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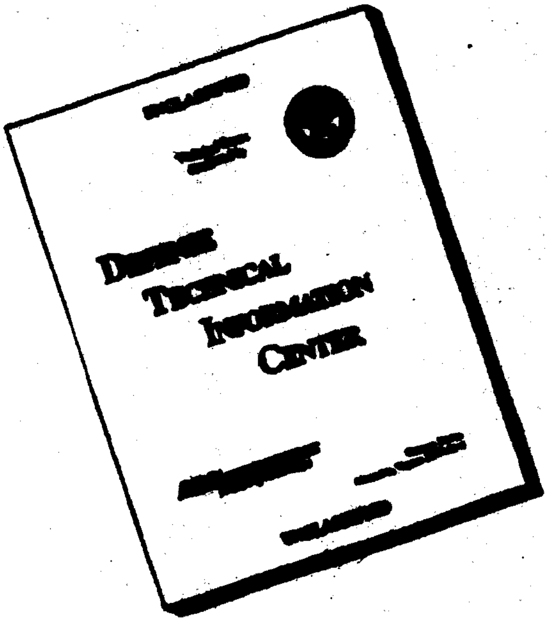

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THE COMMUNIST CHINESE NUCLEAR THREAT: WARHEADS AND DELIVERY VEHICLES (U)

DONALD B. KEESING

International Studies Division

Study Memorandum 17

Institute for Defense Analyses

IDA

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FOREWORD

The author, Donald B. Keesing, is an economist and Far Eastern specialist. Before joining the Institute for Defense Analyses he was with the Systems Analysis Office, Air Force Cambridge Research Laboratories, where he co-authored a number of analytic studies on theater air power, space research needs, command and control, and other subjects. He has also taught economics at Harvard University, where he served on the staff of the Harvard Defense Studies Program and later as an associate of the Harvard Economic Research Project.

This paper was written in support of Study PACIFICA, an analysis of the emergence of Communist China as a nuclear power. Study PACIFICA was prepared by the International Studies Division of IDA for the Department of Defense,under Contract No. SD-50, Task Order T-23, effective 1 July 1961. Brigadier General Sidney F. Giffin, USAF (Ret.) was Study Leader.

JAMES E. KING, JR.
Director
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SUMMARY

An attempt is made to project into the future Communist China's nuclear capabilities in terms of warheads and delivery vehicles, and to analyze Chinese nuclear requirements. It is assumed that the Communist Chinese will accord high priority to advanced weapons programs but will receive no significant Soviet help. Intelligence is accepted to the effect that the Chinese are already engaged, or are about to engage, in production of plutonium by means of a nuclear reactor and that they have also had a chance to observe tests and assembly of Soviet short- and medium-range ballistic missiles on a test range in China. Nuclear stockpile projections are undertaken based in part on the assumption that effective operation of a Chinese metallic uranium facility began as early as January 1961.

If Chinese nuclear programs have been delayed for one or several years by severe technical or economic setbacks, projections of stockpiles and technical characteristics of weapons should, allowing for this delay, still be generally valid. For US policy purposes, it was necessary to give the Chinese the benefit of the doubt, to enable consideration of the more serious threats that China might pose without Soviet assistance.

An accompanying estimate of nuclear requirements (from the Chinese point of view) underscores the immensity of the technical problem for the Chinese. For local and regional purposes Communist China, even when it acquires missiles, will still require a manned-vehicle capability to offset targeting inadequacies and to compensate for the inaccuracy inherent in the early missiles. The problem of attacking ships at sea will be particularly great. Even unhardened, fixed, land targets such as airfields will call for the use of thermonuclear rather than fission-missile warheads to offset moderate circular probable errors /CEPs/. The ballistic missile requirement will be for ranges of at least 700 nautical miles /NM/, and preferably 1,100 nautical miles, which will permit flexible deployment against all the important bases and capital cities around the Chinese periphery. Of particular importance to the Chinese will be concealment of missiles, to prevent targeting by the United States.

The Communist Chinese must jump to operational missiles with ranges of as much as 6,000 nautical miles to threaten credibly the United States itself. Intercontinental forces must be made survivable in the face of advanced future weapons and reconnaissance systems. Emplacement by the Chinese of any missiles with ranges of 2,000 nautical miles or more will automatically threaten the Soviet Union.

The projections suggest the following timetable for a Communist Chinese nuclear weapons program that enjoys high priority and that already has a favorable start.

First nuclear test	1963-64
First weapons deliverable by manned bomber	1965
20-weapon stockpile	1965
First warheads suitable for MRBM	1966
50-weapon stockpile	1967
100-weapon stockpile	1968-69
First thermonuclear warheads	1969
200 thermonuclear weapons, or 400 fission weapons, or a combination	1971

Severe technical or economic difficulties, or a deliberate "stretch-out," would result in systematic delays, whereas little acceleration of such a schedule appears possible without direct Soviet assistance. After all, stockpile acquisition depends on the accumulation of production facilities for nuclear weapons, and advances in warhead technology depend on repeated nuclear tests.

Delivery vehicle development is likely to prove even more difficult and expensive for China than warhead development. The obsolescent IL-28 Beagle light bomber, given to China by the

Soviets years ago, will probably have to be retained as the main manned delivery vehicle, despite its small payload and narrow bomb bay, until the 1970s; Chinese technical resources will not be equal to simultaneous bomber and missile development. The Chinese are likely to concentrate on ballistic missiles, in which case, starting some time between 1966 and 1968, they could probably have the capability to deploy a few nuclear-tipped medium range (700 to 1,100 NM) ballistic missiles of their own manufacture. The threat would reach the vicinity of 100 fairly accurate MRBMs, supplemented by bombers, in 1970 at the earliest. ICBMs cannot be deployed by China until some time in the 1970s. Apart from minor clandestine threats, seaborne strategic systems are unpromising and unlikely. A crude intercontinental aerodynamic threat is also unlikely, unless an ICBM program encounters unforeseen difficulties.

I. INTRODUCTION

PURPOSE AND SCOPE

This discussion of the Communist Chinese nuclear threat is intended to supplement and complement existing national intelligence estimates.

The intention is to reflect, in addition to the basic intelligence indications, underlying considerations discussed only to a limited extent in the estimates. These factors include Chinese requirements for nuclear weapons systems, numerical projections of the Chinese threat based on plausible assumptions, and key choices open to Chinese decision-makers. The purpose is (1) to summarize the evidence and reconstruct some of the basic considerations so that the reader can better judge for himself; and (2) to suggest a relatively specific and quantified picture of the threat.

ASSUMPTIONS

On Soviet Support

Assumptions regarding the future level of Soviet support and assistance to Communist China are extremely important in defining the Chinese threat. Except where otherwise stated the following assumptions are made:

a. No new Soviet commitments to render large-scale technical and economic assistance will be forthcoming. Trade with the Soviet Union in commodities important for Chinese industrialization may continue.

b. No additional weapon systems adaptable for nuclear delivery will be supplied outright to the Communist Chinese.

c. Soviet assistance will not be renewed in the nuclear field, and will not be extended in the missile field.

On the Chinese Economy and Food Situation

Withdrawal of Soviet technical assistance in 1960 and subsequent diminished deliveries of Soviet-built equipment have caused major setbacks to Chinese industrial and technical progress. The agricultural (or food and population) situation, moreover, threatens to be chronically so precarious as severely to retard Chinese industrialization and military-nuclear development over the next decade or longer. Chinese economic troubles pose serious difficulties for estimators, because it is extremely hard to discern how much any particular high-priority effort, such as the nuclear program, has been set back. For US policy purposes, however, it is desirable to explore whether the US could handle the most severe threats that China could pose without outside support. This paper therefore assumes that the nuclear weapons program has not been seriously set back by the general industrial breakdown and food shortages. Instead, projections are based essentially on a judgment of Chinese technical capabilities, including additions to these capabilities likely in the event that the industrial part of the economy resumes its expansion by the mid-60s.

Accordingly economic assumptions chosen for the present paper, except where noted, include the following:

a. Chinese agricultural crises will not cause the ruling regime to set aside its nuclear ambitions, nor lead to a counterrevolution.

b. The regime, although not free from agricultural troubles for many years, will bring the situation substantially under control. By the mid-1960s China will begin to meet its agricultural needs.

c. As a result industrial recovery will become effective by 1964-65 and thereafter the industrial sector of the economy will grow by significantly more than 5% but usually not more than 10% a year.

More severe economic difficulties would probably render infeasible a number of the potential achievements discussed in the body of this paper.

