob Woodward, *Veil: Secret Wars of the CIA: 1981-1987* (New York: Simon and Schuster, 1987), p. 170; Conversation of one of the authors with Simmons, undated.

49 Interview by one of the authors with then Canadian Ambassador Mark Moher of the Ministry of Foreign Affairs, October 8, 1997. Moher had earlier held various positions in the ministry and was involved from 1977 to 1986 in the Canadian discussions with the United States about Taiwan.

50 Ibid.

- 51 Agreement between the International Atomic Energy Agency and the Government of the Republic of China for the Application of Safeguards to the Taiwan Research Reactor Facility, INFCIRC/133, October 30, 1969. https://www.iaea.org/sites/default/files/publications/documents/infcircs/1969/infcirc133.pdf
- 52 Agreement between the International Atomic Energy Agency, the Government of the Republic of China, and the Government of the United States of America for the Application of Safeguards, INFCIRC/158, March 8, 1972.
- 53 See Chapter 4 in Chang's personal account, as detailed in the Mandarin language book transcribed for him by a Chinese academic: Chen Yishen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi* (Taiwan: Walkers (Yuan Zu Wen Hua), 2016) (Translated by the Institute for Science and International Security, 2017).

54 Ibid.

CHAPTER 4 TAIWAN CROSSES THE LINE

There were good reasons for the United States to worry about Taiwan's nuclear weapons intentions. As the 1970s progressed, and power moved to Chiang Kai-shek's son, Chiang Ching-kuo, Taiwan would undertake several initiatives to put in place a rudimentary capability to make nuclear weapons. Despite U.S. efforts to stop it, Taipei continued to make progress through the early and mid-1970s toward building the infrastructure to produce and separate weapon-grade plutonium, apparently all under Plan Tao Yuan.

In 1972, Chiang Ching-kuo was named Premier of the ROC, a post where he would serve until 1978. On April 5, 1975, longtime ruler spanning two nations, Chiang Kai-shek, passed away at the age of 87. Vice President Yen Chia-kan succeeded Chiang for the remainder of his term. However, Chiang Ching-kuo assumed KMT party leadership soon after his father's death, effectively making him the true leader of the country. He was officially elected president by the National Assembly in 1978. Taiwan's political system continued to be a one-party system and martial law remained in effect. Chiang Ching-kuo continued his father's goal of Taiwan acquiring a nuclear weapons capability.

To this day, Taiwan has not been willing to reveal publicly, or as far as we can determine, confidentially, details about its nuclear weapons program in the 1970s. Many U.S. government documents relating to the issue remain excised or have not been declassified. We have reconstructed here,

from a variety of firsthand sources, key aspects of the program and its status as of about 1977 when it came under intense scrutiny by the IAEA and the United States. Due to the difficulty of finding comprehensive information, we believe our picture remains incomplete.

NUCLEAR WEAPONIZATION

Taiwan's work on nuclear weapons gradually accelerated after the short pause following the review by Wu Ta-you. According to Chang Hsien-yi, whose colleagues briefed him on their advances since he returned to INER in 1977, by the early to mid-1970s, the team of experts at CSIST working on computer codes for nuclear weapons had grown to 10-12 experts.

Chang said that by this time the team had expanded their codes to two dimensions and were even doing some three-dimensional work. However, the team's calculations were constrained by the lack of memory in their computers.

The nuclear weapons program also included a high-explosive group that was coupled to this computer group, and was also started in the 1960s. In parallel, the high-explosive group was conducting theoretical work on high explosives and high-explosive tests, allowing parameters in the code to be better defined and adjusted. One of the most consistent features of the nuclear weapons program was the integration of simulations and theoretical and experimental high-explosive work. According to Chang, these groups were constantly having meetings and discussions about their work. From early on in the program, their emphasis was on making advancements and achieving miniaturization.

The high-explosive group was working on flyer plate experiments, where two plates made from a metal substituting for plutonium, typically uranium, are slammed together at a tremendous velocity and high-speed diagnostic equipment monitors the impact, looking for temperature and pressure data important to refining nuclear weapons codes. According to Chang, who knew the leaders of the high-explosive group well, the team would calibrate experiments on the roof of one of the buildings at CSIST before moving equipment to another site to conduct the actual experiment. One of these sites was not far from INER at a site controlled by the army. Chang was shown pictures of the flyer plate experiments. High

explosive components and shapes came from the military using designs and specifications from the high-explosives group.

When Chang returned to INER in 1977, Wei Yuan-hsun, one of the leaders of the high-explosive teams, showed Chang a working nuclear weapon model that was soccer ball-shaped, with a 32-point detonation system, a common number to ensure spherical compression of the nuclear core. Taiwan had been working on the 32-point system since the late 1960s or early 1970s.

The United States learned of at least part of this work. A now-declassified U.S. intelligence community assessment found that computerized nuclear weapon design experiments taking place at CSIST during 1974-1975 had been successful.² According to the memorandum:

During 1974 and 1975, a group of ROC nuclear scientists reportedly used computer facilities at the Chung-Shan Institute of Science and Technology to conduct extensive theoretical design calculations for a first generation nuclear device. Experiments were carried out, presumably in the areas of high explosives, shockwaves, and detonating systems. Problems were encountered in the experiments, but these were solved and the program was considered a success in September 1975.³

The agencies estimated in this report that Taiwan could build a crude nuclear device within three to four years.

TAIWAN RESEARCH REACTOR

A major coup for the nuclear weapons program was acquiring the TRR. The 40-megawatt thermal (MWth), heavy water-moderated, light water-cooled reactor used natural uranium metal fuel. It was ideally suited to make weapon-grade plutonium. It was the same type Canada earlier supplied to India, which used its reactor to produce the plutonium for its 1974 underground nuclear explosion. When India tested its nuclear device, it referred to the explosion as a "peaceful" nuclear explosion.

Beyond the economic cost that Taiwan could easily afford by that time, the intangible price for acquiring this precious asset was low—merely the appearance of cooperation with the IAEA and a hearty, but disingenuous, commitment to peaceful uses. Moreover, the peaceful use of the reactor itself, including the U.S.-origin heavy water, was not clearly

insisted upon by Canada. Nonetheless, the United States would seek to rectify this ambiguity over time while preventing another India incident.

If the reactor had operated at full power for 80 percent or more of the time, it could have produced more than 10 kilograms of weapongrade plutonium per year. But it typically did not operate that well. From 1973, after achieving criticality, through 1976, the reactor had an average capacity factor of slightly above 30 percent; in the period from 1978 through 1980, its capacity factor was about 65 percent (the reactor was shut down for most of 1977 and 1978). Most of the plutonium at the time was produced in the Canadian supplied fuel, and the fuel discharged from the TRR had an irradiation exposure, or burnup, implying that it



Figure 4.1 A 2004 Google Earth image of the former Taiwan Research Reactor building and its immediate surroundings. Several buildings were added after the 1970s. The image shows the irradiated fuel cooling pond discussed in the next chapter and the building hosting the Hot Laboratory. Based on the accounts of a former IAEA inspector who visited the site in the 1970s, the Norwegian reprocessing plant was situated between the reactor building and the Hot Laboratory in what seemed to be a separate building. We were not able to identify the exact building, and adjacent buildings may appear as connected in overhead imagery. The Hot Laboratory was likely located in the green-roofed building next to the irradiated fuel pond, which is the roof pointed out on the right in the annotation "hot cell building or buildings." The nearby Plutonium Fuel Chemistry Laboratory, which hosted a plutonium metal furnace and glove boxes, was believed to be near the Norwegian reprocessing plant, based on the accounts of the former IAEA inspector.

did not contain weapon-grade plutonium, which is typically plutonium with more than 93 or 94 percent plutonium-239. However, the irradiated fuel characteristically contained more than 90 percent plutonium-239. Moreover, running fuel through the reactor to make weapon-grade plutonium was easy to do; but this method of operation would have used more uranium fuel, which Taiwan wanted to conserve at the time.

Figure 4.1 is a commercial satellite image of the TRR and surrounding facilities as of 2004. Earlier than that date, high-resolution images were unavailable. Figure 4.2 shows the INER and CSIST site in 2004.

BUILDING A FUEL FABRICATION PLANT AND OBTAINING NATURAL URANIUM

In 1971, INER decided to develop its own fuel fabrication plant for the TRR. Taiwan finished the plant and produced the first fuel element in 1974.⁶

By 1979, U.S. officials reported that the facility had a floor space of about 50,000 square feet and used top quality CERCA (French) equipment, a company which specializes in manufacturing research reactor

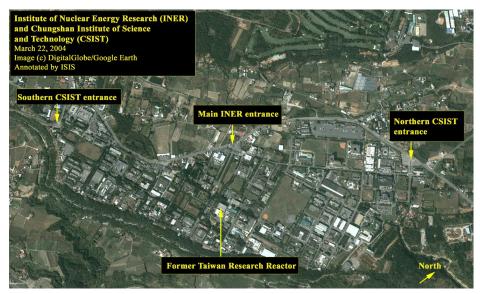


Figure 4.2 A 2004 commercial satellite image of the INER and CSIST site. The TRR can be seen in the image, as well as major gates into the facilities. INER was built to be part of CSIST.

fuel.⁷ Its capacity in 1979 was about 200 fuel elements per year and operators claimed to be operating at this level.⁸

Because Taiwan envisioned receiving uranium metal from South Africa, the fabrication plant could more directly work the uranium metal billets into fuel elements, clad them in aluminum, and assemble a fuel element. There were no uranium conversion activities as there would need to be if Taiwan had acquired natural uranium yellowcake.

That Taiwan started building the fuel fabrication plant in 1971 is probably no coincidence. It was the year when Taiwan was expelled from the United Nations and the PRC gained international recognition as the legal government of China. As a result, Canada's on-going supply of fuel for the TRR was no longer assured. It was also the year when Taiwan began to fear more for its security and the commitment of the United States to ensure it. Thus, Taiwan had civil and security reasons for building a fuel fabrication plant and seeking supplies of unsafeguarded uranium.

If Taiwan were to produce plutonium for nuclear weapons, it would need its own supply of uranium fuel outside of IAEA safeguards. Canadian fuel would have been harder to justify making plutonium for non-peaceful uses. If it were going to produce plutonium in secret, Taiwan would need to ensure that the fuel was less subject to international scrutiny. Moreover, Canada had supplied only 25 metric tonnes of natural uranium fuel elements and these elements were not enough for sustained operation of the TRR in any case. Each year, the reactor would nominally need up to 13-15 metric tonnes of uranium in the fuel assemblies. Canada's supply of uranium was only enough to get the reactor up and running, which as discussed above, took several years after it started in 1973.

Fortunately for Taiwan at least, South Africa at the time was willing to sell natural uranium metal in secret to countries, with no strings attached. Taiwan bought over 100 metric tonnes of South African uranium metal, which it received in 1973 and 1974. IAEA safeguards at the time did not require a country to report uranium imports, and surprisingly, Taiwan's safeguards agreements did not require IAEA inspection of the uranium metal, as would be required under a comprehensive safeguards agreement associated with the NPT. But Taiwan's purchase of the uranium metal became known to IAEA inspectors and was an early concern about the potential direction of Taipei's nuclear program.¹⁰

Taiwan also was acquiring uranium from German suppliers that was not reported to the IAEA.¹¹ The uranium was reportedly sent in small batches of less than 400 kilograms from Germany to Britain and then on to Taiwan. Several shipments went to Taiwan, likely involving up to a few metric tonnes of uranium.

Earlier, INER had developed a pilot plant to extract uranium from phosphates.¹² The pilot plant started in 1969 and operated successfully. INER scaled this plant up to production scale, with a capacity to produce ten metric tonnes per year of yellowcake. It was completed at the end of 1980 and reportedly went into operation in 1981.¹³

BUILDING OF SMALL-SCALE REPROCESSING CAPABILITIES

Although Taiwan's efforts to buy a turn-key reprocessing plant failed, it developed several small-scale reprocessing capabilities on its own during the 1970s. Although we call them indigenous, they depended on the foreign procurement of equipment, designs, and know-how. Nonetheless, considerable confusion exists about Taiwan's reprocessing plans, and we were unable to fully sort it out.

Hot Laboratory. In 1971, when Taiwan was expelled from the United Nations, it also decided to build a hot cell laboratory next to the TRR.¹⁴ The ostensible purpose was to conduct post-irradiation examinations of irradiated nuclear fuel and reactor structure materials, but many U.S. officials worried that it would serve to separate plutonium from irradiated TRR fuel.

Building construction and equipment installation at the Hot Laboratory were completed in June 1977. It was built using imported equipment from the United States, Germany, Japan, and France that were not then covered by export control laws.¹⁵ This facility contained three high-density concrete hot cells, with nearly one meter-thick walls, and nine lead cells. Whether Taiwan ever intended to use this facility to separate plutonium is unknown. It would not have been able to separate enough plutonium in a year for a nuclear weapon. Whether Taiwan originally envisioned expanding it is also unknown.

After six months of cold testing, the Hot Laboratory was ready for operation in early 1978. However, the actual commissioning date was March 1979, when an irradiated TRR fuel element underwent post-irradiation

examination. In August 1980, INER scientists examined a failed TRR fuel element. 16

Norwegian Small-Scale Reprocessing Laboratory. Adjacent to the Hot Laboratory, but not in the same building, the IAEA learned in about 1973 or 1974 that INER was building a small reprocessing laboratory with the aid and design of a Norwegian who had previously been involved in Norway's reprocessing program.¹⁷ It had a single hot cell containing a fuel dissolver and a very small mixer-settler for the separation of fission products.¹⁸ The purpose stated in design information given later to the IAEA was that this experimental facility was for the handling of test reactor fuel elements from Taiwan's small experimental reactor, referred to as ZPRL, which started in 1971 at INER. However, this information may have been inaccurate or may have been only part of the purpose of this reprocessing plant (see next chapter). For example, U.S. officials reported that the reprocessing plant would process irradiated near 20 percent enriched uranium fuel from the THOR reactor. ¹⁹

The ZPRL used U.S.-supplied 20 percent-enriched uranium fuel, although a press report said it used highly enriched uranium fuel.²⁰ In 1975, Taiwan requested approval from the United States to reprocess some of this fuel.²¹ By June 1976, the United States had not approved this request, and it reiterated to Taiwan that it opposed reprocessing.²²

If the reprocessing laboratory was used to separate plutonium, it could only have separated minute amounts, according to an inspector who visited the facility. But it could have been used to research various aspects of reprocessing irradiated material. Moreover, it would have already served as a way to train people in building and bringing into commission a much larger reprocessing plant. Thus, its small size should not be discounted, since experience with it would be invaluable in building a scaled-up reprocessing plant.

How was it outfitted? Steven Weisman and Herbert Krosney, in *The Islamic Bomb*, obtained a February 5, 1973 letter from Bertrand Goldschmidt of the French Atomic Energy Commission to Gilles Curien, the chief of scientific affairs at the French Foreign Ministry, in which Goldschmidt wrote that Saint Gobain had "already supplied the Taiwanese with some sort of smaller reprocessing facility." The relationship of this

supply to the discussions in late 1972 and early 1973, discussed earlier in Chapter 3, remains unclear.

According to an IAEA inspector, Svein Thorstensen, the chief of the Far East Section of the IAEA safeguards department, this equipment was for the Norwegian plant. Thorstensen learned of this transaction while in Japan conducting inspections at a Japanese reprocessing plant being built with Saint Gobain's help. On one occasion, he met a Saint Gobain employee on vacation and Thorstensen remarked that he was a long way from home. To his surprise, this Saint Gobain official said he was based in Taiwan and had taken a one-year leave of absence. Based on this conversation, Thorstensen concluded that the person was in Taiwan to install the Saint Gobain equipment in the Norwegian reprocessing plant. The "leave of absence" gave Saint Gobain deniability for what it clearly recognized as highly sensitive business. This arrangement allowed Saint Gobain to deny to the French government that it was violating its policy not to provide a reprocessing plant to Taiwan, albeit a tiny one.²⁴

This facility may be the one that declassified State Department cables identify as a tiny laboratory-scale reprocessing plant. In late 1972 and early 1973, AEC Secretary-General Cheng told officials at the U.S. Atomic Energy Commission and State Department that progress was being made on constructing a laboratory-scale fuel reprocessing plant at INER.²⁵ The declassified State Department cable did not identify exactly which facility it was, but the information is consistent with the Norwegian plant. Cheng stated that the building was complete but stood empty, with equipment expected to be installed by the end of 1973. He added that the facility would be tiny. It would process two fuel elements per year, yielding 300 grams of plutonium per year.²⁶

Another Reprocessing Plant—Off-Site to INER. There is some evidence for the existence of another, small reprocessing plant located outside INER (which will be discussed in Chapter 5). It is largely by implication. The site was suspected to be near the Shihmen dam, not far from INER, where CSIST was suspected to have other secret sites.

PLUTONIUM METAL LABORATORY, OR "PLUTONIUM FUEL CHEMISTRY LABORATORY"²⁷

A critical step in making a nuclear weapon is producing metal fissile material components. A disturbing discovery at INER during a mid-1970s IAEA visit was an undeclared laboratory to make plutonium metal from a small quantity of U.S.-supplied separated plutonium. It was called by IAEA inspectors the "Plutonium Fuel Chemistry Laboratory" and had a number of gloveboxes along its walls. The room was about 10-12 meters long and 7-8 meters wide.²⁸ It had four gloveboxes and interconnecting pipework for handling and transferring plutonium liquids. One glovebox was equipped with special neutron-shielding material. It also contained a glovebox with a vacuum reduction furnace for producing plutonium metal billets. Plutonium in metallic form is rarely if ever used in civilian programs.

Even without a declaration from INER, the presence of the glove-boxes, the reduction furnace, and neutron shielding, were strong indicators to anyone who saw the laboratory that its true purpose was to make plutonium metal. The neutron shielding would typically be present to protect against neutrons emitted by alpha-neutron reactions during the chemical conversion of plutonium compounds into forms such as plutonium tetrafluoride. Fluorine produces a significant number of neutrons when bombarded with alpha particles from the decay of plutonium, potentially exposing workers to excessive amounts of neutrons and necessitating neutron shielding. Plutonium tetrafluoride is mixed with calcium or magnesium metal, and put into a reduction furnace to produce plutonium metal billets.

This laboratory was operating in 1975 or 1976—using a supply of 1,075 grams of separated plutonium oxide that Taiwan had received in two shipments in 1974, the first in January and the second in November.²⁹ The plutonium was U.S.-origin. It had been approved for export to Taiwan and was sent to Taiwan from Belgium, and from the NUMAC Apollo plant in the United States.³⁰ The United States was unaware of the plutonium processing in this laboratory until being told by the IAEA, according to a senior IAEA official.³¹

As of July 1976, when the IAEA team visited, Taiwan had processed 490 grams of this plutonium, ostensibly to extract americium on an

experimental basis. The existence of the reduction furnace and neutron radiation shielding was strong evidence that the main intent of the laboratory was to make plutonium metal and not extract americium. Another 176 grams were stated to be unaccounted for, lodged in the pipework and equipment in the gloveboxes. The second shipment of 585 grams of plutonium was still in its transport container. None of this material had been previously declared to the IAEA; likely each of the plutonium shipments were viewed as too small of an amount to report under the safeguards agreement.

The origin of the equipment was foreign, possibly also Saint Gobain. Inspectors wondered if the Saint Gobain expert had also helped establish the Plutonium Fuel Chemistry Laboratory. One year was a long time to work only on installing equipment in the small Norwegian reprocessing laboratory.

It is important to note that these experiments involving a couple hundred grams of plutonium should have been sufficient to learn how to make plutonium metal. A program does not need to wait for kilogram quantities of separated plutonium to do the necessary experimentation to produce plutonium alloys.

U.S. ASSESSMENT ON REPROCESSING

An August 6, 1976 State Department report by U.S. Ambassador to Taiwan, Leonard Unger, updated U.S. officials on the status of nuclear research and development in Taiwan, particularly with regard to reprocessing and plutonium use. He noted that Washington had intervened to stop the ROC acquisition of a reprocessing facility from West Germany. The United States had become aware of on-going talks between the ROC and Comprimo, which started around 1972, but Unger believed the United States had adequately conveyed its concern to Taipei and to the Netherlands after finding out about visits by Comprimo technicians to Taiwan, and ROC officials to Comprimo.³² Taiwan's preliminary agreement for an overseas reprocessing contract with BNFL was cancelled in early 1975.³³ Unger also noted, "GROC officials have expressed concern over the current lack of reprocessing agreements and have indicated their belief that domestic or regional reprocessing will be necessary if agreements with foreign suppliers are not obtained."³⁴ Unger viewed the idea

of establishing a regional reprocessing effort as having "the effect of removing at least part of the ROC argument for acquisition of reprocessing technology/capability."

INER had recently developed an interest in developing a domestic ability to fabricate mixed oxide fuel, or fuel made from a combination of plutonium and uranium oxide. The United States assessed that Taiwan's development of mixed oxide fuel fabrication technology was "a discipline dependent upon the acceptability of plutonium recycle, but it provides the ROC with another forceful argument for establishment of a domestic irradiated fuel reprocessing facility." ³⁵

Ominously, the report assessed Taipei's nuclear stance:

It may well be that the ROC would prefer to convey the impression of having a nuclear weapons capability (much in the pattern of the Israel model). It follows, to a certain [extent](sic), that the ROC would want to complete fabrication of at least one, but perhaps several, simple [nuclear] devices which could give substance to the impression it wishes to create.³⁶

Regarding the relationship between INER and CSIST, Unger stated:

The proximity (both in physical sense and in the complementary nature of some research projects and the sharing of research facilities)... and continued apparent interest in acquisition of spent fuel reprocessing technology are all viewed as strong indications that the GROC intends to maintain the option to develop a nuclear device capability as a part of its overall national defense policy.³⁷

Still, the report noted, "There is no indication of intention to develop a large scale nuclear weapons system and even less indication of how or under what conditions a device (or weapon) might be used."³⁸ The ambassador pledged to continue monitoring the situation.

Nonetheless, U.S. officials increasingly realized that their efforts to stop Taiwan's march to nuclear weapons had not been adequate.

NOTES

- 1 Interview by one of the authors with Chang Hsien-yi, July 18, 2017.
- 2 Central Intelligence Agency, Defense Intelligence Agency, and Bureau of Intelligence and Research, Department of State, *Interagency Intelligence Memorandum: Prospects for Arms Production and Development in the Republic of China*, May 1, 1976, p. 9.
- 3 Ibid, p. 9.
- 4 Chien Ji-pen and YangChao-yie, "Experience and Utilization of the Taiwan Research Reactor," Presented at the 3rd Pacific Basin Conference, February 16-18, 1981, Acapulco, Mexico.
- 5 Ibid.
- 6 Ibid.
- 7 Cable from American Institute in Taiwan, Taipei to American Institute in Taiwan, Washington, D.C., *U.S. Nuclear Team Visit*, May 11, 1979, see section 5. 8 Ibid.
- 9 At most, the reactor could produce about 14,600 MWth-d per year. At an 80 percent capacity factor and a burnup of about 800-900 MWth-d/metric tonne of uranium, the TRR would need almost 13-15 metric tonnes of uranium per year. The actual annual need was usually less. In addition, during the 1970s, Taiwan achieved higher burnups of 1200-1400 MWth-d/metric tonne of uranium, reducing the annual need of uranium. See Chien and Yang, "Experience and Utilization of the Taiwan Research Reactor."
- 10 Interviews by one of the authors with a former senior IAEA official, Svein Thorstensen, 1996.
- 11 Ibid.
- 12 INER, "Research Programs of the Institute of Nuclear Energy Research," INER-0380, June 1981, p. 69.
- 13 Ibid.
- 14 Chien and Yang, "Experience and Utilization of the Taiwan Research Reactor."
- 15 Cable from American Embassy in Taipei to Secretary of State, *ROC's Nuclear Intentions: Conversation with Premier Chiang Ching-Kuo*, September 15, 1976, p. 2.
- 16 Chien and Yang, "Experience and Utilization of the Taiwan Research Reactor."

- 17 Interviews by one of the authors with a former senior IAEA official, Svein Thorstensen, 1996 and 1997.
- 18 IAEA, "Taiwan Inspection Report July 1976," October 12, 1976.
- 19 Cable from American Embassy in Taipei to Secretary of State, *Current Status of Nuclear R&D in the Republic of China*, August 6, 1976.
- 20 Edward Schumacher, "Taiwan Seen Reprocessing Nuclear Fuel," *The Washington Post*, August 29, 1976.
- 21 Ibid.
- 22 Ibid.
- 23 Steven R. Weisman and Herbert Krosney, *The Islamic Bomb* (New York: Times Books, 1981), pp. 152–53.
- 24 Proposed Reprocessing Plant for Republic of China, December 21, 1972.
- 25 Cable from Secretary of State to American Embassy in Taipei, *ROC Nuclear Research*, March 21, 1973.
- 26 Ibid.
- 27 The descriptions and the plutonium inventory in the Plutonium Fuel Chemistry Laboratory are from IAEA, "Taiwan Inspection Report July 1976."
- 28 Interview by one of the authors with Svein Thorstensen, October 24, 1997.
- 29 IAEA, "Taiwan Inspection Report."
- 30 Facsimile from Roger Heusser, U.S. Energy Department Office of Declassification Security Affairs (NN-52), to David Albright, regarding Plutonium Return from Taiwan, September 17, 1996.
- 31 Interviews by one of the authors with Svein Thorstensen, 1996 and 1997.
- 32 Cable from US Mission in Brussels to Secretary of State and several American Embassies, *Proposed Reprocessing Plant for Republic of China*, December 21, 1972.
- 33 Cable from American Embassy in Taipei to Secretary of State, *Current Status of Nuclear R&D in the Republic of China*, August 6, 1976.
- 34 Ibid.
- 35 Ibid.
- 36 Ibid.
- 37 Ibid.
- 38 Ibid.

CHAPTER 5 INTERNATIONAL INSPECTORS AND THE UNITED STATES ACT

Throughout the 1970s, IAEA inspectors and U.S. officials became increasingly alarmed about Taiwan's nuclear developments. Although concerns about efforts by Taiwan to buy a reprocessing plant from abroad were well known, it was covert, small-scale activities that started to become the most disturbing. At least, with foreign procurement of a turn-key reprocessing facility, it is likely to become public information long before a facility is transferred, and governments would be vulnerable to U.S. pressure to block the sale. However, the slow, persistent acquisition of smaller, but still dangerous nuclear capabilities, was much more difficult to stop.

IAEA CONCERNS

Sometime in 1973 or 1974, IAEA officials started to become alarmed by on-going nuclear activities at INER.¹ Svein Thorstensen, then chief of the Far East Section of the IAEA safeguards department, had become aware of the leave of absence of the official from Saint Gobain to help install sensitive plutonium-related equipment at the Norwegian reprocessing plant at INER. The plant had not been declared by Taiwan, although its safeguards agreements did not require that it be declared if it did not have any nuclear material in it that was subject to safeguards. With the weak safeguards agreements in place, Taiwan was not obligated to do more.

Nonetheless, the IAEA inspectors became concerned about potentially undeclared nuclear activities and the need to improve the safeguards agreements.

The IAEA wanted to broaden safeguards at INER and started to push Taiwan to act as if it did have a comprehensive safeguards agreement in effect. It was also concerned that the existing safeguards that applied at the TRR did not include proper surveillance.

On a visit to INER in 1974 or 1975, after learning about the Norwegian reprocessing plant in Japan, Thorstensen asked to see it, which Taiwan allowed. While there, he asked about other plutonium-related facilities, such as analytical laboratories, which the inspectors expected to exist. However, Taiwan did not want to show anything else. After some hours of insisting, Taiwan finally brought the inspector(s) to what would turn out to be the Plutonium Fuel Chemistry Laboratory. But no one there would explain the purpose of this laboratory. To inspectors, it was far too large to support the tiny Norwegian reprocessing plant or to turn the small amount of separated plutonium expected from that plant into metal. Suspiciously, INER officials called the reduction furnace "probably an incinerator," greatly increasing Thorstensen's suspicions.

At that time, Taiwan did not have a very credible inspection system in place for the TRR. Regular inspections at INER were limited to twice a year for the TRR and did not include the fuel fabrication plant, despite the presence of uranium metal, which under NPT-type safeguards in non-nuclear weapon states, would have been regularly inspected. The safeguards cameras in the TRR often failed or were on predictable cycles of taking photos. Moreover, the operator could tell if the cameras were operating by using a stethoscope and learning when its mechanical shutter would work, according to Thorstensen.

In response to questions to the TRR operators about whether they had transferred any irradiated fuel from the cooling pond, or whether a cask had moved irradiated fuel, they denied these actions had occurred.² As he walked around the TRR that day, however, Thorstensen noticed in the corner of the TRR's cooling pond a specialized transfer cask for irradiated fuel. He could see that the cask was from a French manufacturer and was large enough to move entire fuel elements, leaving him suspicious that irradiated fuel elements had been moved and not declared to the IAEA, as required even under the existing safeguards agreements.

Based on what he had learned and the growing number of inconsistencies in Taiwan's story, Thorstensen pressed IAEA Inspector General Rudolf Rometsch of the importance of him personally visiting INER to improve the safeguards situation. The trip took time to organize and finally occurred in late May 1976. At first, INER officials resisted Rometsch's request to tour the Plutonium Fuel Chemistry Laboratory, but finally relented. On the night of May 22, at a dinner with senior INER nuclear officials, Rometsch said that he could support all nuclear activities linked to civil purposes. But based on what he had seen that day, he could see that activities were going on that were not related to the civil use of nuclear energy. He questioned some of INER's activities, which he said could have a devastating impact. He asked the officials to rethink whether those activities were in their interest, and he ended by saying that whatever happened, Taiwan should not bring safeguards into disrepute. This visit reinforced the need for a major inspection at INER.

Soon after this dinner, the Washington Post reported that IAEA inspectors checking the TRR in early 1976 had failed to locate ten fuel elements, containing about 500 grams of plutonium.3 According to the story, the ten fuel elements had been moved from the TRR to another facility, likely the fuel fabrication plant. U.S. officials were reportedly surprised that inspectors did not insist on going to the other site to examine the fuel elements. The IAEA denied that any inspection had revealed missing irradiated fuel elements.4 However, a physical inventory of all nuclear material had not yet been done, so it was difficult to disprove the press report. Moreover, the media report raised suspicions that the fuel elements could have been diverted, and the IAEA simply did not know whether they had indeed gone to the fuel fabrication plant or had been diverted elsewhere and reprocessed. The negative publicity motivated the IAEA to dig deeper on its upcoming inspection trip which had been months in preparation, including committing to push harder that more facilities were subject to IAEA inspections, particularly the fuel fabrication plant.

In July 1976, the IAEA returned to INER in order to conduct a major inspection. Five inspectors took part in this inspection, planning for which had started in October 1975.⁵ The main purpose was to verify the physical inventory of Taiwan's nuclear material and try to find out if non-safeguarded uranium had been introduced into the TRR. The areas visited were the TRR, the fuel fabrication plant, the Norwegian

reprocessing facility, and the Plutonium Fuel Chemistry Laboratory. They also wanted Taiwan to declare more facilities as "Principal Operating Facilities," subject to regular, NPT-type IAEA safeguards inspections and material accounting, and as research facilities, such as the Plutonium Fuel Chemistry Laboratory, subject to IAEA access.

With regard to the TRR, the inspectors focused on improving the surveillance measures and taking more detailed radiation measurements of irradiated fuel elements in the cooling pond. The former was motivated by the cameras installed at the TRR, which had shown "a variety of faults, including some with the mechanical timers and some with the cameras themselves." A new, closed circuit TV system with tamper-indicating features was installed in the pond area. Instead of just testing fuel elements for radioactivity, as they had done earlier, inspectors took extensive measurements of about half the irradiated fuel elements in the pond to see if their measurements were consistent with Taiwan's declaration of where the fuel elements had been located in the core. This involved determination of the fuel elements' burnup and cooling time. When the inspectors reportedly later found discrepancies in Taiwan's declaration, INER officials said the declaration had been mistaken. Still, the IAEA found it difficult to reconcile this inconsistency.

At the fuel fabrication plant, the purpose was to establish the initial inventory of nuclear material at the plant as part of safeguarding it for the first time. This required establishing a nuclear material baseline at both the TRR and the fuel fabrication plant. At the fuel fabrication plant, the results showed a difference within the inherent measurement uncertainties of about 0.34 metric tonnes between the inspectors' and operators' figures in a total inventory of 105.7 metric tonnes, which is not a very significant difference.

However, the IAEA discovered a very high uranium scrap rate in the fuel fabrication plant, about 30 percent, and all allocated to process losses, which are notoriously difficult to measure accurately. This is a very high rate and could easily hide the diversion of uranium that was slated for irradiation in the TRR and subsequent diversion to a plutonium separation plant. In fact, the bookkeeping was sloppy enough that Taiwan could have diverted raw uranium metal ingots and falsified the bookkeeping, calling this material scrap or lost during processing, according to a U.S. official. However, during the visit, the IAEA did not find any evidence that

natural uranium or irradiated fuel elements had been diverted, but these problems in accurately knowing the scrap amount called into question the relatively precise measurements recorded by the IAEA inspectors.

The inspection team also visited the Norwegian reprocessing plant and the Plutonium Fuel Chemistry Laboratory. They found that the reprocessing plant hot cell was opened up to allow construction work. According to the inspection report, the inspectors concluded that no radioactive material had been introduced into the cell. They saw that its size precluded the possibility for "serious production scale reprocessing," but as discussed earlier, this characterization downplays the risk posed by this facility.⁸ Taiwan showed no material on the facility inventory and the inspectors could not find evidence of any being present during the inspection.

At the Plutonium Fuel Chemistry Laboratory, the inspectors saw the characteristic color of plutonium precipitate in the visible filters and other places in the glove boxes. This confirmed that the equipment had indeed processed plutonium.

Overall, while the IAEA received credit from U.S. officials for first finding the two undeclared plutonium-related facilities, its physical inventory verification was treated skeptically by the United States. Over the following months, the IAEA focused on improving the safeguards over nuclear material at INER and kept trying to convince Taiwan to act as if had a comprehensive safeguards agreement in place. In the early fall of 1976, Thorstensen proposed sending a letter to Taiwan seeking further improvement in its INFCIRC/133 safeguards agreement.

Although INER's safeguards were greatly improved after the July inspection, the IAEA still could not determine if Taiwan had diverted any fuel elements, and the United States was increasingly worried about Taiwan's intentions and whether the IAEA would respond aggressively enough to detect any secret reprocessing. An official from the U.S. Arms Control and Disarmament Agency said, "I don't like Taiwan reprocessing secretly or openly, large or small."

As IAEA inspectors conveyed what they were learning to the United States, however, Washington became more alarmed. Moreover, new, more troubling information emerged.

EVIDENCE OF REPROCESSING LEAKED

On August 29, 1976, the *Washington Post* reported that U.S. intelligence findings over the previous six months indicated Taiwan had been secretly reprocessing irradiated fuel elements.¹⁰ The next day, the *New York Times* confirmed the reporting.¹¹ The exact amount or source of plutonium was not known. The *Washington Post* also reported, quoting knowledgeable officials, that the United States had not yet formally confronted Taiwan with the new information. At least two former U.S. officials with direct knowledge of this reprocessing episode confirmed to us that the report was accurate.

During this six-month period, the United States had detected indications that reprocessing had occurred through taking air samples, reportedly at an unidentified, nearby U.S. facility. The sampling had detected fission products on three separate occasions, or in three distinct plumes of radioactive material indicative of reprocessing. Although the United States could not pinpoint the exact location of the reprocessing, analysis based on wind patterns led to the vicinity of INER. At the time, the United States maintained extremely sophisticated capabilities to detect minute amounts of radiation. The methods were viewed as reliable. U.S. officials felt confident that reprocessing had occurred, but they did not know where.

Under continuing U.S. pressure, on September 14, President Chiang made a promise to the U.S. ambassador—followed three days later by a diplomatic note to the same effect—that Taiwan would not acquire its own reprocessing facilities or engage in any activities related to reprocessing. ¹² U.S. officials said soon after that any violation of Chiang's commitment would "fundamentally jeopardize" nuclear cooperation—and the United States was by then the only supplier of low-enriched uranium to Taiwan's growing number of nuclear power plants.

Despite this pledge, the United States learned a few months later that negotiations between Comprimo and INER had continued after the president's assurances in September 1976.¹³

WASHINGTON ACTS DECISIVELY

In spite of the actions of the IAEA and Rometsch and the U.S. threats, Taiwan continued its nuclear weapons work. More drastic action was necessary, according to U.S. officials who participated in these debates.

In September 1976, Premier Chiang had made an offer to finance up to three U.S. nuclear scientists stationed in Taiwan, with full access to all ROC nuclear facilities and activities. ¹⁴ This offer was not picked up by the United States, because placing resident experts in Taiwan could be seen as an indication of U.S. dissatisfaction with the IAEA. Moreover, these experts would be subject to the "hospitality of their Chinese hosts, perhaps reducing their effectiveness as inspectors." ¹⁵ However, the United States thought that the president's offer provided an important opportunity to send nuclear teams with access to all nuclear facilities and activities in Taiwan with his direct support. ¹⁶

But some of the most compelling evidence about Taiwan's nuclear weapons activities was also then highly classified intelligence information, and the United States did not want to have questions raised by Taiwan about how it was gathered. A solution was to leak the same or similar information to the media or to use reports containing leaked information, in particular the recent *Washington Post* and *New York Times* reports on secret reprocessing and potentially missing fuel elements, as a means of pressuring Taiwan. The media reporting allowed the United States to raise the issue with Taiwan as a potential problem. This approach succeeded in helping open up important parts of Taiwan's secret nuclear program. In essence, a public revelation was needed to raise and then solve problems, according to one of the U.S. participants.

The U.S. team went to Taiwan in January 1977 (see figures 5.1 and 5.2). The transport of Burton Levin, State Department; Gerard Helfrich, Energy Research and Development Administration (now Energy Department); Joerg Menzel, Arms Control and Disarmament Agency; Raymond Wymer, ORNL; Murray Kavanagh, Lawrence Livermore Laboratory; Allen Locke and Dean Cooper, State Department. The U.S. embassy in Taiwan assigned an escort officer.

Ambassador Levin, the team leader and a fluent Mandarin speaker originally from the ROC office at the State Department, once again reiterated U.S. nonproliferation policies using key talking points cleared by



Figure 5.1 Members of the U.S. team who visited Taiwan in January 1977.

an interagency review. Vice Foreign Minister Chien Fu and top nuclear establishment officials warily listened on.²⁰

Chien ingenuously asked "what penalties" a noncompliant nation would face? Levin stated that, "sanctions would not be confined to nuclear matters but would also affect a wide range of relations, including military cooperation." During the U.S. team's meeting with Deputy Defense Minister Admiral Feng Chi-tsung, the admiral commented about the inherent difficulty of separating civilian and military nuclear programs. ²²

The U.S. team next met with nuclear officials and staff while touring INER and CSIST, including INER's Director Chien Chi-peng and General Tang, who had by then been re-appointed to a directorship post as president of CSIST. The team laid out for the scientists the limits to which their fuel cycle-related research could extend. After the presentation, the establishment leaders sat in "deep silence." INER scientists were not pleased to have the U.S. team paying them a visit, and Vice Foreign Minister Chien complained in his meeting with the team that U.S. policy with regard to preventing acquisition of a reprocessing facility imposed a double standard.