On the Chinese Choice of Policies for Nuclear Development

As a result of economic limitations, the Communist Chinese have in the next few years a basic choice between policies which at the extreme are as follows:

a. They can put their emphasis on the short run, producing whatever nuclear-missile systems are possible, starting in the 1960s. Chinese industrial and agricultural capabilities will then still be woefully inadequate for giving a secure base to China as a nuclear power, and the resulting weapons capabilities may be marginal. In this case their other national goals will be set back, including their conventional military capabilities, their civil needs, and possibly their long-run performance in the nuclear-missile field.

b. They can scale down short-run nuclear-missile efforts, particularly production of equipment for operational use, and divert the resources so saved into raising the general level of output and technology in industry and agriculture. This choice means deferring systematic production of advanced weapons until the 1970s, when Chinese industrial and technical capabilities should be more developed. Efforts on advanced weapons would be at the experimental and prototype level. An exception would presumably occur in the production of fissionable materials, because stockpile growth is a cumulative process. The adoption of this alternative policy would possibly produce over time a greater advance in the level of nuclear-missile technology.

In this paper the assumption is generally made that Communist China will choose essentially the first policy. Over the present decade such a course would offer the more serious threats, and these should be weighed. Where the resulting capabilities appear unequal to the intended military task, however, the Chinese will have good reasons not to undertake production and deployment of the systems in question. In such instances the Communist Chinese will probably choose the second policy rather than the first.

INTELLIGENCE LIMITATIONS

(b)(1),(b)(3):50 USC §403(g) Section 6

(b)(1),(b)(3):50 USC §403(g) Section 6, and at this early stage, development and production of nuclear materials and modern delivery means in China are beclouded (even for the Chinese) by many uncertainties. The small existing base of intelligence makes extrapolation hazardous; but technology sets strict limits on the outcome.

Despite uncertainties, a quantified description of the threat, with variants, is necessary to develop the implications of a Chinese nuclear capability

SECURITY LIMITATIONS AND ACKNOWLEDGMENTS

Presentation of the subject in this form precludes extended discussion of existing estimates.

Assistance from within the intelligence community has been generously forthcoming. The cooperation of the Central Intelligence Agency has been outstanding, and has been supplemented by the excellent cooperation of experts from the Atomic Energy Commission, the Defense Atomic Support Agency, the Department of State Bureau of Intelligence and Research, the United States Air Force, and other agencies.

II. AN ESTIMATE OF CHINESE NUCLEAR REQUIREMENTS

GENERAL CONSIDERATIONS

External objectives of Communist China that can be directly furthered through an early nuclear capability include:[1]

1) Security for the Chinese mainland.

2) Consolidation of Communist power in China by the "liberation" of Taiwan.

3) Enhancement of China's regional role through reduction of the power and influence of the United States in Asia and the Western Pacific, and through projection of Chinese influence in nearby areas.

4) Increased influence and prestige on the world scene, and progress toward eventual superpower status.

Mastery of advanced weapons technology would also appeal strongly to feelings of national pride and thus have important internal advantage. Any sense of urgency which the Chinese may

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[1] For a more detailed treatment, see Harold C. Hinton, Communist China's External Policy and Behavior, UNCLASSIFIED, ISD Study Memorandum No. 18 (IDA, Washington, D. C.). This PACIFICA paper will be issued shortly.

have with regard to their nuclear program would be reinforced by a fear that China might be permanently excluded from major nuclear-power status by an American-Soviet "deal" or arms control agreement.

In furtherance of their objectives the Communist Chinese require nuclear forces that are useful in the defense of the Chinese mainland; capable of attacking the cities and forces of non-Communist nations in Asia; capable of effective attack on US forces and military facilities in the Western Pacific and the Far East, whether on their own bases or deployed to forward areas; and capable, in some future period, of attacking the United States and other distant areas.

The Chinese require regional nuclear forces sufficient to impose caution and restraint on American non-nuclear operations, and to decrease the attractiveness to American forces of employing nuclear weapons in situations involving China. A well-developed regional capability could give the Chinese military advantages they now lack in some situations, particularly in hostilities involving Korea or Taiwan, and would permit a Chinese nuclear response to US nuclear attack. Under special circumstances, with sufficiently powerful forces, a pre-emptive attack on US forces might be advantageous to China.

REGIONAL REQUIREMENTS

Range

The range requirements for attack on possible objectives are given in Table II-1 on pages 11-12.

Communist Chinese range requirements are relatively short for regional purposes and relatively long for intercontinental purposes. A minimum of 700 nautical miles [NM] range is necessary to make China a full-fledged regional nuclear power, although half that distance would be useful against Taiwan, Korea, and the northernmost portion of Southeast Asia and in defense of the Chinese mainland. A missile of 700 NM range would reach not only Korea and Taiwan, but also Okinawa and all Japan, not to mention Saigon, Bangkok, Manila, Rangoon, and New Delhi. This range would not only suffice for almost all important peripheral targets but would also give some flexibility of deployment within China. A range of 1,100 NM would be advantageous--if it could be achieved without substantial delay in the program--to cover additional peripheral targets and particularly to provide further flexibility of deployment. At the other extreme, a range of 5,000 to 6,000 NM would be necessary to constitute a serious threat to the United States, and at least 6,500 NM would be desirable.

Vehicles with ranges between 1,100 NM and 3,000 NM could only be interpreted as designed for use against the Soviet Union, which could be more safely threatened as a byproduct of building forces designed against the United States. This circumstance imposes an operational requirement to jump directly from the 1,100 NM range to the vicinity of 5,000 NM or more.

TABLE II-1

RANGE REQUIREMENTS

Approximate distance in nautical miles
from a roadhead or railhead in Communist China

0-350 NM

Taiwan	120-200
New Delhi (from Tibet)	270
Vientiane-Udorn-North Thailand	290-325
Korea (Pusan)	350

350-700 NM

Okinawa	375
Central Thailand (Khorat)	445
Northern Japan (Misawa)	480
Southern Japan (Itazuki)	480
Saigon (from Hainan)	480
Phnom Penh	490
New Delhi (from Sinkiang)	525
Bangkok	560
Manila	575
Rangoon	600
Central Japan (Tokyo)	620

700-1,100 NM

Karachi	875
Kuala Lumpur	1,030
Sverdlovsk	1,040
Singapore	1,090

1,100-3,500 NM

Guam	1,500
Djakarta	1,605
Moscow	1,765
Adak, Aleutians	1,885
Leningrad	2,005
Darwin, Australia	2,230
Anchorage, Alaska	2,630
Bonn	2,960
Paris	3,090
London	3,140

3,500-9,000 NM

Honolulu	3,620
Seattle	3,890
Sydney	3,910
San Francisco	4,250
Los Angeles	4,540
Chicago	4,930
New York	5,200
Washington	5,250
Miami	6,030
New York (from Chungking)	6,630
Buenos Aires	8,000

Numbers

Depending on the type of campaign, Chinese nuclear operations would require attack on approximately the following number of soft[1] targets:

1) Hostilities involving a specific locality such as Korea or Taiwan: 5 to 25.

2) A minimum counterforce operation against unprotected US delivery forces on fixed bases in the Western Pacific: 15.

3) Attack on all important fixed, soft US military targets in the Western Pacific and Far East (including those just mentioned): 60.

At 4 missiles per target (see discussion of CEP requirements, below) for 15 to 85 targets, the Chinese requirement for attack on the above target system would be 60 to 340 missiles.

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[1] In the sense of unhardened; i.e., not underground or otherwise heavily protected against nuclear effects.

Forces for use against hardened, dispersed, and mobile targets would be additional.

Survivability

In view of their nuclear inferiority and their exposure to overhead reconnaissance, the Chinese are likely to consider concealment of missiles, however difficult, as mandatory. They will probably carry secrecy to great lengths to prevent targeting of their nuclear capability. Mobility would also be highly desirable to facilitate concealment and add to the flexibility of (and hence economy in) Chinese nuclear striking forces.

Targeting

China and the lands in its vicinity are among the most poorly mapped regions of the world. There is no evidence that the Chinese have succeeded in obtaining geodetic and other data needed for accurate location of targets. With probable inaccuracies at both ends of their trajectories, early Chinese missiles will be militarily useful only against very large, fixed, soft targets, and even then their effectiveness will not be accurately predictable. China will need manned vehicles that can seek their own targets for use against large soft targets when assurance of destruction is necessary, and against hardened, dispersed, and point targets, at least until Chinese weapons and supporting systems begin to achieve real sophistication.

A second targeting problem stems from the need to be able to attack mobile targets in the Western Pacific. Unless and until it acquires an adequate reconnaissance capability, Communist China can only hope to meet this requirement in a minimal manner through the dual use, for reconnaissance and bombardment, of whatever bombers are available.

CEP, Yield, and Reliability

Accuracy and reliability are further difficult requirements for the Chinese. The neutralization or destruction of the structures and aircraft typically dispersed above ground on an airfield could be accomplished by a single first-generation fission weapon [redacted] only if the device were exploded at optimum airburst height near the exact center of the target. A probable circular error [CEP] of as little as half a nautical mile would reduce the expected disabling damage to only two thirds of the aircraft and structures. Clearly, a ballistic missile with such a small warhead would be an inadequate regional weapon except in very large numbers, or except with unrealistically high reliability and low CEP. A thermonuclear warhead of one-half megaton (500 KT), on a missile with one nautical mile CEP and 60 per cent reliability,

---

1. A kiloton [KT] is equal to the explosive power of one thousand tons of TNT, a megaton [MT] to one million.

could be expected to destroy over 90 per cent of a soft air-base target system only if four missiles were programmed per target.

For aircraft-delivered weapons, the Chinese will need to accept the CEP characteristics of the aircraft they have in hand (primarily the IL-28 Beagle unless they get the TU-16 Badger). For lack of modern, maintainable, all-weather bombing equipment they will probably have to rely basically on a visual capability to attack targets inconsistent with their missile technology.

Warheads adaptable in size and weight to both aircraft and missile requirements will be found desirable by the Chinese to avoid separate warhead development programs for each type of delivery system.

Manned Vehicles vs. Missiles

The Chinese will face a serious problem in trying to obtain favorable military results from their possession of regional forces, because of the difficulty of making such forces survivable against a pre-emptive strike. Targeting and other delivery problems will require the retention of a significant number of manned vehicles for many years, even though such vehicles are difficult to conceal or otherwise protect; whereas rigorous Chinese requirements for survivability appear to call for mobile ballistic missiles.

Because of the vulnerability of manned vehicles, the Chinese are likely to exaggerate their missile capability and to understate their manned vehicle capability.

INTERCONTINENTAL REQUIREMENTS

There is thus far little or no evidence that the Communist Chinese see intercontinental nuclear forces as a priority objective for the immediate future.

With even a primitive nuclear capability, Communist China will be able to develop a minor capacity for direct attack on the United States by means of nuclear mines, short-range sneak seaborne attacks on coastal cities, and clandestine delivery. During the period when the Chinese are unable to do more, they may at least tacitly threaten the United States with such attacks.

The Chinese are unlikely to divert significant resources to developing a sea-based (submarine or surface) missile capability, in view of the long lead time and high costs involved in obtaining such a capability, and its low utility in the face of US seapower

A credible nuclear-armed missile or airborne threat against the United States would require a range of at least 6,000 nautical miles, preferably more, and, at a minimum:

1) Either (a) ballistic missiles with warheads of at least one megaton, and a CEP not greater than 3 to 5 NM, for use against metropolitan areas; or (b) crude ballistic or aerodynamic vehicles carrying large (at least 10 MT) warheads with a CEP on the order of 25 to 100 miles, for use in operations aimed at producing damage by fallout.

2) The ability to absorb a first strike attack and/or to prevent the United States, and also probably the Soviet Union, from locating the Chinese force accurately enough to permit an effective pre-emptive or preventive attack. This latter requirement means concealment, and either mobility or hardening. Rapid reaction would not necessarily be required. Excavated storage sites in mountainous areas might be used to provide hardening at low cost.

Missiles with a small CEP would give greater assurance of damage and, as compared to aerodynamic vehicles, would be less subject to post-launch attrition. Sophisticated intercontinental ballistic missiles [ICBMs] would also appeal to the Chinese love of prestige, and would provide an important step into space technology.

For one type of vehicle or another the Chinese minimum requirement, even if only for political purposes, would hardly be less than about 100 missiles deliverable against the United

States. Eventually the Chinese would probably want a missile force comparable numerically to those of the United States and the Soviet Union.

OTHER REQUIREMENTS

There is clearly no logical limit to the Chinese need for higher-yield warheads, especially warheads for missiles, just as there is no limit to the need to reduce CEPs and to improve reliability.

Atomic demolitions (primarily a retardation device) and anti-submarine devices would appear to have little utility for China.

Small battlefield types of weapons might be useful to the Chinese, but to a lesser extent than to the United States, whose development of these weapons has been designed to compensate for smaller ground forces. In view of the generally less efficient use of fissionable materials involved in producing small-size weapons the Chinese are unlikely to give any priority to the development of these weapons at least until they have satisfied their requirements for regional and intercontinental use.

Air defense nuclear armament would be of considerable utility to the Chinese. Such armament could not, however, be available for at least a decade, by which time the Chinese must estimate that the primary nuclear threat to China will be from ballistic missiles. Thus, again, little priority is apt to be given to the development of these weapons.

Space achievements are desirable as a matter of prestige, and an 1,100 NM MRBM would probably be used to launch the first small Chinese satellite.

SUMMARY OF EARLY CHINESE REQUIREMENTS

For local and regional uses, the Chinese will have requirements for both ballistic missiles and manned aircraft.

The manned vehicle capability, to include if feasible a small hunter-killer force, appears necessary to offset targeting inadequacies as well as the lack of accuracy inherent in early Chinese missiles.

The ballistic missile requirement will be for ranges of at least 700 nautical miles, and preferably 1,100 nautical miles. Missile forces should be movable (preferably mobile) and readily concealable. The specific compromise among CEP, yield, reliability, numbers, time, and resource requirements which the Chinese may adopt can only be surmised. However, a reasonable initial goal would include a CEP of not over one nautical mile; a yield on the order of 500 kilotons or more; and an early inventory of not less than 60 weapons, growing to at least 340.

III. NUCLEAR WARHEADS

GENERAL EVIDENCE

Information on the Communist Chinese atomic energy program is fragmentary and often indirect. From available indications the history of the program appears to be as follows:

In the period 1950-55, Communist China engaged in preliminary preparations for a nuclear effort, including prospecting for uranium with Soviet help. The first mining of uranium began near the end of this period, and the mainland regime also recruited about forty capable Chinese nuclear physicists from the West. Chinese technical and industrial capabilities were still so low that independent quantity production of fissionable materials was out of the question.

The key Chinese decisions to start a full-scale military nuclear weapons program, with as much Soviet assistance as could be obtained, were apparently made in stages between 1955 and 1957 (or possibly early 1958). In 1955 the Soviets publicly agreed to supply laboratory quantities of fissionable materials and other assistance to research, and in 1955-56 the Chinese drew up a twelve-year plan for developing science and technology in which atomic energy was given first priority. During the 1956-57 period Soviet cooperation apparently began on production of nuclear-weapons materials in China. The late 1950s were marked by intensive, high-priority, Chinese efforts with reluctant Soviet assistance. On the research front, the Soviets provided a small five-to-ten megawatt /MW/ nuclear reactor and other equipment. They also trained Chinese scientific personnel in Soviet institutions including the Joint Institute for Nuclear Research at Dubna, and helped launch an intensive study of nuclear physics in Chinese universities. Information about the weapons program is much scantier, but the Soviets apparently furnished technical advisers, plans, and certain equipment for various facilities--uranium mines, ore concentration plants, at least one metallic uranium plant (on which work started in 1957), and, possibly, a small cascade for oralloy production.[1] It is not yet clear whether assistance was given on construction of one or more nuclear reactors for plutonium production, or on facilities for chemical separation of plutonium.

Several uranium mines have been identified, but no ore is believed to have been shipped to the USSR. The quantity and

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[1] A cascade or gaseous-diffusion plant is a facility for raising the proportion in uranium of the fissionable isotope U-235. Oralloy, which is uranium with a high proportion of the isotope U-235, and plutonium are the principal fissionable materials from which nuclear weapons can be made.

quality of ore mined is not known with accuracy. Available evidence is consistent with the accumulation by mid-1962 of the equivalent of several hundred tons of metallic uranium, probably less than two thousand tons.

From about the second half of 1956 there was a subtle change in the Chinese propaganda line on modern weapons and war. In May 1958, came the first public statement, in an article by the air force chief,[1] that in the future the Chinese would have nuclear weapons. Rumors and reports of related busy activity also pointed to a large-scale nuclear effort. In these years there was abundant evidence, much of it "between the lines" in public statements, of friction between the two Communist powers related to Soviet reluctance to see the Chinese armed with nuclear weapons. Some observers suspect that Soviet assistance was not only curtailed, but also designed to limit the Chinese program.

In 1959 photographs were made of a long, unidentified building in Lanchow, near two major hydroelectric projects that offer a prospective future electric power "surplus." The building is a slim rectangle, in the shape of one half of a Soviet U-shaped gaseous diffusion plant (cascade) for uranium isotope separation,

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[1] Liu Ya-lou, "Seriously Study Mao Tse-tung's Military Thinking," Liberation Army Newspaper, May 23rd, 1958. Cf. Leonard Beaton and John Maddox, The Spread of Nuclear Weapons (London, 1962), p. 133.

although some experts say the resemblance to Soviet facilities is not close. An ample industrial water supply, and a railroad spur that does not come right up to the building, add to the indications that this might be an incomplete cascade. Power lines did not appear to be installed in 1959. As of early 1962, power lines were still not constructed, and the Yenkou Dam upriver, although complete, was not yet producing electric power; comparisons with 1959 suggested that construction was abandoned or suspended in 1960. The only advance had been in finishing the roof, and the site appeared inactive.