The U.S. team was later treated to an extravagant dinner hosted by the Taiwanese government. The event, in a spectacle worthy of headlines,

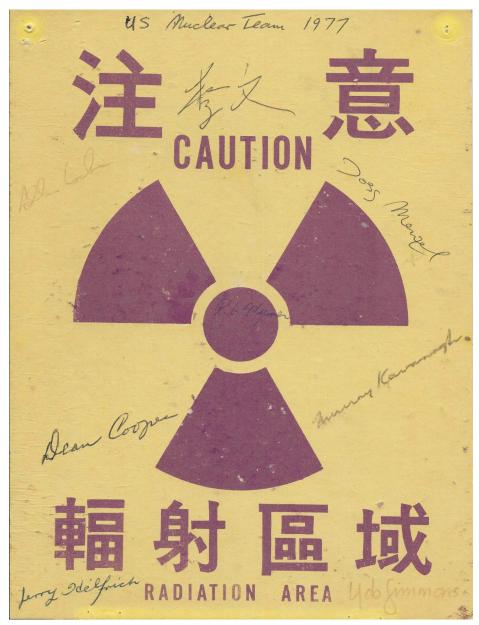


Figure 5.2 U.S. team members on an unknown date signed a cardboard radiation warning poster they found in Taiwan, likely from the January 1977 visit.

was attended by scantily-clad, dancing ladies who offered to take members of the all-male team to private bedrooms.²⁴ None of the team members accepted the overtures. But at least the team learned the perils and temptations of their hosts' "hospitality."

The team visited all the major nuclear sites. They took samples in the small Hot Laboratory next to the TRR. They concluded that it could not accommodate full-size TRR fuel elements. Taiwan had dismantled the Norwegian reprocessing plant prior to the team's arrival, making sample taking difficult.

The team inspected the Plutonium Fuel Chemistry Laboratory that the IAEA had told the United States about. They confirmed that it looked like it was for making plutonium metal from oxide. They concluded that the reduction furnace had likely been tested with the U.S.-origin plutonium, not indigenously separated plutonium.

A perplexing mystery was how the TRR's irradiated fuel could have been transported out of the reactor and processed in a reprocessing laboratory or plant. There were sawing stations in the pond holding the irradiated fuel. They were routinely used to saw off the ends of the fuel elements to ease storage. But, sawing the irradiated fuel elements in the pond would contaminate it, which would be easily measured by IAEA inspectors.

At first, the team was coming up empty, in particular not finding any smoking guns. It was getting worried. The team met at night to recap the day's events. It received real-time intelligence of Taiwan officials' reactions to the visits. They were reported to have called the American team barbarians who would never find anything. They said that one just needs to be polite and wine and dine them. The Americans would not find anything.

This intelligence insulted and motivated the team. They were determined to look harder.

One innovative approach was to access the nuclear waste inventory records for the Plutonium Fuel Chemistry Laboratory. It turned out that there had been several spills in that lab and an INER official monitoring it was a meticulous record collector. He had received training at Oak Ridge National Laboratory for waste recording. In the records of the spills, the team found evidence of fission products in at least one spill, which would indicate that plutonium had been separated. The U.S.-origin plutonium would not have contained fission products. The spills had been cleaned up

and the team could not access the waste directly. But this raised evidence that reprocessing had occurred, perhaps even in the Plutonium Fuel Chemistry Laboratory, although without shielding against gamma rays provided by hot cells, the possibility seemed remote. But small amounts of the products and wastes from reprocessing may have ended up there for analysis and been spilled.

But how would the fuel elements be cut without contaminating the cooling pond? This mystery was partially solved by a visit to the fuel fabrication plant. The U.S experts likely knew from IAEA reporting that the facility had an unusually high scrap rate. But there appeared to be too much uranium in the scrap, even accounting for an inexperienced program just starting to run a fuel fabrication plant. As a result, INER personnel could have falsified the accounting records, hiding a diversion of uranium into fuel elements.

In line with this suspicion, a U.S. expert saw two odd-looking fuel elements on the floor of the fuel fabrication building and asked what they were. The INER person called them segmented fuel elements with slugs of uranium interspersed with aluminum spacers. The segmented fuel elements looked identical to the normal ones. It immediately clicked that this was how Taiwan could have diverted irradiated fuel from the pond. Such fuel elements could have been sawed into small pieces in the irradiated fuel pond without releasing radioactive materials, and they would have been much easier to transport to another location—possibly a reprocessing facility—that was not known to the IAEA. Because full size irradiated fuel elements could not fit into the smaller reprocessing laboratory, some officials speculated that these look-alike elements were designed to overcome that problem.

In early 1977, the IAEA discovered two more troubling facts, one of which confirmed the U.S. finding at the fuel fabrication plant. First, inspectors found five fuel elements, three in the core and two in cold storage, that looked exactly like other research reactor fuel elements but contained only 70 percent as much uranium, 39 kilograms versus 54 kilograms. INER officials said the fuel elements contained 10-centimeter pieces of uranium rods separated by solid pieces of aluminum. One U.S. official said that they would have appeared to be normal fuel elements, and before July 1976, they would only have been tested by the IAEA to see if they were radioactive.

While demonstrating a new, more safeguards-friendly approach to the transfer of irradiated fuel from the cooling pond, an IAEA inspector found a hidden "canal gate," or port, at the back end of the cooling pond that had not been declared by Taiwan in its original design information. ²⁶ This gate was within meters of the Hot Laboratory. It was about half a meter in diameter and had been covered by scrap and other debris. It exited to a vertical shaft that had a concrete cap. INER officials said that the gate had been part of the original Canadian design for the transfer of irradiated fuel to the Hot Laboratory, which had a wall about three meters away from the vertical shaft. But the gate did not appear in the facility's design information as it should have.

Although the design information submitted to the IAEA did not show the gate, the Canadian drawings at INER clearly showed its design and construction, according to an unidentified person who was likely an IAEA official asked by the United States to look at the drawings at INER.²⁷ Further, the "Canadians had told him earlier that the port had been designed and constructed at ROC request."²⁸ The unidentified person climbed down the manhole to examine closely the bolts on the external port cover. In contrast to the rusted rungs on the manhole ladder, he found the bolts to be in very good condition. Moreover, there was evidence that the port cover had been removed sometime after construction was finished.

The U.S. team made a comparative analysis of the fuel elements produced at the fuel fabrication plant versus those accounted for at the TRR and the transfers between the two facilities. The difference in this accounting was ten fuel elements. Both sets of records were internally consistent. However, if the two sets were compared, a discrepancy emerged. All ten could have been segmented fuel elements. This relatively small number, while quite disturbing, would be consistent with a slow-moving nuclear weapons effort that was focusing on learning. It was not a breakout strategy, for example, but an important step in learning about reprocessing on a large-scale.

In parallel, the IAEA approached Canada and INER for more detailed information about the TRR's operation. According to a March 8, 1977 declassified U.S. diplomatic cable, also quoted above, the IAEA's Far East Section of the safeguards department had:

Compared the fuel inventory records provided during previous inspections with a detailed analysis of the recently acquired TRR operation computer data. This analysis seems to indicate that the irradiation and discharge of nine fuel rods had not been declared to IAEA.²⁹

Two independent results concluded that nine or ten fuel elements had been diverted. These results referred to different fuel elements than the ten fuel elements moved from the TRR in early 1977 and reported by the *Washington Post* in June 1977.³⁰

These latest revelations caused a furor, and ambiguous statements from the ROC government only fueled the fire. With all this analysis, the United States developed a theory that about ten fuel elements could have been fabricated in the fuel production plant, irradiated in the TRR, unloaded with other elements, and cut into pieces in the pond, avoiding any pictures being taken by the safeguards cameras of the diversion. (Because of the weaknesses of the safeguards system, the unloading of specific fuel elements or their numbers would not have been recorded).³¹ The cut elements could have been put into a transfer flask and transported from the TRR. Alternatively, the cut-up elements could have been taken from the pond via the canal gate in a transfer flask able to fit through it.

What happened to the missing fuel elements? Were they reprocessed, and if so, where did the reprocessing occur? Those questions remain unanswered. Many U.S. officials believe reprocessing occurred, despite Taiwan's consistent denials. If it did happen, one of the more intriguing possibilities is that the reprocessing occurred off-site, such as at the rumored, secret reprocessing site near the Shihmen dam. But the site was never found. If it existed, did it continue to operate?

The United States reportedly knew about a site or sites where Taiwan conducted high-explosive and other tests related to the development of nuclear weapons. At least, it was known that the nuclear weapons program was using a streak camera in these tests.

We could not fully reconstruct where the U.S. team went in relation to investigating these potential sites. As best as we could determine, the U.S. team was accompanied by General Tang and taken a short distance from INER to a military facility that used a streak camera in developing high-explosive components of nuclear weapons and obtaining data for its theoretical nuclear weapons simulations. Chapter 9 discusses one such site in more detail.

The team may have also traveled to a southern site in Taiwan, at the opposite end of the island from Lungtan's northwesterly location that was a military missile testing area. Here, members of the team may have viewed a high-explosives site that was able to detonate larger amounts of high-explosives than the smaller site near INER and was suspected of being used for the development of nuclear weapons, including simulating atomic explosions.

It is unclear how the United States learned of these sites, although it likely had a source that told it where to look. It is also unknown what became of the high-explosives test sites after the inspectors' visit. These sites had other uses and were not known to have shut down. At least, they may have been used later by the nuclear weapons program (see Chapter 9).

The U.S. team also visited the computer center at CSIST which was shared with INER. They looked for evidence of work on nuclear weapons codes, but a knowledgeable former U.S. official did not remember finding anything.

After all these visits and analysis, the team had succeeded in uncovering secret nuclear programs and efforts to deceive the IAEA. The central technical conclusion of the U.S. team was confirmation of suspicions about INER's role in implementing the "apparent ROC decision to acquire the capability to produce a nuclear explosive device." ³²

Did the United States think that it could end Taiwan's pursuit of a nuclear weapons program? Some officials certainly did, but others were far less sure. Overall, there was little confidence that Taiwan would not try again, particularly with decisions approaching on the United States formally recognizing the PRC as the sole government of China.

Such uncertainties led to an approach to put a significant number of hurtles in Taiwan's path to nuclear weapons and improve inspections and oversight. Looking back, this approach was like Taiwan signing an income tax form. It would set down a record. It would involve expectations and norms. If something was seen in the future that did not fit, then there was an easy way to talk to the other party about it.

WHY THE LARGE AMOUNT OF SECRECY?

We have often wondered why this episode was kept secret for so long, and later, why the U.S. government publicly downplayed the reports of secret reprocessing and resisted declassifying or discussing this case. Certainly, making segmented fuel, and to most, the detection of fission products in air samples would signify strong evidence of secret reprocessing. The likely answers are sobering. Taiwan was an important ally with a unique dependency on the United States, and it was thus subject to significant leverage. The United States also did not want to add to a deterioration of relations between Taiwan and the PRC, and potentially give cause to PRC military action.

Taiwan was also an excellent customer of U.S. power reactors and enriched uranium fuel. If the United States alleged Taiwan had violated its safeguards agreements, the U.S. Congress or the Nuclear Regulatory Commission could have cut nuclear assistance to Taiwan. In addition, Congress was moving to tighten economic and military sanctions against countries that acquired reprocessing and uranium enrichment facilities. For example, the 1977 Glenn Amendment to the Foreign Assistance Act banned U.S. economic and military assistance, and export credits to countries that acquired or transferred nuclear reprocessing technology or exploded or transferred a nuclear device. Sanctioning Taiwan would have been unacceptable to most Americans and could have spurred military adventurism by the PRC. Secrecy made it easier to keep China out of the entire debate. U.S. allegations of safeguards violations and secret reprocessing could have also led to Chinese protests and demarches about U.S. actions in Taiwan. Keeping everything secret was viewed as less troublesome by the U.S. government, but this policy also restricted Congress' and the public's role in finding out about and stopping dangerous proliferation.

NOTES

- 1 Interview by one of the authors with Svein Thorstensen, October 17, 1997.
- 2 Interview by one of authors with Svein Thorstensen, November 22, 1996.
- 3 Don Oberdorfer, "U.S. Upset by Taiwan A-Inspection Slipup," *The Washington Post*, June 6, 1976.
- 4 Ibid and Memorandum to R. Rometsch from S. Thorstensen, "TRR Inspection on 9 February 1976 by Mr. H. Frittum," June 11, 1976.
- 5 IAEA, "Taiwan Inspection Report July 1976," October 12, 1976.
- 6 Ibid.
- 7 The fuel fabrication plant had shipped a total of 88 fuel elements to the TRR containing 4,726 kilograms of uranium and received from the TRR nine fuel elements containing 483 kilograms of uranium. The losses were listed as 2,152 kilograms. These nine fuel elements could be the ones mentioned in the *Washington Post* story in the previous citation.
- 8 IAEA, "Taiwan Inspection Report July 1976."
- 9 David Binder, "U.S. Finds Taiwan Develops A-Fuel," *The New York Times*, August 30, 1976.
- 10 Edward Schumacher, "Taiwan Seen Reprocessing Nuclear Fuel," *The Washington Post*, August 29, 1976.
- 11 Binder, "U.S. Finds Taiwan Develops A-Fuel."
- 12 Senate Subcommittee on Arms Control, International Organizations, and Security Agreements, Committee on Foreign Relations, *Hearings on Non-Proliferation Issues*, March 19, April 16 and 28, July 18 and 22, October 21 and 24, 1975; February 23 and 24, March 15, September 22, and November 8, 1976 (Washington, D.C.: U.S. Government Printing Office, 1977), pp. 345–71.
- 13 Cable from American Embassy in Taipei to Secretary of State, *Taiwan's Continued Interest in Reprocessing*, January 8, 1977.
- 14 Cable from American Embassy in Taipei to Secretary of State, *ROC's Nuclear Intentions: Conversation with Premier,* October 12, 1976.

15 Ibid.

16 Ibid.

17 "U.S. Nuclear Experts in ROC Talks," Central News Agency (CNA), January 17, 1977.

- 18 Cable from Secretary of State to American Embassy in Taipei, *US Nuclear Team*, January 10, 1977.
- 19 "U.S. Nuclear Experts in ROC Talks."
- 20 Cable from American Embassy in Taipei to Secretary of State, *US Nuclear Team Visit to ROC Calls*, January 19, 1977, p. 1.
- 21 Ibid, pp. 2-3.
- 22 Ibid.
- 23 Cable from American Embassy in Taipei to Secretary of State, *US Nuclear Team Visit to ROC*, January 22, 1977, p. 1.
- 24 Ibid.
- 25 Memorandum to L. Thorne from H. Frittum, "Observations in connection with proposed procedures for transferring TRR spent fuel elements from rod bay to the dry storage," January 31, 1977.
- 26 Ibid.
- 27 Cable from American Embassy in Tokyo to Secretary of State, *ROC/IAEA Safeguards*, March 8, 1977.
- 28 Ibid.
- 29 Ibid.
- 30 "U.S. Upset by Taiwan A-Inspection Slipup," *The Washington Post*, June 6, 1976.
- 31 Cable from American Embassy in Taipei to Secretary of State, *US Technical Team Visit*, May 31, 1977, p. 4. The IAEA system at the time did not provide quantitative information about the number of fuel elements going in or out of the reactor because the system did not reflect the fuel elements inside the refueling machine.
- 32 Cable from American Embassy in Taipei to Secretary of State, U.S. Nuclear Team Conclusions and Recommendations, February 17, 1977.

CHAPTER 6 DENUCLEARIZING AND CONSTRAINING TAIWAN'S NUCLEAR PROGRAM

With the incriminating evidence of the U.S. nuclear team in hand and enthused with a new determination to stop the proliferation of nuclear weapons, the administration of newly elected President Jimmy Carter decided in early 1977 to firmly demand in a demarche that Taiwan halt its sensitive nuclear activities and re-orient INER's nuclear activities to the support of nuclear power reactors. This was a novel attempt at coercing a country into denuclearization, or the closure of certain sensitive proliferation-relevant activities, albeit mostly focused on the fuel cycle and not the nuclear weaponization program.

1977 SECRET AGREEMENT ON REORIENTING OR HALTING TAIWAN'S SENSITIVE NUCLEAR ACTIVITIES

Around April 12, 1977, Washington presented Taiwan with a basic list of six principles regarding its nuclear activities and a pre-written, suggested response, indicating the level of seriousness. Among the demands were that Taiwan temporarily suspend the TRR and plan a wholesale "reorientation" of its activities, including a verified halt to proliferation-relevant fuel cycle research. The United States had decided that "determined and far-reaching action is required to eliminate the nuclear proliferation risk...

[faced] on Taiwan." Ominously, and as a means of coercion, Washington told Taipei that it saw "no other means of sustaining both our deep commitment to non-proliferation and our peaceful nuclear relationship with the ROC."

A diplomatic cable from March 1977 lays out the text of the initial demands, and a cable from December 1977 indicates what had evolved in the understandings by the end of the year, in what was frequently referred to as the "basic" or "secret agreement" or "basic principles" between the two countries, and more informally as the "U.S. note." The demarche presentation was made orally to Premier Chiang (who had not yet been elected president but was considered the center of power) by Ambassador Leonard Unger on or around April 12, 1977 in carefully coordinated talking points drafted by U.S. nuclear team leader Burton Levin. The oral talking points included the frank statement: "...Following a review of all the available evidence, the US is convinced that much of INER's current activities have far greater relevance to a nuclear explosive research program than to the ROC's nuclear power program." At the meeting, Unger left Chiang with the formal written U.S. note (typographical errors corrected):

The government of the United States views the prevention of further proliferation of nuclear weapons as one of the most important tasks facing the international community, and considers it vital that countries avoid activities which in any fashion cast doubt as to their nuclear intentions.

The US believes it important in that regard, that the Republic of China take certain steps to reorient its program for the peaceful uses of atomic power in order to dispel any residual doubts as to ROC intentions or capabilities. Toward that end, the US believes the following measures should be adopted:

1. All nuclear materials, equipment and facilities currently in the Republic of China or which may subsequently be acquired or constructed would henceforth be covered by the provisions of Articles VIII, X, XI, XII of the Agreement for Cooperation between the government of the United States of America and the government of the Republic of China Concerning Civil Uses of Atomic Energy, signed at Washington, April 4, 1972, as amended, in the same manner as if

such materials, equipment and facilities had been received from the United States. In that regard, we would appreciate reaffirmation by the ROC of its offer to open all of its nuclear facilities to the US government on a continuing basis.

- 2. All spent [irradiated] fuel from existing and future reactors located in the ROC would be disposed of under conditions mutually acceptable to our two governments.
- 3. The ROC would terminate all fuel cycle activities and reorient facilities involving or leading to weapons-usable materials, such as the separation or handling of plutonium and uranium-233, and the development of uranium enrichment and heavy water production capabilities.
- 4. The ROC would transfer all present holdings of plutonium to the US under appropriate compensatory arrangements.
- 5. The ROC would henceforth avoid any program or activity which, upon consultation with the US, is determined to have application to the development of a nuclear explosive capability.
- 6. Pending the establishment of a research program acceptable to our two governments, disposition of spent fuel in a mutually acceptable manner, and a mutual determination that effective safeguards could be applied to the reactor and associated facilities, the ROC would suspend operation of the TRR and would so notify the IAEA.

Agreement to these measures by the government of the Republic of China will be of significance in assuring a continuation of our mutual cooperation in the use of nuclear power to produce electricity. Moreover, by undertaking these measures the ROC can make an important contribution to a reduction in the dangers of nuclear proliferation, and to the solution of global energy problems.⁴

The suggested reply by Taiwan for agreement to the "basic principles" included:

Suggested ROC reply:

The government of the Republic of China, as a party to the Treaty on the Non-Proliferation of Nuclear Weapons, and as a party to safeguards agreements with the International Atomic Energy Agency strongly supports the goal of non-proliferation, and reiterates its determination to utilize nuclear power exclusively for peaceful purposes. To that end, the government of the Republic of China in its note of September 17, 1976, indicated that it would henceforth not engage in any activities related to reprocessing.

(The six basic principles followed verbatim from the U.S. note).5

Taiwan had no choice but to agree. In still-classified letters between the U.S. and ROC governments between March and May 1977, the terms of the American demands were worked out. A key provision was that the United States would be "afforded unlimited access to all ROC nuclear facilities on an ongoing basis." Moreover, all nuclear material, equipment, and facilities would be subject to the trilateral U.S./ROC/IAEA safeguards agreement.

INER faced the brunt of the new restrictions. It would need to "terminate all fuel cycle activities and reorient facilities involving or leading to weapons-usable materials, such as the separation or handling of plutonium and uranium-233, and development of uranium enrichment and heavy water production capabilities." It had to "avoid any program or activity which, upon consultation with the US, is determined to have application to the development of a nuclear explosive capability." Many of INER's activities were subject to cancellation or reorientation.

Regarding the demand that INER present a new research program to the United States for approval, Washington expected it would not adversely impact Taiwan's nuclear power program. The United States was prepared to offer technical assistance to work out "details and technical arrangements required to give effect to the basic agreement reached between our governments." An underlying U.S. strategy was to shift INER's purpose to supporting Taipower's nuclear power reactor program rather than the military's nuclear weapons effort.

This re-orientation was not welcome to the scientists engaged in INER's affected programs. According to U.S. government reporting, "there are rumors of discontent among some members of the 'nuclear leadership" that they are merely victims of either political policy of the U.S. related to accommodation with the PRC, or of an energy policy that will guarantee our continued monopoly over enriched uranium fuel for ROC power reactors."9

Despite this discontent, the United States remained determined to implement the secret agreement. To further that goal, a team of U.S.

technical experts would go again to Taiwan to observe modifications of the nuclear program's activities and discuss plans for reorientations. From May 25 to 27, 1977, a team of five experts was dispatched, including three of the technical members of the nuclear team that had visited five months earlier, Gerard Helfrich of ERDA, Joerg Menzel of ACDA, and Ray Wymer of Oak Ridge National Laboratory, as well as R. Adams of Argonne National Laboratory and R. Simmons of the U.S. embassy.¹⁰

On May 21, prior to the visit, Secretary-General of the Atomic Energy Council, Victor Cheng, visited Washington, D.C. His main concern was resolving the dispute so that the recently shuttered TRR could be re-started, and he viewed arrangements for irradiated, or spent, fuel disposal as key. U.S. team member Gerard Helfrich was in attendance at the meeting and stressed that Cheng should ensure all agreements were being implemented by INER staff and not just focus on the TRR. Cheng noted that INER staff were unaware of the U.S. demarche and thought the TRR was shut down for maintenance. This lack of transparency with INER and CSIST staff would persist and complicate the re-orientation of the nuclear program.

During the May visit to Taiwan, the U.S. team found that Taiwan's initial compliance with the six demands, including enforcing a halt to fuel cycle-related research activities, appeared to be on track.¹³ The team met with INER personnel including Director Chien Chi-peng and three deputy directors. Officials were cooperative and appeared ready to implement the agreed demands.

From the beginning of the implementation of the secret agreement, INER personnel expressed their desire to continue several nuclear research programs, including heavy water reactor development, LWR [light water reactor] fuel development, uranium recovery from phosphates, thorium separation from monazite sands, thorium-uranium-233 separation, and other activities. The team explained that several of the activities, such as uranium-233 separation, could be questionable (see below). However, the United States did not object to all of these activities.

In June 1977, INER Director Chien presented the United States with the formal plan regarding the reorientation of Taiwan's nuclear research program. Two facilities, which are not described in cables, required further discussions. Around that time, Washington provided Victor Cheng with a letter thanking him for INER's cooperation with the U.S. team visit which would "materially contribute to the reorientation of the nuclear activities at INER..."

The letter continued with a confirmation that the United States viewed INER programs as generally consistent with the U.S. note of April 1977, with the exception of the several outstanding issues discussed at the team visit. It would take until the end of 1977 to agree on a final plan and then some disagreements continued.

The reorientation of the nuclear activities at INER..."

The letter continued with a confirmation that the U.S. note of April 1977, with the exception of the several outstanding issues discussed at the team visit. It would take until the end of 1977 to agree on a final plan and then some disagreements continued.

The United States was cognizant of the need to ensure that the U.S. Nuclear Regulatory Commission and Congress were well informed of the proliferation constraints relating to any nuclear-related exports to Taiwan. If not, particularly in light of the troubling media reports on Taiwan's covert activities, Congress could block exports of nuclear fuel and equipment to Taiwan and jeopardize ongoing military and economic cooperation, and with it, U.S. leverage over reigning in Taiwan's activities.

SPECIFIC DENUCLEARIZATION STEPS

In an unprecedented manner and with little prior experience in denuclearizing a country, the United States and Taiwan voluntarily implemented a detailed effort that fixed or reduced some of the most glaring proliferation risks posed by Taiwan's nuclear program and ended certain fuel cycle activities, in particular reprocessing, enrichment, and plutonium handling. Other nuclear activities in a grey area were harder to deal with, particularly since key factions in Taiwan opposed U.S. efforts and wanted to ensure the survival of a residual nuclear weapons capability.

Dismantling all of the major nuclear weaponization activities was not an apparent priority, based on an evaluation of declassified U.S. cables and discussions with knowledgeable former U.S. officials. However, this aspect of the issue was highly classified, and key actions may have been excluded from the declassified information, which forms the core of this chapter.

TRR Operation and Safeguards Practices. In one of the first major steps, the TRR was shut down in April 1977.¹⁶ This shutdown was to continue, according to diplomatic cables, "pending the establishment of a research program acceptable to the two governments, disposition of spent fuel in a mutually acceptable manner, and a mutual determination that effective safeguards could be applied to the reactor and associated

facilities."¹⁷ The shutdown would last fifteen months, or until the summer of 1978.

The United States insisted that every fuel element in the core be radioactively scanned by scientists from Los Alamos National Laboratory. ¹⁸ This process verified Taiwan's declaration of the irradiation history of the fuel elements that were in the core, making it likely that any future diversions of this fuel would be detected. But it did not, and could not, settle questions about past fuel diversions. That question was apparently set aside, as the priority was stopping current and future activities instead of constructing a history of past ones.

The TRR's shutdown also allowed for the implementation of new practices for unloading the reactor and storing the irradiated fuel that would make IAEA safeguarding more effective and fuel diversion less likely. A key, initial goal was reducing the inventory of irradiated fuel in the cooling pond to as low a level as feasible.

Taiwan had always intended to move irradiated fuel from the pond to a nearby dry storage facility that was in an open field 500 meters from the cooling pond.¹⁹ The facility was a collection of silos dug into the ground, each with a cap, that could receive the irradiated fuel. Each hole was planned to hold no more than seven irradiated fuel elements. After putting the elements in the silo, a concrete plug was installed over the hole before welding the cap and storage hole shut. Afterward, the storage hole was evacuated of air and charged with nitrogen to create an inert atmosphere devoid of oxygen which corrodes the metal fuel.

Under the new arrangement, the transfer of the irradiated fuel would be expedited and inspected by the IAEA. The inspectors would also place special tamper-proof seals on the silos, so any effort to open and remove the fuel would break the seal and be detected by the IAEA. By the end of May 1977, 118 irradiated fuel elements, containing about five kilograms of plutonium, had been measured and transferred by the IAEA to dry storage and sealed, awaiting arrangements for final disposition.²⁰ This number represents most of the irradiated fuel elements discharged by July 1976, when the total inventory was 136 irradiated fuel elements, based on IAEA records from its July 1976 inspection.²¹ Most of the irradiated fuel elements that were moved to dry storage by mid-1977 had cooled in the pond for over two years, enough time to allow for safe transport.²²

To keep the inventory in the pond as low as possible, Taiwan agreed that the cooling pond would not hold more than one quarter of the core of irradiated TRR fuel elements (approximately 50 irradiated fuel elements) at any one time.²³ Depending on their irradiation level, or burnup, these fifty irradiated fuel elements would typically contain about two to almost three kilograms of plutonium.²⁴

Under the older arrangement, the IAEA was unable to determine with its cameras the number of fuel elements loaded into or unloaded from the reactor or know independently whether the reactor had been shut down for refueling. This type of reactor is refueled while shut down,²⁵ so to fix these problems, Taiwan agreed that the loading and unloading of fuel could only occur in the presence of IAEA inspectors, except in emergency circumstances.²⁶ Later, safeguards instrumentation, called a "bundle counter," is thought to have substituted for the IAEA's presence during refueling. The United States also appears to have committed to developing instrumentation that would allow the IAEA to check if the reactor was shut down. This instrumentation would provide the IAEA greater assurance that the operator had not shut down the reactor without IAEA inspectors being present.

Details about the new safeguards arrangements at the TRR are excised from a relevant cable. However, "improved surveillance systems and instrumentation" would be implemented.²⁷ The cable also noted that if the TRR's fuel was converted to a lower-proliferation-risk fuel, the measures could be reevaluated, implying that they could be reduced in terms of operator inconvenience.

TRR Restart. The United States had earlier made it clear that any resumption of operations of the TRR would be based on the "premise that the ROC will adhere to its non-proliferation policies and to the various nuclear agreements and undertakings to which it is a party." The two governments would need to reach a variety of arrangements, including adequate safeguards agreements, guidelines for acceptable nuclear research projects, and plans for the return of irradiated TRR fuel, the latter of which would involve complicated discussions about who would finance it, where it would go, and what its ultimate fate would be. They also reconfirmed that the United States would continue to be afforded unlimited access to all ROC nuclear facilities upon request.

The United States had decided to acquiesce to the re-start of the TRR "in its present configuration using natural uranium fuel for a period of up to two years," for Taiwan's production of radioisotopes and for its agreed research program.²⁹ Restart finally occurred in the summer of 1978. There are some indications implied in the declassified cables that Taiwan put great pressure on the United States to allow the restart of the TRR, and the United States resisted as long as possible to maximize its leverage on INER and CSIST programs.

Reprocessing and Hot Laboratory. The United States insisted that Taiwan agree not to conduct any chemical analysis of irradiated fuel or samples of such fuel without a mutual agreement on "definitions distinguishing such chemical analysis from reprocessing." Although the Hot Laboratory was ready for commissioning in early 1978, it was not commissioned until March 1979. The delay was likely due to negotiations on its utilization with the United States.

The United States did not shut down the Hot Laboratory but it wanted to ensure that plutonium separation or related experiments would not be conducted. In May 1979, the U.S. nuclear team visited the Hot Laboratory and saw that all the equipment related to examination of spent fuel was in place and operating but there was not equipment to allow reprocessing. The team viewed an irradiated TRR fuel rod being gamma-scanned to determine the fuel's integrity.³² Later, the United States agreed to the use of the Hot Laboratory to conduct post-irradiation examination of TRR fuel that was consistent with agreed upon constraints.³³

Taiwan had dismantled the tiny Norwegian reprocessing facility. A 1979 visit to the building, then called the Hot Development Laboratory and dedicated to another purpose, showed a "nearly abandoned building...in a state of rusting disrepair and devoid of the radiation and contamination monitoring and control equipment characteristic of fuel reprocessing areas."³⁴

Taiwan also terminated its reprocessing agreement with Comprimo.³⁵ This agreement had continued past then-Premier Chiang's September 1976 commitment not to engage in any reprocessing. Its existence was one of the main triggers for the U.S. team visit in early 1977.

Uranium-233 Separation. Despite INER's desire to continue with thorium-uranium-233 separation programs, uranium-233 separation

was viewed as reprocessing and inconsistent with the secret agreement. Uranium-233 is another nuclear explosive material that in separated form can be used to fashion nuclear weapons, although doing so is not easy given the intense radiation associated with uranium-233.

To meet the conditions of the deal, INER agreed to dismantle the process line that had been prepared for installation in the Hot Laboratory to separate uranium-233 from irradiated thorium and store sensitive equipment under IAEA seal.³⁶ INER officials told U.S. officials that they would like to continue thorium fuel development and would try to prepare a program that did not involve the separation of uranium-233. Later, INER annual reports showed work on thorium fuel development.³⁷

NPT-type safeguards. A key improvement was that Taiwan's nuclear program would be safeguarded in effect as if it had a comprehensive safeguards agreement in place. Clause 1 of the secret U.S./Taiwan nuclear agreement helped establish this new arrangement through ensuring that all nuclear materials, equipment, and facilities either present in Taiwan or subsequently acquired would be subject to IAEA safeguards. Previously, this arrangement covered only U.S.-supplied items. Unlimited U.S. access to any facility it wanted to visit was on-going.

Plutonium Fuel Chemistry Laboratory, Return of U.S. Plutonium. Taiwan was in no hurry to remove plutonium from and shut down the Plutonium Fuel Chemistry Laboratory. Nonetheless, the secret agreement required Taiwan to return the plutonium to the United States and shut down the laboratory.

Part of the initial problem was that INER's leadership did not inform staff about the new restrictions on nuclear work. In mid-March 1977, people in the laboratory started to process more plutonium, extracting americium for smoke detectors.³⁸ Plutonium processing work was continuing in late May 1977 during that month's U.S. nuclear team visit. Taiwan and the United States agreed that this on-going work was inconsistent with the agreement. INER stopped the dissolution of any more plutonium oxide, processed what had been dissolved, converted the plutonium liquid back to oxide powder form, and prepared it for shipment by June 30, 1977.³⁹ Later that year, INER Director Chien reiterated to Washington that "separation of americium from plutonium had been terminated."⁴⁰

The U.S.-origin plutonium was removed as expected.⁴¹ The plutonium was given to a captain of a U.S. naval vessel who stored it in his cabin for the journey back to the United States. Upon arrival, the plutonium was delivered to Los Alamos National Laboratory in New Mexico. The total quantity returned was 863 grams.⁴² The remainder, about 212 grams, was held up in the processing equipment and glove boxes at INER. As of September 1978, INER was still executing the decontamination of the glove boxes and treatment of "alpha," e.g. plutonium and americium containing wastes.⁴³

As mentioned above, the U.S. nuclear team took the position that there was no need to keep the plutonium processing line in the laboratory. Yet, Taiwan continued to slow-roll the dismantling, or even the reorientation, of this process line. Fifteen months after the April agreement, this "laboratory designed to produce plutonium metal ha[d] not yet been reoriented."⁴⁴ It is unclear when the process line was dismantled. It may have not been until the early 1980s. In the end, INER dismantled the process line. All the glove boxes and equipment, including the plutonium furnace, were stored under IAEA seal in metal containers in a warehouse within the INER site.

Heavy Water Reactor and Heavy Water Production. INER was mostly interested in heavy water reactors, despite Taipower pursuing imported light water reactors. Heavy water reactors are much better sources of weapon-grade plutonium than LWRs, and this on-going interest in heavy water reactors was viewed as suspicious by the United States. Under the secret agreement, Taiwan had to immediately end any research on heavy water reactor development and suspend research on heavy water production, pending TRR redesign. Further, "analytical studies and conceptual design work on a heavy water reactor" could not occur until mutual understandings were reached on a heavy water reactor design that minimized proliferation risks. Heavy water related research needed to be limited to paper studies only.

In an apparent violation of the secret April 1977 agreement, in September 1978, INER was still carrying out organic loop design, construction, and irradiation tests, relating to heavy water reactor design, and Washington had unconfirmed reports that heavy water production research continued (see Chapter 7 for more on the latter). 46 Some evidence

for a subsequent stand down in this work on heavy water reactors can be seen in a 1981 report on the experience and utilization of the TRR, where uranium carbide fuel testing in the organic loop in the TRR had been stopped.⁴⁷ The original purpose of installing this loop was to test the uranium carbide fuel to be used in a heavy water moderated, organic cooled reactor. According to this report, because of "the policy change in INER, this loop is now under modification to become a light water loop."⁴⁸ Shifting to fuel testing for light water moderated reactors would be consistent with a shift in INER support to nuclear power reactors, which in Taiwan were exclusively water moderated and cooled.

Uranium Recovery from Phosphates. The United States was willing to allow work related to the recovery of uranium from wet process phosphoric acid to continue, despite its proliferation risk of providing Taiwan a difficult to monitor domestic capability to produce uranium.⁴⁹ A U.S. nuclear team visit in May 1979 involved a meeting with the director of that effort and a visit to the uranium extraction pilot plant in Kaohsiung.⁵⁰ The facility, which began operation in March 1979 and involved 30 staff members led by Kuo Tsai-shu, was aimed at the first stage of uranium recovery. This plant was removing uranium, viewed as a contaminant, from a food supplement for livestock and producing ammonium uranyl phosphate.⁵¹ Uranium products from the plant (28 kilograms by May 1979) were transferred to INER, which had built a pilot and production-scale plant for subsequent purification and conversion of the uranium.⁵² Future plans included building an 18-ton per year production facility to be located next to the pilot plant.

TRR Irradiated Fuel Takeback. Faced with little will to permanently shut down the TRR as an unacceptable proliferation risk, the United States launched a key initiative to reduce the long-term threat posed by the TRR's plutonium. It obtained INER's approval to remove plutonium-bearing irradiated fuel from Taiwan for storage and ultimate disposal. This led to a highly controversial project to remove Taiwan's irradiated fuel to another country. The original recipient was planned to be Canada, which supplied the reactor, but eventually the United States agreed to receive all the irradiated fuel.⁵³

The project was plagued by delays from the start. Taiwan soon expressed concern about whether it had a ship suitable to move irradiated

fuel and about the cost of packaging it.⁵⁴ This would require dry transfer of the fuel to a massive shipping cask with a weight of 25 to 30 tons.⁵⁵ As worked out by December 1977, Taiwan would agree that disposition of irradiated TRR fuel would need to involve INER preparing "for shipment, and ship[ping] to a site selected by the United States all irradiated fuel from the TRR, following an appropriate period of cooling."⁵⁶ All preparation and transportation costs would be carried by Taiwan, but the United States would pay for storage and ultimate disposition in the United States.

In July 1980, the idea was floated that Canada would be asked to assume responsibility for transport of about 475 Canadian-origin irradiated TRR fuel elements while the United States would cover their reprocessing and disposal. Under the plan, the United States would bear up to \$3 million of the costs, Canada would cover up to \$5.2 million, and Taiwan would face up to \$1.8 million of the burden.⁵⁷ The United States decided to press Canada and Taiwan to agree to the plan.

It took until 1982 for the United States to reach agreement with the ROC authorities on the project to move all TRR irradiated fuel to the United States. The agreement, however, covered only an arrangement regarding who would pay the costs of disposing of the Canadian-origin fuel elements, which were expected to be only a relatively small fraction of the total amount of irradiated fuel requiring transport to the United States. Cost allocation and a schedule for the remainder of the irradiated fuel and for that generated in the future—for example, the fuel elements made using South African uranium—were not agreed upon at that time and were expected to involve difficult negotiations.

With the apparent support of Canada and Taiwan, the State Department proceeded to generate the necessary consultations and paperwork within the U.S. government to have the authorization to bring the irradiated fuel to the United States. The approach involved treating the TRR fuel as a "subsequent arrangement" under the 1972 U.S./ROC agreement for nuclear cooperation, where the Department of Energy would take possession of this non-U.S-origin nuclear material.⁵⁹ The subsequent arrangement was submitted in January 1983 with the stated intention to import and reprocess the Canadian-supplied irradiated TRR fuel at the Savannah River Plant in South Carolina, a facility that was producing plutonium and tritium for nuclear weapons. For reasons that are not clear, the subsequent arrangement was not published in the U.S.

Federal Register for more than two more years, or until late 1985. This was a necessary step before the arrangement was finalized and the first shipment could take place. The subsequent arrangement was amended on December 11, 1986.