Of course, there is a possibility that this plant was intended as a more innocent industrial facility. If the building were the start of a cascade, it would be a small one, a sort of pilot plant. Even with another similar building added, the resulting complex could use little more than one third of the 595 MW capacity which was planned to be installed at Yenkou, and would produce only a handful of nuclear weapons a year. There appears to be room at the site for no more than two additional similar buildings, without major modifications of the surroundings. A facility of this size would not account for the 1,050 MW of electric power to be installed in a few years at the large nearby Liuchia Gorge dam.

The Soviet withdrawal of technicians in mid-1960 seems to have included those in the Chinese atomic energy program. The official Communist Chinese line on the military value of weapons and men reverted for some months to a pre-1956 note. Then in November 1960, at the Moscow Conference of Communist parties, the number two Chinese Communist leader, Liu Shao-ch'i,[1] declared that China would have nuclear weapons in the near future, and said that China already had four reactors capable of producing plutonium (an ambiguous statement that could have referred to known research reactors, which are too small to produce quantities sufficient for weapons). Premier Chou En-lai, in a September 1961 interview with Field Marshal Montgomery, reiterated China's intention to obtain nuclear weapons, but implied that the nuclear timetable had been extended to accommodate other pressing needs of China.

Japanese and other newspaper stories pointing to sizable plutonium accumulation from China's small research reactors, including the one in Peiping, do not correspond to other evidence. Research experiments reported in the Chinese technical literature as having been made with the Peiping reactor are incompatible with

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[1] Liu Shao-ch'i is Chairman of the People's Republic of China and second to Mao as Vice-Chairman of the Central Committee of the Communist Party of China. Chou En-lai ranks third in the top party organization and party protocol.

its operation for a significant output of weapons-grade plutonium. There is, however, indirect evidence of possible plutonium production on a much larger scale than these unclassified reports would suggest.

The most important (b)(1),(b)(3):50 USC §403(g) Section 6 indications points to the probable operation, from early 1961 and possibly from mid-1960 (but with serious delays and difficulties), of a plant for producing metallic uranium, the exact site of which has not been pinpointed. This plant is believed to have been built, starting in 1956-57, with Soviet help, and is believed to have been almost complete at the time of the withdrawal of technicians. The plant presumably is now turning out uranium slugs for use in a reactor or reactors for producing plutonium. By correlating these fragments of information with the known mining and ore-concentrating activities, and by making assumptions regarding the plant's capacity--probably not much over one ton of metallic uranium output a day--it is possible to guess that by mid-1962 China had processed several hundred tons of metallic uranium, perhaps 500 tons, but probably less than 1,000 tons.

A major uncertainty stems from the failure to locate a plutonium-producing facility or to obtain positive evidence of its existence. Presumably the Chinese have taken great pains to hide the reactor and its associated plutonium-separation complex.

In view of the Chinese need for concealment and secrecy to avoid being targeted and of the apparent existence of a uranium metals plant, a reactor may be assumed to be in existence and probably already in operation. This assumption makes it possible to estimate the timing of the first Chinese nuclear test on the basis of production of the metallic uranium plant and of other countries' experience.[1]

CHOICES ON FISSIONABLE MATERIALS PRODUCTION

General

The principal choice in fissionable materials production is whether to produce plutonium, oralloy [U-235], or both.[2] Plutonium is produced from natural uranium through bombardment of U-238 with neutrons, usually in a nuclear reactor. The production problem for oralloy and lesser degrees of enriched uranium is one of separating U-235 from the common isotope U-238;[3] the two isotopes differ for purposes of separation only in characteristics relating to their slightly different mass.

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[1] See below, pp. 34-39.

[2] U-233 is also fissionable, but its co-product U-232 has undesirably heavy radiation emission, making U-233 for practical purposes an inferior weapons material.

[3] The concentration of U-235 in natural uranium is only 1/140th or 0.714%. Oralloy with 93.5% U-235 is known as "top product." Any uranium in which the proportion of U-235 has been raised is considered enriched.

Military Considerations

Apart from fabrication and handling difficulties, plutonium is a little better than oralloy in most military uses, permitting a greater degree of miniaturization for a device of a given yield. "Clean" plutonium, that is, plutonium containing very little of the undesirable isotope Pu-240, is better than oralloy in almost all respects, but is expensive. The Pu-240 content of plutonium increases, so that the quality decreases, with the period of irradiation in producing the plutonium within a reactor--but the longer the irradiation period, the less expensive is the plutonium. A compromise is thus necessary between purity and low cost.

Pu-240 has the effect of increasing the neutron radiation background, multiplying problems of safety and the likelihood of predetonation (preinitiation), which can greatly lower yeild.

(b)(3) 42 USC §2162(a) - (RD) [redacted]

Enriched uranium--not so enriched as to be called oralloy--is necessary to a military nuclear program for at least two relatively sophisticated purposes: first, to permit boosting[1] of fission weapons, by making possible the production of significant quantities of tritium, and second, to permit the construction of

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[1] Boosting refers to injecting a gas mixture of deuterium and tritium in the core of an implosion device.

military reactors, for example, power plants for nuclear-powered submarines. (Plutonium-fueled reactors are impractical and present extremely difficult problems.) (b)(3):42 USC §2162(a)-- (RD) the result is to increase safety margins and permit greater miniaturization. But the requisite tritium, though used in much smaller quantities, is roughly [redacted] as expensive by weight as oralloy. Tritium must be produced in a reactor fueled by enriched uranium, because the lithium used for tritium production "poisons" the reaction and makes use of natural uranium impractical. Enriched uranium also permits more economical production of plutonium.

(b)(3):42 USC §2162(a)-- (RD)

(b)(3)42 USC §2162(a)--(RD)

Without boosting, however, the Chinese will be restricted to lower yields for a given weight. For this reason if not for others, they will probably want to add production of enriched uranium, if not oralloy, early in their program.

Production Considerations

Large-scale plutonium production, although believed feasible by linear acceleration, is accomplished in the weapons programs of the United States, Great Britain, the Soviet Union, and France by means of relatively large--and occasionally extremely large--reactors, which may be fueled by natural uranium or by a combination of natural and enriched uranium. Quantity production of plutonium may be attained with reactors having thermal outputs of 100 to 350-megawatts; the largest reactors exceed 1,000 MW thermal power. The US cost of plutonium, of which the cost of the metallic uranium reactor fuel is a large proportion, is on the order of (b)(1) per kilogram depending on quality (i.e., Pu-240 content).

(b)(3)42 USC §2162(a)--(RD)

Oralloy, and enriched uranium in general, is produced in the United States, United Kingdom, and Soviet Union in gaseous diffusion plants (cascades). The French, having decided that plutonium was an easier material with which to start, have not yet moved into oralloy production. They have, however, spent nearly one billion dollars on their first cascade, without as yet putting the plant into production. When the United States first started to produce oralloy in 1944 the atomic-energy program used two other processes, relying mainly on the electromagnetic or mass spectrographic process. Gaseous diffusion, which started operations in 1945, proved to be much less expensive, and the other methods were dropped. For financial reasons other possible processes of uranium-isotope separation have also been rejected. Among these, the centrifuge process has been subsequently developed by the West Germans. The security classification on related research has been reinstituted by the United States, although for large-scale production the centrifuge process is not yet competitive with gaseous diffusion.

A great deal of information on reactor technology, applicable to plutonium production, has long been available in the unclassified technical literature, including the design of 150 to 300 MW reactors for electric power production; and the Chinese since 1958 have had some experience operating small reactors supplied by the Soviets. Plutonium production is therefore presumably something the Chinese will be able to master; difficulties should prove only moderate, and should center on details of engineering and execution.

Technical problems with a reactor include producing uranium and graphite of high purity, designing and operating the reactor, and separating the plutonium afterward. The latter is a major chemical engineering project that gave the French some difficulties. Because plutonium is radioactive, highly toxic, starts fires, and can cause explosions, plutonium separation and weapon fabrication must be remote-controlled.

It is an interesting commentary on the economic conditions in different countries that in the United States oralloy is considerably cheaper for a given fission yield (all things considered) than plutonium. US oralloy costs about (b)(1) per kilogram. In the Soviet Union oralloy is likewise produced in larger quantity, and is believed to be cheaper, than plutonium. In countries such as China, however, the reverse is likely to be true because oralloy production (U-235 separation) is likely to be extremely difficult and expensive.

Every method of producing oralloy or enriched uranium is essentially a brute-force method relying on the repetition thousands of times of processes each of which has a very small capacity for increasing the percentage of U-235. The engineering, whether in a cascade or with an array of centrifuges, is of a fine-precision nature with extremely demanding manufacturing tolerances. In a cascade the highly corrosive gas, uranium hexafluoride, is pumped into several thousand chambers or stages, in each of which it is forced through a fine metallic membrane, which ideally allows only individual molecules to pass. This system requires thousands of huge compressors and other special machines, with rotors and other parts coated with nickel or aluminum against the corrosive gas. The complex "plumbing" includes special seals. Total electric power consumed by the three US cascades today is approximately equal to the electric power produced in China. (By comparison, the large plutonium reactor complex at Hanford, Washington, requires about one eighth as much electric power as a single US cascade and such a complex can furnish the thermal power for its own electric needs.)

In general, centrifuges present equal or even greater engineering difficulties than cascades and involve higher capital costs; but they could potentially save on operating costs. A US centrifuge plant designed in the 1940s but never built would have had 30,000 individual centrifuges connected by a complex system of pipes and valves. The design of a centrifuge involves serious alloy and rotor design problems connected with the high speed of rotation.

The difficulty of the oralloy production problem is indicated by the fact that apparently the first Soviet cascade did not work satisfactorily, but had to be redesigned and rebuilt with more stages; even today [redacted] (b)(3):42 USC §2162(a)-- (RD) The first US cascade and its additions and successors are still a tribute to US engineering skill.

In view of these considerations and of Chinese shortages of engineers, technicians, and skilled manual labor, it is generally expected that China will put emphasis on the use of plutonium rather than oralloy for weapons.

FACTORS INFLUENCING THE TIMING OF THE FIRST TEST, POSSIBILITIES OF SERIES TESTING

Most estimates assume that the first fissionable material produced by China in testable quantity will be plutonium, and that it is likely to be produced in a reactor or reactors fueled with natural uranium, presumably with metallic uranium slugs from the metals plant that probably began operating about January 1961.

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[1] E.g., in output of oralloy per unit input of electricity.

The process of plutonium production starts with producing enough metallic uranium for a reactor (100 to 200 tons), loading the reactor, getting it to go critical, and then raising it to full power, the last of which can take several months the first time. The uranium is irradiated for several more months by neutrons produced within the pile. Then the reactor is shut down, much of the fuel is removed, and the slugs are "cooled" for 60 to 90 days to reduce radioactivity. Finally, the processing of the irradiated uranium begins in a plutonium-separation plant that probably is capable of processing each day no more than one or two tons of the uranium from the pile. The processing of (b)(1) (b)(1) should yield (b)(1) of plutonium required for a single nuclear test. Then the plutonium must be fabricated into a nuclear device.

The allowable "cooking" time, and therefore the quantity of plutonium obtained from one batch of uranium, is limited, as already suggested, by the fact that as time goes on some of the plutonium is converted into undesirable isotope plutonium-240.

From the time concentrated ore arrives at the uranium metals plant, up to the point of obtaining enough plutonium for one test, the entire process described above is likely to take anywhere from 18 to 30 months or more depending on (1) the size of the reactor and capacity of the uranium metal and plutonium-separation plants, (2) irradiation time in the reactor, and (3) the degree of difficulty experienced in producing uranium metal of the requisite purity and in operating the reactor and plutonium-separation plant for the first time. Numerous possibilities exist for a delay of the program, notably as a result of accidents and errors.

Assuming that the Chinese (1) use metallic uranium produced beginning as far back as early 1961, (2) build a reactor of about 200 MW thermal power (requiring about 200 tons of uranium), (3) aim at an early buildup of their military stockpile at the expense of slightly retarding the first test, and (4) experience difficulties comparable to those of the French, the production period is likely to be 24 to 30 months. Thus plutonium for the first test could become available between January and July of 1963. The date would be later if the metals plant had a lot of "down time" or produced an inferior product in early 1961, or if operating difficulties exceeded those of the French, either for lack of technical expertise or because of the general economic crisis in China.

How long the Chinese, having the plutonium, would then require to fabricate a device and explode it in an instrumented test depends on outside help received, if any; the extent of Communist Chinese familiarity with United States, Soviet, British, and French tests, weapons, and calculations; and Chinese fabrication difficulties with plutonium. The resulting delay caused by fabrication time could be from 3 to 12 months. This gives a spread for the first test, assuming 24 to 30 months for the production of plutonium, of from April 1963 to July 1964. As indicated, operating difficulties and accidents could cause further delays; economic difficulties have probably done so already. On the other hand, the Chinese might hurry the first test[1] in a special effort to obtain an early propaganda vehicle.

Assuming that the Chinese had no technical difficulties whatever, knew how to fabricate a device, did in fact put their metals plant into effective operation in January 1961, and hurried to achieve early propaganda benefits at some possible expense to the accumulation of a stockpile, the first test could have taken place as early as 21 months after January 1961, that is, by October 1962. At the other extreme, if the metals plant has not been operating effectively, and in view of economic difficulties, this test could be delayed by as long as several years. Most US experts feel that the Chinese program has probably already slipped at least one year compared to an early 1963 schedule based on technical feasibility.

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[1] E.g., by irradiating the pile only long enough on the first cycle to produce plutonium for one test.

It is important to note that the scale and timing of the subsequent buildup of the Chinese stockpile depends only in a minor way on whether the first test is in 1963, or in 1964, or even 1965. Assuming that the metals plant has in fact operated since 1961, the later the first nuclear explosion, the more rapid is likely to be the subsequent accumulation of a stockpile, and the closer the second test is likely to be to the first, especially if the delay is not caused by faulty basic design of production facilities. If the Chinese drive toward an early stockpile and, although experiencing few technical difficulties, do not conduct their first test until late 1963 or 1964, they could be testing two or three other devices within six months after the first. If they do not hurry for propaganda purposes, their plutonium-production cycle could be such that plutonium production becomes virtually continuous,[1] except for "down time" caused by accidents and other troubles, starting with the plutonium for the first device. Thus, estimates of the timing of the first test are somewhat independent of stockpile estimates, which depend instead on the program for setting up production facilities for plutonium and oralloy.

It is interesting to compare the prospective Chinese lead time for "joining the nuclear club" with those of other nuclear

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[1] That is, no sooner is the reactor unloaded for the cooling of the irradiated pile than another pile is loaded and made to go critical; and plutonium separation facilities are kept steadily at work.

powers. Presumably the Chinese decision to produce nuclear weapons was made about 1956, and intensive efforts on construction of facilities began in late 1957 or 1958 at the latest. Chinese industrial capabilities, however, were more spotty and backward at that time than those of any previous nuclear power. If the first Chinese test takes place as early as 1963 this will represent a lead time of approximately six years, based on the period of full-scale effort. By comparison, the French achieved a first test five and one-half years after beginning a plutonium-production program that had already been authorized two years earlier, and four and one-half years after the decision to enlarge and accelerate the program with military funds. The Soviet Union and the United States both had "crash" programs that took a little under four years.[1]

WEAPONS DESIGN TECHNOLOGY

First Deliverable Device

The prevailing estimate is that the first deliverable Chinese nuclear weapon will be a crude six- to ten-thousand-pound fission device based on a plutonium-implosion system. On military

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[1] This assumes that the Soviet "crash" program dates from shortly after the A-bombing of Hiroshima in 1945. Some progress had been made prior to 1941; the Soviet nuclear effort was apparently downgraded when the Germans gave up their high-priority effort in 1941. See Arnold Kramish, Atomic Energy in the Soviet Union (Stanford, 1959).

grounds, however, there would be little incentive for the Communist Chinese to stockpile a device so large unless they had acquired from the Soviets or otherwise expected to obtain TU-16 Badger bombers or the equivalent. The only other aircraft that could carry such a large bomb is the TU-4 Bull (a copy of the US B-29), which is already hopelessly obsolete as a threat against modern military forces and is available only in small numbers. In the absence of Badger, the Chinese manned-bomber force would continue to rely as it does at present on the IL-28 Beagle. Beagle is a rather small aircraft restricted by its bomb-bay design to a nuclear bomb about 37 inches in diameter, which might weigh somewhere between 1,800 and 2,500 pounds.

A powerful argument can therefore be advanced that the Chinese will try to jump straight to a 2,500-pound plutonium-implosion device, starting possibly with the first nuclear test. Any effort on a 6,000-pound bomb for which there was no adequate delivery means would be unnecessarily wasteful of scientific and engineering skills. There is also good reason to believe that, having experimented extensively beforehand with non-nuclear explosives in relation to implosion techniques, the Chinese could achieve an initial weapon of the lighter weight without severe delay to their warhead development program. A deliverable 2,500-lb. device might be available within one to two years after the first successful Chinese nuclear test. However, the Communist Chinese may choose to conduct an earlier test with a larger device, as a physics experiment, a political gesture, and a more conservative but surer means of reaching the smaller weight class.