Under this subsequent arrangement, the first shipment was scheduled to arrive at the Savannah River Plant (SRP) in March 1986,⁶² but it was delayed for a few more months by opponents of the shipments who were worried about the dangers posed by radioactive shipments passing through local ports and towns. The opposition was ironically intensified by concerns that the TRR fuel could be reprocessed and the separated plutonium used in U.S. nuclear weapons. The entire controversy was worsened by the government's intense secrecy about the shipments and the compelling reason for them.

Originally, the TRR fuel elements were to be shipped to the west coast of the United States and then by road to Savannah River. However, intense local opposition forced the Department of Energy to ship them directly to Portsmouth, Virginia on the east coast and then by road to the SRP. In 1988, an environmental group blocked such shipments through Virginia. After that, shipments were redirected to the Charleston Naval Weapons Station in South Carolina.

Under this first 1985 subsequent arrangement, all the Canadiansupplied irradiated fuel, or a total of 474 fuel elements, arrived at Savannah River from 1986 into 1988.

In 1988, another subsequent arrangement was submitted covering about 1,100 fuel elements. These elements contained almost exclusively uranium from South Africa and were fabricated at INER.

All but 118 of these fuel elements arrived at Savannah River. Opponents of the shipment succeeded in convincing a federal court to block the last shipment, based on the need for additional DOE analysis of its risk.⁶³ The issue was that half the elements had failed, in the sense that they had visible damage to aluminum cladding, including having large gapping cracks along the length of the fuel element, they were in pieces, or they were otherwise releasing fission products.⁶⁴ These elements needed to be put in special, sealed containers prior to shipment, in a process called "canning." This last shipment never took place, and Taiwan is disposing of these remaining fuel elements domestically (see Chapter 11).

Conversion of TRR Fuel to Low Enriched Uranium. Shipping irradiated fuel did not eliminate the risk posed by the TRR, since the reactor would continue to make plutonium. Irradiated fuel in storage at INER awaiting shipment abroad, and that in the core, would contain enough plutonium for at least one nuclear weapon. As a result, in order to further reduce the proliferation concerns posed by the TRR, the United States insisted on Taiwan agreeing to convert in an expeditious manner this reactor to a different type of fuel that would lead to far less plutonium production. The proposal was to replace the natural uranium fuel with near 20 percent low enriched uranium (LEU) fuel, dramatically reducing the amount of weapon-grade plutonium produced. INER could "undertake research contributing to ongoing international efforts to develop a [LEU] fuel of approximately 20 percent enrichment suitable for use in reactors such as the TRR."65 The United States was itself engaged in such a review with Canada. Although in its initial demarche, it was not able to commit guaranteed fuel supply assurances, the United States later stated in December 1977 that if near 20 percent LEU was deemed suitable for the TRR, it would provide the enriched uranium for the reactor.

By May 1979, plans for the conversion of the TRR's core from natural uranium to LEU fuel were progressing steadily; however, it had an overly ambitious timetable of two years for a two-step conversion of half of the core to near 20 percent LEU, and another five years for the remaining half.⁶⁶ This timeline turned out to be optimistic, and the political and technical inability to convert the reactor in a timely manner remained a major weakness in the U.S. agenda of blocking Taiwan's ability to misuse the TRR.

The DOE's Argonne National Laboratory led the initial technical reactor conversion effort. This laboratory also hosted the Reduced Enrichment for Research and Test Reactors (RERTR) program started in 1978 in the Carter administration to replace highly enriched uranium (HEU) fuel in reactors with new, far less proliferation-prone LEU fuels.

In July 1980, the United States in consultation with Canada, had finalized their conversion plans for the TRR, and the United States decided to press both Canada and Taiwan to accept the conversion and irradiated fuel removal plans (as a package and as soon as possible). ⁶⁷ Initially under consideration with regard to assured fuel supply for the TRR was a plan for "billet fabrication in the U.S., fuel fabrication in Canada, and

transshipment of fuel through the U.S. to Taiwan..." The State Department now viewed that plan as "unworkable," since it required Taiwan to rely on an unidentified foreign fuel supplier (apparently Canada) and keep the Canadian role a secret from Taiwan and the rest of the world. The plan also did not re-direct the activities of Taiwan's TRR fuel fabrication plant. Instead, the United States urged a joint cooperative effort between the DOE and Taiwan on building in Taiwan a near 20 percent enriched uranium fuel fabrication facility that did not have any direct Canadian role. However, Canada would need to supply fuel and manufacturing designs and manufacture a few specialized items. With these designs, the TRR's natural uranium metal fuel production facility would be converted to process near 20 percent enriched uranium fuel. The United States would sell Taiwan near 20 percent enriched uranium and transfer it, but Taiwan would take on the rest of the fuel manufacture, using fuel design and manufacturing technology from Canada.

The package proposal for reactor conversion and irradiated fuel removal was accepted by Canada and Taiwan, but both plans progressed slowly. Taiwan appears to have treated the conversion as secret; INER annual reports from the early 1980s do not mention any fuel conversion activities taking place. It is also uncertain how seriously Taiwan took the conversion project. One could speculate that Taiwan may have stalled its implementation. It is also true that core conversion was a difficult, untested, and lengthy process.

Nonetheless, the project did advance, albeit not as expeditiously as originally planned by the United States and later declassified cables would acknowledge that the project was taking far longer than originally projected or expected.⁶⁹ A 1983 RERTR status report includes the TRR as a conversion project.⁷⁰ The TRR is listed in a table, "Foreign and Domestic Programs Intersecting RERTR Program," and it falls under the subheading of core conversion studies, in particular involving physics, engineering, and safety. Based on this citation, the TRR conversion project had not yet tested new fuel elements in its core. However, this was expected to change.

In about April 1983, the Nuclear Regulatory Commission issued a license for the delivery of 70 kilograms of seven percent-enriched uranium for fabrication in Taiwan into fuel for the TRR.⁷¹ This would allow testing of the partial conversion of the TRR core. Taiwan was to receive

the enriched uranium in the chemical form of hexafluoride. Conversion to enriched uranium oxide and fabrication into fuel were to take place at INER. INER annual reports show a capability to convert uranium hexafluoride to oxide, although a subset of INER annual reports, namely from 1981 and 1985, do not discuss these new fuels for the TRR.

According to a former senior State Department official, as of 1986, the TRR was still using natural uranium fuel, and the success of the conversion project had not yet been established.⁷² He referred to the project as like a RERTR program, but it was not yet known if the new fuel would work.

CSIST/INER Computer Center. There is little in the declassified State Department cables on how the United States sought to limit INER and CSIST's work on the design or development of the nuclear weapon itself via computer simulations or high explosive testing. One suggestion that the United States was working to limit these activities as well appears in a 1979 declassified cable on a visit by U.S. experts to the CSIST/INER computer center located at CSIST.⁷³ Although the purpose of the visit was not provided, it can be surmised that the United States remained concerned that computer simulations of nuclear weapons continued, and it wanted to send a signal about that concern by visiting the computer center.

The visit report stated that the computer center used a Cyber 70 model. At that time, it was "presumably the largest facility on the island."⁷⁴ The report observed that the computer could be accessed remotely within CSIST and INER as well as from other locations on Taiwan.

Chang stated that the persons involved in nuclear weapons simulations used the computer center or a restricted terminal to run their code. He said that they avoided sending anything via a telephone because that signal would be very easy for U.S. and other intelligence agencies to intercept. Nonetheless, the simulation work was carefully portrayed as civilian in nature, e.g. part of reactor safety calculations.

Operators told the U.S. team that the computer was nearing "saturation," and they wanted to buy a more powerful computer. As will become clearer, the nuclear weapons teams would need a more powerful computer, including much more memory, as their nuclear weapons codes advanced in the late 1970s and early 1980s.

NOTES

- 1 Cable from Secretary of State to American Embassy in Taipei, *Nuclear Representation to the ROC*, March 26, 1977, p. 1.
- 2 Ibid, p. 10.
- 3 Ibid, p. 1; Cable from Secretary of State to American Embassy in Taipei, *The Taiwan Research Reactor*, December 22, 1977 (declassification date December 3, 2015). Available via the National Archives Interagency Security Classification Appeals Panel (ISCAP): https://www.archives.gov/files/declassification/iscap/pdf/2011-007-doc1.pdf. Two key U.S. diplomatic cables with the same title and date of December 22, 1977 are referenced here and are differentiated in citations by their declassification date.
- 4 Nuclear Representation to the ROC, March 26, 1977.
- 5 Ibid.
- 6 *The Taiwan Research Reactor*, December 22, 1977, p. 3 (declassification date December 3, 2015).
- 7 Nuclear Representation to the ROC, March 26, 1977.
- 8 Ibid.
- 9 Cable from Secretary of State to White House, *Visit of CAEC Secretary General—Dr. Victor Cheng*, May 6, 1977.
- 10 Cable from American Embassy in Taipei to Secretary of State, *US Technical Team Visit*, May 31, 1977.
- 11 Cable from Secretary of State to American Embassy in Taipei, US Technical Team Visit, Victor Cheng Visit to Washington, May 21, 1977.
- 12 US Technical Team Visit, Victor Cheng Visit to Washington, May 21, 1977.
- 13 US Technical Team Visit, May 31, 1977.
- 14 Cable from Secretary of State to American Embassy in Taipei, *Follow-Up to the U.S. Technical Team Visit*, June 17, 1977.
- 15 Cable from Secretary of State to American Embassy in Taipei, *The Taiwan Research Reactor*, December 22, 1977 (declassification date July 13, 2004). Available via the U.S. National Security Archive: https://nsarchive2.gwu.edu/nukevault/ebb221/T-18a.pdf.
- 16 Chien Ji-pen and Yang Chao-yie, "Experience and Utilization of the Taiwan Research Reactor," Presented at the 3rd Pacific Basin Conference, February 16-18, 1981, Acapulco, Mexico.

- 17 Cable from Secretary of State to American Embassy in Taipei, *US Nuclear Team*, January 10, 1977.
- 18 J. R. Phillips, et al., "Nondestructive Verification of the Exposure of Heavy-Water Reactor Fuel Elements," Los Alamos National Laboratory, LA-9432-MS, UC-15, June 1982.
- 19 IAEA, "Proposed Procedures for Transferring TRR Spent Fuel Elements from Rod Bay to the Dry Storage," Attachment to Memorandum to L. Thorne from H. Frittum, "Observations in connection with proposed procedures for transferring TRR spent fuel elements from rod bay to the dry storage," January 31, 1977.
- 20 *U.S. Technical Team Visit*, May 31, 1977, see section 2. Each fuel element contained on average about 42.4 grams of plutonium.
- 21 IAEA, "TRR-Spent Fuel Cooling Time on 76/07/18," handwritten table. 22 Ibid.
- 23 *The Taiwan Research Reactor*, December 22, 1977 (declassification date December 3, 2015).
- 24 In this bounding estimate, the plutonium content of each fuel element is taken as between 40 and 60 grams (see also Chapter 9).
- 25 There have been reports that the reactor had "ports" that could irradiate a small number of uranium targets that could be unloaded while the reactor operates.
- 26 *The Taiwan Research Reactor*, December 22, 1977 (declassification date July 13, 2004).
- 27 *The Taiwan Research Reactor*, December 22, 1977 (declassification date December 3, 2015).
- 28 Ibid, p. 5.
- 29 Ibid.
- 30 *The Taiwan Research Reactor*, December 22, 1977 (declassification date July 13, 2004).
- 31 Chien and Yang, "Experience and Utilization of the Taiwan Research Reactor."
- 32 American Institute in Taiwan, Taipei to American Institute in Taiwan, Washington, D.C., *U.S. Nuclear Technical Team Visit*, May 11, 1979.
- 33 Chien and Yang, "Experience and Utilization of the Taiwan Research Reactor."

- 34 U.S. Nuclear Technical Team Visit, May 11, 1979.
- 35 Cable from Secretary of State to White House, *Visit of CAEC Secretary General—Dr. Victor Cheng*, May 6, 1977.
- 36 U.S. Technical Team Visit, May 31, 1977, see section 2.
- 37 See for example, INER Annual Report, October 1985.
- 38 US Technical Team Visit, May 31, 1977, p. 4.
- 39 Ibid.
- 40 *The Taiwan Research Reactor*, December 22, 1977 (declassification date December 3, 2015), p. 4.
- 41 Proposed Talking Points for INR [State Department Bureau of Intelligence and Research] Expert Joe Hayes Briefing of NRC on the ROC Nuclear Program, circa September 1978.
- 42 Facsimile from Roger Heusser, U.S. Energy Department Office of Declassification Security Affairs (NN-52), to David Albright, regarding "Plutonium Returned from Taiwan," October 4, 1996.
- 43 Proposed Talking Points for INR, circa September 1978.
- 44 Cable from Secretary of State to American Embassy in Taipei, *Follow-Up to Nuclear Team Visit: Demarche to President Chiang*, September 5, 1978.
- 45 *The Taiwan Research Reactor*, December 22, 1977, (declassification date December 3, 2015), p. 4.
- 46 Proposed Talking Points for INR, circa September 1978.
- 47 Chien and Yang, "Experience and Utilization of the Taiwan Research Reactor."
- 48 Ibid.
- 49 Proposed Talking Points for INR, circa September 1978.
- 50 U.S. Nuclear Technical Team Visit, May 11, 1979.
- 51 Ibid.
- 52 Ibid.
- 53 Cable from Secretary of State to American Embassy in Taipei, *TRR Spent Fuel Disposal in Canada*, July 7, 1977; Cable from Secretary of State to American Embassy in Ottawa, *Conversion of Taiwan Research Reactor to Use of Low Enriched Uranium Fuel and Disposition of Natural Uranium Spent Fuel*, September 23, 1978.

- 54 Cable from American Embassy in Taipei to Secretary of State, *The Taiwan Research Reactor (TRR)*, December 27, 1977.
- 55 U.S. Nuclear Technical Team Visit, May 11, 1979.
- 56 The Taiwan Research Reactor (TRR), December 27, 1977.
- 57 Cable from Secretary of State to American Embassy in Ottawa, *Taiwan Research Reactor*, July 25, 1980.
- 58 Memorandum to Ambassador Richard T. Kennedy from OES-John Negroponte, *Taiwan Research Reactor (TRR) Spent Fuel*, March 13, 1986.
- 59 Interview by one of the authors with a senior official at the Nuclear Regulatory Commission (NRC), February 27, 1986. The imports of the irradiated fuel by the DOE were exempt from NRC licensing, although the NRC was consulted by at least 1981, if not earlier. The senior NRC official stated that one relatively early, internal follow-on study about the irradiated TRR fuel was published on December 10, 1981 by Joerg Menzel, ACDA.
- 60 "Proposed Subsequent Arrangement," *Federal Register*, Vol. 50, No. 247, December 24, 1985, p. E2552-3.
- 61 For these dates of the subsequent arrangements, see for example, Department of Energy, *Environmental Assessment of the Risks of the Taiwan Research Reactor Spent Fuel Project*, DOE/EA-0515, May 1991.
- 62 U.S. Department of Energy, Savannah River Operations Office, Savannah River Plant, "Fuel Movement Project," February 1986. This slide presentation does not mention Taiwan; it only uses "foreign research reactor" involving a project requested by the State Department.
- 63 Al Roberts, "Judge Blocks Nuclear Waste from Port," *Virginian Pilot*, December 10, 1991.
- 64 Environmental Assessment of the Risks of the Taiwan Research Reactor Spent Fuel Project.
- 65 *The Taiwan Research Reactor*, December 22, 1977 (declassification date December 3, 2015), p. 4.
- 66 U.S. Nuclear Technical Team Visit, May 11, 1979, p. 1.
- 67 Taiwan Research Reactor, July 25, 1980.
- 68 Ibid.
- 69 See for example, Taiwan Research Reactor (TRR) Spent Fuel, March 13, 1986.

70 Armando Travelli, "Current Status of the RERTR Program," Argonne National Laboratory, 1983, https://inis.iaea.org/search/search.aspx?orig_q=RN:36023711

71 NRC license XSNM02035, Amendment No. 01. The amendment mainly extended the expiration date from December 31, 1983 to July 1, 1984 and slightly increased the quantity and enrichment level of the uranium.

72 Interview by one of the authors with a former State Department official, March 6, 1986.

73 U.S. Nuclear Technical Team Visit, May 11, 1979, section 5. 74 Ibid.

75 Interview by the authors with Chang Hsien-yi, August 2, 2018.

CHAPTER 7 PUSHBACK

Although the United States had considerable success in reducing the proliferation risk of INER's nuclear programs, ultimately several demands would languish as only partially fulfilled, while the matters of conversion of the TRR reactor core and long-term removal of its irradiated fuel would not be decided for several more years.

INER staff did not appear to have been well-directed in which activities to close down, continuing some until the United States raised them as problematic. Washington likely only knew about some of the activities from sources deep inside INER or CSIST, which led to on-going confrontations with Taipei. Taiwan responded with dismay over U.S. demarches to halt its activities, since it was unclear how the United States could even know about them. Despite this dismay, overall, INER and CSIST leaders shut down the nuclear weapons-related projects that were uncovered. However, Taiwan kept some nuclear weapons-related research going or on standby, ready to be restarted.

Separately, the military leadership was upset that the leaders of INER and CSIST had agreed to shut down all of these programs.¹ In a secret effort led in the Ministry of National Defense, a plan was developed to quietly take steps to institute better direction and coordination of nuclear weapons-related activities at INER and CSIST, all under peaceful guises. The military was highly resentful of the U.S. demands and had developed a view that INER's dispersed oversight and coordination over the nuclear

weapons projects was counterproductive. In the late 1970s, the military started to discuss improving the readiness of a nuclear weapons capability. Although its involvement is not surprising given Taiwan's investment in educating its military personnel in nuclear matters, it meant that the military's growing direction over INER would ultimately corrode the April 1977 secret agreement.

Yet, the basic terms in the 1977 secret agreement with Taiwan were clear. Many discussions and visits after the 1977/78 period took place on how to restructure INER's nuclear program. To the United States, the agreement established a strong norm against nuclear weapons development that Taiwan would violate at its own risk.

SIGNS OF RESISTANCE

Taiwan's leaders cooperated, albeit reluctantly, with the United States when it raised issues about on-going nuclear weapons-related efforts. They had little choice, given the island's precarious national security situation. However, they only did so when Washington backed up its threats through U.S. nuclear team visits and demarches, where cutoffs in nuclear and military assistance were threatened.

In March 1978, the United States had lingering suspicions, not entirely without foundation, that "bomb-related work may be continuing on Taiwan" including high explosive testing, laser isotope separation experiments, and other activities. While some of the work could be related to nuclear weapons, Washington was unsure whether it was so intended and represented the efforts of a few overzealous scientists, or something more organized.²

The United States became worried about work continuing at low levels in the areas of laser enrichment of uranium and heavy water production, activities inconsistent with the April 1977 agreement. Washington had sent a nuclear team to Taiwan in July 1978 to check the status of reorientation of nuclear activities with a particular interest in the status of uranium enrichment-related R&D carried out by a Dr. Ma (his full name, according to Dr. Chang, was Ma Ying-chun, and he worked on laser isotope experiments). The team reiterated U.S. nonproliferation expectations and Taiwan's officials in return reiterated their commitment to the U.S. agreement.³

On the July 1978 visit, the U.S. team met with CSIST Director General Tang, after he had initially declined. Ambassador Unger told Tang that as the senior official responsible for military R&D work, it "in effect placed heavy responsibility upon [him] to ensure that military R&D work did not violate relevant nuclear agreements, thus forcing a termination of U.S. exports." He iterated that the on-going close relationship between CSIST and INER had "given rise to uncertainty about whether INER's research was solely for peaceful purposes." Tang confirmed newly elected President Chiang's pledge not to develop nuclear weapons and "carefully stated and then repeated that his institute would 'honestly and strictly observe government policy." Tang also affirmed that he had received instructions to give the U.S. team full access to all nuclear facilities requested. U.S. team member Gerard Helfrich expressed interest in seeing the facility relating to uranium enrichment. Tang pledged that CSIST would not be involved in this research.⁵

In a separate comment about Tang, the team noted that it was important that Tang told his assembled staff in the meeting that CSIST would "honestly and strictly observe government policy." However, Tang's phraseology suggested his personal disagreement with declared ROC policy.⁶ This attitude was not surprising, since Colonel Chang considered Tang to be the father of Taiwan's nuclear weapons program.

The team was allowed to go to laser-related labs that were associated with Dr. Ma's work. This could have involved the enrichment-related facility mentioned in the visit with Tang.

On July 30, 1978 just before the U.S. team departed, DOE's Helfrich met with Victor Cheng.⁷ He explained that the team was concerned about both the close association of CSIST and INER, and also the work of Dr. Ma. Cheng told Helfrich that the work had been suspended and Dr. Ma had left the country. Helfrich noted his concern that there was no way for the United States to know whether the work secretly continued and wanted Taiwan to ensure that if it were underway by anyone else, that it was "terminated immediately."

During a meeting with a Taipower official, Helfrich was told that Tang would soon retire. As far as we can tell, he left his CSIST directorship position, although his influence continued in another role at CSIST, according to Chang. For example, he provided advice to his successor until at least 1982. 10

Over the course of the summer, the United States continued to receive reports that experiments relating to laser isotope separation were on-going and could involve uranium enrichment. It also received reports that isotope separation using uranium vapor were underway but was unable to confirm them. Washington admitted internally that laser isotope separation was a grey area in the April 1977 agreement, because it could be used to separate non-uranium isotopes and was not explicitly banned by the agreement. Nonetheless, it could lead to the development of a method to make a nuclear explosive material, namely highly enriched uranium, and thus Ma's work on laser isotope separation was judged as non-compliant with the agreement's broader goal of banning the development of capabilities to enrich uranium.

Another serious violation was Taiwan's apparent concealment of heavy water production equipment during a U.S. team visit in the summer of 1978. Unnamed U.S. officials reported to then-U.S. National Security Advisor Zbigniew Brzezinski that this concealment suggested the production of heavy water was potentially planned, in violation of the secret agreement, and was "but the latest in a series of moves by [INER] to implement the weapons option." These officials added that "some, at least, of these undertakings have Cabinet level approval." The source of this report, perhaps in Taiwan but unidentified, said that the U.S. team had been "occupied with 'useless' briefings and tours of various facilities in northern Taiwan while the equipment they were looking for was concealed in various locations in southern Taiwan." The source added that the equipment was well camouflaged so as not to be visible in overhead imagery.

By September 1978, the U.S. administration was facing another concern about the case of secret laser isotope separation. U.S. officials had reached a point where they worried about whether Washington could authorize nuclear exports to Taiwan, in particular enriched uranium fuel exports to Taipower nuclear power reactors. With new, stricter U.S. nonproliferation laws in place, secret uranium enrichment efforts could trigger a cutoff in U.S. assistance and nuclear exports.

The United States stressed with ROC officials that Taiwan had agreed to stop "all activities leading to the development of such capabilities rather than just to actual production activities per se." ¹⁶ Laser isotope separation would clearly fall into this category, and the U.S. government insisted that all such work stop.

The United States reemphasized the "thrust of INER's research work should be to support your nuclear power program, and this has not yet been brought about substantially." ROC research and development should be carefully reviewed to "ensure they are in compliance with our agreements, particularly concerning the development of capabilities in the sensitive areas of reprocessing, enrichment, and heavy water production." ¹⁸

A NEW DEMARCHE

To ensure that Taiwan would comply with the agreement, Washington sent Ambassador Unger in September 1978 to deliver a new demarche to President Chiang. This time, however, it was met with anger. Chiang refused to listen to the demarche, stating that "on numerous occasions, he ha[d] formally declared (including in testimony to the Legislative Yuan) the policy of the Republic of China, i.e. that the Republic of China has no intention of manufacturing nuclear weapons, and this policy remains unchanged." Chiang said that given the highly technical nature of many of the U.S. questions, the government had tolerated investigations and done everything requested, working hand in hand with the United States. "There is nothing that is not open to U.S. surveillance," he stated, adding that Washington was dealing a "serious psychological blow" to the scientific and technical experts of the country. Moreover, Taiwan had avoided informing its public on the subject of the "U.S. attitude and actions," which he implied would incite antagonism.

Chiang referred Unger to the Foreign Ministry if he wished to delve deeper into the issue, reversing an earlier pledge to personally oversee resolution of U.S. concerns about Taiwan's nuclear activities. He reiterated his father's longstanding offer to allow U.S. scientists to be stationed at INER to "watch over the ROC programs day by day."²⁰

Unger iterated that President Carter was now bound by a new law regarding nuclear exports and broader economic and military sanctions if countries were involved in reprocessing or enrichment. Chiang responded that the United States "must take the president's word." Unger later remarked to Washington that President Chiang was "more obviously annoyed and disturbed than I have ever seen him." He left Chiang with a full written demarche from Secretary of State Cyrus Vance.

President Chiang replied to the demarche in a letter, technical portions of which remain redacted, that stated once again the ROC commitment to nonproliferation, as well as additional details:

I wish to assure you that my government is not engaged in any research work in the sensitive fields of nuclear enrichment, reprocessing or heavywater production. The [redacted] research work currently conducted at [CSIST] has never aimed at [redacted]. While there was some research work on this subject at [INER] in the past, this has long been stopped and will not be revived in light of our commitment to the United States not to engage in any work that might lead to nuclear proliferation.²²

Another declassified document makes it clear that Chiang admitted some laser isotope separation work did take place in the past.²³ To the United States, this effort strengthened the norms against uranium enrichment in the secret 1977 agreement.

INSIDE VIEW

As the crisis started, Dr. Chang was just returning to INER. In 1976, he had received his Ph.D. from the University of Tennessee and returned in 1977 to assume the post of section leader of the INER Reactor Control Dynamic Simulation Group. At that time, he was not senior enough to know what had been taking place in the confrontations with the United States, and admittedly, he was not fully trusted right away due to concerns about people returning from studies in America to become informants.

However, General Tang and INER Director Chien Chi-peng were close mentors of Chang's, which quickly boosted his credibility and access to sensitive information. In 1967, while Chang was a young First Associate and Army captain at Chungshan Institute, Tang taught Chang how to play bridge and they began playing together in a group on a weekly basis.²⁴ His connections to Tang and Chien would turn out to be productive ones professionally. Chang had direct access to Tang until the early 1980s, when Tang's involvement diminished. But when Chang first returned to INER in 1977, he did not know about the secret U.S. agreement or the reorientation of activities that had occurred. He learned more details as his role grew in significance as a trusted insider.

Chang did not know for certain if reprocessing had occurred in the 1970s, and he remains skeptical of many of the claims. A personal friend and colleague, Wang Wei-ko, was always involved in the reprocessing experiments. Chang heard that there was a secret site outside of INER that Wang was involved with which was also associated with chemical weapons, perhaps called Ching Shan. Chang also heard many other rumors about the alleged diverted fuel and reprocessing but he was never able to conclusively establish what happened. He heard that fuel may have been diverted for inspection without notifying the IAEA. He also said that in 1976, INER conducted an experiment involving the separation of a "micro-quantity" of plutonium.²⁵

Chang remembers seeing a furnace used for processing small quantities of U.S.-supplied plutonium into plutonium metal at the Plutonium Fuel Chemistry Laboratory, and by 1978, the plutonium had disappeared. He heard that there was an accident in this laboratory involving fission products, as described earlier by former U.S. officials (see Chapter 4).

Chang thinks INER staff moved and hid sensitive equipment before the U.S. nuclear team's first visit in January 1977. However, he was not senior enough to have been involved in meetings with the U.S. nuclear team. He understood that they asked to see INER's computers and questioned personnel about computer codes for weapons design. INER Director Chien was angered by the U.S. demands, he recounted, and had great pressure on him for the meetings and inspections to go well. Chien thought the United States was being unreasonable in not accepting their explanations for activities.

After the 1977 confrontation, Chang says that "things changed" at INER. He knew that certain activities were halted or put on hold. High-explosive work related to nuclear weapons development was stopped. According to Chang, Yu Shih-kao, who oversaw all high-explosive work for the program, had been identified as a person involved in the program by the Americans. He was moved to another, less conspicuous department in CSIST or INER. But Chang says his team's work resumed later.

Secret procurements were also affected. Up until 1977, Taiwan had many secure, overt procurement channels and company representative contacts for needed items, in particular for reprocessing activities. It had also set up its own front companies, according to Chang. Special funding was available for such items and they were handled by INER's

vast procurement department. Now, these channels were being watched intensely by the United States. If Washington detected a sensitive procurement attempt, it questioned INER.

Chang went on two to three occasions to his friend General Tang and complained about the slowdown in Taiwan's nuclear activities, but Tang just smiled. He said to be patient. Afterward, Chang was treated as a trusted, rising star at INER. He suspects Tang had something to do with it.

Although Tang and Chien appear to have remained committed to resuming the development of Taiwan's nuclear weapons capabilities, they told Chang that military leaders were not happy with the way they had handled the situation with the United States. These leaders were particularly upset that nuclear weapons-related high-explosive work, which was conducted at military sites, was curtailed by Tang and Chien. They argued that these tests were important to developing conventional military capabilities, and in any case, the IAEA could not go to such sites, even if the high-explosive testing involved uranium, particularly if it was called anti-tank munitions research and development. To be fair, Tang and Chien were likely following strict orders issued by President Chiang's office, and as the above discussion shows, they clearly did not like implementing these decisions.

Nonetheless, dissatisfaction with their leadership and actions at the higher levels of the military in the Ministry of National Defense started to coalesce in the late 1970s and early 1980s. In the late 1970s, the military had started internally debating how to better carry out the activities of a nuclear weapons program without openly violating the United States' restrictions. However, they rejected a strict ban on all the activities in the secret 1977 agreement. They argued that fulfilling Taiwan's agreed upon nonproliferation commitments did prevent Taiwan from improving its nuclear capabilities under a peaceful use umbrella. Several of these capabilities necessarily were in contravention of the 1977 deal, but these military officials believed they should be pursued under the guise of either advancing peaceful nuclear activities, or improving non-nuclear conventional military weapons.²⁷

These same leaders also believed that the nuclear weapons work was not sufficiently directed and coordinated at INER and CSIST. In the late 1970s, according to Chang, the military started to become more involved

in the top-down direction, planning, and coordination at these institutes. Following the 1977 agreement, INER scientists were still working on their own projects in their typical, loosely-directed fashion. There was always a mutual understanding that people should only talk about peaceful uses of nuclear technology. However, the military leaders identified weaknesses in INER's management and lack of integration of the aspects of the program. Without integration of the various programs, each of the teams were in a poor position to make progress on delivering an eventual capability to make nuclear weapons. Simply working on their own aspect of nuclear weapons development was not enough to render the production of nuclear weapons achievable within any short period of time. Moreover, Taiwan's leaders had never set a target for what INER was supposed to achieve and when.²⁸ The military planners decided that a clear target and the need to reverse the slowdown instituted by the United States required a new set of leaders at INER and CSIST.

CHANGE IN RELATIONS

While the U.S. teams were implementing all the steps in 1977 and 1978 to limit Taiwan's nuclear program and convince it to abandon all ambitions for nuclear weapons, Taipei did not know that the Carter administration was internally discussing how to carry forward President Nixon's policy of rapprochement with the PRC. Washington would embark on negotiations with the PRC in December 1978 regarding establishing diplomatic relations and mutual recognition, which would involve American de-recognition of the ROC as the legitimate government of China. The Mutual Defense Treaty between Taiwan and the United States would be set for cancellation in 1979 with the resumption of ties.

In December 1978, President Carter dropped his political bombshell when he publicly announced that the United States would terminate the 1954 U.S.-ROC Mutual Defense Treaty in one year's time. Taiwan was apparently only given 24 hours' notice before the public announcement.²⁹ All military personnel would be withdrawn from Taiwan, and a quasi-unofficial "American Institute in Taiwan" would be set up to replace the U.S. embassy. The United States would continue to sell defensive military items to Taiwan under a new Taiwan Relations Act.

Taipei went immediately into a state of "total diplomatic shock." A Taiwanese newspaper carried the report of a National Defense Committee convener who publicly called for nuclear weapons production and suggested procurement of some needed materials from third world countries. U.S. officials expected a policy of increased nuclear ambiguity on the part of President Chiang. Meanwhile, U.S. officials acknowledged that crucial leverage for convincing Taiwan to abandon its suspicious nuclear-related activities was reduced.

Unidentified U.S. officials began to muse in the press about the possibility that a hawkish faction in Taiwan's defense establishment would use the collapse of the treaty to justify a crash nuclear weapons program. The TRR had by then produced enough plutonium in the irradiated fuel for several small nuclear bombs, and the TRR core conversion and irradiated fuel repatriation matters still remained years from fruition. U.S. government experts feared that given two years' time, Taiwan could secretly produce its first nuclear weapon.³²

On the ground, however, U.S. nuclear inspection teams did not report anything alarming. The results of the May 1979 inspection by the U.S. nuclear team was that nothing major was amiss except for still-unresolved questions about which potentially sensitive programs should be shut down.³³

Ambassador Unger had earlier previewed the dramatic changes to come in the U.S. relationship with the PRC, musing that Taiwan's security concerns would manifestly augment as U.S. "role and policies in Asia develop and change, and our 'protection' becomes increasingly less credible" in a "post-normalization situation." He believed that steady watchfulness was called for to ensure Taiwan's compliance with the basic nuclear principles.³⁴ Unger could not have known how correct he was.

NOTES

- 1 Interview by the authors with Chang Hsien-yi, August 2, 2018.
- 2 Memorandum from Ambassador-at-large Gerard Smith to Allen, reply from "AL," March 10, 1978, p. 1.
- 3 Cable from Secretary of State to American Embassy in Taipei, *U.S. Nuclear Team Visit*, August 9, 1978.
- 4 Cable from American Embassy in Taipei to Secretary of State, *Nuclear Team Visit: Initial Calls: Discussions with CIST Director Tang*, July 31, 1978, p. 2.
- 5 Ibid, p. 4. The cable is slightly reducted so as to prevent full understanding of the conversation about uranium enrichment.
- 6 Nuclear Team Visit: Initial Calls: Discussions with CIST Director Tang, July 31, 1978.
- 7 U.S. Nuclear Team Visit, August 9, 1978.
- 8 Ibid.
- 9 Ibid.
- 10 Hau Pei-tsun, *Diary during my Eight Years as Chief of the General Staff* (Taipei: Commonwealth Publishing, 2000) (Translated by the Institute for Science and International Security, 2018), p. 217.
- 11 Proposed Talking Points for INR [State Department Bureau of Intelligence and Research] Expert Joe Hayes Briefing of NRC on the ROC Nuclear Program, circa September 1978.
- 12 Ibid.
- 13 Memorandum for Zbigniew Brzezinski, from Global Issues, "Evening Report," August 21, 1978.
- 14 Ibid.
- 15 Ibid.
- 16 Cable from Secretary of State to American Embassy in Taipei, *Follow-Up to Nuclear Team Visit*, September 5, 1978.
- 17 Ibid.
- 18 Ibid.
- 19 Cable from American Embassy in Taipei to Secretary of State, *Follow-Up to Nuclear Team Visit: Demarche to President Chiang*, September 8, 1978.
- 20 Ibid.

- 21 Ibid.
- 22 Ibid.
- 23 Proposed Talking Points for INR, circa September 1978.
- 24 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 25 Chang Hsien-yi, "Taiwan Nuclear Weapons R&D Chronology of Events/ Talking Points," undated (Translated by Institute for Science and International Security, 2017).
- 26 Interview by the authors with Chang, August 2, 2018.
- 27 Ibid.
- 28 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 29 Yu San-wang, ed., *Foreign Policy of the Republic of China on Taiwan* (New York: Praeger Publishers, 1990), p. 34.
- 30 Ibid, p. 9.
- 31 Appearing in the newspaper *Ta Hua Wan Pao*, Dec. 31, 1978 as described in: Cable from American Embassy in Taipei to Secretary of State, *The Nuclear Option Again*, January 10, 1979, p. 1.
- 32 Milton R. Benjamin, "Taiwan's Nuclear Plans Concern U.S. Officials," *The Washington Post*, December 20, 1978, A21.
- 33 American Institute in Taiwan, Taipei to American Institute in Taiwan, Washington, D.C., *U.S. Nuclear Technical Team Visit*, May 11, 1979.
- 34 Cable from American Embassy in Taipei to Secretary of State, *U.S. Technical Team Visit*, June 6, 1977, pp. 1, 3.

SECTION III THE 1980s

CHAPTER 8 NORMALIZATION AND GROWING RESURGENCE

With the crisis of the 1970s seemingly behind it, in June 1980, the American Institute in Taiwan (AIT), the new "non-governmental" representative of the U.S. government, was anxious to demonstrate that the United States would be a reliable nuclear supplier to Taiwan, and by doing so, help re-establish a more positive relationship with Taiwan's nuclear establishment. A principal way to do this would be to approve a backlog of U.S. nuclear exports ordered by Taiwan's Atomic Energy Commission, INER, and Taipower that had been held up as Taiwan re-oriented its nuclear programs.¹

One request from INER was for four tons of heavy water for the Taiwan Research Reactor. Another was for the import of light water reactor (LWR) test fuel irradiated in the European Halden reactor to support cooperative Hot Laboratory experiments related to LWR fuel development for Taipower; the United States viewed this work as consistent with the April 1977 secret agreement and useful for encouraging cooperation between INER and Taipower. It saw that cooperation as important to reorienting INER's research focus away from military purposes to civilian nuclear power reactors. Another export request was for spare coolant pump parts and accessories for equipment already installed in Taipower's nuclear power reactors. The U.S. delay in approving this particular export fed a false narrative in Taiwan that the United States was an unreliable supplier. INER also sought to conduct post-irradiation examination

related to thorium fuel research at the Hot Laboratory, which Washington stressed was acceptable with regard to proliferation concerns.

Later in June 1980, the State Department submitted a favorable executive review for the Nuclear Regulatory Commission's export of a wide range of nuclear power plant related materials and equipment, including low enriched uranium, coolant pumps parts, fuel rod materials for power reactor fuel, and 5.2 kilograms of 19.9 percent enriched uranium for a reload of Taiwan's small THOR research reactor.² The NRC approved the export of 4,000 kilograms of heavy water in October 1980.³ Taiwan received the other items from the United States as well. The ultimate fate of the specific thorium fuel research request is unknown.

Taiwan was interested in obtaining nuclear reactors, materials such as uranium, and equipment from other suppliers. However, the United States appeared to have remained leery of allowing other nuclear suppliers to sell power reactors to Taiwan, or at least that Taiwan's safeguards requirements post-1977 secret agreement could be onerous for a non-U.S. commercial nuclear power reactor supplier to agree to. In the summer of 1980, West Germany's nuclear reactor builder, KWU, weighed a project to bid on the supply of two nuclear power reactor units to Taipower. However, the West German government was unsure how safeguards would be applied to the reactors and their enriched uranium fuel. Since Taiwan was no longer a member of the IAEA, it was unable to create another safeguards agreement involving German reactors and fuel. Moreover, as part of settling the 1970s reprocessing controversy, Taiwan and the United States had agreed that all nuclear material would have to be covered under the U.S./Taiwan/IAEA trilateral agreement (INFCIRC/158), not just U.S. items. In principle, the United States offered to add KWU reactors and nuclear materials to the trilateral list of facilities, nuclear materials, and equipment. However, in the event that Germany built reactors in Taiwan, the United States would become partially responsible for their safeguarding.4 In case the United States were forced to terminate its bilateral agreement with Taiwan, if for the reason that it conducted a nuclear detonation, for example, it wanted assurances that the Germans would not take up their own agreement with Taiwan that would further any proliferation efforts.