The same 2,500-pound device should be capable, with only external modifications, of serving as a warhead for the medium-range ballistic missiles /MRBMs/ that the Chinese are apparently trying to build, and as a ready-made primary for conducting the nuclear tests necessary for the development of thermonuclear warheads, which would presumably be the next big step. Once perfected, a 2,500-pound basic weapon should produce (b)(3) 42 USC 2162(a) (RD) [redacted]

First Thermonuclear Weapons

The problem of developing thermonuclear weapons is of quite a different order than the problem of producing atomic weapons, which is largely an industrial question. The atomic-to-thermonuclear problem is largely a question of scientific and technical imagination, and it would be dangerous to base estimates on the idea that a people such as the Chinese were lacking in imaginative power, or in scientific talents.

A still current estimate suggests that the Chinese will not be able to attain deliverable thermonuclear [TN] weapons until about 1970; but this estimate should probably be revised in the direction of shortening the required time. Most experts seem to feel that the problem is not excessively difficult and should be soluble within five or six years of the first atomic test. Thus 1969 appears a feasible date, assuming a first fission test in 1963 or 1964.

Advancement toward a thermonuclear capability must proceed in steps, each of which requires at least one and probably several nuclear tests. The Chinese should be able to take an initial fission device, such as the 2,500-pound device just mentioned, and use it as the primary in a series of experiments designed to obtain information on radiation flow, temperatures, pressures, casing materials, secondary behavior, and other aspects of thermonuclear design. For such tests it would be desirable to have highly sophisticated instruments, but up to a point mathematical computations and a "trial and error" procedure with more numerous tests can be used as a substitute for good instrumentation.

Information relevant to TN design can be gathered as a by-product of any nuclear test, if the Chinese can produce the instrumentation. The first tests specifically aimed at a thermonuclear device would probably involve a mockup of the secondary with measuring devices attached to record such items as compression and temperatures. (b)(3) 42 USC §2162(a) - (RD) [redacted] For all these tests the Chinese would be advantaged if they fully understood the behavior of their primary.

One interesting facet of the problem is the possibility that the Chinese intelligence services could get hold of TN weapon designs from any of the four nations that by then should be thermonuclear powers. (b)(3) 42 USC §2162(a) - (RD) [redacted] The results of even one good "steal" might save two years' experimentation. As it is, the Chinese will be considerably helped by their knowledge of the shapes and approximate weights of US warheads. This can be obtained from publicly available sources. Such information can be supplemented by covert operations in which the Chinese doubtless attain some success, in Europe if not in the United States.

When a thermonuclear device is developed for use with the earliest primary, it could be delivered by Badger or Bull. Again, however, the emphasis will probably be on producing a smaller thermonuclear warhead suitable for MRBM delivery. The main requirement for this purpose would be a much smaller primary, and in this connection it seems reasonable to suppose that the Chinese will try to proceed to an [redacted] (b)(3):42 USC §2162(a)-- (RD) but the Chinese--lacking numerous computers, pure quality materials, and advanced engineering capabilities and experience--cannot be expected at first to execute optimum designs.)

[redacted]

Economizing Nuclear Materials

Something has already been said on the problems of converting weights of plutonium, oralloy, or combinations of the two into nuclear weapons.

Underlying considerations include the following:

1) Theoretical maximum achievable yields are 19 KT/kg for plutonium and 18 KT/kg for oralloy. This means that, regardless of design, 6 kilograms of plutonium cannot produce more than 114 KT, and in practice efficiencies in fission devices are typically [redacted] of this achievable maximum with plutonium, and [redacted] (b)(3):42 USC §2162(a) -- (RD) Boosting can greatly increase the fission efficiency.

2) The critical mass for plutonium, without any compression, is 16 kg with no tamping and 5.8 kg with infinite tamping.[1] For oralloy the comparable critical masses are 52 kg and 17.2 kg.

(b)(1),(b)(3):42 USC §2162(a) -- (RD) [redacted]

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[1] Tamping refers to surrounding the fissionable material with a neutron-reflecting substance such as depleted natural uranium.

3) (b)(3):42 USC §2162(a)-- (RD)

4) (b)(3):42 USC §2162(a)-- (RD)

In the stockpile tables to be presented,[1] 6 kg of plutonium and 30 kg of oralloy are each equated with one nuclear weapon. Given enough surrounding high explosive and tamper, these quantities will permit production of a nominal-yield weapon; the yields will scale up or down with device weights and technology. The first US (b)(3):42 USC §2162(a)-- (RD) tests, in Operation CROSSROADS in 1946, required (b)(3):42 USC §2162(a)-- (RD) for 20- to 25-KT yields; the device weighed about 6,000 pounds.

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[1] See below, pp. 58, 59, 60, and 61.

(b)(3):42 USC §2162(a) (RD)

[redacted] This will have the result of accelerating the effective growth of the stockpile, compared to the figures shown in the tables.

STOCKPILE PROJECTIONS

Plutonium Production

As suggested above. stockpile projections may be made with little reference to the date of the first nuclear detonation, assuming that Chinese uranium metals plants and plutonium producing facilities are adequately designed. The size and nature of the program for setting up production facilities for plutonium and oralloy are most important for stockpile purposes. Of course, some types of delays in the Chinese program could enforce a time lag of one or more years on otherwise valid stockpile projections.

The experiences of other countries suggest that the scale of the initial plutonium effort will be a reactor of 150- to 200-MW thermal power, unless a pioneer 100-MW reactor is built to hurry the first test explosion.

(b)(1) [redacted]

The first four nuclear powers all started serious production of plutonium for weapons with reactors in the 150- to 220-MW thermal power range.[1] On this basis it is reasonable to suppose that the Chinese will start near this range, probably close to 200 MW, and that they will serialize the design long enough to build several that can utilize the experience of the first. Power output of the basic reactor should improve with experience. Perhaps some years from now the Chinese will jump to a large reactor, on the order of 1,000 to 2,000 MW, but there is no pressing reason for doing so until they become very sophisticated, possess enriched uranium, and seek to economize by way of a new investment.

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1. The French started with a small reactor (G-1), which achieved only 30 MW, and then jumped to a second (G-2) at 200 MW, and a third (G-3) that was a copy of the second. The copy was under construction long before the original went critical and was phased into production about 18 months after its twin. The British, who pooled nuclear information with the US, have built a series of some ten plutonium-producing reactors in the 180- ton 300-MW range (power output improves with experience), all more or less identical to the first one. The US series of reactors at Hanford has included some "monsters" of over 1,000 MW, but the first was in the same medium-sized range (after a 1-MW model to demonstrate the method); and the initial Soviet experience was also in this range.

By assuming an initial reactor in the 100- to 250-MW range followed by a series of similar reactors, it is possible to arrive at numerical stockpile projections. For this purpose 1 January 1961 will again be taken as the approximate date on which the Communist Chinese uranium metals plant began to produce slugs suitable for use in a reactor.

As a first estimate, it will be assumed that the Chinese are able to design and build a reactor of 200-MW thermal power, that a second similar reactor will be built and put into operation two years after the first, and, after that, new reactors of the same size will be introduced at a rate of one each year. This would, of course, imply a matching buildup of uranium mining,[1] metallic uranium output, and plutonium separation. Accompanying assumptions must be made regarding the rate of improvement in reactor power levels for this one design; the test schedule; the amount of "down time" in the process, for which 25% reduction in output will be allowed; the timing of the production process; and so on.

The results are shown in Table III-1. It must be remembered that any oralloy production would add to the warhead stockpile. The projection is carried to the beginning of 1970, by which time seven reactors are assumed to be in operation.

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[1] There is probably no serious limitation on the natural uranium available in China, but the remote location of most mining areas could impose high costs in terms of investment and transportation.

TABLE III-1

PLUTONIUM OUTPUT AND WARHEAD STOCKPILE FROM A SERIES OF REACTORS OF INITIAL 200-MW DESIGN

(b)(1)

[redacted]

Assumptions:

1. First test occurs about the end of 1963.

2. Reactor construction schedule is as shown in text (p.49): first reactor goes critical December 1961, the next two years later, then one per year until December 1968.

3. Power level of reactors rises 33-1/3 MW per year after late 1963. By end of 1969 all reactors are operating at 400-MW thermal power. Each new reactor falls 45 MW short of current power output of older reactors its first time in operation.

4. Reactors operate on equivalent of nine-month cycle including six months for irradiating time. The first reactor's first cycle requires an extra three months for learning time.

5. After discharge from reactor an average of eight months is required for separation of plutonium and fabrication into weapons.

6. Fabrication of deliverable weapons starts in second quarter of 1964. If Chinese must wait longer for an acceptable design, they would of course be temporarily limited to accumulation of plutonium.