A U.S. interagency non-paper explaining the U.S. government's proposal for Germany stated that if Germany accepted certain, albeit onerous,

conditions, the sale could proceed.⁵ It noted that the U.S./Taiwan bilateral nuclear cooperation agreement would make any German transfers subject to that agreement, essentially acting as a fallback in case the IAEA safeguards were not adequate to achieving non-proliferation goals (e.g. Taiwan built an unsafeguarded reprocessing plant). West Germany would need to establish its own bilateral agreement with Taiwan that would entail a non-proliferation and peaceful use-only commitment as well as assurances that nuclear material would not be transferred to Taiwan without U.S. approval. Moreover, the West German government would have to agree to take back nuclear material, equipment, and facilities, or material produced through the use of that material, such as plutonium, if it ever became necessary for the United States to exercise this right. Germany and the United States would also need to work out irradiated fuel disposition, reactor safety, and financial obligation issues.

Overall, the list of conditions would be difficult for KWU and the West German government to meet, particularly given Taiwan's non-reprocessing commitment at the heart of the discussion. At that time, West Germany viewed reprocessing as the most feasible way to dispose of irradiated fuel. From the declassified cables, it is unclear how this discussion ended, but not surprisingly, Taiwan did not end up buying West German nuclear power reactors.

This episode showed that the United States would remain Taiwan's sole supplier of safeguarded nuclear facilities. Alternative suppliers of natural uranium and low enriched uranium would be easier to arrange. Nonetheless, the dependency would continue to grate the nerves of Taiwan's nuclear and military establishments.

After much debate, the United States decided not to send an American scientist to Taiwan to assume a technical post, as President Chiang Chingkuo had offered several times in the 1970s. On the surface, this would appear to be counterproductive, as an on-the-ground, permanent presence at INER and CSIST would help deter Taiwan from violating the April 1977 agreement. But the United States had considerable concerns about undermining the IAEA's safeguards mandate or giving the PRC reason for concern, where Beijing might misread the scientists' presence as confirmation that the United States believed Taiwan had an on-going nuclear weapons effort. As the 1980s progressed, there was a better reason why the United States did not require a watchdog presence at INER or CSIST.

It developed a high-level informant to work from inside the program to serve as its eyes and ears about sensitive procurements, activities, and plans.

CHANG'S RECRUITMENT AND SPYING

In his Mandarin-language book, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi*, Colonel Chang writes that the CIA had likely been interested in him since sometime when he was an undergraduate at the military Chung Cheng Institute of Technology and Science (now called the National Defense University), which he attended from 1963 to 1967. The CIA probably followed his trajectory while he was studying nuclear engineering in the United States, particularly while he was earning his Ph.D. in nuclear engineering from 1972 to 1976.7 He was first contacted by the CIA in 1975, like many from Taiwan, but stated that he declined their attempts to recruit him. In 1976, he returned to Taiwan to take a senior position as a nuclear engineer in INER's Reactor Dynamic Control Simulation Group, rising rapidly through the ranks. Part of that rise, according to Chang, was because he was a major proponent of Taiwan pursuing nuclear weapons development, a fact that was widely known at INER.

Chang wrote in his book that the CIA likely followed students' careers first rather than attempting to recruit them while studying abroad, a time when they would likely report the contact and their future direction was uncertain.⁸ Once he returned to INER, while attending U.S. conferences, he and many of his colleagues would receive random phone calls to their hotel rooms or in-person approaches from people who claimed to work for companies and wanted to meet over dinner to discuss employment. Most of the Taiwanese scientists were suspicious. Usually they declined.

Former military Chief of the General Staff General Hau Pei-tsun, the person who would oversee a resurgent nuclear weapons program on behalf of the military in the 1980s, wrote in his published diary about CSIST scholars being approached for recruitment by the CIA while studying in the United States, to serve as informants back home. Hau kept a daily diary that he published in 2000 in Mandarin, which reveals much about the internal dynamics and events relating to the nuclear program

throughout the 1980s.⁹ The diary is a key source apart from Dr. Chang about events during that time period, since U.S. diplomatic cables remain classified. Hau made clear that the leadership was very aware that people in the program were being recruited, and in response, Taiwan ran extensive counterintelligence efforts. Hau wrote in July 1983 that CSIST researchers who went to study in the United States confessed to the CIA trying to recruit them as spies. Dr. Chang confirmed that Hau was concerned that Taiwan's missile experts were providing secret information about the program to the Americans.

Recruitment into spying for the PRC was always a major source of concern for Taipei. The Chinese had reportedly penetrated the Kuomintang, or KMT, the Nationalist Party led by President Chiang, and many Chinese spies were believed to be part of Taiwan's political elite. (See sidebar on Chinese cooperation with United States in penetrating Taiwan's nuclear program).

Chang says his initial opening to the CIA started in 1981 or 1982 after an approach at a U.S. conference. A CIA officer told him that they would like to maintain stability in North Asia and that nuclear weapons were not a good idea for the people on Taiwan—the weapons would create an unstable situation with China. The officer and his colleagues appealed repeatedly to the safety of the people of Taiwan.

A subsequent contact in 1982, which Chang said was the most serious for him, involved a CIA officer appealing yet again to what he calls his growing "soft spot"—increasing doubts and uncertain convictions about the wisdom of the nuclear weapons effort and the implications for conflict with China. Despite his early support for nuclear weapons, he was coming to doubt the wisdom of continuing to pursue them. The officer was kind and purported to reveal his own personal identity to establish trust. The same few CIA people continued to contact him, providing continuity.

Later, a different officer appealed to Chang's personal prestige and complimented his work. He felt appreciated and perceived in general that his professional achievements received more accolades at U.S. conferences. The CIA never threatened or entrapped him or offered money for his help as a recruitment incentive, but they did offer protection. They did not offer citizenship at that point. Despite claims by David Ho, a former INER employee and nuclear engineer who headed one of the departments under Chang, claims which Dr. Chang resents since he was happily

married—he was never offered alcohol or seduced by women as blackmail to secure his cooperation. ¹⁰ His cooperation became a matter of him deciding that the nuclear weapons program needed to stop.

U.S. intelligence appeared to know about Chang's close friendship with General Tang Jun-po. Throughout the 1970s and early 1980s, Chang and General Tang continued to be good friends, a fact that positioned Chang well to become part of the inner circle devoted to nuclear weapons development. Tang and those who oversaw sensitive nuclear weapons related activities discussed nuclear weapons plans and progress openly around Chang. Chang believed that while Tang was the CIA's "key target," they would not mind settling for someone close to him.

Around 1982 or 1983, Chang assisted the CIA with a few ad hoc tasks, but the CIA was never certain that he was not a double agent. They were interested in what Chang could tell them about information and activities they had already received reports about. He described one task where he helped the CIA access the CSIST computer center. He did not know the purpose and did not ask. He speculated that he may have helped perpetrate one of the earliest cyber intrusions on a nuclear facility.¹¹

In 1984, after much consideration—having finally been convinced that developing nuclear weapons would be harmful to Taiwan's interests, and unsettled by what he viewed as poor management decisions at INER and a growing military role in the program—Chang finally agreed to become an informant and take a polygraph test.

During another U.S. conference, he underwent the polygraph testing at a hotel. Afterward, he recalls, he dined on buffalo. The officers reiterated that he and his family would be protected, though they could not guarantee his safety 100 percent. They also seemed apprehensive for a time that he could be a double agent. Over the next few years, he had to take additional polygraphs, and they would often check his information multiple times with other experts.

Chang was assigned case officers or "handlers," as is a standard and well-known intelligence practice. Later, "Mark" would be Chang's primary contact. Chang met his handler every two to three months on Taiwan at a CIA safehouse located near Shilin market. Chang served as the United States' personal observer over the nuclear weapons program over the next four years. The CIA came to value him immensely.

In 1984, Chang was named one of INER's four deputy directors at the age of 40, a surprising appointment for someone so young. However, Dr. Chang says that he did not gain access to a great deal more information as deputy director than he had access to as an engineer. Part of Chang's new job was to help develop civilian cover stories for aspects of Taiwan's research that was part of developing a nuclear weapons capability. He estimates that these efforts represented some 30 percent of his discussions once he assumed the deputy director post. Any proposed, new activity related to the nuclear weapons program had to be considered carefully as part of the broader picture of Taiwan's known, civilian activities and how it would appear to the Americans before receiving approval. If a civilian cover story could not be worked out, INER would not pursue the project and would not try procuring commodities or equipment for it.

David Ho claimed that Chang was instructed by the CIA to surreptitiously reorient programs at INER away from nuclear weapons activities. Lang denies that claim and believes that Ho may have obtained that impression from the actions of the program to reduce certain activities that they could not find a civilian cover story for. Chang was, perhaps deceitfully, simply meeting the external constraints imposed by the United States to keep activities oriented toward peaceful uses.

For the first few years following his recruitment, his handler never asked Chang to physically remove any classified documents from work. Doing so would always carry extra risks of being caught. In about 1986, Chang was asked to take photos of sensitive documents he encountered. His handler was especially interested in seeing a 20-page CSIST document on budgeting and funding. The CIA was concerned about any CSIST surface-to-surface ballistic missile programs, particularly after Washington shut down a program to develop one in the early 1980s out of fear that it was being created to carry a nuclear weapon that could strike mainland China (see Chapter 9 on missile development). Chang photographed the CSIST document in his office and then returned it. Chang was also asked to help gain access to CSIST's new supercomputer that had been purchased in about 1984. During this task, he was not nervous and was never told the purpose of the access. The computer was not connected to the internet, so he surmised that his task could have been for bugging or monitoring.

His handlers would often ask Chang to corroborate information the CIA already possessed and to share any new plans he heard about. Often, they asked about illicit or attempted procurements for the nuclear program that the CIA had detected or heard about from allies and wanted to know their intended purpose. If Chang did not know the answer, he

would go back to INER and find out. This was not difficult since he could investigate procurements through budget and appropriations information.

Dr. Chang never worried for his personal safety despite his informant activities. He did not consider the possibility that he could be imprisoned or even executed for his actions. He developed total trust in his handlers, particularly in Mark. However, in his book, Chang acknowledges that he "decided to risk my life, family and career to stop Taiwan's further development of nuclear weapons."¹³ Hindsight is often more nuanced.

Chang ended up being a prized informant. He was a senior official who appeared to be a hawk on nuclear weapons and was privy to high-level planning for the development of nuclear weapons on Taiwan. More senior officials understood that they could speak frankly in front of Chang about nuclear weapons-related projects. He was the close friend and confidant of General Tang, Director Chien, and many other members of the nuclear weapons program. He was

CHINESE COOPERATION WITH U.S. INTELLIGENCE¹⁴

The Chinese became involved in the U.S. intelligence effort to penetrate Taiwan's nuclear establishment around 1978 or 1979. Allegedly, a U.S. intelligence officer had recommended the idea of collaborating with China to Secretary of State Henry Kissinger in 1975. Once normalization occurred, this became much more workable. Since China already had a far-reaching effort to infiltrate Taiwan's nuclear establishment, the PRC became a natural ally to the U.S. operation.

Most often, Chinese and American agents would meet to discuss recent findings or developments at INER and CSIST at opera performances, dubbed "Opera Organizations." It is logical that China had its own agents inside Taiwan as well, but they may not have achieved as high a level of access as the U.S. informants.

adequately senior to be informed about covert nuclear plans and projects, capable of access to gather new information as needed, and affable and good humored enough to avoid suspicion by senior Taiwanese officials about his allegiances, while continuously collecting information about secret activities. Chang became the perfect listening post for the CIA to understand Taiwan's actions and intentions.

RECONSTITUTION

Taiwan's tensions with China remained high during the 1980s, motivating an on-going interest in nuclear weapons. But Taiwan regularly issued assurances to the United States and publicly that it had no interest in nuclear weapons. In December 1980, Taiwan's Ministry of National Defense publicly stated that Taiwan would never develop nuclear weapons. ¹⁵

At least part of the United States intelligence community appears not to have fully believed these pronouncements and understood that the capabilities Taiwan had developed to date, along with the TRR's resumption of operations, constituted a dangerous nuclear weapons capability. In 1982, a report by the Defense Intelligence Agency was leaked which stipulated that Taiwan could build "a small amount" of nuclear weapons in less than six months. ¹⁶ Looking back, this time frame was too short, but the general concern underlying the assessment was true.

In 1981, Chang says, "the situation changed." He reported that the pace of sensitive nuclear weapons activities picked back up, although he was not aware of any formal discussion about doing so. He learned that new military leadership was behind the effort. People who had been moved outside INER were asked to return.

In 1982, the United States signed a joint communiqué with China specifying a gradual reduction of arms sales to Taiwan. In response, President Chiang hedged. He publicly announced that Taiwan had the ability to develop nuclear weapons, but Taiwan's Executive Yuan later backtracked by reiterating its opposition.¹⁷

Despite the U.S. constraints and disruption, the TRR continued to operate on natural uranium fuel, generating more plutonium potentially useable in nuclear weapons. There was confidence that this situation would remain for years to come, since the prospects of the TRR's conversion to LEU fuel were distant. Moreover, the removal of TRR irradiated

fuel to the United States was going slowly. By 1985, the issue had still not been dealt with, ensuring that enough plutonium for many nuclear weapons remained in Taiwan. INER had also preserved its domestic capability to produce uranium through its recovery from phosphates.

The nuclear weapons development program may have been moth-balled but it never really ended. The United States, while aware of this program, did not take enough concrete steps to end it. At the same time, President Chiang directed the military to take an even greater role in the nuclear weapons program.¹⁸

A NEW CHAIN OF COMMAND

The continuation of the nuclear weapons program had much to do with the troubling political events, from the perspective of Taiwan's defense establishment. The United States had recognized the PRC in 1978 but China remained Taiwan's deep enemy. In the late 1970s, the military was actively thinking about how to keep the nuclear weapons projects going without openly violating the secret 1977 agreement with the United States. As political events unfolded, the military got its chance in the early 1980s to assume a greater role in reconstituting and better coordinating the nuclear weapons program. To military planners, fulfillment of the 1977 U.S. demands did not mean INER could not continue carrying out activities relevant to developing a nuclear weapons capability, as long as they could be justified as having a civilian use. In practice, this meant that their view was INER should continue and improve its 1970s nuclear weapons-related work, just not produce nuclear weapons.

As President Chiang's health began to fail in the early 1980s, he decided to establish a new military chain of command at INER that would help deliver Taiwan a threshold nuclear weapons capability. Chiang put his powerful military general and ally, General Hau Pie-tsun, in place to oversee the effort. In December 1981, this former bodyguard to President Chiang became Chief of the General Staff of the Armed Forces, the highest military official in the country, and the primary military officer in charge of monitoring the nuclear weapons program's progress. Hau was also made the president of CSIST to replace General Tang. Hau's deputy and a planner at the Ministry of National Defense who had been formulating how to re-orient the nuclear weapons issue, General Yeh Chang-tung,

was assigned to report to him on overall planning at INER. Generals Hau and Yeh were major proponents of resuming Taiwan's sensitive activities following the 1977 slowdown.

President Chiang remained outwardly committed to the secret U.S. agreement and was hesitant about covert nuclear weapons related work that would get Taiwan in trouble. He preferred instead trying to "get out" of the restrictions. The president and General Hau were aware of conflicts among INER leadership regarding nuclear weapons development, where some wanted to avoid conflict with the United States and others did not agree with all the constraints. Hau lamented a "lack of a consistent policy for our nuclear research." Hau firmly represented the military's view that believed nuclear weapons development activities were somehow outside the scope of the secret 1977 deal and that only Taiwan's commitment not to produce nuclear weapons themselves mattered. Hau evidently also believed that missile work was also outside the scope of the agreement. He concluded that there was a need for "better coordination among ourselves" at INER, or "even personnel adjustments, if needed." 122

As Chief of the General Staff from 1981 to 1989, General Hau with General Yeh was heavily involved in the planning for the nuclear program. Hau's diary shows that he was clearly a driver of the reconstitution and expansion of the nuclear projects useful for making nuclear weapons. In fact, the United States started to fear Hau's influence.

Washington was not pleased about the naming of Hau as president of CSIST and urged President Chiang to choose a civilian head.²³ Chiang complied. Though Dr. Chang says in his book that President Chiang did not fully trust Hau's pick, in October 1982, Hau appointed Huang Hsiao-chung, a dual citizen of the United States and Taiwan, as acting president of CSIST, chairman of its Science Preparatory Committee, and concurrently president of Tsing-hua University.²⁴ Huang was designated a "foreign consultant" and represented General Hau on general operations at CSIST. Huang was often a presence at INER.

Chang maintains that Huang was only a front for General Hau's full control of CSIST. Chang did not like Huang and viewed his direction as erratic. But Hau brought Huang on to better direct the "1st division of CSIST" [INER], because Director Chien "lack[ed] management and leadership skills" and Hau felt INER was not "working under a clear goal." Hau's referral to INER as the first division of CSIST shows that he saw

INER as a key part of the military research and development effort headquartered at CSIST. Reinforcing this impression, the two sites still were not physically separated, with nearly free passage between them and many shared capabilities. Moreover, military personnel continued to dominate INER. Another surrogate, Liu Shuxi, was named vice president of CSIST.

By October 1982, Hau had settled on the impression, following a meeting with INER Director Chien, that "although our country's policy is not to develop nuclear weapons, we have already established the capability to make them. Having the capability to make nuclear weapons is different from actually making them." He wrote, "I am proud of INER's capability in nuclear weapon development. I encouraged INER staff not to be frustrated by obstructions from the US." Hau also viewed the U.S. rapprochement with the PRC as a poor strategic move ("absolutely foolish"), since it would do the United States little good to have an alliance with China if nuclear war broke out with the Soviet Union, as China would not assist. 27

General Hau motivated INER staff to continue their secret activities at a September 1983 meeting. He told them they needed to have five goals, including to "be prepared and willing to be the heroes behind the scenes." They should "maintain and enhance their capabilities to make nuclear weapons." They should also "implement INER's core project," in what had become a goal to acquire another small nuclear reactor. They should "support CSIST's core initiatives and collaborate with Taipower." Finally, and importantly, INER staff should treat US "concern and monitoring of INER's work as a sign of INER's worthiness to the US, which INER should be proud of rather than upset with." ²⁸

Around late 1983 or early 1984, Chang's close friend INER Director Chien was replaced and reassigned to an advisory role in CSIST. Chang said that he was diagnosed with brain cancer in 1981 and sometime around 1985, he passed away. His illness may have contributed to the military taking the opportunity to replace him.

Dr. Chang knew the director, dating back to when he started working for him at the Chungshan Science Research Institute in 1967. Becoming emotional, Dr. Chang described that in about 1978, he and Dr. Chien were driving together in the late afternoon at sunset to Tsing-hua University, where Chang taught a class the next morning. Looking at the brilliant sunset, Chien said that he wished he could make a "man-made" sunset

like that. Chang understood that it was Chien's way of saying he wanted Taiwan to be able to make a nuclear explosion, despite all the U.S. efforts at that time to end the nuclear weapons program.

Liu Guang-ji (Kuang-chi) was named INER's new director. Dr. Chien had been General Tang's person, whereas Liu would report to General Yeh and had his own set of people more amenable to the general. In fact, both Yeh and Liu had come out of the ROC navy. Director Liu would oversee the emerging picture of a resumed nuclear weapons program. Plan Tao Yuan was put in place to produce fissile material using the TRR. Chang says that the next plan to be able to weaponize it had no name.²⁹

In 1984, Director Liu selected Dr. Chang as one of his four deputy directors of INER. Another of the deputies was Chou Jen-chang, a close friend of Dr. Chang's from the reactor physics group and the first deputy director.³⁰ Even though he was a friend, Chang frequently disagreed with Chou on technical issues. The combination of the growing military oversight of General Hau, the placement of Acting CSIST President Huang, and Chou's appointment, caused Chang to grow increasingly frustrated with the direction of INER and its leadership.

Only this "inner circle," according to Chang, was allowed to discuss nuclear weapons. It was understood that no one else should openly discuss them at INER. The program was increasingly back on track and on a collision course with the United States.

RENEWED U.S./TAIWAN CONFLICTS

The United States continued to regularly send teams to Taiwan.³¹ Most of the cables associated with those visits have not been declassified. This limits what is publicly known about the on-going efforts of the U.S. government to reduce the proliferation threat posed by Taiwan. Clearly, there must have been extensive discussions about TRR reactor conversion and the removal of its irradiated fuel. Based on information available from Hau's diary, Chang, and public information, two controversial issues emerged in the early 1980s that the United States viewed as inconsistent with the secret April 1977 agreement.

Enrichment. One controversy involved uranium enrichment and nuclear cooperation with South Africa. In October 1982, Hau lauded South Africa as Taiwan's "best partner to survive in today's global environment,"

and complained about "being pressured and limited by the United States." Hau saw that South Africa could benefit from Taiwan's nuclear experts, and Taiwan needed South Africa's uranium. Earlier, in 1980 Taiwan, reportedly contracted 4,000 tons of South African uranium for its nuclear power program to be provided over a six-year period. It seems from Hau's diary that this deal had not happened as of late 1982, or Taiwan wanted more uranium.

In March 1982, Hau wrote that South Africa, which was free from the restrictions of the NPT, could sell Taiwan uranium in return for personnel support. He viewed this as "the best approach to obtain uranium at present." In November 1982, Hau wrote that Taiwan was considering sending personnel to secretly work with South Africa but should "assess pressure from the US and the potential consequences." Dr. Chang corroborated that teams from INER made up of three to four people went to South Africa periodically, and that they even had office space to work from in Johannesburg.³⁶

INER Director Chien went to South Africa in March 1983 and reported to Hau that South Africans "at the operations level are willing to collaborate with us on laser enrichment research," and added that South Africa was willing to cooperate on building a small nuclear reactor.³⁷ Hau went himself in April 1983 and brought greetings from President Chiang to South African Prime Minister Botha.³⁸ At the time, South Africa was in the initial stages of a secret 150 megawatt-thermal reactor project, called the Gouriqua reactor project, based on enriched uranium and a light water moderator and aimed at producing plutonium and possibly tritium for nuclear weapons.³⁹ Its laser enrichment program started in 1983 based on the molecular laser isotope separation (MLIS) process which enriches uranium hexafluoride.⁴⁰

Hau described to President Chiang in May and June 1983 that South Africa had also agreed to cooperate with Taiwan "on uranium enrichment through chemical methods."⁴¹ He updated the president on plans for the acquisition of a small nuclear reactor, which was an INER priority.

In June 1983, Hau informed James R. Lilley, then director of the AIT and a former CIA station chief in Beijing with deep knowledge of Taiwan's nuclear weapons efforts, about cooperating with South Africa on laser enrichment and a small nuclear reactor. While he did not provide Lilley's response, Hau informed the president about the conversation. Chiang

wanted Hau to be cautious and to coordinate with the President (Premier) of the Executive Yuan. Premier Sun Yun-suan "approved of the proposed nuclear cooperation" with South Africa. President Chiang concurred.⁴² In October, "the feasibility of…cooperation with South Africa on nuclear energy" was established.⁴³

In his discussion with Lilley, Hau did not mention chemical enrichment. Part of the reason could have been that INER had been running a secret chemical enrichment program that violated the April 1977 secret agreement. Hau wrote in late May 1983, based on a briefing by INER researchers, that INER had already achieved a chemical enrichment of uranium to the level of 0.75 percent uranium 235 from the natural level of 0.71 percent.⁴⁴ Although this increase in enrichment was slight, the researchers told Hau they planned to reach three percent within three to five years. He viewed the goal as sufficient to make nuclear fuels for power reactors without relying on the United States for enriched uranium. He awarded the scientists on the project one million Taiwanese dollars.⁴⁵

During the late summer and fall of 1983, Hau reported on concerns from Washington. In August, he noted that the United States was becoming suspicious of the relationship between INER and CSIST.⁴⁶ In November, Lilley met with Hau to convey his concern that INER was developing nuclear weapons; Hau responded that there was no plan to make them.⁴⁷

The following year, in January 1984, Hau reported that covert enrichment activities had caught the attention of the State Department. The United States viewed any work on enrichment as violating the April 1977 agreement and wanted to carry out an inspection.⁴⁸ With regard to chemical enrichment, U.S. experts saw that a chemical enrichment program making only three percent enriched uranium could "with very little extra effort" make highly enriched uranium.⁴⁹ Hau complained, "Our government has repeatedly stated that we will not make nuclear weapons. However, where do you draw the line between peaceful use and weapon development?" Hau noted in this diary entry that the United States must have had insider knowledge of INER's research. On January 26, 1984, a U.S. nuclear team visited to inspect these efforts and Hau wrote that he instructed INER staff to "let them inspect as they want to," and to "temporarily pause our research work."⁵⁰

Hau reported on the U.S. inspection over enrichment to President Chiang two days later and he "disapprove[d] of the idea of moving our work in the dark." Instead, Chiang thought Taiwan "should try to get out of the unfair secret agreement we have with the US on nuclear energy development, so that we are able to continue our research on peaceful use of nuclear energy."⁵¹

In the end, faced with a strong reaction from the United States, INER likely ended its chemical enrichment program. However, no direct confirmation was found.

Moreover, it is unclear what happened to Taiwan's nuclear cooperation with South Africa. South Africa cut back its small reactor project in 1985, faced with severe budgetary shortfalls, and canceled it completely in 1989 or 1990, so any reactor cooperation does not appear to have materialized. ⁵² Cooperation may have continued at some level on laser enrichment, which South Africa continued for several more years, until further budget cutbacks ended it. Dr. Chang was unaware of what became of the cooperation with South Africa. ⁵³

Hot Cells. Another controversy involved a set of hot cells which were allegedly linked to learning more about separating plutonium. At some point in the early 1980s, INER built a relatively small set of hot cells in a building separate from the Hot Laboratory. The source of this information told the authors that the hot cells were interconnected, meaning that they could be capable of processing irradiated fuel and separating plutonium. This alone would cause U.S. concern.

According to Chang, the hot cells were dual-use with a civilian medical isotope cover, and a hidden plutonium separation purpose. He said that INER had set up a lab-scale molybdenum-99 (moly 99) program, where it built some process lines in a hot laboratory. Chang said that the project aimed to separate molybdenum-99 from enriched uranium targets irradiated in a reactor. Moly 99 decays to technetium-99, which is widely used in medical diagnostic procedures. In about 1980, as Taiwan was planning the moly 99 program, Chang attended a U.S. Reduced Enrichment for Research and Test Reactors conference, which was developing new targets to make moly 99 using low enriched uranium instead of the more commonly used weapon-grade uranium.

In the 1980s, the program was also planning on building a hospital nearby, to be called Shiyuan, which would use the medical isotopes on patients.⁵⁴ Another facility was being planned to package the molybdenum-99 for medical use.

However, Chang said that the project was dual-use and tied to INER's plutonium separation agenda. He said that the moly 99 processing line could be viewed as a way to practice skills and develop readiness for separating plutonium for nuclear weapons. Moreover, the medical isotope program also provided a way to practice separation techniques, since moly 99 production requires separating this isotope from fission products and the uranium in the target. He said that Taiwan had conducted in 1983 a "dual purpose" waste volume reduction, peaceful moly 99 separation process aimed at separating long-lived fission products at INER.⁵⁵

Chang implied that Taiwan never received U.S. permission for separating moly 99. Moreover, the hot cells were completed, according to someone who visited them later, before they were discovered by the United States. Washington evidently viewed the hot cells as inconsistent with the secret 1977 agreement and insisted that they be shut down. Evidently, they remained intact at INER with offices built in front of them.

To Chang, the next step was scaling up the plutonium separation operations to a full-size plant. Others think that after these hot cells were shut down, Taiwan decided to build a larger reprocessing plant away from INER (see Chapter 9).

SEEKING LESS RELIANCE ON THE UNITED STATES

Hau's diary supports Chang's assertions that all while placating the United States on the surface, Taiwan's new military leadership continued its covert nuclear weapons efforts and wanted less reliance on the United States as a nuclear supplier. The leadership remained deeply aggrieved by the United States' 1970s intervention in Taiwan's affairs. Hau wrote that he viewed the United States' terms with regard to restrictions on Taiwan's activities as "a humiliation for our nation." He mused, "Complete dependence on the US is dangerous, but leaving them is unviable. This is how we should see our relationship with the US." 57

As the South Africa cooperation shows, Taiwan reached out to countries to obtain less restricted nuclear materials, facilities, and technology

for its civil nuclear program, including that run by Taipower, and for a potential military nuclear use, such as small secret reactor and laser enrichment projects. Although a laser enrichment program could conceivably be kept secret, albeit while violating the terms of the April 1977 agreement, a nuclear reactor, even a small one, could not be hidden. It is difficult to understand Hau and INER's priority of obtaining cooperation from abroad on importing a small reactor, which would inevitably raise proliferation concerns.

In any case, this small reactor effort was titled Plan Ping Dong (or Pingtung). The plan was budgeted to cost \$700 million.⁵⁸ In May 1983, Hau iterated in his journal that INER's priority was still "the development of a small nuclear reactor."59 How did Taiwan plan to cooperate on a small reactor project with a country like South Africa while navigating its agreements with the United States? Taiwan would have to place all nuclear facilities and materials under the U.S./Taiwan/IAEA trilateral agreement and subject the transfer to conditions of the U.S./Taiwan bilateral nuclear agreement, giving all kinds of veto rights to the United States, as discussed at the start of the chapter. Hau and INER may have believed that they could find a supplier of a small reactor, but importing it from a responsible state, let alone a pariah state like then-apartheid South Africa, would have been extremely complicated. An exception is if an off-shore arrangement was being contemplated, where Taiwan would be funding or helping staff a secret overseas reactor project, such as South Africa's Gouriqua project. However, this type of arrangement would surely find little U.S. support if uncovered.

Moreover, South Africa was under international pressure to stop its sale of sensitive nuclear materials such as uranium, and of equipment to unsafeguarded nuclear programs. It was just this type of sale in the early 1970s that allowed Taiwan to acquire about 100 metric tonnes of uranium metal for the TRR outside of safeguards (see Chapter 4). In 1984, South Africa pledged to abide by the guidelines of the Nuclear Suppliers Group and not export nuclear-related goods or sensitive technology to any unsafeguarded nuclear program. Thus, after 1984, whatever Taiwan did in terms of uranium or nuclear reactors would have to be fully visible to the IAEA and thus to the United States, unless it could find another alternative supplier. This further constrained its ability to procure goods and materials in secret.

In December 1983, Deputy Director Huang discussed in a meeting that INER should continue to focus on peaceful nuclear energy uses, fuel production, and building nuclear plants. However, he viewed peaceful nuclear development and nuclear weapons development as "fundamentally the same thing." Plan Ping Dong for a small nuclear reactor would only be for research purposes.⁶¹ In October 1984, Taiwan ruled out buying a heavy water reactor due to the restrictions of the U.S. agreement.⁶² In the end, Plan Ping Dong never materialized.

Reaching Out to France. Taiwan was also interested in larger power reactors. In March 1982, Hau wrote that Taiwan was considering France as a partner for fulfilling its nuclear power needs:

The US has imposed unfair and unreasonable restrictions on our research on the peaceful use of nuclear energy. Therefore, we are considering France as an alternative supplier for our new nuclear plants. The US is forcing us to accept unfair restrictions by threatening to suspend uranium supplies. This is such a humiliation for our nation. 63

That month, Hau met with Taiwan's ambassador to France, Kung Cheng-ting, to discuss his recent conversations with French officials. Taiwan wanted to buy additional nuclear reactors, and it seemed that the French were interested. They also discussed sales of fighter jets and fighter jet engines, which Hau viewed as "an alternative route...to obtain high-precision weapons." He appreciated the willingness of the French to act independently of the United States, and lamented Taiwan's inability to do so.

In March 1983, a delegation from Taipower visited French nuclear facilities, including the La Hague reprocessing plant in Normandy, which was ramping up its commercial contracts to process irradiated power reactor fuel from France and a range of other countries, such as West Germany and Japan.⁶⁵ According to U.S. intelligence, France wanted to "impress foreigners with their leadership in reprocessing as an incentive for sales of French power reactor to developing countries that are concerned about disposition" of irradiated fuel.⁶⁶ However, since 1976, France was not willing to sell reprocessing technology or plants to countries of proliferation concern such as Taiwan.

Because this visit was politically sensitive, Taipower's delegation did not include any nuclear scientists. However, the visit raised the possibility of Taiwan in the future contracting for its irradiated fuel to be reprocessed in France, if such a contract would become politically acceptable. The visit also served notice to the United States that Taiwan did not necessarily agree with the U.S. policy of no reprocessing.

Military Cooperation with Israel. Hau considered cooperation with Israel to be "extremely important" in terms of acquiring and learning about precision technologies, since South Africa "lacked experts in this area." Hau complained about Israel, however, writing that Israel was anxious to continue arms sales with Taiwan, but used it "to get rid of their obsolete weapons," even seeking to damage deals between the United States and Taiwan. He wrote that at a time when Taiwan had made "great progress" in arms development, it wanted to rely less on Israel for arms. Hau met with the Director General of the Israeli Department of Defense, Menachem Maron, on September 30, 1983 to discuss trilateral cooperation with South Africa and Israel, Taiwan's independence with regard to choosing which Israeli arms to buy (its position that Israel should not interfere with U.S. arms sales), and the need for secrecy in the Israel/Taiwan relationship. 88

Offer of Illicit HEU. In August 1984, Hau wrote about an offer from a Japanese right-wing group to sell 100 grams of 90 percent enriched uranium for research. Hau "absolutely" refused to buy it.⁶⁹

Discussions with Saudi Arabia. Hau mentioned in his diary in November 1984 that Liu Shuxi, the vice president of CSIST, met with then-Executive Yuan President (Premier) Yu Kuo-hwa to discuss nuclear cooperation with Saudi Arabia and an earlier trip to Saudi Arabia taken by Yu's predecessor, Premier Sun Yun-suan, and INER Director Chien. The two discussed a proposal with Saudi Arabia for nuclear cooperation, including building a heavy water reactor. Hau wrote that day in his diary that what the Saudis addressed as research for peaceful nuclear programs was "in fact for nuclear weapon development." He stated that Saudi Arabia was overestimating its ability to develop nuclear weapons using foreign experts. "Given the current circumstances," he wrote, "we ourselves are unable to develop nuclear weapons, either." He noted that

any cooperation could only be for peaceful use and would require U.S. approval.

As Taiwan strove for less dependence on the United States, it encountered several roadblocks dictated by its own standards, and by the norms in the April 1977 agreement as enforced by the United States. Although Taiwan curtailed many activities, it persisted in pushing ahead with its central focus on plutonium-based nuclear weapons.

NOTES

- 1 Cable from American Institute on Taiwan, Taipei to American Institute on Taiwan, Washington, D.C., *Exports of Nuclear Materials and Equipment to Taiwan*, June 16, 1980.
- 2 Cable from Secretary of State and American Institute on Taiwan, Washington, D.C. to American Institute on Taiwan, Taipei, *Export of Nuclear Materials and Equipment to Taiwan*, June 19, 1980.
- 3 NRC License Number XMAT0103, October 14, 1980. The license allowed for an initial heavy water export not to exceed 2,000 kilograms and subsequent annual shipments not to exceed 500 kilograms.
- 4 Cable from Secretary of State to American Embassies in Bonn and Vienna, *Nuclear Exports to Taiwan*, July 3, 1980.
- 5 State Department Taiwan Secret Non-Paper, *Nuclear Export to Taiwan Taiwan Non-Paper*, August 22, 1980.
- 6 See for example, Cable from American Embassy in Taipei to Secretary of State, *Proposed Assignment of U.S. Nuclear Scientists to ROC*, September 18, 1978.
- 7 Chen Yishen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi* (Taiwan: Walkers (Yuan Zu Wen Hua), 2016) (Translated by the Institute for Science and International Security, 2017).
- 8 Ibid, Chapter 3.
- 9 Hau Pei-tsun, *Diary during my Eight Years as Chief of the General Staff* (Taipei: Commonwealth Publishing, 2000) (Translated by the Institute for Science and International Security, 2018), pp. 470-471.
- 10 Chen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi*, Chapter 3; Liwei He (David Ho), *Nuclear Bomb MIT:"A" Bomb Made in Taiwan* (Taipei: Women Chubanshe, 2015).
- 11 Interviews with Chang Hsien-yi, Washington, D.C., June 2017; Interview by the authors with Chang, August 2, 2018.
- 12 Ho, Nuclear Bomb MIT: "A" Bomb Made in Taiwan.
- 13 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 3.
- 14 Interview by the authors with former U.S. Ambassador James R. Lilley, November 27, 2007.

- 15 Chang Hsien-yi, "Taiwan Nuclear Weapons R&D Chronology of Events/ Talking Points," undated (Translated by Institute for Science and International Security, 2017).
- 16 Jack Anderson, "Secret Report Sees Taiwan Near A-Bomb," *The Washington Post*, January 25, 1982.
- 17 "Taiwan Makes Nuclear Arms Claim," *The Washington Post*, May 13, 1983, p. A18; "Cabinet Rules Out Developing Nuclear Weapons," *Chung Yang Jin Pao*, Translated from Chinese by Taiwan Central News Agency, November 29, 1983, p. 1.
- 18 Chen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi*; Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 19 Hau, Diary during my Eight Years, pp. 470-471.
- 20 Ibid, p. 470-471.
- 21 Ibid, p. 435.
- 22 Ibid.
- 23 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 24 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 3; Hau, Diary during my Eight Years, pp. 200-201.
- 25 Hau, Diary during my Eight Years, p. 282.
- 26 Ibid, pp. 200-201.
- 27 Ibid, pp. 60-61.
- 28 Ibid, p. 402.
- 29 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 30 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 3.
- 31 See for example, Cable from AIT Washington, D.C. to AIT Taipei, [Subject Redacted], November 16, 1983. This cable discusses the logistics of an elevenperson U.S. team, including personnel from State, ACDA, NRC, DOE, and three U.S. national laboratories.
- 32 Hau, Diary during my Eight Years, pp. 204-205.
- 33 Judith Miller, "3 Nations Widening Nuclear Contacts," *The New York Times*, June 27, 1981, p. A15.
- 34 Hau, Diary during my Eight Years, pp. 204-205.

- 35 Ibid, pp. 217, 225.
- 36 Interviews with Chang Hsien-yi, Washington, D.C., June 2017; Interview by the authors with Chang, August 2, 2018.
- 37 Hau, Diary during my Eight Years, pp. 293-294.
- 38 Ibid, p. 296.
- 39 Albright with Stricker, *Revisiting South Africa's Nuclear Weapons Program* (Washington, D.C: Institute for Science and International Security, 2016). Available as a PDF on the Institute's web site: http://isis-online.org/uploads/isis-reports/documents/RevisitingSouthAfricasNuclearWeaponsProgram.pdf. The book is also available as an e-book from Nook and Kindle, and a paperback version in black and white is sold on Amazon.
- 40 Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium 1996* (Oxford: Oxford University Press, 1997).
- 41 Hau, Diary during my Eight Years, pp. 339-340.
- 42 Ibid, pp. 341-342, 344-345.
- 43 Ibid, pp. 204-205.
- 44 Ibid, p. 332.
- 45 Ibid, p. 332.
- 46 Ibid., p. 377.
- 47 Ibid, pp. 429-430.
- 48 Ibid, p. 469.
- 49 Ibid.
- 50 Ibid, pp. 469-470.
- 51 Ibid, pp. 470-471.
- 52 Albright with Stricker, Revisiting South Africa's Nuclear Weapons Program.
- 53 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 54 Interview by one of the authors with Chang, August 14, 2017.
- 55 Chang, "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points." See also: "Research Programs of the Institute of Nuclear Energy Research," INER-0380, June 1981, p. 39, which discusses that the separation of moly 99 "from fission products is also in progress."
- 56 Hau, Diary during my Eight Years, pp. 60-61.

- 57 Ibid, p. 61.
- 58 Ibid, p. 440.
- 59 Ibid, pp. 327-328.
- 60 Albright with Stricker, *Revisiting South Africa's Nuclear Weapons Program*, p. 262, citing AEC Press Release by J.W.L. de Villiers, January 31, 1984.
- 61 Hau, Diary during my Eight Years, pp. 441-442.
- 62 Ibid, p. 629.
- 63 Ibid, pp. 60-61.
- 64 Ibid, p. 61.
- 65 CIA, Directorate of Intelligence, *French Nuclear Reactor Fuel Reprocessing Program*, SW-84-10057, September 1984, redacted version. For information on the French reprocessing program, see also *Plutonium and Highly Enriched Uranium 1996*.
- 66 CIA, Directorate of Intelligence, *French Nuclear Reactor Fuel Reprocessing Program*.
- 67 Hau, Diary during my Eight Years, p. 367.
- 68 Ibid, p. 407.
- 69 Ibid, p. 585.
- 70 Ibid, p. 633.
- 71 Ibid.

CHAPTER 9 GOING TOO FAR

As Taiwan tried to develop nuclear cooperation internationally, President Chiang Ching-kuo remained committed to his policy of not building nuclear weapons but having the capability to do so. However, he also appeared sensitive to meeting on-going U.S. concerns about Taiwan's nuclear program. In April 1985, President Chiang told General Chief of the General Staff General Hau Pei-tsun, "We should not have any plan to work on nuclear weapons," and, "We should arrange to ship the spent fuel from the research reactor back to the US as soon as possible." Hau wrote in his diary about the meeting, "[Chiang] instructed that INER should retain its existing nuclear capabilities while at the same time engage in more research on the peaceful use of nuclear energy."

While the military appeared more committed than President Chiang to nuclear weapons development under a civil cover, Chang Hsien-yi reported that even though Chiang may not have been as forceful about the nuclear weapons program as Hau, and more worried about provoking U.S. protests, they had a mutual understanding about moving the work forward.² Hau thought he had the support of the president in further developing Taiwan's nuclear weapons capabilities but understood the need not to provoke the United States too much.

Many high-level planning meetings had started to occur in about 1983 and 1984 under the new chain of command at CSIST/INER.³ At one of the meetings, Chang Hsien-yi recalled that Yu Shih-kao, formerly

of CSIST/INER's high explosives team and director of INER's physics department, suddenly re-appeared after having been reassigned. Yu had been moved from INER (the first division of CSIST) in the late 1970s to the fourth division (chemistry) after the Americans had made clear that he was under tight surveillance for both his high explosives role and conducting illicit procurements for the program. Yu turned to Chang at a meeting and asked, "Do we really want to go this far?" Yu had been ordered "not to touch" the high explosives work since being reassigned. But Yu and others had been brought back. Hau met with him in April 1985 and encouraged him to maintain research progress.⁴ This appeared to be an oblique reference by Hau to maintaining progress on nuclear weapons.

One of the concerns pushing Hau forward was his increased preoccupation with an invasion by the People's Republic of China. At a 1985 high-level military and defense review meeting chaired by General Hau, which was attended by INER Director Liu Guang-ji, the general informed the attendees that Taiwan could likely only hold out for three to six months following the start of a PRC invasion.⁵ INER estimates at that time allowed for a year or two to make a nuclear weapon.

Later, at an April 1986 meeting with Director Liu, Hau ordered feasibility studies to reach the three to six-month timeline. In this meeting, according to Hau's diary, Liu met with Hau to discuss the "goal...for INER to be able to complete the making of nuclear weapons, if and when INER were ordered to do so." Hau also wrote in this journal entry, "This policy does not contradict our policy of not making nuclear weapons. The President already declared that we have the capability of making nuclear weapons, but will not make them. Maintaining the capability to make nuclear weapons is exactly INER's task."

Chang was not present at the meetings with Hau but heard afterward about Hau's order from Director Liu. Liu told him Hau "wanted it done." General Yeh and Director Liu were tasked with working out a master plan for integrating the aspects of the program to accomplish this. If nuclear weapons were built, Chang understood, at that time, Taiwan had enough plutonium on-hand to build about three to five weapons.⁹

In 1986, General Yeh and Director Liu set to work on their master plan and found that if INER bettered access to materials and improved techniques, Taipei could shorten the time frame to reach a nuclear weapon to meet the constraint of approximately three to six months. Yeh and Liu presented their plan for integrating all aspects of nuclear weapons related work to General Hau. Hau approved the plan, and commended INER for its achievement.¹⁰

Through his subsequent discussions of these meetings with his CIA handlers, Chang began to understand better that the United States had red lines on Taiwan's nuclear-related research and activities. To the United States, Hau, CSIST, and INER were taking Taiwan across them.

TAIWAN'S NUCLEAR STRATEGIC THINKING

Every covert nuclear weapons program has its own culture and myth, whether related to prestige or survival as the motivating factor. Dozens of scientists and support staff work quietly and diligently around it. Taiwan's nuclear weapons program was no exception. Dr. Chang stated that Taiwan's reasons for seeking the bomb were prestige, survival, and seeking independence from the U.S. nuclear guarantee, which they had severe doubts about. Would the United States risk its territory to a PRC nuclear strike just to safeguard Taiwan? Many on Taiwan doubted that it would if that dire day ever came. Moreover, many doubted that U.S. help would arrive in time.

There is little information on what Taiwan's nuclear strategy would have been, and it is unclear how deterrence would have succeeded in the case of Taiwan. According to Chang, the general belief among the leadership was that Taiwan's possession of nuclear weapons would deter Beijing from attacking, despite its stated commitment to do just that. The leadership may have also believed that in the event of a confrontation between two nuclear-armed adversaries, the United States would intervene to stop the conflict, similar to the strategy pursued by South Africa in the 1980s. As far as the authors could tell, the development of a formal nuclear strategy was rudimentary or involved only military planners and had not been made known to INER staff such as Chang.

Taiwan's approach was to secretly develop a latent nuclear weapons capability, which Chang termed a "soft defensive capability," while remaining a signatory to the Nuclear Non-Proliferation Treaty. Indeed, the NPT served as a

means by which to acquire the nuclear capabilities that would allow them to reach a breakout capability of several months.

Taiwan's military appears to have been well aware of its extraordinary vulnerability to conventional attack by the PRC while it was building its first nuclear weapon. Much of its focus was on ensuring that it could build a nuclear weapon before Beijing, the United States, or the IAEA learned of its breakout.

Chang did not witness discussions about first- or second-strike capabilities. Taiwan never considered conducting an underground nuclear test, even as a demonstration. It may have been the case that he knew of no military planning because Taipei had not yet reached the stage of ordering assembled devices. The military may have engaged in planning and strategy sessions as the date of such a decision approached or breakout times reduced further.

MAIN PILLARS OF TAIWAN'S NUCLEAR WEAPONS PROGRAM

What did Taiwan's nuclear weapons capabilities look like in the 1980s? How could it have built a deliverable nuclear weapon in three to six months following a decision to do so, as General Hau ordered? When could it have been ready to build a nuclear weapon?

Taiwan's apparent calculation was that it could build its first weapon in secret and emerge with a nuclear weapon or weapons before the PRC or the United States would learn about it. The longer-term goal would have apparently been to rapidly build several more, according to Chang. This latter goal would help provide guidance on the size of the industrial endeavor needed.

The military controlled the nuclear weapons program. CSIST was in charge of researching, developing, and building them, including ensuring an adequate delivery system. INER as a division of CSIST was responsible for producing nuclear explosive materials for the nuclear weapons, in this case separated plutonium metal, and contributing importantly to nuclear weapons simulations and other nuclear weaponization research and development activities. INER also played a key role as the civilian cover for the program. The bulk of the high-level planning within the military leadership appears to have been focused on obtaining nuclear weapons; planning for their use seems to have been in its early stages (see Sidebar on Taiwan's Strategic Nuclear Thinking).

It is difficult to estimate when the infrastructure would be in place to be able to build a nuclear weapon within three to six months. Some programs moved faster than others, but all the necessary infrastructure components should have been finished by about 1989 to 1991, although a potential bottleneck was developing an aircraft able to deliver a warhead against targets in the PRC, and Taiwan had stopped its nuclear weapons-capable ballistic missile programs. Whether Taiwan could execute a breakout in secret was another matter, and this time period would inherently represent a time of great danger with regard to both U.S. and PRC reactions.

BREAKOUT INFRASTRUCTURE

Building a first nuclear weapon within three to six months is a remarkably short period of time. This demand required Taiwan to accelerate its development of a range of nuclear capabilities, all in utmost secret to try to avoid U.S. and PRC detection. Taiwan was able to build the necessary capabilities based on its more than two decades of work already done.

One way to understand what was accomplished by late 1987 or early 1988, when Chang left Taiwan, is to use Chang's description of his understanding of the red lines for the United States in Taipei's nuclear development. According to Chang, the most important red line was a capability to make deliverable nuclear weapons in three to six months following a governmental decision. This rapid pace required the preparation of many capabilities, including a reprocessing plant, and a willingness to maintain a type of readiness not typically required in other latent nuclear weapons programs. Using Chang's recollection, the task implied by this red line can be further characterized in order to understand how Taiwan put together its rather unusual breakout capability. Chang identified five tasks, called "5 sub-redlines," which "can then be derived from this main red line, all of which are necessary conditions for the main red line to be established." They can be understood as the goals of the program at that time. In summary, the major tasks were the following:

1. Having nuclear explosive materials exceeding a critical amount, i.e. 10 kilograms of weapon grade plutonium or 20 kilograms of weapongrade uranium;

- 2. Mastering the high explosive detonation system and the control devices, for example, the ability to perform a successful cold test of a nuclear explosive with a surrogate nuclear core.
- 3. Having the ability to separate high purity plutonium from irradiated fuel, for example, possessing a hot cell with sufficient radiation protection and the capacity of performing safe plutonium separation processes, and converting the separated plutonium into metal weapons components.
- 4. The ability to refine and shape plutonium metal into components for nuclear weapons. In the case of plutonium, this meant making and working with the lower density delta phase of plutonium, which is formed by alloying plutonium metal with another material, typically gallium. ¹⁵ Chang specifically gives the example of being able to set up and successfully test a high-temperature crucible in the metal refining facility.
- 5. Producing and maintaining a reliable and effective delivery system, for example, the indigenous defense fighter aircraft outfitted to carry nuclear weapons.

To that list should be added building the capability to use computer codes to simulate a nuclear weapons explosion. Taiwan's leaders realized early in their nuclear weapons program that an underground nuclear test was not feasible on their small, densely populated island, nor was a detonation over the ocean desirable since Taiwan had ratified the Partial Test Ban Treaty when it was still recognized as the official representative of China. Thus, Taiwan would have to learn how to build nuclear weapons without conducting a full-scale nuclear test. As a result, the leaders of the program focused on developing methods to gain high assurance in the functioning and reliability of a nuclear device absent a full-scale test. Its theoretical teams, backed by parallel teams tasked with designing and implementing experiments to gather data and strengthen the simulation, ensured that a full nuclear test would not be needed before Taipei could deploy its first nuclear weapon.

Taiwan's nuclear weapons program faced another peculiar problem. Taiwan's effort had to ensure that its nuclear weapons personnel would be ready to build nuclear weapons in three to six months, all the while denying that there was a nuclear weapons program. If a decision were made

to start separating plutonium and building the bomb, it needed to ensure that the personnel were well practiced and ready to act. There would not be time to develop needed skills. But Taiwan could not work openly on all the activities necessary to build nuclear weapons without arousing U.S. suspicions and resistance. This readiness required practicing preparation or the honing of a skill to break out via activities that were civilian or non-nuclear military in nature.

To circumvent detection by the United States, while developing and refining necessary skills, Taiwan developed many "dual-use" activities, such as anti-tank experiments and molybdenum-99 separation, with the clear intent of furthering its work on nuclear weapons. These dual-use activities allowed scientists, engineers, and technicians to practice daily the skills they would need to implement a decision to have a deliverable nuclear weapon in three to six months. In essence, according to Chang, these on-going dual-use activities put those personnel on "hot standby" and ready to act to build nuclear weapons on schedule, if a decision to proceed happened.

PLUTONIUM PRODUCTION IN THE TRR

Fundamental to Taiwan's nuclear weapons program was a source of plutonium. Although it may have explored a uranium enrichment pathway to nuclear weapons, as discussed in earlier chapters, by the late 1980s, Taipei had not developed an ability to make highly enriched uranium. Moreover, according to Chang, these enrichment methods were never seen as a replacement for the use of a known technology, such as reprocessing, which remained in Taiwan's "inner core of interests." Its nuclear weapons program would depend on the plutonium produced in INER's Taiwan Research Reactor.

It is significant that despite the revelations of the 1970s, Taiwan managed to convince the United States that restarting the TRR would not pose an intolerable proliferation threat. Washington had falsely believed that it could prevent Taiwan's march to nuclear weapons while acquiescing to this reactor's operation. Part of the reason was that it had obtained a commitment from Taiwan to convert the TRR core to one unable to make significant amounts of plutonium and ship the reactor's irradiated fuel to the United States. However, despite initial expectations of rapidly

accomplishing both initiatives, they both lagged. Little concrete progress on core conversion had happened by 1987, and the first shipments of irradiated fuel did not start until 1986. By 1988, only a relatively small fraction of the fuel elements had been shipped to America (see sidebar on TRR reactor conversion). Thus, in 1987, Taiwan had a significant inventory of high quality, albeit not quite weapon-grade, plutonium in irradiated fuel located in the TRR's irradiated fuel pond and in a nearby dry storage area. For many more years, it could expect to continue making more plutonium in the TRR, ensuring that it could reach this first task of having at least ten kilograms of plutonium.

How much plutonium was in the discharged, irradiated fuel? By early 1988, the Taiwan Research Reactor had produced in total nearly 85 kilograms of plutonium in irradiated fuel elements, almost all weapon-grade or near weapon-grade. Only in 1986 did the amount of TRR plutonium at INER start to decrease, as a total of 474 Canadian-supplied irradiated fuel elements were received in the United States from 1986 to 1988, as discussed in Chapter 6. That left in Taiwan about 1,100 other irradiated elements that utilized South African uranium. These elements contained an estimated 59 kilograms of plutonium, based on scaling the plutonium quantity by the number of irradiated fuel elements.

Over time, the remaining stock of plutonium was expected to further decrease. Nonetheless, a weakness of the irradiated or spent fuel take-back approach, absent reactor conversion, was that if the reactor continued to operate, the amount of plutonium in Taiwan would not have reached zero. Even if the spent fuel take-back policy worked as planned, it would not have prevented Taiwan from accumulating plutonium in the reactor itself, in the adjacent irradiated fuel pond, and in the nearby dry storage facility.

An upper bound estimate of the amount of plutonium in the core can be determined from information about irradiated fuel discharged from the TRR. Following the U.S. actions in the late 1970s aimed at ending Taiwan's nuclear weapons efforts, the United States insisted that all the irradiated fuel from the reactor be removed and scrutinized. A core load of fuel containing 137 fuel elements was discharged. Each fuel element contained about 54 kilograms of natural uranium, giving a total of about 7.4 metric tonnes of uranium in the core, somewhat less than a full core load of about eight metric tonnes. By using Department of Energy data

on the average amount of plutonium in the irradiated fuel returned to the United States, 137 fuel elements would contain up to about 7.2 kilograms of plutonium, where the upper bound assumes 52.6 grams of plutonium per fuel element (or about 0.97 grams of plutonium per kilogram of uranium). This is an upper value of the amount of plutonium in the core because not all of the irradiated fuel was discharged at its full burnup, so those elements on average had a lower amount of plutonium per fuel element. However, on average, the plutonium was likely weapon-grade.

The average annual production of plutonium in the reactor provides another rough measure of the amount of plutonium Taiwan would have had on hand. Until 1988, or during 15 years of operation, the TRR produced, on average, about 5.7 kilograms of plutonium per year.²³ This average includes the early years of the reactor's operation, when operation was affected by start-up problems and was halted temporarily, as described in Chapter 4. Thus, this average value likely underestimates how much plutonium the reactor could produce annually in 1987, when it was running more reliably.

Another challenge is that the shipment of irradiated fuel could not be immediate. Prior to shipping the irradiated fuel off-site, it had to "cool" radioactively and thermally in the pond sufficiently to allow its safe transport. A cooling period of two years is often viewed as long enough to sufficiently cool irradiated fuel prior to shipment. With this amount of cooling time, the reactor pond and dry storage would be expected, on average, to contain the equivalent of at least two years-worth of plutonium, or over ten kilograms in this irradiated fuel, using the annual plutonium discharge figure derived above. Another way to calculate the buildup in the amount of plutonium in irradiated fuel is to consider the amount of irradiated fuel discharged in a year, given a fixed capacity factor and fuel irradiation or burnup. At average achieved values, about 16 metric tonnes of uranium would be discharged in two years, or about 296 fuel elements.²⁴ This irradiated fuel would contain about 15.5 kilograms of plutonium, using the above concentration values (0.97 grams of plutonium per kilogram of uranium). Moreover, at any point, Taiwan could seek to delay shipments of the irradiated fuel, concocting logistical or safety issues and build up even more plutonium in irradiated fuel on-hand.

One countermeasure was Taiwan's agreement in the 1970s to limit the amount of fuel elements in the pond to no more than one quarter of the core, or about 50 fuel elements (see Chapter 7). However, other than off-site shipments, there were no limits on the number in dry storage. Diversion from dry storage would be significantly more difficult and time consuming than taking the irradiated fuel elements from the pond. However, in order to send the irradiated fuel to the United States, Taiwan was constantly taking irradiated fuel out of dry storage after 1985. So, opening the dry storage silos was relatively commonplace. Likely to improve this situation, the United States insisted by 1986 that after the removal of the backlog of irradiated fuel from Taiwan, an "equilibrium" state would be reached where the amount of irradiated fuel remaining in Taiwan would be minimized at one and one and half years for fuel discharge.²⁵

Using the irradiated fuel discharge estimates discussed above, this equilibrium state would correspond to about 5.7 to 11.4 kilograms of plutonium, or an average of about 8.6 kilograms of plutonium. Considering typical fuel discharges as above, namely about 8 metric tonnes of uranium in 148 fuel elements, the range becomes 7.8 to 11.6 kilograms of plutonium, with an average of 9.7 kilograms of plutonium. In 1986, when this equilibrium state was discussed, the TRR was discharging about 180 fuel elements per year, which translates to about 9.7 metric tonnes of uranium per year. At this rate, and assuming similar burnup as above, e.g. the reactor was achieving a higher capacity factor, the equilibrium state would entail that the discharged fuel on-hand in Taiwan would contain 9.4 to 14.1 kilograms of plutonium, or an average of about 11.7 kilograms of plutonium.

Between the reactor core, the irradiated fuel pond, and dry storage, Taiwan had in 1987 a large stock of plutonium, far in excess of its threshold of ten kilograms. Even if the United States succeeded in achieving an equilibrium state of only one to one and a half years for discharge, under a wide variety of conditions, Taiwan would still possess at INER more than its threshold of ten kilograms of plutonium on-hand.

However, this plutonium was not on average weapon-grade, but it did likely contain over 90 percent plutonium-239. This value is an average, and likely some of the fuel elements contained weapon-grade plutonium, but we could not determine how much from available data. In any case, which plutonium would Taiwan have decided to use? Was there enough weapon-grade plutonium? At the right moment, would Taiwan

have arranged to irradiate a new core load of fuel in the TRR, timed for discharge with weapon-grade plutonium in time to meet the three to sixmonth breakout timeline? If ten kilograms of weapon-grade plutonium were desired, and because of cooling requirements for the fuel, which would be reduced from the time needed for safe transport internationally, Taiwan would have needed to plan to take steps prior to starting its breakout and pre-produce one or two cores of fuel in the year prior to a breakout to ensure it had that goal quantity of weapon-grade plutonium.²⁷ This operation would be expected to occur under continuing IAEA inspections, meaning that under-irradiating the fuel may have been seen as alarming by the United States, the PRC, and the IAEA, although Taiwan could concoct safety and other reasons for taking the fuel out early. Alternatively, would Taiwan have used the high-quality plutonium it had?

Faced with the question of plutonium quality, since the 1960s, Taiwan's nuclear weapon designers had studied this problem of using lesser quality plutonium.²⁸ Initially, the teams assumed that the core would contain weapon-grade plutonium with less than about 3-5 percent plutonium-240. This isotope is generally recognized as an undesirable isotope to have in nuclear weapons since it can cause the device to pre-detonate, leading to a fizzle or no explosive yield. The greater the fraction of plutonium-240, the more difficult it is to get a reliable, higher yield explosion. Thus, nuclear weapons designers typically try to obtain plutonium with as little plutonium-240 as possible, given the constraints imposed by the reactor that produces the plutonium. But as the program matured and scientists realized that much of the TRR plutonium was not that pure in plutonium-239, according to Chang, it explored the use of higher fractions of plutonium-240 in its nuclear weapons. Chang had explored this subject while he was at Oak Ridge in the 1960s (see Chapter 3), and his colleagues had come to realize, as other nations' programs had done as well, that non-weapon-grade plutonium could also work in a nuclear explosive, although with a potential sacrifice in yield and confidence in the warhead's performance. However, Chang said that if the main purpose of the weapons was deterrence, then the exact yield and confidence was less important. One long-time observer of secret nuclear weapons programs, who reviewed this book, commented that a country like Taiwan would not need to achieve tens of kilotons of explosive yield to create plausible deterrence. Although weapon-grade plutonium is desirable, if it is not

available, a program planning to deploy its first nuclear weapons might opt for lower explosive yields as sufficient to meet its security needs.

On balance, as long as the TRR operated and was not converted to low enriched uranium fuel, Taiwan would have enough plutonium for nuclear weapons and could likely cobble together enough weapon-grade plutonium to meet this first and most important goal using plutonium produced in the TRR. In 1987, the reactor could expect to see many more decades of operation, making reactor conversion the main threat to its continued existence as a source of plutonium. However, if it did not plan in advance to make weapon-grade plutonium, Taiwan's nuclear weapons program may have had to settle for non-weapon-grade, albeit high quality, plutonium.

TRR CONVERSION

The conversion of the core of the Taiwan Research Reactor would ensure that it would not produce significant amounts of plutonium. This goal was a clear priority for the United States since 1977. Coupled with TRR irradiated fuel removal, core conversion would effectively render the TRR a far more reduced nuclear proliferation threat. However, despite its claim to be on board with the plan, Taiwan did not view core conversion as a priority, and it raised many technical arguments that delayed conversion. It showed little interest in moving forward expeditiously on core conversion, even as the program dragged on into the late 1980s. Part of the reason for slowing core conversion was that unlike irradiated fuel removal, a successful core conversion would strike at the heart of Taiwan's nuclear weapons program.

In 1980, after studying the issue for almost three years, Argonne National Laboratory (ANL) near Chicago proposed a conversion strategy involving near 20 percent enriched uranium fuel, a typical and mostly successful fuel for conversion. Nonetheless, INER proposed oxide fuel instead and a partial core conversion, and according to a State Department summary, at the meeting, it "denigrate[d] the ANL plan."²⁹

After several more years of work, core conversion was far from fruition. In a November 1987 meeting

The nuclear weapon program appears to have recognized the potential shortcoming of relying only on the TRR. This may be one reason General Hau supported the acquisition of a small reactor (see Chapter 8). Moreover, to augment its potential plutonium production capability over the long term and provide a surge capability, according to Chang, the program assigned a few people to evaluate diverting plutonium in irradiated fuel from its nuclear power reactors, which are each far larger than the TRR. They evaluated the case where power reactors could be shut down prematurely, only one or two months after refueling, when the new fuel was barely irradiated. They estimated that the irradiated fuel could contain 100 kilograms of high quality, or even weapon-grade, plutonium.

at Brookhaven National Laboratory (BNL) in New York, INER officials outlined a newer plan that comprised six primary tasks for converting the TRR.30 With regard to project management, INER presented a schedule for only three of these tasks and just one task (core design and safety analysis) had a detailed work breakdown with a monthly schedule for completion. U.S. experts were anxious to suggest ways to move the project toward completion and INER agreed to "continue to improve the project plan and would work out the plan for task 2 with a monthly schedule."31 Other tasks were discussed and faced their own complications and delays. In any case, "more assistance from BNL [was] expected by INER," which would "involve direct help under contract" in a variety of areas.³² After the meeting, BNL, in a December 2, 1987 letter, proposed providing technical assistance to INER on core conversion over the next few years.³³ However, the letter implied that core conversion could have taken several more years.

Interestingly, the head of the INER delegation to the BNL meeting and the addressee of the BNL letter was Chang Sen-i, otherwise known as Chang Hsien-yi. When we asked him what Taiwan's true intent was in these meetings, he said, "We really tried to convert to 20% U-235 TRR core, if we can pass all the safety and performance evaluations." Chang would certainly have every reason to support TRR conversion, even if important leaders in his government did not. However, as he was likely aware, time would soon run out.

Defeating IAEA Inspections. Another question was whether in 1987, Taiwan could have diverted irradiated TRR fuel without being detected by the IAEA before it had separated enough plutonium for a nuclear weapon. We consulted with a variety of experts, who were skeptical that significant numbers of irradiated fuel elements could have been removed without breaking IAEA seals or being recorded by more modern safeguards cameras in the irradiated fuel pond. However, with regard to small amounts of irradiated fuel, there was much less confidence about detecting a diversion.

A more troubling strategy would have been to divert irradiated fuel and reprocess it in-between inspectors' visits. At the time, inspections of the irradiated fuel in research reactors' ponds occurred only about every three to six months.³⁵ If Taiwan required more than three months to build its first nuclear weapon, its diversion of irradiated fuel could have been detected. However, in the 1980s, Taiwan could have more easily than today used excuses to delay access by the inspectors without triggering much alarm. If one inspection was skipped, Taiwan could have diverted the irradiated fuel and finished separating its plutonium between inspections without being detected by the IAEA, even if its diversion activities required the breaking of seals or were recorded on cameras. A denial of the inspectors' visit would have alarmed the United States, meaning that it is unclear if Taiwan could have accomplished its goal in secret since the United States could demand immediate access.

It should be noted that safeguards technologies and approaches were steadily improving with time. Moreover, they rapidly improved after the uncovering of Iraq's vast nuclear weapons program during the 1991 Persian Gulf War showed their major deficiencies. As a result, by the early to mid-1990s, Taiwan would have faced severe challenges in diverting irradiated fuel without being detected by the IAEA early in the diversion process.

PLUTONIUM SEPARATION PLANT

While plutonium remains in irradiated fuel, it cannot be used in nuclear weapons. The spent fuel must be chemically processed and the plutonium separated and purified before being fashioned into nuclear weapons components.

In an attempt to avoid U.S. discovery, Taiwan was building a plutonium separation plant away from INER at a CSIST military site not linked to any nuclear program. It certainly had not been declared to the IAEA. In early 1988, the reprocessing building was well along toward completion. The project had started in about 1983, according to Chang. The plant was designed to separate approximately 10-20 kilograms of plutonium per year, according to a knowledgeable former U.S. official.

The site is still under the control of CSIST and is now called the Lung-Yuan Research Park. We did not learn what its name was in 1987. Figure 9.1 is a 2018 Google Earth image giving an overview of the Research Park and identifying the location of the former reprocessing plant. Figure 9.2 is a February 2004 Digital Globe commercial satellite image of the plant and its immediate surroundings. We were unsuccessful in acquiring high resolution commercial imagery from the 1980s.

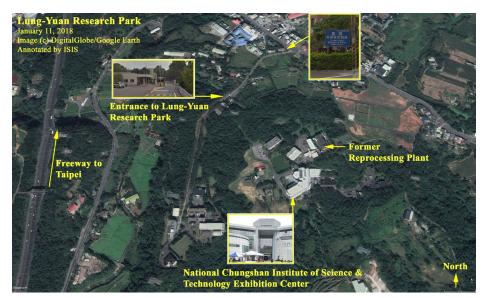


Figure 9.1. The Lung-Yuan Research Park in 2018. Most notable is the addition of a CSIST Exhibition Center years later near the former reprocessing building. CSIST Exhibition Center image credit: Central News Agency

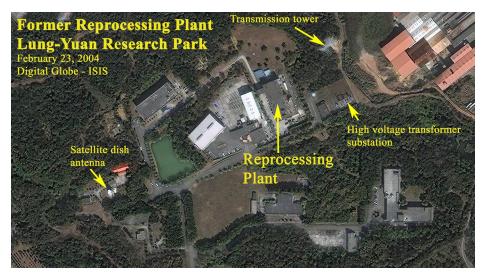


Figure 9.2. The reprocessing building as it appeared in 2004. While the immediate surroundings appear to have undergone construction since the United States visited the site in 1988, the building itself seems to have remained largely the same (from the outside).

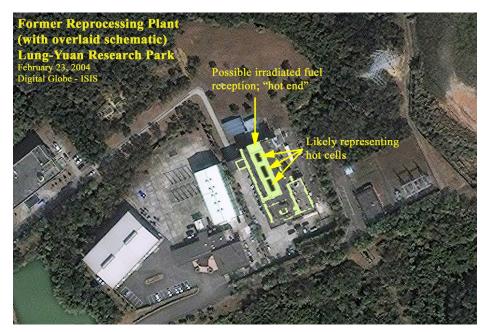


Figure 9.3 shows a reconstructed schematic of the interior of the building, overlaid on a 2004 Digital Globe image, and how the interior was organized to serve its original purpose: separating plutonium for Taiwan's nuclear weapons capability.

Unlike in more recent commercial satellite images, the reprocessing building in 1987 was relatively isolated from any other buildings at the site. The plutonium separation building was (and still is) about 30 to 40 feet tall. The main section is about 20 meters wide by 50 meters long. It is difficult to say that it looks like a typical reprocessing building, which can be far longer than wide. Figures 9.3 and 9.4 show the building in more detail.

We did learn that it was built in a manner to hide its purpose from overhead surveillance. Chang said in interviews that he may have unknowingly revealed the site to the United States, although he did not know about its specific purpose. According to Chang, he had visited an area where several of his chemical engineering friends and colleagues worked. The reprocessing area, which was controlled by the military, may be the same area that Chang visited. It hosted buildings related to biological and chemical agents and was known to Chang under the code name Ching Shan, or "Green Mountain."

According to two knowledgeable officials, the reprocessing plant had a classical design, with multiple, thick-walled, concrete hot cells. Because of the intense radiation emitted by irradiated fuel, the processing occurs in these hot cells. The building had a basement that was about three meters or so deep that contained two hot cells, one longer than the other. The



Figure 9.4 is a more recent 2018 Google Earth image of the building. The angle at which the satellite photo was taken reveals additional features of the building.

building had a first and second floor, with three hot cells on each level. There was a maintenance corridor on each floor running along the hot cells. It is possible that the three or fewer hot cells on the first and second floor extended for two stories. These floors had remote manipulators and windows and comprised the main working areas to process the irradiated fuel and separate the plutonium. Above the second floor was a "make-up" gallery that held a crane and this was where chemicals could be mixed for use below. Because a reprocessing plant works with the use of gravity, the basement would likely have held containers for nuclear waste, including discarded fuel cladding sections or other wastes generated during the processing. Typically, once operational, no one would enter any of the hot cells.

We attempted to locate the position of the hot cells in the building (see Figure 9.3). In addition, what looks like an elevator shaft is at one end of the building (see Figure 9.4). Experts assessed that the irradiated fuel would have entered the building from the opposite end with the elevator shaft. No stack or exhaust vents are visible in the available images and we do not know if one had been built by the end of 1987. However, something would be expected to have been built at the end where the irradiated fuel is initially processed. A stack or vents are for exhausting radioactively contaminated air that passes through the hot cells and a subsequent filtration system. Typically, a stack is used to dilute radiation levels downwind of the building.

Taiwan did not provide a process flow sheet for the plant, as far as we could determine. A reprocessing plant like this one would have comprised several sections, including:

- Chopping or cladding removal
- Dissolution of the decladded fuel elements
- Coextraction of the uranium and plutonium from the fission products
- Extraction/separation of plutonium
- Stripping of uranium
- High level waste tanks
- Medium level waste tanks

It is unclear what would have been the chemical form of the separated plutonium. Chang thought that plutonium metal would have been the likely end state, ready to be shipped to a plant to fabricate it into nuclear weapon components. In that case, the facility would have had a plutonium conversion line to go from oxide form to metal, as INER had deployed on a small scale in INER's Plutonium Fuel Chemistry Laboratory in the 1970s. This line does not require operation in hot cells but in glove boxes in a few labs. There should have been an area converting a fairly large volume of uranyl nitrate into uranium oxide.

Overall, the hot cells seemed designed to separate plutonium from TRR irradiated fuel and not to separate plutonium from light water reactors. However, this could not be confirmed.

When the authors asked experts about this plant, one speculated that its process design likely most closely approximated a European reprocessing plant. Although there are other possibilities, one model could have been the German reprocessing plant, WAK,³⁶ which had a capability of reprocessing about 35 metric tonnes of uranium per year and had hot cells organized on several levels. The speculation was based in part by Taiwan's 1960s and 1970s efforts to acquire a reprocessing plant in Germany. Although these discussions ultimately failed, during the contract discussions, Taiwan may have received a range of designs, plans, and procedures relevant to building a reprocessing plant. More generally, INER officials had built up relations with German, French, Dutch, and Belgian reprocessing experts in the 1960s and 1970s, who could have been sources of unofficial technical assistance for a reprocessing plant.

By early 1988, Taiwan had acquired from abroad and had already installed in the hot cells some equipment, including specialized manipulators to allow workers to move objects inside the hot cells while they remained safely outside. It also procured especially thick, specialized windows to allow workers to safely peer into the hot cells that had not yet been installed by 1988. According to Chang, most of these procurements had happened from 1984 to 1988. He said that Taiwan was capable of domestically producing dissolvers and fuel chopping equipment.

Chang's friend Wang Wei-ko was in charge of the chemical engineering department and responsible for building this plant. Wang told him that the reprocessing plant would be finished on schedule, although

Chang did not know the exact date. Estimates of 1989 or 1990 for initial operation appear reasonable.

Based on information about the site in the late 1980s, near to the reprocessing building was an area with concrete plates, implying that perhaps another building may have been removed. It is not known if another building at this site was where Taiwan conducted small-scale plutonium separation experiments in the 1970s (see Chapter 6). However, no evidence of this activity has been discovered. For example, Chang said he was unaware of that activity.

Cover Story. As with many of its nuclear weapons related projects, Taiwan created an extensive cover story for its reprocessing facility. It said that this plant was to separate molybdenum-99 (moly 99) from targets irradiated in the TRR. However, this cover story was not very compelling, although the plant could have been used for this purpose. Why build it in secret, at a military site? That alone would increase suspicions and protests from the United States. Moreover, the facility was much too large for a moly 99 plant. Later, during IAEA inspections in 1994, Taiwan's officials stated forthrightly that the true purpose of the facility was plutonium separation (see Chapter 11).

As discussed in Chapter 8, Taiwan's moly 99 program was a reality, and it included other facilities to package the moly 99 for medical use and a hospital that would administer treatments to patients. But Chang said in interviews that while on the surface, the program looked peaceful and all written documents confirmed that, its misuse as a cover story to build a capability to separate plutonium for nuclear weapons was always in the minds of the team.

The cover story also aided Taiwan in acquiring needed equipment and technology. To gain additional expertise in moly 99, Taiwan sent "quite a few people" to the U.S. Department of Energy Oak Ridge facility for training, according to Chang. Under this cover, Taiwan could more easily buy equipment for the reprocessing plant. Although much of the equipment for the moly 99 program was procured openly, Taiwan also used illicit procurement networks to obtain sensitive goods.

WEAPONIZATION

By the late 1980s, Taiwan had made substantial progress on designing, developing, and learning to make nuclear weapons using plutonium. Since this weaponization effort's small start in the mid-1960s, at a time when Chang first started modifying nuclear reactor safety codes for nuclear weapons, it had grown and accomplished much. Taiwan had worked on miniaturization of implosion-based nuclear warheads since the 1970s, and by late 1987, it was moving from a spherical implosion design to a miniaturized nuclear device that would fit under its domestically-manufactured attack aircraft (see below).³⁷

To reduce the device's diameter, the nuclear core was designed to be oval-shaped. With an oval design, the high explosives are concentrated on the ends and little high explosives are on the side of the device, making the device narrower. After compression, the shape of the core returns to spherical.

Taiwan's nuclear weapons program contained many divisions that included teams working on computer codes; designing, testing, and making critical high explosive lenses; conducting key experiments for gathering nuclear weapons development data; developing expertise in manufacturing metal components from plutonium and uranium; and conducting cold tests of nuclear explosions. For example, Chang gave an example that engineers and technicians improved micro-switch timing accuracy from microseconds to about 100 nanoseconds for use to trigger the high explosive lenses and neutron initiator.³⁸

These computations depended critically on the quality, memory, and speed of the computers running the codes. As a result, Taiwan made the acquisition of powerful computers a priority. The nuclear weapons program took advantage of other countries' supercomputers to learn more about software and test their codes prior to obtaining its own supercomputer.

Insight into Taiwan's methods has been provided by David Ho, who was the first insider of the nuclear weapons program to write about his experience in a book. He has provided many useful insights into the program. In a short draft biography that he provided the Institute several years ago, he wrote that in the 1970s, a major part of his work was the computer simulation of atomic bomb neutron performance and neutron power distribution.³⁹ In his published 2015 book, he provides more details about his simulation work for the nuclear weapons program.

Without test results from a nuclear explosion, Ho said the team could not verify the accuracy of their computer's results. Moreover, the software on the market that simulates neutron behavior in three dimensions is mostly for commercial nuclear reactor applications and subject to export controls that would forbid exports to Taiwan. Software to simulate nuclear weapon detonations therefore had to be written. However, the codes are extremely difficult to write, in particular writing them so that the results were accurate.⁴⁰

As a result, the team developed other solutions. One was Ho taking a post-graduate research position at the University of California at Berkeley in 1983 to access via a university terminal the then-fastest supercomputer in the world, a recently released Cray computer. Ho's position was organized by a university professor of Chinese descent that he referred to as "Dr. C." Dr. C was a consultant to Taiwan's nuclear project and worked with a U.S. company on developing nuclear power reactor simulation software. This professor, who was also a friend and colleague of Dr. Wu Ta-you's, was suspected by U.S. officials of having provided nuclear-related software to Taiwan in the 1970s.

During Ho's year at Berkeley, he used this computer with the aid of Dr. C to further refine and test his computer calculations. Ho accessed export-controlled, three-dimensional nuclear commercial software that Taiwan could not purchase and input a set of codes that were then calculated in the controlled software. Then, the results from the controlled software could be compared with INER's results from running their own software at CSIST on this ostensibly civil calculation. If there were differences, the team could adjust the software until the number stayed within an acceptable variation. In this way, the team became more confident in its own software. Later, the team would use the refined code to run the real figures it wanted to test for the nuclear weapons program.⁴² Ho wrote that his job at Berkeley was similar—to continuously do this type of testing work.⁴³ INER or its officials would also hire foreign firms to run their input values on controlled software.⁴⁴

Dr. C also helped Taiwan buy its own supercomputer from the Japanese Fujitsu Company.⁴⁵ Although the authors learned Dr. C's identity, we did not make contact.