7. Output determined by assumptions above is reduced 25% to allow for technical difficulties and accidents.

8. Large number of tests is made as shown to accelerate weapons technology.

Some observers may consider this an unrealistically rapid buildup. It is accordingly labeled "moderately fast," and slower alternatives are offered. In considering this schedule, however, it must be remembered that technical and economic delays might cause as much as a two- or three-year lag in the dates, in which case the Chinese might be hurrying to retrieve the lost ground.

A second estimate is made by assuming that the initial reactor pile is only 100 MW. A design level of 150 MW is achieved the second time the reactor is operated. A similar reactor is again put in operation two years after the first, but this time new reactors are added every 18 months rather than every year, and they continue to be of this smaller type. The other assumptions are identical. By 1970 five reactors are in operation rather than seven.

Together these two projections furnish a "moderately fast" and a "moderately slow" picture. For those who are extremely skeptical of Chinese industrial capabilities, the Communist Chinese priority on nuclear weapons, or the emphasis on plutonium, a third series is appended in Table III-2, based on only two reactors of 150-MW design (the first produced 100 MW on the first cycle), with no follow-on. The same brisk pattern of tests is still assumed.

TABLE III-2

PLUTONIUM OUTPUT AND WARHEAD STOCKPILE FROM A SERIES OF REACTORS OF INITIAL 150-MW DESIGN

(b)(1)

In each of the tables, as already indicated, a conversion is used whereby six kilograms of plutonium are equated with one weapon or test, except that nine kg are assumed for each of the first two tests. The yield, depending on warhead weight and design, might be higher or lower than nominal yield (20 KT).

(b)(3):42 USC §2162(a)-- (RD)

Oralloy Production

Chinese production of plutonium will presumably be supplemented at some point, perhaps already in the late 1960s, by production of oralloy. The most likely guess is that China, like the other nuclear powers, will build a gaseous diffusion plant. The Chinese may already have been assisted in cascade technology by the Soviets in the 1956-60 period. If the building seen in Lanchow is the start of a small cascade, the Soviets must have given some help, probably including the design of the basic machinery.

There are two approaches to estimating future Chinese oralloy production: to assume that the first production will come from the building at Lanchow, or to compare other countries' experiences and make an independent projection of what the Communist Chinese might reasonably be expected to do.

The present facility at Lanchow, if a cascade, and if and when machinery is put in place under the roof, should utilise only 50 to 100 MW of electrical power, probably 75 MW (depending on the technology), a figure that may be compared to the more than 2,000 MW for a US gaseous diffusion plant. As already noted, hydroelectric projects not yet complete would provide an unexplained future power surplus that could reach an eventual level of as much as 1,000 MW, well in excess of known requirements in the Lanchow area.

If the unidentified building was intended as a complete cascade with very small-sized machinery, it can be estimated on the basis of the roof area that, operated at an efficiency comparable to what the Soviets achieved with their first successful cascade, the plant might produce about (b)(1) oralloy a year. An alternative assumption would be that the plant is or was intended to provide enriched uranium for reactor use, including tritium production.

The oralloy requirement for a single nuclear weapon, depending on design and the efficiency of implosion or compression, is (b)(1) It can thus be estimated that the potential increment to the Chinese stockpile by operating a cascade of the apparent size of this plant is only in the range of [redacted] weapons a year, depending on the efficiency achieved. The existing plant area could also be used to take uranium halfway through the separation process to obtain a product enriched about 5%, perhaps [redacted] tons of it a year, a quantity that would have about double the total U-235 content of the oralloy that could be produced.

If it were not for the space difficulty, one similar building could eventually be added each year. This is the way US cascades have developed; the first one at Oak Ridge started with about one-tenth of its present electric power input.

The Lanchow plant, whatever its purpose, has not been completed or put into operation. As already suggested, a cascade puts a heavy burden on the machine-building industries. Possible explanations for the halt or delay of the work include the withdrawal of Soviet technical assistance, deliberately insufficient Soviet help at the beginning, recent industrial setbacks caused by the food crisis, increased priority of agriculture as opposed to heavy industry, delays caused by possible Chinese inability to manufacture the requisite machinery as yet, or a decision to concentrate on plutonium instead.

The Chinese, assuming they are producing plutonium, may be in no hurry to obtain oralloy. In this case, whether they add to a small pilot facility at Lanchow or build a new one does not matter much. In relation to the stockpile obtainable with plutonium alone, a handful of extra weapons due to oralloy production will not basically change the stockpile picture already presented. Oralloy will have a profound impact on the stockpile situation only when yearly production is sufficient to fabricate scores or hundreds of nuclear weapons, and this will require a much larger cascade than could be housed in or around the building photographed in Lanchow.

How large a cascade might the Chinese build, and with what weapons output? The first US and Soviet cascades utilized 200 to 250 MW of electric power. This is perhaps a useful scale to consider. If the Chinese experimented before building a plant, to improve and check their technology, they might be able to start a serious production program at a technical efficiency yielding [redacted] [redacted] of electricity, economizing to about [redacted] At [redacted] the result, for a production plant of 200 MW, would be about [redacted] or enough for [redacted] The yearly addition to capacity, like the initial capacity, can be expressed in terms of the additional megawatts of electric power required, which

A handful of extra tests would probably be undertaken, reducing the stockpile increment correspondingly. Offsetting this or more than offsetting this, there would be economies from putting oralloy and plutonium combinations in the same weapon, some of which are already assumed in using 30 kg as the equivalent of one weapon. Other variants could be postulated, but slightly faster schedules would not accelerate stockpile growth much until after 1970. From 1970 on, the schedule shown in Table III-3 would result in accelerating Chinese stockpile accumulation, compared to an all-plutonium program, by 50 to 100 weapons a year.

The results of combining this oralloy schedule with the three plutonium production schedules already shown are summarised below in Table III-4. The extremely slow all-plutonium variant is omitted because there seems to be little reason for the Chinese to build two plutonium reactors in the first half of the 1960s, amidst an economic crisis, and then not expand production in some way later. The two slower plutonium schedules shown earlier are combined below, not with the oralloy schedule shown in Table III-3, but with the same schedule lagged one year. Thus only in the first variant does the oralloy production schedule have a substantial effect on the outcome. The last four variants are all moderated in one way or another, to show the range within which the program might be slowed down compared to the first variant. Attention is again drawn to the possibility that stockpile acquisition would take place at one or another rate, but that the entire schedule would be shifted back one or more years by technical and economic difficulties.

TABLE III-4

STOCKPILE (NOMINAL-YIELD FISSION WARHEAD EQUIVALENT)

Mid-Year	A	B	C	D	E
1964	5	5	4	4	4
1965	21	21	17	17	16
1966	45	43	30	30	24
1967	92	75	50	48	34
1968	163	119	89	72	56
1969	264	177	147	103	90

A: "Moderately fast" plutonium, plus oralloy schedule shown
B: "Moderately fast" plutonium, but no oralloy
C: "Moderately slow" plutonium, plus oralloy schedule lagged one year
D: "Moderately slow" plutonium, but no oralloy
E: "Extremely slow" plutonium, plus oralloy schedule lagged one year

(Table III-5 is appended to show in more detail the derivation of III-4.)

As a generalization, the 20-weapon mark appears likely to be passed sometime in 1965, the 50-weapon mark in 1967, and the 100-weapon mark in 1968. As a rough extrapolation, the level of 200 thermonuclear or 400 fission weapons, or some combination, should be reached about 1971. On the basis of such calculations it appears unlikely that China, relying on its own resources alone, could accumulate a stockpile of as many as one hundred weapons without the world's obtaining four or five years' notice that the program is achieving successes.

TABLE III-5

TOTAL STOCKPILE

A. Results of Combining "Moderately Fast" Plutonium Production from Table III-1 with Oralloy Schedule Above. (Result summarized in Table III-4, Column A)

End of year	Plutonium in warheads equivalent	Oralloy in warheads equivalent	Total in fission warheads equivalent	Mid-year warheads
1964	13	—	13	5
1965	30	—	30	21
1966	57	6	63	45
1967	95	30	125	92
1968	146	61	207	163
1969	213	114	327	264

B. Results of Lagging Oralloy Production Shown in Table III-3 by One Year and Combining with "Moderately Slow" Plutonium Schedule from Table III-2. (Result summarized in Table III-4, Column C)

End of Year	Plutonium in warheads equivalent	Oralloy in warheads equivalent	Total in fission warheads equivalent	Mid-year warheads
1964	12	—	12	4
1965	23	—	23	17
1966	38	—	38	30
1967	59	6	65	50
1968	86	30	116	89
1969	121	61	182	147

C. "Extremely Slow" Schedule from Table III-2 Plus Lagged Oralloy Schedule. (Result summarized in Table III-4, Column E)

End of Year	Plutonium in warheads equivalent	Oralloy in warheads equivalent	Total End of year	Mid-year warheads
1964	12	—	12	4
1965	20	—	20	16
1966	28	—	28	24
1967	36	6	42	34
1968	43	30	73	56
1969	50	61	111	90

SUMMARY

The following key points can be postulated on the chart of Chinese nuclear progress. The dates are only approximations. There could be systematic delays, of one or more years in all dates, due to Chinese economic or technical difficulties.