According to Chang, a major milestone was in 1984, when Taiwan established a supercomputer laboratory at CSIST/INER able to run codes

for designing and verifying miniaturized nuclear designs, determining the energy release, improving the efficiency of the design, predicting its explosive yield, improving the reliability of a nuclear explosive, and optimizing the warhead's design.⁴⁶ We assume that this was the Japanese supercomputer.

From a modest beginning, Taiwan built a sophisticated group of specialists who worked on nuclear weapons design and simulations. In the 1980s, according to Chang, the priority was to develop codes for designing the high explosives for nuclear weapons, the best configuration for the nuclear core, and minimizing the radius of the assembly. They conducted design sensitivity analysis to optimize and minimize the amount of high explosives needed and the size of the core. The goal was a reliable, miniaturized device that could achieve a yield of ten kilotons, according to Chang.⁴⁷ They settled on ten kilotons being enough, since a higher yield would inevitably lead to a larger device that would undermine their priority of miniaturization.

The theoretical, or simulation, work was complemented by a team that had over the years developed key data and techniques for nuclear weapons via a range of tests, including high explosive tests, detonating system tests, and projectile tests involving flying plates. This team's usual cover story was anti-tank work.

Originally, the program was working on a beryllium-polonium neutron initiator, of the type used in early U.S. nuclear weapons. However, the program acquired a neutron generator, and the program was apparently trying to develop a miniaturized version for nuclear weapons. The authors were unsuccessful in learning the status of this effort in 1987, or whether Taiwan had moved on to a different type of neutron initiator.

Acquiring and developing fast electronics was a CSIST priority starting in the 1970s. In 1981, Taiwan decided to greatly expand its electronics industry. Nonetheless, Taiwan continued to seek from abroad fast electronic equipment for nuclear weapons. It obtained fast firing devices, e.g. Krytrons, from a U.S. supplier, which Taiwan falsely declared as being for jet ejection seats, according to knowledgeable U.S. officials. Krytrons are ideal for use in triggering a nuclear weapon.

In sum, CSIST focused on creating an oval core of delta-phase plutonium metal and a "levitated," optimized, miniaturized design. In Chang's words, "The latter was 'to design a multipoint flying plate implosion shock wave system which could compress plutonium faster and more stably in order to reach its criticality." ⁴⁹

The leadership of program also had a passing interest in thermonuclear research for both civil and military applications. In September 1982, General Hau met with a Professor Hsu Chia-lun, who suggested Taiwan start researching controlled nuclear fusion, such as via plasma fusion. Hau saw the nuclear weapons potential, although he realized that any military application would not be ready for years in the future. Nonetheless, Hau wanted Taiwan to set up a fusion research center at CSIST, train "high energy physicists interested in this area and acquire necessary equipment." He noted that he would want to first consult with experts such as Wu Ta-you, but if they advised in favor, the military could fund the effort. ⁵⁰ However, the main goal of the nuclear weapons program remained developing a reliable, miniaturized fission weapon.

Other Sites. In addition to the main CSIST sites, the nuclear weapons program had high explosive testing capabilities at two, or possibly more, sites. For these sites, Taiwan procured streak cameras and flash x rays, two fast-acting diagnostic tools critical to understanding experiments with high explosives components of nuclear weapons. According to Chang, INER did not procure this equipment; instead it relied on other governmental procurement channels, implying that this equipment was likely procured secretly or at least discretely without tying its use to any nuclear project.

The authors identified a smaller test facility at a reported army site not far from the reprocessing facility and bordering a golf course that was used by the nuclear weapons program. Figures 9.5 and 9.6 show commercial satellite imagery of the site taken in 2004 and 2017, respectively. The site looked like a shooting range, as can be seen from the placement of a large earthen berm at the end of a field. One facility believed to be part of the nuclear weapons program in the 1970s, and perhaps later, is annotated as a "flash x ray experiment bunker." This bunker may have been involved in testing small amounts of high explosives using a flash x ray. From the imagery, it could not be determined if, when the tests occurred, the diagnostic equipment was inside the bunker and the small high explosive test was conducted outside, similar to the types of facilities that existed in South Africa at Pelindaba in the 1970s or at the Potchefstroom

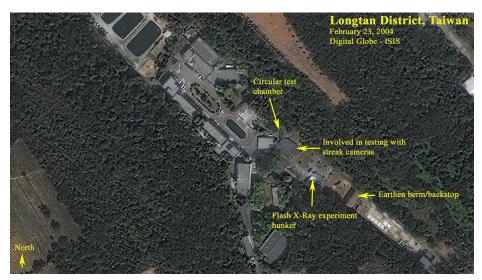


Figure 9.5. A military facility where CSIST/INER is believed to have conducted small-scale high explosive and other tests related to the development of nuclear weapons.



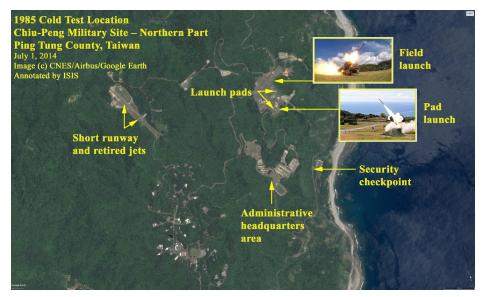
Figure 9.6. A close-up of the main facilities believed to have been used by the nuclear weapons program.

high explosive site in the 1980s.⁵¹ Alternatively, a small amount of high explosive could have been tested in a specialized chamber and the flash x ray situated outside the chamber.⁵² Another facility at the CSIST site was an indoor facility that used streak cameras in conducting explosive tests, apparently related to developing nuclear weapons, although not high explosive tests. The purpose of an adjacent circular test chamber could not be ascertained.

The nuclear weapons program also used larger high explosive testing capabilities at the Chiu-Peng (also referred to as Jioupeng) military missile testing range in Ping Tung in the south of Taiwan (see Figures 9.7 and 9.8). There, it could on short notice conduct full cold tests of the device, which simulate a plutonium implosion device using uranium as a surrogate material for the plutonium. This type of test is as close to an actual nuclear detonation as possible in the absence of any plutonium and a nuclear yield. This type of experiment provides important information about the firing, assembly of the device, and the performance of the neutron initiator. Moreover, such a test would allow for certifying that the design would work. To conduct these tests, the site was outfitted with a high explosive test site and fast diagnostic equipment, including a streak camera. This approach to certify that a nuclear weapon would work as planned was also used by Pakistan in the mid-1980s and was being planned by Iraq in 1991, when its program was ended by the first Persian Gulf war.

In about 1985, Taiwan successfully conducted a cold test at Chiu-Peng, according to Chang, who visited the site twice. It was likely not a miniaturized design; for example, it may have used a relatively large neutron generator, Chang reported. Although Chang did not witness the test, his colleagues told him that it was a great success in establishing the final configuration of the device and showed that "everything went successfully." The data collected from this test was sent to the simulation team, which ran the data at the supercomputer center, making revisions and further optimizing the design.

The weaponization program acquired a wide range of equipment and technology. In addition to streak cameras, flash x-rays, software, and high-speed switches, it acquired high-speed oscilloscopes and a great volume of open source information in the United States related to nuclear weapons development, in particular information made available by the U.S. Plowshares program to use peaceful nuclear explosions for civilian





Figures 9.7 and 9.8. 2014 Google Earth images of the northern and southern part of the Chiu-Peng military testing site which hosted the 1985 cold test simulating a plutonium implosion explosion. The location of the 1985 cold test could not be determined at this site. It is unclear if the facilities still exist, as these particularly facilities could have been dismantled in 1988. The military base still exists today and most recently in June 2018 was used to conduct tests of domestically designed and produced missiles.⁵³ Missile launch imagery credit: Ministry of National Defense R.O.C.

applications. There are suspicions that the program also acquired classified information about nuclear weapons.

In 1984, the program obtained a high temperature vacuum induction furnace from abroad able to melt heavy metals, like uranium and plutonium.⁵⁵ This type of furnace is critical for melting and casting uranium and plutonium metal components for nuclear weapons. Although Taiwan is not believed to have had a significant amount of plutonium in 1984, this furnace would be critical to any future nuclear weapons manufacturing, or alternatively, to fashioning uranium metal components of

IRAQ VS. TAIWAN

The authors asked Dr. Chang to compare Taiwan's nuclear weapons program to parts of the Iraqi nuclear weapons program as described in the official Iraqi *Full, Final, and Complete Declaration (FFCD)*. The Iraqi program ended in 1991 following the Persian Gulf War, and after the defection of Saddam Hussein's son-in-law in 1995, Iraq decided to reveal all its nuclear weapons activities to the IAEA.

Chang reviewed a part of the declaration on nuclear device development. When he worked on developing the nuclear weapons computer codes in the 1960s before he went to the United States, his theoretical work was more advanced than Iraq's work described in this section of the FFCD. He said that he reached the stage of Iraq's work during the one or two years he worked on creating nuclear weapons codes.

Iraq had not yet reached the state of adjusting its key equations for higher pressures and temperatures that would be experienced in a nuclear explosion and are classified. He said Iraq had not yet done the experiments to generate the necessary data.

Another contrast with Iraq was that Taiwan was well-supplied with technicians that could set up and run experiments associated with developing nuclear weapons. As a result, the Taiwanese nuclear weapons program was much more capable of putting together and running experiments relevant to nuclear weapons research and development.

nuclear devices. Obtaining such a furnace was far easier in the 1980s because most supplier countries did not apply strict controls on this type of furnace until the early 1990s.

In 1987, the nuclear warhead design was close to being finished, according to Chang. But the design had not yet been finalized. The diameter of the design was about 60 to 70 centimeters, Chang said, including its casing. Its mass was up to 900 kilograms.

Taiwan's plan at that time was to place a nuclear warhead inside the external fuel tank to be mounted under an indigenously built attack aircraft that Taipei was building in the 1980s (see below). Chang said that the nuclear weapons team had received design data on the external fuel tank and needed to produce a warhead design that would be about 50 centimeters in diameter in order to fit into the tank, meaning that the program had more miniaturization work to do. In addition, the delivery of the warhead was being contemplated as essentially a bomb dropped via the sky.

The air force's role in the nuclear weapons program was only just starting. Chang did not think concrete designs to arm and deploy the warhead on the aircraft yet existed or that pilots had been trained to deliver a nuclear weapon. However, at the request of the nuclear weapons team, the military was working on extending the range of the attack aircraft to be used to deliver a nuclear weapon to 1,000 kilometers (see below).

Absent a full-scale underground test, the nuclear weapons program remained highly dependent on computer model simulations. Taiwan proved, however, that its computer simulations, coupled with experimental data, were good enough to design nuclear weapons.

DELIVERY SYSTEM

Taiwan's breakout strategy depended on having an ability to deliver a nuclear warhead to targets in the PRC. By 1987, Taiwan did not have a way to deliver nuclear weapons except on outdated U.S.-supplied aircraft. However, it was getting close to producing the first prototype indigenous defense fighters (IDFs) that could deliver a nuclear weapon. Earlier efforts to develop nuclear-capable ballistic missiles were thwarted by the United States.

In 1982, President Ronald Reagan decided not to sell Taiwan advanced U.S. attack aircraft. He reckoned that such a denial would build

better relations with the PRC. In response, Taiwan launched its own program to build a modern indigenous attack aircraft. Although the Reagan administration blocked Taiwan from buying F-16 and F-104 aircraft, it did not block U.S. companies from providing technical assistance on building its own version. This assistance enabled Taiwan to launch an ambitious project with the extensive support of U.S. defense contractors.

General Hau discussed in his diary setting up the infrastructure to build the IDF. According to a January 5, 1983 entry, the Aerospace Industrial Development Center was moved under CSIST.⁵⁶ He believed that only CSIST could integrate Taiwan's resources and capabilities successfully to develop a high-performance fighter. Thus, the same group in charge of developing nuclear weapons would then also develop Taiwan's primary warhead delivery system.

The first prototype of the IDF was rolled out in December 1988.⁵⁷ It was named the "Ching Kuo," after President Chiang Ching-kuo. Production models were delivered starting in 1992 and they were introduced into service in 1994.

Although Taiwan developed this aircraft with foreign-made parts, it was not under any restriction regarding their use. As a result, Taiwan was free to modify and use the aircraft as it saw fit.

The goal of the nuclear weapons program was to be able to deliver a nuclear weapon out to a range of at least 1,000 kilometers so that Taiwan could better attack the PRC. However, because the nuclear warhead would be in the external fuel drop tank, sacrificing critical extra fuel, and add weight, the aircraft's range was expected to be less than 1,000 kilometers if it were carrying a nuclear weapon. As a result, according to Chang, in order to achieve this range, the aircraft's designers were planning to reduce the ability of at least one of the aircrafts to accelerate rapidly, something needed in a "dog fight" with enemy aircraft but not to deliver a nuclear weapon. By making adjustments in the aircraft's engine, the designers were able to ensure that the aircraft could have a maximum range of over 1,000 kilometers.

Even with an extended range, Chang raised the question in his book about whether the nuclear-armed aircraft would have enough fuel for a return flight. If not, the pilot would have to bail out over the PRC, in essence possibly conducting a suicide mission.⁵⁸

The aircraft deployment date provides some concrete insight into when Taiwan would have been prepared to break out to nuclear weapons. Although in an emergency it could have used prototype IDFs, Taipei still needed until late 1988 before its first protype IDF was delivered and several more months before the first one was flight tested. If Taiwan wanted to wait for production models, it would have required waiting another three years. Thus, a potential bottleneck in Taiwan's breakout strategy was the delivery vehicle, although in the worst case, a nuclear weapons delivery capability could have been achieved in mid-1989, after flight testing.

Taiwan's original delivery system of choice for a nu-**Ballistic Missiles.** clear weapon was a ballistic missile to be developed by CSIST. In the early and mid-1970s, Taiwan worked on developing a ballistic missile with a range of 110 kilometers, but it was not expected to be operational before 1980.59 It was called the Green Bee and could carry a 200-kilogram payload. 60 This missile was viewed as a stepping stone toward the development of longer range ballistic missiles. In the late 1970s and early 1980s, CSIST used progress on this missile to help it develop the solid-fueled Tien Ma (Sky Horse) ballistic missile, with a range of almost 1,000 kilometers, but with a limited payload. 61 Its original purpose, according to Chang, was to be able carry a nuclear warhead for use against the PRC. However, the Tien Ma project was terminated before it was deployed in the early 1980s under U.S. pressure, and as a result of other CSIST priorities, namely development of anti-ballistic missile systems. This cancellation apparently did not end U.S. suspicions about Taiwan's missile program at CSIST.

Hau wrote in his diary on September 30, 1984: "The US may be suspecting that our missile development could be related to nuclear weapon development. They have no right to interfere with our research on ground-to-ground missile." He evidently believed that missile work was outside the scope of the April 1977 secret agreement. Moreover, he also expressed concern about U.S. infiltration of CSIST, writing that "this incidence shows that there are issues in CSIST's confidentiality policy or practice."

Hau was also looking for outside experts to help Taiwan's missile program. His diary entry for September 6, 1985 stated:⁶³

Dr. L graduated from National Southwest Associated University, got his Ph.D. from MIT, and is a retiree from Boeing in Seattle where he used

to work on missile development. Today's the first time I met Dr. L. I got to know he is an expert about missiles. He had been to the mainland before. I heard the CCP is also trying to recruit him. Hsu, Hien-Hsiu hopes Dr. L will join CSIST, and therefore invited him to Taipei. After his visit to CSIST, Dr. L was really impressed by how much CSIST had improved. If Dr. L sincerely wants to service our nation, I reassured him that I would not mind his prior visit to the mainland, as long as he is loyal to our country and his background checks out with no security concern.

However, despite all this missile work, CSIST appears to have avoided work on nuclear-capable ballistic missiles in the 1980s.

Later, in the 1990s and 2000s, Taiwan would successfully use the argument that it had given up nuclear weapons to build a stronger case for making longer range, conventionally-armed missiles. CSIST continues to develop these missiles today.

NOTES

- 1 Hau Pei-tsun, *Diary during my Eight Years as Chief of the General Staff* (Taipei: Commonwealth Publishing, 2000) (Translated by the Institute for Science and International Security, 2018), p. 722.
- 2 Interview by the authors with Chang Hsien-yi, July 26, 2018.
- 3 Interviews with Chang Hsien-yi, Washington, D.C., June 2017. There is some debate on the exact chronology of the events described in this first part of Chapter 9. As far as we could determine, Taiwan's military did not keep written records of meetings discussing nuclear weapons and memories can fade with time.
- 4 Hau, Diary during my Eight Years, p. 729.
- 5 Interviews with Chang Hsien-yi, Washington, D.C., June 2017; Chang, "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points," undated (Translated by Institute for Science and International Security, 2017).
- 6 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 7 Hau, Diary during my Eight Years, p. 906.
- 8 Ibid.
- 9 Interview by the authors with Chang Hsien-yi, July 26, 2018.
- 10 As described in Chang's memoir by Chen Yishen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi* (Taiwan: Walkers (Yuan Zu Wen Hua), 2016), (Translated by the Institute for Science and International Security, 2017), Chapter 3; Interviews with Chang, Washington, D.C., June 2017.
- 11 Albright with Stricker, *Revisiting South Africa's Nuclear Weapons Program* (Washington, D.C.: Institute for Science and International Security, 2016).
- 12 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 6.
- 13 Ibid; Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 14 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, p. 162.
- 15 Unalloyed plutonium at room temperature forms into the alpha phase. It is difficult to machine since it is brittle and subject to phase changes even when heated only somewhat. Alloying the plutonium with other materials, typically gallium, produces plutonium in the delta phase which is stable at room temperature. Moreover, the delta phase plutonium is more workable than alpha phase and can be welded when assembling weapons components. The density

of delta phase is less than that of alpha phase, easing its compressibility in the initial stages of an explosion.

16 Interview by the authors with Chang, August 2, 2018.

17 Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium 1996* (Oxford: Oxford University Press, 1997), citing data from the U.S. Department of Energy. The average density of plutonium in the irradiated fuel elements was about 52.6 grams of plutonium per fuel element.

18 See also Stephen Engelberg with Michael R. Gordon, "Taipei Halts Work on Secret Plant to Make Nuclear Bomb Ingredient," *The New York Times*, March 23, 1988.

19 J.R. Phillips, T.R. Bement, C.R. Hatcher, S.T. Hsue, and D.M. Lee, "Nondestructive Verification of the Exposure of Heavy Water Reactor Fuel Elements," Los Alamos National Laboratory, LANL-9432, June 1982. A 1983 IAEA publication gives the nominal core loading as eight metric tonnes with a burnup of 800 MWth-d/tonne. See James A. Power, "Safeguarding Research Reactors," IAEA Department of Safeguards, STR-118, March 1983.

20 Albright et al., *Plutonium and Highly Enriched Uranium 1996*. By 1991, under the take-back policy, the United States had received about all but 118 out of 1,600 fuel elements. According to Department of Energy data, the fuel rods received in the United States contained about 78 kilograms of plutonium, giving an average of 52.6 grams per element, where the 118 elements not returned are not included in the average.

- 21 Another example of the plutonium content in irradiated fuel is from a shipment of 91 irradiated fuel elements in 15 containers, which may be part of the last one that was blocked by a court order from coming to the United States [Source: Undated table from Rod Fisk, Edlow International Company]. These 91 fuel elements, with a mass of 4.632 metric tonnes, contained 4.1 kilograms of plutonium, or an average of 42.2 grams per fuel element. The fuel elements had an average of 0.86 kilograms of plutonium per metric tonne of uranium and the uranium had an average of 0.6162% uranium 235. The irradiation level, or burnup, was not provided but these elements appear to have had a lower burnup than that of the fuel rods discharged in 1977 and discussed above. The plutonium may not have been weapon-grade but it would contain more than 90 percent plutonium 239, which is high quality plutonium.
- 22 The fuel burnup of each fuel element varied from 100 to 1000 MWth-d per metric tonne of uranium.
- 23 Albright et al., Plutonium and Highly Enriched Uranium 1996.

- 24 This estimate assumes a capability factor of 65 percent and a fuel burnup of 1200 MWth-d/metric tonne of uranium.
- 25 Cable from Secretary of State to American Embassy in Ottawa, *Taiwan Research Reactor (TRR) Conversion*, November 15, 1986.
- 26 Memorandum from OES-John Negroponte to Ambassador Richard T. Kennedy, *Taiwan Research Reactor (TRR) Spent Fuel*, March 13, 1986.
- 27 This estimate assumes the reactor would have a capacity factor of 80 percent.
- 28 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 29 Department of State, *Chronology of TRR Conversion/Spent Fuel Return Program*, undated.
- 30 Cable from Secretary of State to American Institute in Taiwan, Taipei, *Meeting at Brookhaven on TRR Improvement*, November 23, 1987.
- 31 Ibid.
- 32 Ibid.
- 33 Cable from Secretary of State, to a recipient that was not declassified, *Assistance to TRR Conversion*, December 22, 1987.
- 34 E-mail exchange between Albright and Chang, August 22, 2018.
- 35 See for example, IAEA "Evolution of IAEA Safeguards," *International Nuclear Verification Series*, No. 2, 1998. Available at: https://www-pub.iaea.org/books/iaeabooks/5264/The-Evolution-of-IAEA-Safeguards
- 36 WAK is short for Wiederaufarbeitungsanlage Karlsruhe.
- 37 Chen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi*; Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 38 Chang, "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points."
- 39 David Ho, Short biography provided to Institute for Science and International Security, circa 2002.
- 40 Liwei He (David Ho), *Nuclear Bomb MIT: "A" Bomb Made in Taiwan* (Taipei: Women Chubanshe, 2015), p. 69.
- 41 Ibid, p. 66.
- 42 Ibid, p. 70.
- 43 Ibid.
- 44 Ibid.

- 45 Ibid, p. 67.
- 46 Chang, "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points."
- 47 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 48 Ibid.
- 49 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 6.
- 50 Hau, Diary during my Eight Years, pp. 180-181.
- 51 Albright with Stricker, *Revisiting South Africa's Nuclear Weapons Program*. See for example Figure 2.5, which may be similar to a smaller version of the CSIST facility.
- 52 A larger version can be seen in Albright with Stricker, *Revisiting South Africa's Nuclear Weapons Program*, Figures 7.12-14.
- 53 Teng Pei-ju, "Taiwan President inspects missile launches during Han Kuang military exercises," *Taiwan News*, June 5, 2018, https://www.taiwannews.com. tw/en/news/3448795
- 54 Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 55 Chang, "Taiwan Nuclear Weapons R&D Chronology of Events/Talking Points;" Interviews with Chang Hsien-yi, Washington, D.C., June 2017.
- 56 Hau, Diary during my Eight Years, p. 252.
- 57 "IDF Dedicated to Late Pres. Chiang," Central News Agency, December 12, 1988.
- 58 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 6.
- 59 Central Intelligence Agency, Defense Intelligence Agency, and Bureau of Intelligence and Research, Department of State, Declassified Interagency Intelligence Memorandum, *Prospects for Arms Production and Development in the Republic of China*, NIO IIM 76-020, May 1976, p. 3.
- 60 Ibid, p. 7.
- 61 See for example: "Paper Views Development of Medium Range Missiles," *Lien Ho Pao (United Daily News)*, Taipei, November 17, 1982.
- 62 Hau, Diary during my Eight Years, p. 615.
- 63 Ibid, p. 797.

CHAPTER 10 FINAL DENUCLEARIZATION

One morning in January 1988, Colonel Chang Hsien-yi, secret informant of the Central Intelligence Agency and a deputy director of INER, failed to show up for work. He was scheduled to return from a vacation.

Former INER scientist, David Ho, recounted that Chang was supposed to lead a regular 8 AM meeting on January 12. Ho, one of Chang's section leaders, was scheduled to deliver a report. After a half hour, with 10 to 20 people waiting, the meeting was ended. Several people decided to go to his house to check on him, which was two minutes away. They rang the doorbell and even climbed his backyard wall. The house was empty. His colleagues were increasingly worried about his safety. They phoned his parents, but even they had not heard from him. Ho reported that Chang's car was found later in an eastern mountainous region of Taiwan.

Allegedly, scenes of alarm and disarray occurred over the next few days at INER, as still no one had heard from him or his family. Dr. Chang's office and residence were cordoned off and searched as it became clear that he, along with his wife and children, had vanished.² The disappearance of any individual would certainly have warranted worry. However, in the case of a missing high-level engineer who had direct knowledge about a secret initiative to produce nuclear weapons in Taiwan, it ignited sheer panic.

SHUTTING DOWN THE PROGRAM ONCE AND FOR ALL

The United States had been in a cat and mouse game with Taiwan over its nuclear program for years. For the last several years, Chang had provided a detailed look into how the violations of the secret April 1977 agreement between Washington and Taipei on limiting the program were increasing, not decreasing. Information indicated that Taiwan was maintaining its nuclear weapons development work, including conducting computer simulations and high explosive tests. The United States also strongly suspected that Taiwan was building a relatively large reprocessing plant at a CSIST military facility near the Shihmen dam. However, the program was still at least a year or two from having a three to six-month breakout capability, as General Hau Piet-sun had ordered a few years earlier, even while Taiwan maintained that it would not build nuclear weapons.

Despite there being more time to play whack-a-mole with Taiwan's nuclear infractions, other reasons dictated a need to act soon—but not before exfiltrating Chang. The United States needed to check out new information about a suspected reprocessing plant and on-going nuclear weapons work, but a U.S. request to visit these sites would reveal it had inside information that could lead to Chang. However, the United States did not want to wait much longer to request a visit to determine conclusively whether Taiwan was building a reprocessing plant. It likely worried about the plant starting operations, which could complicate its shutdown because of radioactive contamination.

Washington also had pressing political reasons to act. In 1987, President Chiang Ching-kuo had not been in good health for some time, suffering from diabetes. He was expected to die soon. In early 1986, Chiang had announced that he had "no desire, no intention, and no plan" to pass on his presidency to his sons or brother.³ He stated that the succession to the presidency would follow the constitution, which meant that the vice president, Lee Teng-hui, would follow him. However, Lee, who was the first native Taiwanese to hold high office in the Kuomintang, was not part of the Chiang family dynasty. There were worries that instability would increase and over how the Kuomintang would evolve, including how the opposition political figures would react and what position Lee would take on the question of Taiwan's reunification with mainland China.⁴ Lee was also perceived to be less strong and charismatic than Chiang, and some

wondered if Lee could control General Hau and the military, or even stay in power.

Despite all his faults, President Chiang had proven himself willing to put some limits on the nuclear weapons program, including enforcing that nuclear weapons should not be built, even as Taiwan continued developing a nuclear weapons capability. There was a stability in Chiang's nuclear positions, especially since he was responsive to ending nuclear programs that the United States strongly objected to. However, the military still controlled the nuclear weapons program, and U.S. intelligence worried that Washington would not be able to prevent the nuclear weapons program from going forward, a step made more tempting as breakout timelines shrank, perhaps unhindered by the restraint exercised by President Chiang. A worry was that General Hau would be even freer to act after Chiang's death.

Dr. Chang explained that his last CIA handler, Mark, was even blunter in explaining the situation after his exfiltration. After the United States started to understand that decision making had shifted to General Hau, it decided that once President Chiang passed away, Hau would be a dangerous military strongman in charge of a threshold nuclear weapons capability. The Reagan administration had evaluated that the death of President Chiang would spell trouble for containing the development of nuclear weapons on Taiwan. Vice President Lee Teng-hui was not part of the inner circle of the nuclear weapons program. They feared Hau may try to seize power as a dictator.

All these questions about the inheritance of the nuclear weapons program following the expected death of President Chiang, combined with the program's on-going progress, led the United States to decide to rip out the program root and branch.

EXFILTRATION OF CHANG

Although the United States apparently decided that it was time for dramatic action, it required time to put its plan in place, which included ensuring that Chang was safely extricated from Taiwan. In mid-1987, the CIA asked Chang to take another polygraph test to ensure he was not a double agent. Around that time, Mark told Chang during one of their safe house meetings that a U.S. company wanted him to come to America for

a job position and asked if he was interested. He gave no time frame for when the job would start. Chang told Mark that he would be interested if his wife, two sons, and daughter could come.⁵ Mark responded that this should not be a problem. Chang discussed the possibility with his wife, and she was enthusiastic. Still, she had no idea what her husband had been doing. She had no notion that her life was about to dramatically change.⁶

Meanwhile, Mark told Chang that this "company" needed four to five months to arrange for his family to move to the United States. Chang did not ask questions. Eventually, he learned that the CIA wanted to exfiltrate him and that he would need to send his family away on a purported vacation. They still did not know the plan. He told them that following fulfillment of work commitments, he would join them on the vacation.⁷

Taiwan's military officials were not allowed to leave the island without permission. Chang sent his wife and children to Disneyland in Tokyo, Japan on January 8, 1988 just before he was extricated. Chang told his INER colleagues that he was joining his family on the vacation, and would return to work on January 12.8

That day, Chang went with Mark to sleep at the safe house. The next morning, Mark woke him, smiling, and told him it was time to go. He would never return to his home country, at least to date. He flew out of Taiwan's Kaohsiung International Airport located in southwest Taiwan to Seattle via Hong Kong. He was given a new passport with his actual photo and a U.S. visa. It listed him as an employee of the "American company" he was going to work for. He did not use his real name, Chang Sen-i, and media reports would later state that official government information did not show him leaving the country. To

Meanwhile in Tokyo, Mrs. Chang was approached upon landing at the airport. A woman handed her a letter from her husband. It read: "I am now in Taiwan. The company has made arrangements for me to fly to Hong Kong from Kaohsiung. From there I will fly to Seattle on a United Airlines flight. I will meet you in Seattle. Please follow Miss Lee's instructions during the whole process." His wife was shocked. "Miss Lee," who had handed her the letter, had previously met with the Changs in Taiwan. She was Chinese and spoke Mandarin and assisted the entire process."

Miss Lee promptly helped the family to a hotel and then took their passports to obtain visas at the U.S. embassy. Two days later, Miss Lee put the family on a plane to Seattle. Chang flew to Seattle on January 9 and

met his wife and children there on January 10. Next, they flew to Dulles International Airport in Washington, D.C. on January 12. They were met by security and three or four vehicles. For security reasons, they were told to get into the middle car.¹²

On January 13, 1988, some say in reaction to the shock of Chang's departure, while others say he may have never even known about it and it was sheer coincidence, President Chiang Ching-kuo died.¹³ That same day, KMT liberal and Vice President Lee Teng-hui was sworn in as acting president.

U.S. ACTION

Over the next two weeks following Chang's exfiltration, the U.S. government took a number of steps to end Taiwan's nuclear weapons program. Because of the seriousness of the situation, President Ronald Reagan personally sent a letter to President Lee calling for cooperation in ensuring that Taiwan's nuclear program was truly peaceful.

General Hau, meanwhile, did not yet know that the CIA was behind Chang's defection or the extent of his informant activities, but he was clearly worried and hoped that the crisis could be contained. He wrote in his diary on January 17:

INER's Deputy Director Chang Hsien-yi and his family just defected to the United States. He will for sure be manipulated by the CIA and give away the information that INER has resumed its nuclear research activities. It is our national policy that we will not make nuclear weapons but maintain the capability of making them. I have instructed [deputy for CSIST planning General] Yeh Chang-tong today to handle the issue so as to minimize damage.¹⁴

Only later would Hau learn that Chang had not defected but that he was part of a CIA operation and had been exfiltrated right before the U.S. government implemented its plan to denuclearize Taiwan.

On January 16, Chang met in Washington, D.C. with American Institute in Taiwan director David Dean and other Reagan administration advisors. Dean welcomed Chang to America on behalf of President Reagan and thanked him for his contribution to world peace. ¹⁵ He explained that

President Chiang's death had created pressure on President Lee to shutter the nuclear weapons program as a condition for U.S. support.

Dean asked Chang's opinion on "what to do" about General Hau and INER. He explained that Hau was still viewed by Washington as a threat to Taiwan's political development given fears that President Lee "had no real power," and concerns remained that Hau would try to seize control. The Americans had trusted President Chiang not to proceed with full, overt nuclear weapons development, but did not have the same faith in Hau. They were unsure how to proceed. The United States needed to decide what to do because Dean was returning to Taiwan to meet with Hau, and a U.S. nuclear team was ready to start the denuclearization process in Taiwan.

Chang replied to Dean that he hoped the United States would not try to get rid of Hau but focus instead on containing the nuclear program and any leakage of know-how. A U.S. priority should be preventing "an exodus of staff at INER" because "there would be inconceivable consequences if other countries who wanted nuclear weapons got hold of these well trained experts." He expressed that, for this reason, he did not think INER should be dissolved. He also thought that Hau could help stabilize the situation and boost morale. Hau needed to be told, however, that he had crossed a red line and had to accept the United States' terms regarding the nuclear program. Dean responded that President Reagan had already sent the secret letter stating his hopes that President Lee would cooperate with the agreement and with Dean. Dean said that President Reagan joked that if President Lee did not cooperate, Dean should stay in Taiwan and not come back.

On January 20, 1988, Dean met with General Hau. Hau wrote in his diary that Dean told him that INER must "dismantle all equipment relating to nuclear weapon development; take heavy water out of the TRR, and TRR should be no longer in use." He said that the United States was willing to cooperate with Taiwan on peaceful nuclear energy but implied that the cooperation was threatened. Dean also provided Hau with satellite images of the Chiu-Peng (also referred to as Jioupeng) military missile testing range in the south of Taiwan and stated that high explosive tests related to nuclear weapons development had occurred there. ¹⁸

Hua wrote in his diary that the United States had presented a non-negotiable memorandum to sign within a week regarding the full dismantlement of Taiwan's nuclear weapons program. Dean told Hau that the letter from President Reagan to President Lee presented similar demands. Hau's diary entry that day is defensive but he promised Dean compliance and cooperation. Hau remarked in his diary, "This incident is a serious crisis in Taiwan-US relations." He wrote, "I agree with the US' request to completely dismantle equipment related to nuclear weapon development. I will report my intent to President Lee." Although Taipei had one week to sign the memorandum, it apparently did so sooner.

By February 24, 1988, Hau had learned of Chang's CIA informant activities but recognized the need to move past the crisis, while also preventing any public commentary by Chang, writing in his diary:

Chang's defection was apparently an illegal action planned by the CIA. This is indeed a shame to our nation. However, considering Taiwan-US relations, we have to swallow the insult and let it go... I specifically ask [General Yeh] Chang-tong to notify David Dean that the US must contain Chang. Dean agreed.²⁰

IRREVERSIBLE DENUCLEARIZATION

Soon after Chang departed, a U.S. team of specialists arrived in Taipei to implement and verify the denuclearization. One nuclear specialist with valuable experience in the 1977 episode was waiting on standby in Hong Kong. He flew to Taipei only after it was clear that Chang had left. A concern was that if this particular person appeared before Chang departed, Taiwan's counterintelligence agencies would have been tipped off that something was seriously remiss on the nuclear file.

Taiwan quickly shut down the TRR in January 1988.²¹ To ensure that it could not be restarted, the heavy water was removed from the reactor. By as soon as March 1988, Taiwan had gathered over 20 metric tonnes of heavy water slated for sea shipment to the United States.²² Under U.S. supervision, the heavy water was packed in 100 drums, each of which was carefully weighed and received a U.S. Department of Energy seal.²³ On June 9, the 100 drums left Taiwan, and arrived at the U.S. Savannah River Plant on July 11.

Efforts to remove all the TRR irradiated fuel were accelerated. Up until early 1988, only 474 fuel elements had been sent to the United States. By 1991, another 1,000 irradiated fuel elements had arrived at

the Savannah River Plant. As discussed in Chapter 6, a U.S. federal court blocked the last shipment of 118 fuel elements because of environmental and safety concerns raised by U.S. environmental groups that opposed the shipments. This last batch of spent fuel contained about 5 kilograms of plutonium and remained at INER.

Taipei would publicly claim that the TRR closure was due to economic concerns. ²⁴ Unlike in the 1970s reprocessing crisis, the government's lack of acknowledgement to its personnel at CSIST and INER did not matter. This time Taiwan was being denuclearized and the changes could not be missed. There would be little left to reconstitute. CSIST and INER personnel were in shock at the extent and speed of the dismantlement. It was reported that some CSIST and INER people cried at having their life's work abruptly shut down. ²⁵

When the U.S. experts arrived at the suspect reprocessing building, it was largely empty. At the time, U.S. officials were unsure that it was a reprocessing plant. One said that "we were all unsure until we landed, until we walked up to the building, until we were inside the building, that this was a reprocessing plant." ²⁶ But once the team started looking around, it became clear it was a plutonium separation plant. Inside the building were manipulators, albeit only partially installed. Another sign that it was indeed a reprocessing plant was the observance of a pile of rusty looking gravel outside the building. When picked up, such gravel was heavier than expected due to being rich in iron. Iron-bearing gravel is key to high-density concrete, which is used to make hot cells. Overall, the evidence seen that day supported that the building was to separate plutonium from TRR fuel. The team felt vindicated about finding confirmation this time that, indeed, Taiwan had gone too far.

Chou Chen-chang, INER's new director, appointed in 1987 after Liu was promoted to Secretary-General of the AEC, accompanied the U.S. team to the reprocessing plant. The German-educated Chou maintained the false cover story about the purpose of the reprocessing facility, insisting that the site was for separating molybdenum-99 for peaceful purposes (see Chapter 9). One U.S. official lost his patience with the subterfuge and told the official to stop lying to him, an act which greatly upset INER officials and led to a formal diplomatic complaint.

The dismantlement plan called for taking all the manipulators, lead boxes, glove boxes, thick windows, and other equipment, throwing them into the hot cells in the basement, and filling them with concrete. Filling the basement required most of the island's concrete production, involving 50 concrete trucks pouring concrete into the basement.

Unlike the situation in the 1970s, this time, the United States wanted all connections severed between INER and CSIST. Accomplishing that separation would took several months. As of June 1988, Taiwan's executive and legislative bodies were considering several options for the split while the United States pressed for finishing sooner.²⁷ The leading contender was maintaining INER's subordination from the AEC but "divorcing" it from CSIST.

Hau wrote on November 20, 1988 that "INER no longer has anything to do with CSIST." The way this delinking was accomplished involved several steps. The AEC's budget was moved from the Defense Department to the Education Department. Secretary-General Liu Kuangchi was replaced by two vice chairmen, and the AEC committed to end all its relationships with the military. As of October 1, 1988, INER was placed under total AEC control; it was no longer under the administrative control of CSIST and did not have a budget independent of the AEC. With sensitive activities ended at INER, many of the military personnel left over the ensuing years.

This left the matter of the need for physical separation of the CSIST and INER sites. CSIST had procured commodities for INER, and this arrangement was ended effective October 1, 1988. From that time onward, the AEC was responsible for INER procurements.³¹ A fence between the sites was erected, and new security procedures were instituted, including CSIST no longer managing INER's security.³² INER was to be open to the public like a university, while CSIST would remain a high security military installation. For buildings interspersed among the two sites, INER and CSIST traded buildings, so as to ensure a clear physical separation. With regard to the shared computer center, INER and Taipower proposed to access it remotely via terminals. As of late October 1988, bus services, the telephone switchboard, and the dining room were expected to continue to be shared.³³

U.S. officials, later briefed on the changes, reacted positively overall to the separation plans. On the computer issue, they recommended that INER get its own computer, although that decision was left to the AEC.³⁴

This time, the nuclear weaponization program was a target for dismantlement. A key priority was the nuclear weapons computer codes developed for the last three decades on CSIST computers. Although details are missing about how, and in fact if, they were destroyed, David Ho, who was one of the developers of these codes, provided confirmation that they were. In his book, he wrote that creating the codes was a huge effort. He stated that although there were many difficulties in developing the codes, the team overcame all of them. What was unexpected, he wrote, was that at this critical moment, due to his superior Chang's defection, all was gone.³⁵

From the available information, it is unclear what exact steps were taken to shut down the nuclear weapons-related activities at the Chiu-Peng site in southern Taiwan and the smaller one near the reprocessing plant (see Chapter 9). At some point (see below), members of the U.S. team flew several hours by helicopter to the high explosive test site at Chiu-Peng, and they may have visited the smaller facility. As the team flew over the Chiu-Peng site, the team's specialists could recognize high explosive research and development facilities.

Declassified State Department cables describe what appeared to be visits to one or both of these sites in October 1988.³⁶ The team visiting in October included ACDA's Joerg Menzel, State's James Shipley, and DOE's William Emel.

The October 1988 visit is outlined in several declassified cables, although there are significant redactions of text describing exactly what was done or learned. The U.S. team in October 1988 not only visited remote CSIST facilities, but aimed to examine CSIST's activities of potential significance to nuclear research, discuss with CSIST, INER, and other officials the splitting of CSIST and INER, and visit nuclear power and university facilities.³⁷ The United States justified its focus on CSIST's activities on this trip as necessary if it were to continue exporting to CSIST commodities subject to control because of their potential use in nuclear weapons activities. CSIST relied heavily on importing goods from the United States for its advanced weapons research and development. CSIST experts raised with the team a number of exports that they had not been able to receive from the United States, presented in the form of a 13-item table, in addition to specifications for spark gaps, a dual-use item with nuclear weapons and missile as well as civilian medical uses, that had been

earlier requested by CSIST.³⁸ The U.S. strategy emerging in the cables appears clear—CSIST must cease and desist all nuclear weapons-related work or be cut off from U.S. exports of sensitive goods needed by CSIST for its advanced weapons development. It should also provide better enduse statements for requested, controlled goods.

The U.S. team reached an important understanding with CSIST and the ROC government more generally. "There is currently, and in the future, no nuclear or nuclear related research and development at CSIST. And there is currently, and in the future, no classified military R&D at INER."³⁹ The message was that any such work that was going on had to be halted, and CSIST should take steps to convince U.S. officials, some of whom made decisions on exports to CSIST, that Taiwan would not seek to acquire nuclear weapons. Again, Taiwan had to choose on-going security relations with the United States, which involved key sensitive military imports, or nuclear weapons development work. This time, the U.S. team had much greater confidence that CSIST and Taiwan had chosen the former to the exclusion of the latter.

Declassified cables pinpoint the CSIST discussions and visits to October 17-19.⁴⁰ The counterparts on the Taiwan side were Vice Chief of the General Staff Admiral Hsia and CSIST Vice President Vice Admiral Liu Shi-hsi (not to be confused with Liu Guang-ji, the former head of INER who had become the Secretary-General of the AEC). The helicopter trip was apparently on October 19 (see Figure 10.1).

The Legislative Yuan debated the matter of Chang's defection and the shutdown of the TRR and all nuclear weapons-related activities by the United States. Leaders from the newly-formed, opposition Democratic Progressive Party (DPP) insisted that General Hau and AEC chairman Yen Chen-hsing resign.⁴¹

President Lee decided against this. The so-called "Palace Faction" of the KMT, led by General Hau and his conservative allies, did try to block Lee from ascending to the presidency, as feared by the United States, but they failed. Despite Hau opposing Lee, the new president decided to try to keep him in government, leaving him as Chief of the General Staff until December 1989 and then appointing him in late 1989 as Minister of Defense. Despite the promotions, Chang believed Hau's authority was actually weaker in these roles, while reducing resentment within the military about its loss of influence.⁴²



Figure 10.1. Members of the U.S. inspection team in October 1988, posing in front of a helicopter with CSIST Vice President Vice Admiral Liu Shi-hsi (middle).

The reality was that Taiwan had started to democratize a few years before and returning to a government dominated by the military was unpopular. The emergence of the DPP in 1986 and the lifting of martial law on July 15, 1987, long in place since the Kuomintang founding on Taiwan in 1949, had started this move toward democratization, contributing to the peaceful transition from the Chiang dynasty to President Lee.

The United States ensured that the transition away from the Chiang dynasty would not be accompanied by a nuclear weapons effort. The U.S. action to eliminate this provocative program helped to weaken the military's role in society and strengthen the legitimacy of the new administration of President Lee.

Around June 1989, Hau's deputy, General Yeh Chang-tung, and Hsu Li-nong, a KMT Central Committee Standing member and head of a military unit responsible for countering Communist ideology on Taiwan,⁴³ visited the United States and met with CIA and U.S. military officials. Yeh and Hsu stated that they wanted to put the past behind them and strengthen military intelligence cooperation.⁴⁴ Even despite this difficult chapter in relations, Taiwan still prioritized its relationship with the United States above all else.

WHY WAS A TAIWANESE ATOMIC BOMB SO DANGEROUS?

The PRC had long threatened Taiwan with retaking the island if Taipei developed nuclear weapons. What would have been the implications of a Taiwanese bomb?

Early on, Dr. Wu Ta-you viewed nuclear weapons on a practical level as not only offensively useless for Taiwan, but also as possibly inciting the attack from the PRC that they were intended to deter. The PRC may have been undeterred by the existence of a Taiwanese nuclear weapon and invaded anyway, predicting that a ROC nuclear strike would be useless since it could not withstand a PRC nuclear counter strike.

Wu elaborated in 1988 on his 1967 evaluation to President Chiang Kai-shek about the nuclear strategic problems associated with Taiwan's nuclear weapons development. He stated:

If we look at it from the perspective of pure strategic power, Taiwan could not use nuclear weapons for offense purposes; on the contrary, by possessing such weapons, we increase the possibility of an attack initiated by our enemy because they would be alarmed. Taiwan is a small place with no room for maneuver if it was attacked with a nuclear weapon, unlike those countries with vast land, which, even if they were attacked first, would still have the opportunity to counterattack. They could rely on that potential power to maintain balance.

Although Taiwan's leaders ultimately ignored Wu's warnings, Washington shared his concerns. A declassified State Department cable to the AIT in Taipei from April 1988, drafted by an official by the last name of Brown and signed by Secretary of State George Shultz, explained the shaky deterrence and stability implications of a Taiwanese nuclear weapon:⁴⁶

As the PRC has not threatened the use of nuclear weapons against Taiwan, Taiwan's pursuit of a nuclear weapons option could expose Taiwan to risks it does not now face. Rather than deterring a conventional attack, nuclear weapons would likely provoke a conventional build-up across the straits, increasing the conventional threat, and create a nuclear threat, by raising the prospect of massive nuclear retaliation against Taiwan.

While some may envisage nuclear weapons as a kind of ultimate bargaining card or deterrent for Taiwan, strategic military planners would recognize that their possession would on the contrary expose Taiwan to much greater military risk and danger.

Taiwan's potential threat comes from the PRC, which has a substantial nuclear force and a variety of delivery systems and could not expect to match PRC capabilities under any foreseeable circumstance.

In geographic terms, Taiwan is a relatively small island whose very dense population and concentrated military facilities would be extremely vulnerable to nuclear threat or attack in confrontation with a continental nuclear power.

With these decisive strategic and geographic advantages, Taiwan would have no sane, rational use for nuclear weapons in a conflict with the PRC.

Moreover, Washington noted that Taiwan would have been extraordinarily vulnerable while it was building its first nuclear weapon. If Beijing learned of its breakout, via IAEA inspections or expressions of American alarm, it may have attacked before Taiwan could finish building a nuclear weapon. The Brown/Shultz memo stated:

During the period in which even the first nuclear weapon with some form of delivery system was being produced, Taiwan would expose itself to the threat of a conventional preemptive strike, such as that conducted by Israel against Iraq's nuclear facility in 1981.

However, as discussed in Chapter 9, this issue preoccupied Taiwan's leaders and led to building a breakout infrastructure aimed at ensuring Taipei could build its first nuclear weapon before it was discovered. Whether it could have succeeded is a remaining unknown.

The United States also recognized the military control element as a problem in Taiwan:⁴⁷

In a society which does not have an established and tested tradition of civilian control over military decisions, the prospect of nuclear weapons acquisition would raise fundamental issues in civil-military relations

and require the creation of reliable control procedures to ensure civilian control.

Stability of nuclear energy supply should have also shaped Taipei's calculations, the United States believed. In 1988, forty-five percent of Taiwan's electricity was supplied by nuclear power reactors and a strict dependence on outside supply of enriched uranium and other goods for these reactors meant that nuclear weapons acquisition would have threatened its nuclear imports and thus its electricity supply. The Brown/Shultz memo stated, "Regardless of whose material Taiwan used for a nuclear weapon, no supplier would have assurance that its supplies would not be misused," and the PRC would "undoubtedly exert its influence to reinforce their opposition to nuclear exports to Taiwan." Even an ambiguous situation with regard to adherence to safeguards could threaten nuclear supply to Taiwan. In addition, even one-time rogue suppliers such as South Africa by then had subjected their nuclear exports to IAEA safeguards.

Washington saw ramifications too with regard to Taiwan's relationships with its regional neighbors. The Brown/Shultz memo explained, in the context of Taipei's efforts to expand its economic and regional relationships, "all of Taiwan's immediate neighbors in East Asia, including Japan, Korea, the Philippines, and the other ASEAN countries, are NPT parties and would be deeply concerned by any change in Taiwan's non-proliferation commitments." The ROC's "desire to break out of what it perceives as its diplomatic isolation would be fundamentally set back should Taiwan deviate..." Moreover, a "violation of IAEA safeguards would be a major international issue, subject to reporting by the IAEA to the UN Security Council." The United States would have been hard pressed to support Taiwan at the Security Council.

It is unclear how the United States would have reacted to a Taiwanese breakout, given that it would have created an extremely dangerous situation that the United States expressly opposed and was trying to prevent. In any case, Washington felt under enormous pressure to work to ensure Taiwan stayed far away from the ability to build nuclear weapons. As stated by the Brown/Shultz memo, "The US has a major interest in preventing

the proliferation of nuclear weapons and in buttressing Taiwan's own non-proliferation commitment." 50

CHANG'S ACTIONS WERE COMMENDABLE

Chang learned that General Hau had labeled him a traitor. He was placed on a national wanted persons list.⁵¹ His arrest warrant did not expire until 2000. The accusation that he is a traitor has continued among some on Taiwan until the present. But was he?

Chang certainly embarrassed Taiwan. One ROC government official said in an interview with an Institute staff member in 1998 that Taiwan was ashamed that the United States could get to their people and change their nuclear policy so easily.⁵²

However, Chang cannot be accused of seeking money or other personal gain for his actions. His family enjoyed a lucrative salary and nice life in Taiwan.

When he left Taiwan, Chang left classified documents in his office safe at INER on the development of air defense missile systems, which was confirmed by Taiwan's National Ministry of Defense report on his departure.⁵³ To Chang, it was one small show of good faith. He wanted to signal that his target was the nuclear program, not CSIST's other projects.

Despite reports that Chang went before Congress and testified in a closed-door hearing, he denies that this ever happened.⁵⁴ He was always circumspect about disclosing his information.

In a 1998 letter to the journalist Wang Ching-hong, following the publication of the investigatory report by the Institute for Science and International Security on Taiwan's secret nuclear program in the January/ February 1998 edition of the *Bulletin of the Atomic Scientists*, Chang encouraged people to "view this episode from a world perspective," and see it as benefiting both the United States and Taiwan.⁵⁵

What did he mean?

Chang did not want to see a conflict with the PRC escalate to the point where former countrymen were killing each other. He felt nuclear weapons may provoke this. He did not see them as a means to improve prospects for peace. He wrote in his book, "My decision to work with the U.S. was not intended to be a betrayal to Taiwan. On the contrary, my intention was to improve the rights and interests of Taiwan and protect its

peace and stability." He reminded in the book that one of the three conditions that would lead to the PRC retaking the island by force was Taiwan making nuclear weapons. The other two were a declaration of Taiwan's independence and Taiwan being occupied by foreign powers (foreign military presence). ⁵⁶

Chang also discussed in his book concern that Taiwan was stepping over the United States' unspoken red lines on nuclear weapons research by going forward with General Hau's three to six-month plan for being able to make a nuclear weapon, in a way that would jeopardize the close relationship. In his book, he wrote, "The only ones I betrayed were the military strongmen who were taking risky military actions and disregarded the interests of the Taiwanese people." To Chang, he was helping to protect them and minimizing the risks posed by fractured U.S./Taiwan relations.

Chang's critics often fail to mention that the government of Taiwan had accepted obligations under the Nuclear Non-Proliferation Treaty and after "normalization," it had continued to assure world governments and the IAEA that it would act strictly in accordance with those obligations. Furthermore, senior officials in Taiwan's government repeatedly assured the U.S. government, particularly after the 1977 agreement, that CSIST/INER would not engage in any nuclear weapons-related activities. The actions by Taiwan's leaders and the activities carried out at CSIST/INER were contrary to those assurances. In the view of the authors, those in the leadership forfeited their right to criticize Chang.

AFTERMATH

After arriving in Washington, the CIA placed the Chang family in a home in Virginia. The CIA continued conducting security checks on Chang. Despite the fact that his children were enjoying this new adventure and his wife was doing fine, Dr. Chang calls this "the hardest time in my life" due to the lack of certainty about what was next. The FBI had received threats from radicals from Taiwan and showed Chang photos of people to watch out for.

The media learned of Chang's role in the shutdown of the TRR and the reprocessing plant two months after Chang departed Taipei. The *New York Times* broke the story on March 23, 1988 and appears to be the first

media outlet to spell his name as Chang Hsien-yi, a common transliteration of his name from Chinese into English.⁵⁷ This sparked a search by journalists for Chang in the United States. The journalist Wang Chinghong, who reported from Washington, D.C. for the *United Daily News* in Taiwan, uncovered Chang's whereabouts in Virginia in April 1988. He went to Chang's home three times to try to obtain an interview, which prompted the CIA to relocate him to Idaho Falls in 1990.⁵⁸ The United States was concerned that Taiwan's military-run Bureau of Intelligence could try to assassinate him; they were at that time suspected of assassinating a double agent in Los Angeles.

Taiwan's military officials visited Chang's and his wife's family members in Taiwan following his defection. During these unpleasant visits, according to Chang, officials mainly wanted to know if they had been aware of his activities and plans to defect. Chang learned that Dean met again later with General Hau and warned him that he must abide by the agreement with the United States and would be held accountable for any infringement on the safety of Chang or his immediate or extended family in or outside Taiwan. Dean also told Hau that he would be held accountable for releasing damaging information about Chang. Soon after, the hostile family visits ended.

Chang was given three additional polygraph tests to ensure he had not informed Taiwan of his discussions with U.S. officials. He also met with CIA and other U.S. officials that the CIA arranged for him to meet with. During one meeting, he asked a CIA official whether the events would negatively impact military intelligence exchanges with Taiwan. The official said, "Yes, considerably," but "we can live with it."⁵⁹

Since being moved to Idaho Falls in 1989 until his retirement in 2013, Chang worked as a consulting engineer at the Idaho National Laboratory (INL). Chang kept his real name but added the first name "Gray" upon becoming a U.S. citizen in 1989. While working at INL, he openly published over 75 analyses on reactor physics as G.S. Chang. 60 His name on his U.S. passport is Gray Sen-i Chang.

Dr. Chang has not returned to his home country since his defection. He is uneasy about how he would be received if he were to return, even though the statute of limitations on any crimes ran out long ago. He became emotional at the question of how his decisions impacted his wife and children. It is clear that his defection and the fact that he had to

uproot the family weighed heavily on his conscience. Still, they have prospered and enjoyed a peaceful life in America.

Interestingly, Chang began seeing old colleagues at U.S. conferences soon after his move to the United States. He said he was not concerned for his safety. At an American Nuclear Society conference in New Mexico in the mid-1990s, he ran into Fu Ying-kai, a scientific technical branch officer at INER who he had attended school with. He also saw Huang Hsiao-chung, formerly the Chairman of the Science Preparatory Committee at CSIST and President of Tsing-hua University, who had represented General Hau on CSIST general operations. He had migrated to the United States.

In 1996, Chang encountered former INER Director Liu at a conference. Liu became emotional and asked why he betrayed them. He had wanted to promote Chang to director of INER one day. Chang responded that he felt what he did was best for Taiwan and Liu understood. They wished one another well. Afterward, the CIA sent someone to Chang to find out what the two had discussed.

After moving to Idaho Falls, the CIA would send someone to check on Chang twice a year. But those visits and all communication ended in 1993. Only once more did the CIA follow up with him in 1998, after James Lilley was interviewed by the *New York Times* and discussed Chang. Chang never had any written non-disclosure agreement with the CIA. They did not contact him when he published his Mandarin-language memoir. According to him, they had only a "gentleman's agreement" for him to stay quiet for safety reasons. He believes it was time for him to tell his side of the story.

Chang's children were among the beneficiaries. They never truly understood what he had done and why, at a young age, they had come to live in the United States, until he published his memoir in December 2016 about his role in stopping Taiwan's nuclear weapons program. In January 2017, one of his sons wrote him the following e-mail:

Dad,

I never really asked you about the topic of how we came to America, but since the book release and all the recent news coverage has opened my eyes and found a whole new level of respect for you. You must have

endured so much pain and agony throughout the years, but I wanted to let you know that I love you and you are my hero!!

I know it must be hard to listen to all the negative responses, but there is no doubt in my mind that you made the correct decision not only for your family but for Taiwan as well.

I really hope that you will finally find peace with this, and enjoy life with no regrets.

NOTES

- 1 Historical Stories of Taiwan: The Mystery of Taiwan's Nuclear Weapons, Mandarin language documentary, April 21, 2013 (Translated by Institute for Science and International Security, 2017).
- 2 According to the former scientist at INER who observed these events, David Ho, in *Historical Stories of Taiwan*; Also see Ho's book, Liwei He (David Ho), *Nuclear Bomb MIT: "A" Bomb Made in Taiwan* (Taipei: Women Chubanshe, 2015).
- 3 Shullen Shaw, "President Chiang Ching-kuo, Son of Nationalist Chinese Leader Chiang," United Press International, January 13, 1988.
- 4 See for example, Eric Pace, "Chiang Ching-kuo Dies at 77, Ending a Dynasty on Taiwan," *The New York Times*, January 14, 1988.
- 5 See for details Chang Hsien-yi's account in Chen Yishen, *Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi* (Taiwan: Walkers (Yuan Zu Wen Hua), 2016) (Translated by the Institute for Science and International Security, 2017).
- 6 Cindy Sui, "The Man Who Helped Prevent a Nuclear Crisis," *BBC News*, May 18, 2017, https://www.bbc.com/news/world-asia-39252502
- 7 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi. 8 Ibid.
- 9 Ibid.
- 10 "Legislators Ask Gov't to Seek Chang's Extradition from U.S.," *The China Post*, March 26, 1988.
- 11 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi. 12 Ibid.
- 13 As described by Alan K. Chang in *Crisis Avoided: The Past, Present and Future of Taiwan's Nuclear Weapons Program* (Honolulu: Hawaii Pacific University, Masters thesis, Fall 2011), pp. 96-97, which cites a Mandarinlanguage documentary called *Critical Times*, hosted by Liu Pao-chieh, *ETToday*, December 2007.
- 14 Hau Pei-tsun, *Diary during my Eight Years as Chief of the General Staff* (Taipei: Commonwealth Publishing 2000) (Translated by the Institute for Science and International Security, 2018), p. 1269.
- 15 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 4.

16 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 4.

17 Hau, Diary during my Eight Years, pp. 1270-1271.

18 Ibid.

19 Ibid.

20 Ibid, p. 1287.

21 IAEA, *Research Reactor Database*, TRR, IAEA Code TW0002, Decommissioning Section, https://nucleus.iaea.org/RRDB/RR/Decommissioning.aspx?RId=345

22 Cable from Secretary of State to US Mission in Vienna, *Transfer of Heavy Water from Taiwan to the U.S.*, May 3, 1988; and Cable from AIT, Taipei to AIT, Washington, *Heavy Water Shipment*, May 28, 1988. The March date corresponds to the time when INER had taken dose rate measurements on the surface of drums containing heavy water and is assumed to have happened when all or most of the heavy water had been removed from the TRR. The exact amount of heavy water slated to be sent back to the United States is illegible in this declassified cable. The 20 metric tonnes part of the number is clear but the rest is not. It could be 20,490 kilograms.

23 Cable from Secretary of State to AIT, Taipei, *Taiwan Heavy Water Shipment*, May 23, 1988.

24 Historical Stories of Taiwan documentary.

25 Ibid.

26 Interview by authors of knowledgeable former U.S. official.

27 Cable from AIT, Washington, D.C., to AIT, Taipei, "Conversations in the Margins on Meeting of AIT-CCNAA Joint Standing Committee on Civil Nuclear Cooperation," May 31, 1988.

28 Hau, Diary during my Eight Years, p. 1395.

29 Cable from AIT, Taipei to AIT, Washington, D.C., Reorganization of Taiwan's Atomic Energy Council, October 17, 1988.

30 Ibid, and Cable from AIT, Taipei, to AIT, Washington, D.C., *Taiwan's Nuclear Power Program: Visit of Victor Stello, Jr.*, December 12, 1987.

31 Cable from AIT, Taipei to AIT, Washington D.C., *Visit to Taiwan/CSIST Facilities*, October 28, 1988.

32 Ibid.

33 Ibid.

34 Ibid.

35 Ho, Nuclear Bomb MIT: "A" Bomb Made in Taiwan, p. 70.

36 Cable from AIT, Taipei to AIT, Washington D.C., *Visit to Taiwan/CSIST Facilities*, October 17, 1988. In this cable, the United States asks for helicopter transport from Kaohsiung, in southwestern Taiwan, to a redacted location. However, this city is relatively near Chiu-Peng. See also Cable from Secretary of State to AIT, Taipei, *Visit to Taiwan Research Facilities*, October 4, 1988. This cable describes the expected itinerary of the U.S. team composed of Menzel, Shipley, and Emel and includes a visit to remote CSIST facilities in the "general area of Lung Tan." Although Chiu-Peng is not in the vicinity of Lung Tan, the visits that day may have involved a helicopter ride to Chiu-Peng. The smaller high explosive testing site would be considered in the general area of Lung Tan.

37 Visit to Taiwan Research Facilities, October 4, 1988.

38 Cable from AIT, Taipei to AIT, Washington D.C., *Visit to Taiwan/CSIST Facilities*, October 28, 1988.

39 Ibid.

40 Cable from AIT, Taipei to AIT, Washington D.C., *Visit to Taiwan/CSIST Facilities*, October 28, 1988; Cable from Secretary of State, Washington D.C. to AIT, Taipei, *Visit to Taiwan Research Institute*, October 4, 1988, and Cable from AIT, Taipei, to AIT, Washington D.C., *Visit to Taiwan/CSIST Facilities*, October 17, 1988.

41 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 4.

42 Ibid.

43 Russell Hsiao, "Political Warfare Alert: Former Head of Taiwan Military's 'Political Warfare Bureau' No Longer Opposes the Communists," *Global Taiwan Brief*, Vol. 2, Issue 36, September 6, 2017, via https://www.linkedin.com/pulse/political-warfare-alert-former-head-taiwan-militarys-hsiao-j-d-/

44 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 4.

45 Dr. Wu Ta-you, "A Historical Document—A Footnote to the History of Our Country's 'Nuclear Energy' Policies," *Biographical Literature*, Vol. 52, No. 5, May 1988 (Translated by the Institute for Science and International Security), http://isis-online.org/isis-reports/detail/a-footnote-to-the-history-of-our-countrys-nuclear-energy-policies/15

46 Cable from Secretary of State to AIT, Taipei, *Taiwan, Nuclear Weapons and Non-Proliferation*, April 29, 1988.

47 Ibid.

48 Ibid.

49 Ibid.

50 Ibid.

51 "Missing Nuclear Physics Expert Put on Wanted List," Central News Agency, March 12, 1988 (Translated by FBIS).

52 Interview by Institute staff with ROC government officials in Washington, D.C., February 27, 1998.

53 From Appendix 1: The Investigation Report of Chang Hsien-yi's Abscondence by the Department of National Defense, undated, pp. 238-242, provided to the authors by Chang Hsien-yi, 2017.

54 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 4.

55 Letter to Wang Ching-hong from Chang, "From the Mountains of Yellowstone," undated but sent on the tenth anniversary of the death of Chiang Ching-kuo. See article by Wang, "Chang Hsien-I: By Hindering Nuclear Weapons, There Was a 'Double Win' by Both the United States and Taiwan," January 14, 1998. Chang sent the letter while refusing an interview with Wang, who had earlier tracked him down in Virginia, sparking his move to Idaho.

56 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 3.

57 Stephen Engelberg and Michael R. Gordon, "Taipei Halts Work on Secret Plant to Make Nuclear Bomb Ingredient," *The New York Times*, March 23, 1988. On the English spelling of his name, our Chinese translator looked up the variants of "Hsien-yi" on the Mandarin language "Foreign name Chinese-English translation system" web page on Taiwan's Bureau of Consular Affairs, Ministry of Foreign Affairs web site.

- 58 Chang, *Crisis Avoided*, p. 111. Chang cites the Mandarin language memoir of Wang Ching-hong, *The Way it Was Memoir of a Taiwanese Journalist* (Taipei: Avanguard Publishing House, 2004).
- 59 Chen, Nuclear Weapons! Spy? CIA: Interview Record with Chang Hsien-yi, Chapter 4.
- 60 *Professional Resume of Gray S. Chang, Consulting Engineer/Scientist (ret.)*, Provided to the authors, 2017.
- 61 Tim Weiner, "How a Spy Left Taiwan in the Cold," *The New York Times*, December 20, 1997.

SECTION IV AFTERMATH AND LESSONS

CHAPTER 11 POST-1988 ACTIVITY

Following the 1988 episode, Taiwan's nuclear weapons program was halted in a way that it was not in the 1970s. However, it had an afterglow. Threats to revive it, and to recreate a proven capability to develop nuclear weapons, as well as on-going activities in potential defiance of the U.S. shutdown, kept alive suspicions that remnants of the nuclear program continued well into the 2000s. However, during this period, no concrete evidence of nuclear weapons work emerged, and a series of actions, including several by the IAEA, progressively made such a reconstitution less likely.

RECALCITRANCE?

After Colonel Chang left Taiwan, ROC government officials were understandably angry and bitter toward the CIA and the U.S. government. General Hau Pei-tsun, the major force behind the nuclear weapons effort in the mid-to-late 1980s, wrote in his diary on February 13, 1988: "That a small number of scientists won't give up their achievements is natural and not necessarily incompatible with our non-nuclear policy. Really, do we have to kill these scientists before America will be put at ease?"

Hau's comment, while self-serving, nonetheless highlights that Taiwan's leaders resisted taking responsibility for their decisions to maintain and bolster Taiwan's nuclear weapons capabilities in violation of the secret April 1977 agreement with the United States. However, due to the

enormity of the violations uncovered, these same leaders did agree to end the nuclear weapons program. Hau's comment also implied that INER and CSIST still had staff that generally supported, or tolerated, Taipei developing a rapid breakout capability. Suspicions remained that certain elements remained supportive of nuclear weapons, and that this group was not limited to just a small number, as Hau asserted, but included part of the top military leadership as well. Hau's thinking reinforced the view that while no one wanted to harm those military officers at INER or CSIST, the nuclear program needed to be independent of the military and staffed exclusively by civilians.

Pockets of resistance would have probably centered at CSIST. Partial confirmation of that occurred in May 1990 when an audit ministry official, fending off requests from the governmental watchdog, Control Yuan, which wanted to examine CSIST's books, explained that its budget was secret because it was "involved in making atomic bombs." This episode became public because of an inadvertent reply by an official to local reporters' questions. Subjecting a military entity to public scrutiny was relatively new in Taiwan, as was a free press, where martial law had only ended in 1987. But this type of public scrutiny, particularly by the media and a newly energized parliament, or Legislative Yuan, would provide a check on any future efforts to revive a sensitive nuclear program.

THREATS OF NUCLEAR WEAPONS REVIVAL

Despite the dismantlement of its nuclear weapons capabilities, Taiwan remained in a complex security situation with the PRC. These tensions were worsened by President Lee Teng-hui's policies in favor of the "localization" or Taiwanization of the culture and a new "state-to-state" policy to describe Taiwan's relationship to the PRC, rather than Taiwan being a province within China. The PRC feared that these developments, combined with democratic reforms, were leading Taiwan away from the One China policy and toward voting for independence. Beijing was so alarmed by these political developments that it threatened that if Taiwan declared independence, the PRC would forcibly reunify Taiwan with China. In one of the more dangerous moves, starting in July 1995, the PRC fired ballistic missiles into the seas near Taiwan.

In response, threatening to build nuclear weapons was not beyond Taiwan's leadership. In July 1995, just after the PRC test-fired its first salvos of missiles into the nearby waters and escalated threats against Taiwan, President Lee Teng-hui told the National Assembly, "We should restudy the question [of nuclear weapons] from a long-term point of view." He added: "Everyone knows we had had the plan before." But a few days later, Lee turned down the heat, saying that Taiwan "has the ability to develop nuclear weapons, but will definitely not" develop them. No evidence emerged that Lee had concrete plans to reconstitute the nuclear weapons program, but threatening to restart it would have been viewed by many as a useful tool to help create an independent deterrent against the PRC and signal to the United States that it needed to maintain strong security arrangements with Taiwan to ensure it did not reconstitute the program.

In 2004, concerns about nuclear weapons increased again, following an editorial by the *Taipei Times* that stated that Taiwan needed a nuclear deterrent against the PRC.⁵ The editorial argued that Taiwan could not hold out long enough against a PRC attack for the United States to come to its aid. The editorial stated: "The ability to obliterate China's ten largest cities and the Three Gorges Dam would be a powerful deterrent to China's adventurism." This comment was viewed by some experts as recommending a national discussion about the need for developing nuclear weapons to deter the PRC.

Suspicions increased about whether anything was going on in secret because of lingering questions about how much control the civilian government had over the military. In late September 2004, Premier Yu Shyi-kun inadvertently fueled the debate by stating at a government training seminar that if the PRC fired 100 missiles at population centers such as Taipei, Taiwan should be able to attack at least ten targets on the mainland, although he said nothing about nuclear weapons.⁶ The situation grew even more intense after an opposition legislator of the People First Party (PFP), retired Admiral Nelson Ku, publicly asked Premier Yu pointed questions about whether a secret nuclear weapons program existed, which the premier strongly denied.⁷ Yu also said his comment about missiles was only a "presumption." Ku then asked if there was a secret five-person team, including active and past members from the current administration, planning the development of nuclear weapons. Premier Yu denied this as well. Ku asked further if there was someone

from Yu's cabinet who once said in Washington, D.C. that although he or she opposed nuclear weapons development, someone else on the team supported it. Yu again denied this, but Chris Nelson in the authoritative *Nelson Report* stated that an ROC cabinet member, Parris Chang, had indeed told people in Washington that "some in the DPP [Yu's party, the Democratic Progressive Party] seem to be thinking about, or to have been seduced by, the nuclear weapon idea." Despite this debate, no technical evidence emerged of a nuclear weapons program. One positive development was that a range of government officials strenuously denied that Taiwan would seek nuclear weapons.

These cases and other similar ones are a reminder that Taiwan remains in a precarious security situation. Given that INER and CSIST developed extensive nuclear weapons capabilities, it is not surprising that periodic discussions about nuclear weapons arise. But in general, the legislative and public response has been against nuclear weapons, or the development of any such capabilities, pushing the government to make strong denials of any nuclear weapons work. This process has created strong norms in Taiwan against building nuclear weapons. A quiet, ongoing International Atomic Energy Agency inspection process has also made any reconstitution even more difficult.

IAEA INSPECTIONS

With the 1988 revelation of the existence of secret nuclear weapons sites, including a fairly substantial reprocessing plant that would have depended on diverting safeguarded uranium fuel, the IAEA wanted to improve its inspections in Taiwan. With on-going cross-strait tensions with the PRC, stepped up IAEA inspections have provided an important, albeit quiet, assurance that Taiwan's nuclear program remains peaceful.

Taipei has remained unable to negotiate a safeguards agreement with the IAEA. It continued to abide by its two outdated safeguards agreements, INFCIRC/133 and INFCIRC/158. However, since the late 1970s, Taiwan has applied the safeguards embedded in the Nuclear Non-Proliferation Treaty, namely it accepts inspections that are the equivalent of those in the comprehensive safeguards agreement. In the early 1990s, it decided to provide the IAEA even more access and information, in line with the

reforms in inspections that were then occurring in the cases of South Africa and North Korea.¹⁰

Hans Blix, then-Director General of the IAEA, had convinced South Africa, and initially at least, North Korea, to agree to allow inspections anytime, anywhere, with a reason. This followed the IAEA's stunning failure in Iraq, where it was revealed in 1991 that Saddam Hussein had constructed a huge, secret nuclear weapons complex under the noses of the IAEA inspectors. Faced with such a monumental failure, Blix sought to find quick ways to remedy the situation and his anytime, anywhere formulation was one of those.

Taiwan agreed to Blix's formulation in the early 1990s.¹¹ Briefed by the United States, IAEA inspectors asked to go to several sites, including the former reprocessing site and the high explosive testing facilities related to nuclear weapons development. Taiwan obliged and senior inspectors visited these sites for the first time starting in about 1994.¹² This started a process of periodic visits to ex-nuclear weapon sites that has continued to this day.

During that initial period, Taiwan's officials were open with IAEA inspectors about their past nuclear weapons work, particularly the associated fuel cycle work. So, for example, they did not obfuscate about the purpose of the reprocessing plant, clearly stating that it was to separate plutonium and not molybdenum-99. One inspector speculated that Taipei was motivated to cooperate to avoid the types of confrontations that Iraq and North Korea were then having with the international community, where noncooperation with inspectors triggered a crisis. Later, he added, its openness about the past faded.

Several years later, the IAEA successfully negotiated the Additional Protocol, an advanced safeguards protocol that fell a little short of Blix's anytime, anywhere condition. Nonetheless, the Additional Protocol, which was approved by the IAEA Board of Governors in 1997, was a clear advancement from earlier safeguards practices brought into disrepute by the 1991 Iraq fiasco.

Taiwan was willing to adopt the Additional Protocol and signed it in 1998. Since it is not a state, the negotiations involved the IAEA Secretariat and Taiwan, but no formal document was brought for the approval of the Board of Governors, as is done for states. According to the IAEA Safeguards Implementation Report for 1998, "The authorities in Taiwan,

China agreed to accept the implementation of measures contained in the Model Additional Protocol."¹³

The IAEA reported progress in Taiwan's implementation of the Additional Protocol in *Safeguards Implementation Reports*. According to the *Safeguards Implementation Report for 1999*:

The measures foreseen in the Model Additional Protocol were being implemented for Taiwan, China; a safeguards evaluation was performed and its findings were reviewed by the Information Review Committee, complementary access was implemented and environmental samples were taken.¹⁴

The inspection process has worked quite well overall, providing assurance of the peaceful nature of Taiwan's nuclear programs. The IAEA has used the complementary access, or short-notice inspection provisions in the Additional Protocol, that allow access within 24 hours. For example, the IAEA obtained Taiwan's agreement to access former nuclear-weapons related sites using this short notice.

In addition to known, past sites, the IAEA also asked to access sites with capabilities relevant to fuel cycle activities, even if no nuclear fuel cycle-related activities were located there. It has at times learned of a capability by studying Taiwan's scientific literature or received a tip from a government. Examples would be work potentially related to nuclear weapons development conducted at CSIST or work on lasers at military or CSIST sites that could be relevant to the laser enrichment of uranium. Taiwan accepted all of these types of questions and requests for access.

In about 2005, an IAEA inspector accessed the high explosive test site at the Chiu-peng military missile testing range in Ping Tung in the south of Taiwan, where cold tests of nuclear weapons had occurred in the 1980s (see Chapter 9). Nothing was there anymore, just a clearing with no buildings.¹⁵

In general, CSIST remained a tougher problem for the IAEA. Visits to CSIST have occurred, where topics associated with technical nuclear weapons capabilities were the focus, although sometimes CSIST personnel were rather uncommunicative with the inspectors.¹⁶

Centrifuge Suspicions. In certain cases, the IAEA learned of activities that sparked a deeper investigation but also revealed some limits to IAEA access. A case in point was gas centrifuges for enriching uranium, which Taiwan has always denied pursuing. Nonetheless, in 2004, the IAEA learned that CSIST was working with equipment suitable for making rotor tubes that could be used in gas centrifuges to enrich uranium.¹⁷ The rotor tube is a key centrifuge component that is a thin-walled tube often made from maraging steel or carbon fiber. The rotor spins inside the centrifuge at high speed to separate uranium isotopes and is difficult to make. Their manufacture requires specialized equipment, albeit it is dual-use, with both civilian and military uses. For making maraging steel rotors, a flow forming machine is used. A winding machine is used to form centrifuge rotors from carbon fiber.

CSIST had acquired both flow forming machines and winding machines.¹⁸ In the late 1980s, according to information provided to the Institute for Science and International Security from one of the owners of the now defunct German company H&H Metalform, two German companies had sold CSIST flow forming machines. H&H Metalform sold CSIST a single machine and mandrel to make rotor tubes of 123-millimeter diameter. The mandrel is a vital part of the machine against which the rotor is pressed through flow forming. This diameter mandrel is not typical of gas centrifuges, but its use for centrifuge rotors could not be dismissed. Moreover, other mandrels could have been obtained and hidden from the inspectors. The German company Leifeld also delivered flow forming machines to CSIST in the late 1980s. The flow forming machines from H&H Metalform and Leifeld, while usable to make centrifuge rotors, were prevalent in military and missile programs to make a variety of tubes for military applications, in particular missile bodies. According to a knowledgeable U.S. official, who visited Taiwan many times, Taipei had also acquired three axis winding machines able to make centrifuge rotors.19

Nuclear Fuel reported that since the 1980s, CSIST experts had continued to make considerable progress in the flow forming of thin-walled maraging steel tubes strong enough to use in gas centrifuges.²⁰ The report added that the research was headed by the Mechanical Design and Manufacturing Center of the Second Division at CSIST, and at the National Chiao University at Hsinchu. Some of the latter's work had been

published in scientific journals. The CSIST second division is dedicated to missile development.

These reports garnered concern because of CSIST's technical capabilities and its past work on nuclear weapons. Moreover, Taiwan had developed a good industrial infrastructure, in addition to CSIST's capabilities, if it wanted to embark on uranium enrichment, whether via gas centrifuges or lasers. According to one U.S. expert who visited Taiwan well over a dozen times, Taiwan had all the technology to enrich uranium with centrifuges.²¹ INER knew how to handle uranium hexafluoride, although it is not known to have made any.²² This expert speculated that there was a 50/50 chance that they had made centrifuges to enrich uranium.

Soon after first learning of the winding machines, IAEA inspectors went to see them at a facility run by CSIST. The facility was a workshop dedicated to researching the manufacture of a range of tanks made from carbon fiber, including light-weight fuel tanks for aircraft. No tubes were seen, although the winding machines and carbon fiber were suitable for making centrifuge rotor tubes. Taiwan denied having a centrifuge program but the IAEA was not able to make a definitive determination.²³ Nonetheless, after that, the facility was subject to on-going monitoring. No subsequent evidence of centrifuge work emerged.

The IAEA was not able to access the flow forming machines, which were located at missile sites.²⁴ Taiwan objected to granting access to missile facilities because of concerns that the IAEA inspection reports may be obtained by the PRC and reveal sensitive military information.²⁵

Over time, the IAEA developed a list of major sites that were either part of the old nuclear weapons program or have capabilities that are potentially related to the development of nuclear weapons, reprocessing, or uranium enrichment. Taiwan has routinely provided access to almost all of these sites. The lack of access to a missile research site discussed above was an exception.

At times, Taiwan's officials complained about the IAEA's focus on the past. In 2005, officials from Taiwan's Atomic Energy Council told a visiting delegation from the American Institute in Taiwan, the non-governmental organization that serves the interests of the United States in Taiwan, that the IAEA's "annual inspection in Taiwan is always directed towards Taiwan's attempt twenty years ago to developing an atomic

bomb."²⁶ Despite the discomfort and difficulty, that focus was necessary for the IAEA to accomplish its safeguards mission.

Reaching a Broader Conclusion Under the Additional Protocol.²⁷ IAEA carried out many of its visits and inquiries under the Additional Protocol with the aim of drawing what is called a "broader conclusion" about the exclusively peaceful use of Taiwan's nuclear materials. The term and the process are inherent to the Additional Protocol, which equipped inspectors with important, additional tools that allow for broader access to information and locations in Taiwan. The IAEA bases a broader conclusion on there being no indications of diversion of declared nuclear material from peaceful nuclear activities and no suggestions of undeclared nuclear material or activities in Taiwan as a whole. To accomplish this in practice, the IAEA carries out a comprehensive evaluation of all safeguards-relevant information available to the IAEA, which includes Taiwan's declaration submitted under the Additional Protocol, and the results of in-field activities, including visits to facilities and environmental sampling. This evaluation is supplemented by assessing the consistency of Taiwan's declared nuclear program and performing complementary accesses to a variety of sites in Taiwan and addressing all anomalies, discrepancies, and inconsistencies identified in the course of the IAEA's evaluation and verification activities. Only once these evaluations are completed can the IAEA draw the broader conclusion that all nuclear material in a state has remained in peaceful activities.

Drawing a broader conclusion was not easy in the case of Taiwan, as some of the earlier discussion shows. In November 2004, Alex Burkart of the State Department commented in a meeting with Taiwan's Minister of the Atomic Energy Council that the "IAEA's evaluation of Taiwan with respect to the history of its nuclear program had not been completed." The AEC's Director of Planning, Dr. David Yao, revealed that INER had not been able to "give satisfactory answers regarding some environmental samplings suggesting possible nuclear activities may have occurred during the 1980s." He added that it is difficult to recreate history because some of the people privy to the relevant information had since died. Burkart emphasized the "importance of explaining the findings and offered assistance in sharing some of his records from the past 30 years to help reconstruct history." He again impressed upon Taiwan's officials the

extreme importance of ensuring a complete evaluation, noting "it is critical to understand the past in order to understand the present situation."³¹

The sampling mentioned in the above discussion refers to the IAEA finding plutonium in those samples. George Jahn of The Associated Press reported in October 2004 that the IAEA had found that "Taiwan's experiments with plutonium extended up to the mid-1980s." He reported that the sampling was done as part of Taiwan's voluntary acceptance of more intrusive inspections, in particular the Additional Protocol.

The plutonium was found in INER's Hot Laboratory. Interpreting the meaning of the plutonium sample was difficult, leading to a variety of explanations. The most straightforward was that it showed that Taiwan had secretly separated plutonium in the 1970s or 1980s. Taiwan, on the other hand, claimed that the plutonium was a remnant of the U.S.origin plutonium experimented with in the 1970s in the Plutonium Fuel Chemistry Laboratory, and it had somehow spread to the Hot Laboratory. A senior IAEA inspector thought the plutonium was brought into the Hot Laboratory by an inspector who had come from a nuclear weapons state, in what is called "cross-contamination." Taiwan's claim was difficult to evaluate since the U.S.-origin plutonium had long ago been returned to the United States. Moreover, the IAEA wanted to sample inside the containers holding the old plutonium metal processing line taken from the Plutonium Fuel Chemistry Laboratory, but Taiwan refused the IAEA's request, citing concerns about spreading nuclear contamination. Some challenged the dating of the plutonium, e.g. the date when it was last separated and purified, stating that the dating can be inaccurate. The dating was important, since if the last separation was in the 1980s, it could not be the U.S.-origin plutonium, since that plutonium was last purified in the 1970s. Overall, the controversy served to open up the whole issue of past reprocessing in the 1970s and broadened it to include possible plutonium separation in the 1980s.

It is unclear how the IAEA and Taiwan resolved all these questions. Perhaps, Taiwan told the IAEA it had separated plutonium, but refused to release the information publicly, sticking to its customary blanket denials. Alternatively, the IAEA simply may have been unable to explain the plutonium sample and gave up. It would not be the first time.

In any case, the IAEA reached a broader conclusion for Taiwan in 2006.³³ It started applying what are called integrated safeguards from

January 1, 2008 onward. Integrated safeguards are highly desired by most states and refer to the optimum combination of all IAEA safeguards measures under a comprehensive safeguards agreement with an Additional Protocol in order to achieve maximum effectiveness and efficiency, within available resources, in meeting the IAEA safeguards objectives.

To provide additional assurance, visits to old nuclear weapons sites have reportedly continued, despite the diminishing number of former members of that program still employed in Taiwan.

NEW NUCLEAR REACTORS

Throughout this long history of strife with Taiwan over its nuclear programs, the United States never tried to eliminate Taiwan's nuclear power program. Although the United States viewed reprocessing, enrichment, and the continued operation of the Taiwan Research Reactor as too risky, it did not oppose the construction of other types of reactors that would not pose the proliferation risk of the TRR. It certainly did not oppose the nuclear power program of Taipower. A key U.S. goal since the 1970s had been to re-orient INER's and Taiwan's nuclear programs to nuclear power and away from sensitive nuclear activities.

After the TRR closed, the U.S. policy goal took root. Taiwan broadly focused its efforts on nuclear power. In the early 1990s, one of the priorities of the government headed by President Lee was to revise plans to build new nuclear power reactors that had been dormant since 1982.³⁴ This push was headed by the AEC and Taipower. After the 1988 episode, both entities had developed a strong opposition to nuclear weapons and wanted all nuclear resources channeled into nuclear power under civilian authorities and not under the military. Taipower knew well how disruptive INER's sensitive activities had been to its own imports of key equipment and materials from the United States for its nuclear power reactors, which as far as could be ascertained, except perhaps in its earliest days, never had anything to do with the nuclear weapons program.

In parallel, Taiwan developed plans in the early 1990s to replace the TRR with the TRR-II in the same building. The TRR-II would be a poor producer of plutonium and would truly be dedicated to civil purposes only. The original INER proposal in 1993 involved dismantling the TRR core and buying a reactor overseas.³⁵ However, this proposal shifted by

about 1995 to INER building its own reactor. Taiwan's government approved the proposal in 1998 to greenlight INER's construction of a new reactor in the original shell of the TRR after finishing dismantling the old reactor.³⁶ The TRR-II would have a power of 20-25 MWth, be moderated with heavy water, and use imported near 20 percent enriched uranium. It was slated for completion in 2006.³⁷

Ironically, just as the transition to exclusively civil nuclear power and research was well underway, growing public opposition in the 1990s and 2000s to nuclear energy in general stunted the nuclear revival. A further casualty of the resulting cutbacks in INER's budget was the cancellation of the TRR-II project.

Today, the Atomic Energy Council, which oversees INER, is an independent civilian agency under the Executive Yuan. In the past, there were efforts to fold the AEC into the Ministry of the Environment, but these efforts apparently did not happen, in part out of concern about how to retain its independent regulatory oversight role over nuclear power inside the Environment Ministry. Over the past two decades, the AEC's (and INER's) most important mission has shifted to reactor safety regulation, radiation protection, radioactive waste administration, environmental monitoring, and R&D for technology development and other civilian nuclear applications.³⁸

INER has focused on decommissioning the TRR. This process has taken years and was on-going in 2017, based on the latest INER annual report.³⁹

The approximately 118 irradiated TRR uranium metal fuel elements that were not shipped to the United States were treated at INER as nuclear waste. According to a series of INER annual reports, the irradiated uranium metal fuel was converted into uranium oxide and placed in specialized containers for long term storage. The plutonium content of the stabilized uranium was carefully measured with assistance from the United States.

The question of the missing ten or so fuel elements remains unanswered. If they, or only a portion, were not reprocessed, did they end up being treated as nuclear waste? What happened to any plutonium separated?

Budget cuts and anti-nuclear policies have led to a drastic reduction in INER's nuclear activities. The military is long gone from INER, as is a

nuclear weapons program. INER is a shadow of what it once was. In addition to focusing mainly on assisting Taipower's nuclear power programs, it has also branched into renewable energy. Of course, Taiwan remains in a difficult security situation; however, INER's strategic emphasis is no longer on nuclear weapons, but on ensuring the availability of energy sources that could withstand a PRC blockade. That strategy is far more likely to strengthen Taiwan's national security, while providing a valuable resource to its people, than would nuclear weapons.

NOTES

- 1 Hau Pei-tsun, *Diary during my Eight Years as Chief of the General Staff* (Taipei: Commonwealth Publishing, 2000) (Translated by the Institute for Science and International Security, 2018), pp. 1282-1283.
- 2 Lincoln Kaye, "Atomic Intentions," Far Eastern Economic Review, May 3, 1990, p. 9.
- 3 James Kynge, "Taiwan to Study Need for Nuclear Weapons," Reuters. July 28, 1995.
- 4 Joyce Liu, "Taiwan Won't Make Nuclear Weapons, Says President," Reuters. July 31, 1995.
- 5 Editorial, Taipei Times, August 13, 2004.
- 6 "Premier Denies Taiwan Making Missiles, Nukes," TaiwanNews.com, October 13, 2004.
- 7 Debby Wu, "PFP Legislator Badgers Premier on Nukes, Editorial," *Taipei Times*, October 13, 2004.
- 8 "Premier Denies Taiwan Making Missiles, Nukes."
- 9 Chris Nelson, The Nelson Report, October 14, 2004.
- 10 For more information on the level of inspections in South Africa and North Korea, see Albright with Stricker, *Revisiting South Africa's Nuclear Weapons Program* (Washington, D.C.: Institute for Science and International Security, 2016) and Albright and Kevin O'Neill, *Solving the North Korean Nuclear Puzzle* (Washington, D.C.: Institute for Science and International Security, 2000).
- 11 Interview by one of authors with a senior official close to the IAEA, June 16, 2000.
- 12 Interview with a former senior IAEA official, July 13, 2018.
- 13 IAEA, Safeguards Implementation Report for 1998, GOV/1999/32, May 4, 1999, p. 10.
- 14 IAEA, Safeguards Implementation Report for 1999, GOV/2000/23, May 12, 2000, p. 11
- 15 Interview with a senior official close to the IAEA, October 1, 2008.

16 Ibid.

17 Mark Hibbs, "Centrifuge Design Proliferation Raises Questions about Taiwan Lab," *Nuclear Fuel*, February 2, 2004; and Interview by one of the authors with a knowledgeable former U.S. official, October 14, 2004.

18 On H&H flow forming machine, see Institute for Science and International Security, "H+H Metalform," undated but from late 1990s. This machine had an export license from the German authorities. Available at: http://exportcontrols.info/h&h_home.html; Also, interview by one of the authors with former senior H&H official, October 2004. On winding machines, interview by one of the authors with knowledgeable former U.S. official, October 14, 2004.

- 19 Interview by one of the authors with knowledgeable former U.S. official, October 14, 2004.
- 20 Hibbs, "Centrifuge Design Proliferation Raises Questions about Taiwan Lab."
- 21 Ibid.
- 22 In the 1980s, Taiwan received uranium hexafluoride and converted it into other uranium compounds. (See annual INER reports).
- 23 Interview by one of the authors with a former senior IAEA official, July 6, 2018.
- 24 Interview by one of the authors with a former senior IAEA official, July 13, 2018.
- 25 Interview by one of the authors with Mark Hibbs about his coverage of Taiwan in *Nuclear Fuel* and *Nucleonics Week*, January 23, 2008.
- 26 Cable from AIT Director Douglas Paal to Department of State, AIT Visits Taiwan's Nuclear Safety Ops Center, October 19, 2005.
- 27 Based on the definition of a broader conclusion in IAEA safeguards reports. See for example, IAEA, *Safeguards Statement for 2014*, GOV/2015/30, undated, https://www.iaea.org/sites/default/files/sir_2014_statement.pdf
- 28 Cable cleared by State Department's Alex Burkart to Department of State, 2004 AIT-TECRO JSCCNC-Side Meetings, November 18, 2004.
- 29 Ibid.
- 30 Ibid.
- 31 Ibid.
- 32 George Jahn, "Diplomats say Taiwan conducted plutonium separation experiments up to mid-1980s," The Associated Press. October 13, 2004.
- 33 IAEA, Safeguards Statement for 2014.
- 34 Margaret L. Ryan, "Officials Back Nuclear, But Mandate More Safety Features," *Nucleonics Week*, April 16, 1992.
- 35 "Status of the TRR-II Project," INER web site (Accessed November 14, 1997).
- 36 Mark Hibbs, "INER to Build New Research Reactor, Not Convert Closed Canadian Unit," *Nuclear Fuel*, March 23, 1998.
- 37 Chou Shih-tung, Ma Ying-pang, Yang Jim-ton, et al., "The Current Status of TRR-II Project," INER, Presented at the 8th Meeting of the International Group on Research Reactors, April 17-20, 2001, Munich, Germany.
- 38 "Atomic Energy Council," December 2016, https://www.aec.gov.tw/english/intro/aec_2016.pdf
- 39 See for example, INER, *2016 Annual Report*, July 2017, https://www.iner.gov.tw/en/attachments/article/121/INER-AnnualReport-2016-EN.pdf

CHAPTER 12 U.S. LESSONS FOR TODAY AND TOMORROW

Taiwan had a nuclear weapons program spanning two decades under the guise of a peaceful use program. The program was controlled and administered by the military. CSIST was the center of this program and used the INER nuclear establishment as a source of nuclear explosive material, nuclear weapons simulations, and other research and development activities. Taiwan's nuclear weapons program made more progress and was working on more sophisticated nuclear weapons than publicly recognized. It came dangerously close to fruition. Taipei excelled at the misuse of civilian nuclear programs to seek nuclear weapons and implemented capabilities to significantly reduce the time needed to build nuclear weapons, following a decision to do so.

The United States' effort to prevent Taiwan from going nuclear was a terrific success story, one for which the U.S. government deserves tremendous credit. Closing Taiwan's nuclear weapons program prevented the nightmare scenario of a nuclear-armed mainland China from confronting a much smaller, nuclear-armed Taiwan. This story needs to be further declassified, used as a case study, and learned from by governments. Intense secrecy has followed Taiwan's nuclear weapons program and its demise. As a result, there has been little opportunity to reflect on this case's meaning and implications for other nuclear proliferation and disarmament cases at issue today and tomorrow. This discussion seeks to start the process of drawing out the major findings and lessons in an open

manner. The Taiwan case is rich in findings for addressing nuclear proliferation challenges.

ENDING DANGEROUS REPROCESSING, ENRICHMENT, AND REACTOR PROGRAMS

A successful outcome in Taiwan depended on a strong position against any reprocessing and enrichment capability, and certain types of reactor technologies, such as those involving heavy water-moderated, natural uranium reactors like the Taiwan Research Reactor. Likewise, the continued operation of gas-graphite moderated reactors such as in North Korea also introduces an element of precariousness. The Taiwan case supports opposing the spread of plutonium separation and uranium enrichment capabilities. Often these capabilities represent the core of a future nuclear weapons program, regardless of official statements claiming the opposite. For example, Iran has sought to cover its nuclear weapons ambitions behind a peaceful nuclear cover. It is difficult to see how any enrichment program in Iran could ever be economic and not represent a nuclear weapons breakout capability, given the availability of enriched uranium abroad at lower costs. The United States should reinvigorate policies that aim for permanent prohibitions on reprocessing and enrichment in Iran. In contemplating agreements to limit nuclear programs in countries like North Korea, the Taiwan case shows that ending, not limiting, reprocessing and enrichment is probably the only method to ensure that denuclearization is achieved.

CREATING AND MAXIMIZING LEVERAGE TO END REPROCESSING AND ENRICHMENT PROGRAMS

The United States used its leverage to thwart Taipei's efforts and over time effectively denuclearize Taiwan. That entailed shutting down its reprocessing programs, uranium enrichment work, heavy water reactor, and nuclear weaponization efforts, bolstered afterward by reformed International Atomic Energy Agency inspections. To that end, the United States focused on shutting down capabilities before they matured into production-scale facilities.

This dismantlement happened despite Taiwan not resolving its fundamental security conflict with mainland China and not fully trusting the United States to guarantee its survival. The key was U.S. leverage and pressure that Taiwan could not resist. In essence, Taiwan had to choose between relying on the United States or going it alone in terms of nuclear supply and security. Doing so would isolate it from its closest ally, deprive it of enriched uranium fuel for its nuclear power reactors, cut it off from being able to import critical goods for its defense and civil industries, and potentially far worsen its security situation with the PRC.

Taiwan made choices to move away from nuclear weapons that apply to all states facing security challenges and dilemmas. Few would argue today that Taiwan's lack of nuclear weapons has made it less secure in dealing with the Peoples' Republic of China; most would admit, however, that the result of Taipei obtaining those weapons could have been a disaster.

The specific type of political and diplomatic leverage brought to bear in the Taiwan case is difficult to replicate in the cases of adversaries, such as the current proliferation challenges of North Korea and Iran. It is unclear if such leverage could have been achieved in the case of South Africa. But the Taiwan case shows that denuclearization may not depend on resolving a nation's security concerns prior to it giving up a nuclear weapons program or the weapons themselves.

One key lesson of the Taiwan case is that it makes sense to develop a strong pressure campaign to address complex proliferation cases. Although few countries are subject to such extreme, external pressure as Taiwan was vis-a-vis the United States, it is worth continuing to establish the most effective ways to increase diplomatic, political, financial, and other economic pressure against countries such as Iran and North Korea until they fully denuclearize, in particular ending reprocessing, enrichment, the development of dangerous plutonium producing reactors, and nuclear weaponization activities. These proliferant states may in the end opt for conventional forces, economic development, and international and regional integration rather than nuclear weapons, even though not all of their security concerns are resolved.

When it comes to U.S. allies, the Taiwan case argues to always link bilateral relations to allies maintaining commitments not to pursue reprocessing, uranium enrichment, or nuclear weaponization. A test case today

for exerting U.S. leverage is Saudi Arabia. It should be expected to agree to forgo reprocessing and enrichment as a condition of U.S. security and nuclear cooperation. If it moves forward with developing these capabilities, the United States should threaten an end to both nuclear and military cooperation.

For countries like South Korea and Japan, the Taiwan case gives optimism that these countries will refrain from building nuclear weapons, regardless of the fate of North Korean nuclear weapons. Maintaining this status quo requires the United States to tend to its alliances with these countries and engage in regular bilateral discussions over the best way to maintain adequate security. In the case of South Korea, part of that discussion should focus on obtaining commitments not to reprocess or enrich. Although Japan's reprocessing and enrichment programs are usually exempt from such linkage, given Japan's large excess stock of separated plutonium, the United States should accelerate discussions with Japan about conditions and means of phasing out its reprocessing program and disposing of its large excess separated plutonium stock.

IGNORE NUCLEAR WEAPONIZATION AT ONE'S PERIL

Not enough attention is paid to nuclear weaponization when considering reducing the threats posed by U.S adversaries. In the case of Taiwan, efforts to shut down the military's nuclear weapons effort were delayed.

Nuclear weapons programs are often seen as too difficult to accurately detect or adequately verify, and the Nuclear Non-Proliferation Treaty has vague restrictions on nuclear weapons development, focusing more clearly on the full manufacture and possession of nuclear weapons. However, the real drivers of the nuclear weapons programs, often close to the military, tend to control these weaponization programs. There is a strong need to identify and target nuclear weaponization efforts via a variety of methods, including through intelligence collection, IAEA inspections, and United Nations Security Council (UNSC) actions.

The 2015 nuclear deal with Iran, or the Joint Comprehensive Plan of Action (JCPOA), sought to clarify this situation by prohibiting weaponization-related research and development work by Iran, but has so far failed to take up an adequate task of verifying that this work has ended. It floundered on Iran successfully stonewalling the IAEA and

blocking access to military sites where nuclear weapons work had occurred and personnel were involved in this work.

In 2018, Israel seized a hidden cache of weaponization-related documents from a secret archive in Tehran, which Israel maintains was curated.² It is worth assessing how this anti-weaponization provision could be better verified by the IAEA. Moreover, using this new information, the IAEA and its member states should re-invigorate inspections in Iran under the comprehensive safeguards agreement.

The IAEA would improve its safeguards mission by insisting on resolving any weaponization related concerns early on in any verification process.

DENUCLEARIZATION

In the end, the denuclearization of Taiwan was a necessity. It was the only way to develop confidence that Taipei would not build nuclear weapons. Likewise, it significantly increased warning times and incentivized the creation of a constituency in Taiwan that was against nuclear weapons.

The norms in the April 1977 secret agreement did not end the operation of the Taiwan Research Reactor, which was at the heart of Taiwan's nuclear weapons breakout strategy. Despite catching Taiwan in the late 1970s, the United States ended up failing to shut down the research reactor then, and later failed to convert its core and remove its irradiated fuel in a timely manner. In 1988, faced with fresh confirmation of cheating on the 1977 agreement, the United States had no choice but to insist on the shutdown of this reactor.

But looking back, in dealing with Taiwan, the United States pioneered many of the definitions and practicalities of denuclearization. Although the 1977 secret agreement had some ambiguities and left room for interpretation by Taiwan, it nonetheless created a strong norm against nuclear weapons and more importantly the means to make them. It insisted that many sensitive activities and programs be ended and dismantled. The process was verified by U.S. and IAEA inspections. In the case of the U.S. inspections, they verged on being anywhere, anytime. If the United States saw something that violated the norm, it had a way to talk to Taiwan and ask it to halt that activity. However, this agreement did not stop the nuclear weapons program, and the United States had to go

further and insist on shutting down all the dangerous parts of Taiwan's nuclear program, including the heavy water reactor and nuclear weapons research and development activities. It also established the key norm of prohibiting nuclear R&D in military programs and banning classified military R&D in nuclear programs. In the 1988 case, the basic denuclearization steps were accomplished in less than a year, or a few years, if one includes removing the vast bulk of the TRR's irradiated fuel.

In contemplating agreements to limit nuclear programs in countries like Iran and North Korea, the Taiwan case shows that verified, irreversible denuclearization is not only possible, but essential. Otherwise, a nuclear weapons program can or will reemerge. In those agreements, it also makes sense for the United States to push for its own inspection rights, or if that is not possible, as is the case with Iran, the IAEA's rights need to be substantially strengthened, including guaranteeing timely access to military sites.

PERSISTENCE MATTERS

For a quarter of a century, Taiwan actively sought nuclear weapons and regularly violated its commitments to the United States. Despite being caught, it continued its violations. Its highest levels of government believed that Taiwan's security depended on continuing and expanding its nuclear weapons effort. Taipei's officials certainly dug in their heels and bristled at U.S. demands and engagement on the issue. Despite the obstacles, Washington did not falter in its goals. Critical to that effort was the ability to be persistent.

The United States was highly motivated to stop Taiwan's sensitive nuclear efforts. The ramifications for PRC intervention or military escalation would have been unpredictable. One clear finding is that the United States needed to maintain a consistent policy against Taiwan's proliferation and ensure that officials stayed focused on this problem year after year.

That they did so is a credit to a series of U.S. administrations, regardless of political party. In 1977, the United States created a norm against Taiwan's efforts to create a nuclear weapons capability via a secret bilateral agreement. Afterward, it enforced and strengthened that deal. When it realized that Taiwan would not stop violating it and it faced an impending

change in regime leadership that could worsen the situation, the U.S. government moved to end the program.

There were many points along the path where U.S. priorities could have shifted, or leniency could have happened. But the United States maintained its commitment to its goals.

It is worth summarizing what that persistence required. It needed the support of multiple U.S. presidents. It required a well-functioning bureaucracy. The State Department, former Arms Control and Disarmament Agency, Central Intelligence Agency and other intelligence agencies, Department of Energy, Joint Chiefs of Staff, Office of the Secretary of Defense, and the national nuclear laboratories all worked together over decades to ensure U.S. objectives were identified and met. These officials had to maintain with Taiwan near constant dialogue, including what amounted to complicated negotiations, and create and enforce the 1977 norms, all the while working to reorient Taiwan's nuclear programs to nuclear power applications. They also had to coordinate with the IAEA and a variety of other governments. The U.S. intelligence community needed to carefully investigate activities in Taiwan and maintain a strong mission there over several decades. It needed to watch Taipei's nuclear and missile scientists and engineers carefully, particularly those sent abroad, and develop inside sources, despite Taiwan being a close ally.

Being persistent required that there be knowledgeable people in the U.S. government who stuck with a proliferation problem over time. The needed expertise included experienced nuclear specialists in the fuel cycle and in nuclear weaponization, intelligence experts, procurement specialists, diplomats, and sophisticated policy people. Cultivating and maintaining the human capital in the U.S. government was crucial to success in Taiwan and remains critical to a variety of proliferation challenges today.

COUNTERPROLIFERATION IS A GLOBAL EXERCISE

Keeping watch over Taiwan's covert activities was a global effort. The State Department and ACDA played important roles in managing and coordinating the U.S. efforts with other countries. They also worked well with the International Atomic Energy Agency, which, while not always effective in the 1970s and 1980s, did uncover and learn important information.

Collaboration and information sharing with U.S. partners and allies, particularly European governments, was instrumental in keeping abreast of Taiwan's covert activities. Countries seeking nuclear weapons must illicitly procure goods and equipment from abroad, offering opportunities for detection. The United States was able to use intelligence and information about planned commercial deals, and about sought-after equipment and material procurements, to find out what Taiwan was seeking and likely doing next in its covert programs. An unlikely but natural partner in sharing information was also the PRC.

HIDING BEHIND CIVIL AND NON-NUCLEAR MILITARY PROGRAMS

A sobering lesson is the extreme measures Taiwan's leaders and its nuclear officials used to disguise their nuclear weapons efforts as carefully sculpted civilian nuclear programs or non-nuclear military programs. One former U.S. official recollected that INER and other officials, "from morning to night, and with great sincerity, would say that all their programs were peaceful." They would challenge any doubters as having no basis in reality, stating, "How could you think otherwise?" This former U.S. official found that after a few days of that, he began to question his own sanity. During the 1970s conflict, he said that if not for other American officials who pushed the nuclear teams back to the correct path, he and his colleagues would have given up. The IAEA faces similar challenges in effectively safeguarding countries.

Iran has pursued a similar strategy by denying its past and possibly on-going nuclear weaponization work and original, planned use of uranium enrichment for nuclear weapons. North Korea may try to keep its uranium enrichment program and reactor programs running in a denuclearization arrangement by claiming that these sensitive facilities have been repurposed to serve a civilian goal, such as enriching uranium for use as fuel in a civil nuclear reactor. But allowing such loopholes would create a dangerous breakout capability. Moreover, agreeing to such a loophole on enrichment makes no sense, particularly given that North Korea's (or for that matter Iran's) production of low enriched uranium will be significantly costlier than simply buying the enriched uranium on the global commercial marketplace. Saudi Arabia may try to develop nuclear capabilities by using similar denial strategies. Breaking through such lies is critical.

IAEA INSPECTIONS MATTER, SO DOES PRESSURE ON THE IAEA BY MEMBER STATES

How close Taiwan came to building nuclear weapons serves as a cautionary lesson for thinking through the implementation and reform of IAEA inspections. Covert research and development activities like those that occurred on Taiwan can proceed undetected for years, and only the most intrusive and inquisitive IAEA safeguards are likely to detect them. The IAEA's strongest inspections regime under the Additional Protocol is still not universally accepted, and even countries with the Additional Protocol in place resist allowing access to military sites. The international community has considerable work in front of it to ensure that the IAEA is conducting the most thorough safeguards efforts possible. One implication of the Taiwan case is that for the IAEA to be effective, the United States and its allies will need to share intelligence information with inspectors, and the IAEA will need to be more effective in using that information.

Although IAEA inspectors played an important role in detecting and stopping Taiwan's secret nuclear weapons effort in the 1970s, they missed Taiwan's on-going or renewed efforts in the 1980s. This failure of IAEA safeguards was systematic at the time. The IAEA also missed the covert nuclear weapons program in Iraq and was unable to establish a safeguards agreement with North Korea throughout the late 1980s. Nonetheless, as part of demands by member states for general reform and strengthening of safeguards after the 1991 Persian Gulf War, the IAEA instituted much more effective safeguards measures, including approving the Additional Protocol in 1997. Taiwan was one of the first countries to agree to increased transparency and the Additional Protocol. Under its arrangement with Taiwan, the IAEA continued to periodically visit the former nuclear weapons sites and delve into the history of Taiwan's nuclear weapons program.

Although the Additional Protocol is critical, more important is how the IAEA assesses information available from various sources, in particular that arising from its own inspection regime. New thinking and the analysis of information has been the key to success. What raised the alarm in Taiwan? It was when an inspector discovered undeclared facilities raising the possibility of undeclared irradiated fuel and plutonium outside of safeguards. In the case of Egypt, inspectors discovered a uranium

tetrafluoride batch in the state's inventory but did not see in its declarations any process pointing to the material. That discrepancy prompted investigations, which exposed additional activities that Egypt had failed to report, all without Egypt agreeing to the Additional Protocol. With North Korea in the early 1990s, inspectors uncovered discrepancies between samples taken from wastes and separated plutonium. The plutonium isotopes did not match, which pointed to the finding that North Korea could have done more plutonium separation than reported to the IAEA. This is why the IAEA has to maintain a rigorous state evaluation process, regardless of whether the state has brought the Additional Protocol into force. Including assessments related to nuclear weapons research and development is an essential part of its efforts to ensure that undeclared facilities and materials are not missed and the state evaluation process is credible.

The IAEA is experiencing new challenges to its effectiveness and credibility today. One could even say the IAEA is in the midst of a new, unrecognized crisis regarding the failing strength of its safeguards mission. Several important countries balk at adapting the Additional Protocol, and others seek to undercut the IAEA Secretariat's authorities to mount inspections at military sites. Iran has systematically refused to allow the IAEA access to military sites linked to past work on nuclear weapons. In fact, Iran still denies ever having had a nuclear weapons program, despite overwhelming evidence to the contrary. In the context of the JCPOA, the IAEA has largely acquiesced to this problem out of fear of undoing the nuclear deal. The IAEA remains without a convincing strategy to resolve the Iran safeguards challenge. In the context of North Korea, the IAEA may be bypassed by the choice of U.S. and foreign inspectors to do the bulk of the verification of a future denuclearization agreement.

The role of IAEA member states in demanding effectively implemented safeguards and reforms to those safeguards is critical today. Twenty years after the negotiations that led to the Additional Protocol, the time has come to revisit the IAEA's safeguards and verification work with an eye toward strengthening it and fixing the loopholes that have been identified during the process of struggling with Iran, North Korea, and other countries that have set out to weaken safeguards.

SPENT FUEL TAKEBACKS MATTER, BUT IN ASSOCIATION WITH REACTOR CONVERSION

For denuclearization efforts, spent fuel take back arrangements for plutonium-producing reactors are less important than often thought. Work arounds are always possible. Although they reduce the reservoir of material that can be used in nuclear weapons, significant amounts will remain in reactor cores and in storage adjacent to reactors.

But combining irradiated fuel removal with reactor core conversion is a workable strategy to nearly eliminate the proliferation threat posed by a reactor. A lesson is the central importance of programs like the Department of Energy's and Russia's Reduced Enrichment for Research and Test Reactor programs and the Arak reactor conversion project in Iran. The difficulty of implementing such an option in the case of Taiwan was a central problem and served to motivate Taipei to persist in seeking nuclear weapons.

EXPORT CONTROLS

Taiwan, despite its advancing industrial state, sought many goods and much information from abroad for its nuclear programs. It created elaborate procurement networks to obtain the more sensitive goods and information as a way to thwart U.S. detection or carry on cooperation with overseas suppliers in secret. The Taiwan case is a reminder that suppliers must constantly update their export and information controls and assist domestic suppliers in detecting and preventing illicit procurement attempts. A specific lesson is that countries need to provide more details about the end user and purpose of the goods, including proprietary information, and establish post-shipment end use checks. It is also critical that suppliers remain alert to suspect approaches and report such attempts, when uncovered, so that governments can have better awareness of the emergence and activities of new proliferant states.³

In more recent periods, several illicit procurements have originated from entities in Taiwan or passed through Taiwan to North Korea and Iran.⁴ However, Taiwan recently banned all trade with North Korea in September 2017, following a major underground nuclear test. Findings from the Institute for Science and International Security's *Peddling Peril Index* show that Taiwan has sufficient national export control legislation.

Because of Taiwan's special status as a non-country and nonmember of the United Nations, ranking Taiwan's implementation and enforcement of export control laws remains difficult.

An increasingly important role of export controls is to track the acquisition of sensitive knowledge by citizens of would-be proliferant states at U.S., European, and other foreign universities, workplaces, or conferences, or by the hiring of foreign consultants. Proliferant states need to send people abroad to acquire knowledge, training, and technology that can be key to the success of nuclear programs. For Taiwan, such efforts were vital for acquiring information, via people studying in the United States, Europe, and elsewhere who would transfer back sensitive information. In order to track such people today, big data tools deployed through international cooperation may be useful for centralizing information. They could be used to pick up indications of a new proliferant state starting early information and technical expertise development efforts.

AN INFORMANT MATTERED, AND DESERVES MORE CREDIT, PARTICULARLY IN TAIWAN

One U.S. response to Taiwan's on-going efforts was to infiltrate the program and find reliable human sources. Chang Sen-i (Hsien-yi) exemplifies this effort. Chang has never been given the respect he deserves in Taiwan; he saved Taiwan from its most dangerous impulses. He deserves praise for his courage and convictions in thwarting what he believed was an effort that would have likely put Taiwan and the PRC on a path to armed conflict. For many in Taiwan, its thwarted nuclear weapons efforts are today often forgotten or downplayed. However, few now regret abandoning the nuclear weapons program as Taiwan charts its future. Chang's actions should be commended by Taiwan's government and its leaders.

GOVERNMENTAL CHANGES CAN BE A CRITICAL TIME TO MOVE TO END PROLIFERATION

The Taiwan case highlights that an intriguing time period for U.S. actions against proliferation is when governments undergo significant leadership changes. The impending death of President Chiang Ching-kuo in 1987 provided the United States with a strong incentive to act and achieve denuclearization before the next government could establish itself.

TOO MUCH SECRECY STILL SURROUNDS THE TAIWAN CASE

Secrecy in dealing with nuclear proliferation offers some advantages. It hides embarrassing conflicts from publics and bureaucracies, allowing one side to back down while easing the implementation of constraints and reducing potential opposition. Both sides save face and avoid critical public and international scrutiny. Operating under secrecy had concrete benefits in the case of Taiwan. It allowed Taiwan to discretely dismantle programs and facilities, making it easier for Taipei to also politically end its programs and reverse course. The largely secret IAEA effort in the 1990s and early 2000s solidified confidence in Taiwan's denuclearization.

However, secrecy also has a cost and can be counterproductive to longer term interests. Ultimately, the United States needed to make its actions public from time to time to help ensure that troubling actions and programs were halted. The deliberate leaking of apparently secret information to the media played a useful role, particularly during the 1970s episode. These leaks could then be used by U.S. officials in their discussions with Taiwan's officials, without the need to provide any source-sensitive information.

Moreover, secrecy led the U.S. government to publicly downplay this case to too great of an extent. Although sparing Taipei embarrassment may have had some justification, it also served to hide major violations of the Nuclear Non-Proliferation Treaty and allow many in Taiwan's government to act as if nothing untoward had happened. This enabled them to keep going.

Persistent secrecy today also makes it more difficult to evaluate what worked and did not work in this important case. Much of the Taiwan story remains classified. It warrants near full declassification due to its importance in history.

CHINA

As the United States was secretly working to denuclearize Taiwan in 1988, China was largely ignoring its close ally North Korea's growing nuclear weapons program, which included covertly finishing a large reprocessing plant at Yongbyon and refusing to apply IAEA safeguards. China did not do the United States any favors or copy the U.S. approach in Taiwan by applying economic and security leverage to ensure North Korea did not build nuclear weapons. A sobering lesson is that while the United States acted responsibly, China did not. Even today, many of the same reasons for Taiwan not to build nuclear weapons apply to North Korea's on-going possession of them. Its security situation is worsening, and it faces severe challenges in developing economically in the face of economic sanctions. It is not too late for China to learn the essential lesson of Taiwan. If it wants to avoid war and promote peaceful development on the Korean peninsula, it should ensure via applying severe leverage that North Korea denuclearizes

IS TAIWAN STILL A PROLIFERATION THREAT?

With security tensions high in North Asia and Taiwan still facing a security threat from the PRC, a natural question is whether Taiwan remains a proliferation threat. Most would say no. Assuming that North Korea's nuclear arsenal does not cause a rash of nuclear proliferation in the region, starting with Japan and South Korea, the odds seem long that Taiwan will build nuclear weapons. A related question is whether it retains a residual capability to build nuclear weapons. According to Chang, "If Taiwan kept up with nuclear energy research and development efforts and talent development, if one day they decided to restart nuclear power or even nuclear weapon development, even without nuclear power plants, they could easily catch up as long as they had the right materials, talents and equipment." Although catching up would likely require several years, and the construction of a range of fuel cycle facilities, if tensions mount in North Asia, Chang's warning is worth keeping in mind.

NOTES

- 1 See for example, Paragraph 16 of the JCPOA: "Iran will not engage in activities, including at the R&D level, that could contribute to the development of a nuclear explosive device, including uranium or plutonium metallurgy activities, as specified in Annex I." *Joint Comprehensive Plan of Action*, Vienna, July 14, 2015.
- 2 Testimony of David Albright before the House Subcommittee on National Security, Committee of Oversight and Government Reform, June 6, 2018, http://isis-online.org/conferences/detail/house-subcommittee-testimony-of-david-albright-on-ending-u.s.-participation/8
- 3 For other recommendations on improving export controls, see Albright, Sarah Burkhard, Allison Lach, and Stricker, *The Peddling Peril Index for 2017* (Washington, D.C.: Institute for Science and International Security, January 31, 2018), in particular Chapter 12's recommendations on strengthening export controls worldwide. Available at: http://isis-online.org/ppi/detail/peddling-peril-index-ppi-2017/
- 4 See for example, David Albright, Andrea Stricker, Daniel Schnur, and Sarah Burkhard, "Additional Taiwan-Based Element of Iranian Military Goods Procurement Network Exposed," Institute for Science and International Security, September 16, 2015, http://isis-online.org/uploads/isis-reports/documents/Hsieh_case_study_16Sept2015-final.pdf and Institute for Science and International Security, "U.S. Company Charged with Pressure Transducer Sales: Who Were the End Users?" May 14, 2012, http://isis-online.org/uploads/isis-reports/documents/Mattson_14May2012_1.pdf
- 5 For a description of these developments, see Albright and Kevin O'Neill, *Solving the North Korean Nuclear Puzzle* (Washington, D.C., Institute for Science and International Security, 2000).