First nuclear test	1963-64
First weapons deliverable by manned bomber	1965
20-weapon stockpile	1965
First warheads suitable for MRBM	1966
50-weapon stockpile	1967
100-weapon stockpile	1968-69
First thermonuclear warheads	1969
200 thermonuclear weapons, or 400 fission weapons, or a combination	1971

Any degree of slowing down or "stretching out" of the program is technically possible.

IV. DELIVERY SYSTEMS

PRESENT PRODUCTION EXPERIENCE AND R&D CAPABILITIES

Thanks to Soviet assistance between 1955 and 1960, China now has a pool of experienced aircraft technicians, a very small research and development capability in the aircraft field, and production experience with a variety of complex military equipment: MIG fighters, light air transport, helicopters, radars and various other electronic equipment, ocean-going submarines, destroyer escorts, medium tanks, and medium artillery. There has also been a beginning acquaintance with a variety of missiles and other highly sophisticated weapons; and there is considerable industrial experience in fields, such as machine-building and metallurgy, that could be brought to bear on the problems of aircraft and missile production.

No true nuclear delivery systems have yet been built, unless one counts submarines. All bombers now assigned to the Chinese air forces were built in the Soviet Union. A single IL-28 (Beagle) was reportedly once assembled in China, and Chinese technicians perform maintenance on such bombers. Preparations for producing TU-16 (Badger) jet medium bombers in China were probably well along in 1960 but the production facility has been left incomplete. Whether any Soviet assistance has ever been received for surface-to-surface missile production is an unanswered question; so far there is no definite positive evidence.

MIG-17 production with Soviet assistance, which later became MIG-19 production, consisted at first, in 1957, simply of assembling Soviet-made aircraft. Later the Chinese began to produce parts, starting with the simplest components and moving on to more complex equipment such as engines and instruments. Today few if any MIGs are being built, but Chinese dependence on the Soviet Union is restricted to a few alloys and parts for engine manufacture. These the Chinese can probably soon make for themselves, using imported nickel and chrome that neither the Soviets nor the West are likely to be able to prevent China from obtaining through foreign trade. There are now five factories suitable for aircraft production and several arsenals and machine works suitable for missile production.

The production of MIGs halted and that of the AN-2 Colt (a small "feeder" transport) slowed sharply after Soviet aid was withdrawn in mid-1960. Production of Soviet W-class submarines, of which twenty-one were built through 1960, was brought to a virtual standstill; the four submarines then being built could not be immediately completed. It is believed that naval shipbuilding efforts were still dependent on the Soviets for complex equipment and instrumentation, not including submarine diesel engines.

In every case, Chinese independent production of even the most complex equipment appears to be just a matter of time. Until the agricultural crisis and withdrawal of Soviet technicians disrupted industry, the Chinese seemed to be learning fast. Engineering and science graduates are pouring out of the Chinese universities. Within the next few years, the Chinese should be able to produce without Soviet help the most complex equipment with which their forces are now armed, in addition to military hardware which they were about to produce in 1960-61. However, research and development resources will remain sufficiently restricted to require careful economy in research and development programs for new delivery systems.

MANNED BOMBERS

The present operational bomber forces of mainland China consist of about 450 IL-28 (Beagle) light jet bombers, two-fifths of them under Navy command. These forces are supported by over 100 propeller-driven light bombers, for training, and about 10 TU-4s (Bulls), of which there were originally more than 20. Most of these aircraft are quite old, having been turned over by the

Soviets in the mid-1950s or soon after. Many bombers are probably becoming maintenance-weary, even apart from attrition and possible cannibalization for parts. Beagle has become obsolescent. Bull is a copy of the B-29, a piston-engine aircraft that is difficult to maintain, and the few Bulls available cannot be considered as an effective delivery force. They will probably not be kept in the inventory.

Beagle (characteristics in Table IV-1) is a light bomber of the early jet era. Pay loads of 4,400 or 6,600 pounds can be carried, but the long, narrow, shallow bomb bay is ill-adapted to carrying early generations of plutonium-implosion weapons, and the aircraft is a small one on which to make major modifications. The bomb-bay limitations of approximately 37-inch bomb diameter would probably restrict the yield of the first fission weapons that could be carried to the nominal (20 KT) range, and the combined weight-size limitations on weapons might delay construction of suitable devices.

The maximum combat radius of the Beagle, 740 nautical miles with tip tanks, will permit attack on all important potential targets in the Western Pacific/Far East, but the aircraft's generally inadequate performance makes it an undesirable, though useable, delivery vehicle. Its slow speed and altitude characteristics make it vulnerable to even unsophisticated air defenses. Beagle has radar bombing equipment, but there is no significant evidence of training or other preparations for instrument bombing operations. The bomber could be used for low-level, visual, offensive operations.

The Chinese have not yet discarded any important military equipment before it is worn out; more relevantly, their requirements, until they solve their targeting problems, will continue to call for manned vehicles. It is therefore almost certain that Communist China will retain its Beagles in the inventory as long as they can be kept operational and as long as the maintenance and manning requirements do not unduly compete with better systems. If the Chinese are unable to build or otherwise obtain more suitable manned delivery vehicles, they are most likely to retain Beagle as a nuclear delivery vehicle. This would require specifically designed weapons for delivery by Beagles,accepting as necessary any degradation in yield or efficiency of the weapons which this may entail.

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TABLE IV-1

IL-28 (BEAGLE)

	w/o Tip Tanks	w/Tip Tanks
Pay load (lbs.)	6,600	4,400
Combat range (NM)	1,100	1,400
Combat radius (NM)	590	740
Average speed (knots)	380	380
Average altitude (ft.)	36,500	35,800
Ceiling (ft.)	39,500	38,700
Target speed (knots)	385	385
Take-off weight (lbs.)	46,600	47,600

2 Bomb Bays: 14' x 3.2' x 3.1'

A still incomplete complex of Chinese facilities for producing medium bombers or medium transports of the Soviet TU-16 (Badger) and TU-104 (Camel) type appears to have been built near Sian with Soviet assistance, starting in 1956. This plant was reported tooling up for production in 1960 before withdrawal of Soviet assistance. In early 1962 the plant appeared incomplete and not ready for production, with no construction activity in progress; but two Badgers were parked at the adjoining airfield, the first sighting of Badger in Communist China. The immobility of these aircraft suggested that they may have been located there

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as prototypes to assist in production when this was still contemplated; they are probably not operational.

Badger would be a major improvement over Beagle and Bull. Characteristics are given in Table IV-2. As shown in the table, the Soviets have built two air-to-surface missiles for use with this aircraft, one with a range of 55 NM and a weight of 8,000 lbs., and the other, 100 NM and 6,700 lbs.

The Soviets have recently delivered at least twelve Badgers to Indonesia in partial fulfillment of an agreement for the delivery of more than twenty. The Soviets might conceivably sell some to China.

In any event, it appears that the Chinese have deferred or eliminated production of Badgers because of the food crisis and the withdrawal of Soviet aid. With Soviet assistance, and a partial recovery, Communist China could begin to produce Badger by 1965, with a production rate of up to six per month by 1967. Without Soviet aid, such production would be a heavy drain on Chinese technical resources and might be delayed for many years, if not given up completely. The earliest independent Chinese production of the Soviet version, or even of a simplified Chinese design, would probably have to wait until 1968-69 or later.

TABLE IV-2

TU-16 (BADGER)

	Regular Badger		Improved Badger	
Payload (lbs.)	10,000	3,300	10,000	3,300
Fuel (lbs.)	75,500	82,200	75,500	82,200
Combat range (NM)	3,200	3,600	3,450	3,900
Combat radius (NM)	1,650	1,850	1,800	2,000

Maximum payload: 22,000 lbs.

Single Bomb Bay: 23.4' x 5.25' x 4.3'

Air-to-Surface Missiles: One 8,000 lb., M0.9, 55 NM
or
One 6,700 lb., M1.6, 100 NM

Assuming that the Chinese retain their Beagles as nuclear delivery vehicles, and that no Soviet assistance is forthcoming for a Badger production program, the resulting minimum and maximum Chinese aircraft delivery force would be as shown in Table IV-3. As already suggested, Badger production is dubious.

TABLE IV-3

AIRCRAFT CAPABLE OF DELIVERING NUCLEAR WEAPONS
(In combat units)

End of year	No. of TL-28	Max. No. of TU-16	Max. No. of Aircraft
1964	345	---	345
1965	310	---	310
1966	280	---	280
1967	250	---	250
1968	225	---	225
1969	205	5	210
1970	185	20	205
1971	165	70	235
1972	150	130	280

[redacted]

[redacted]

[redacted]

[redacted]

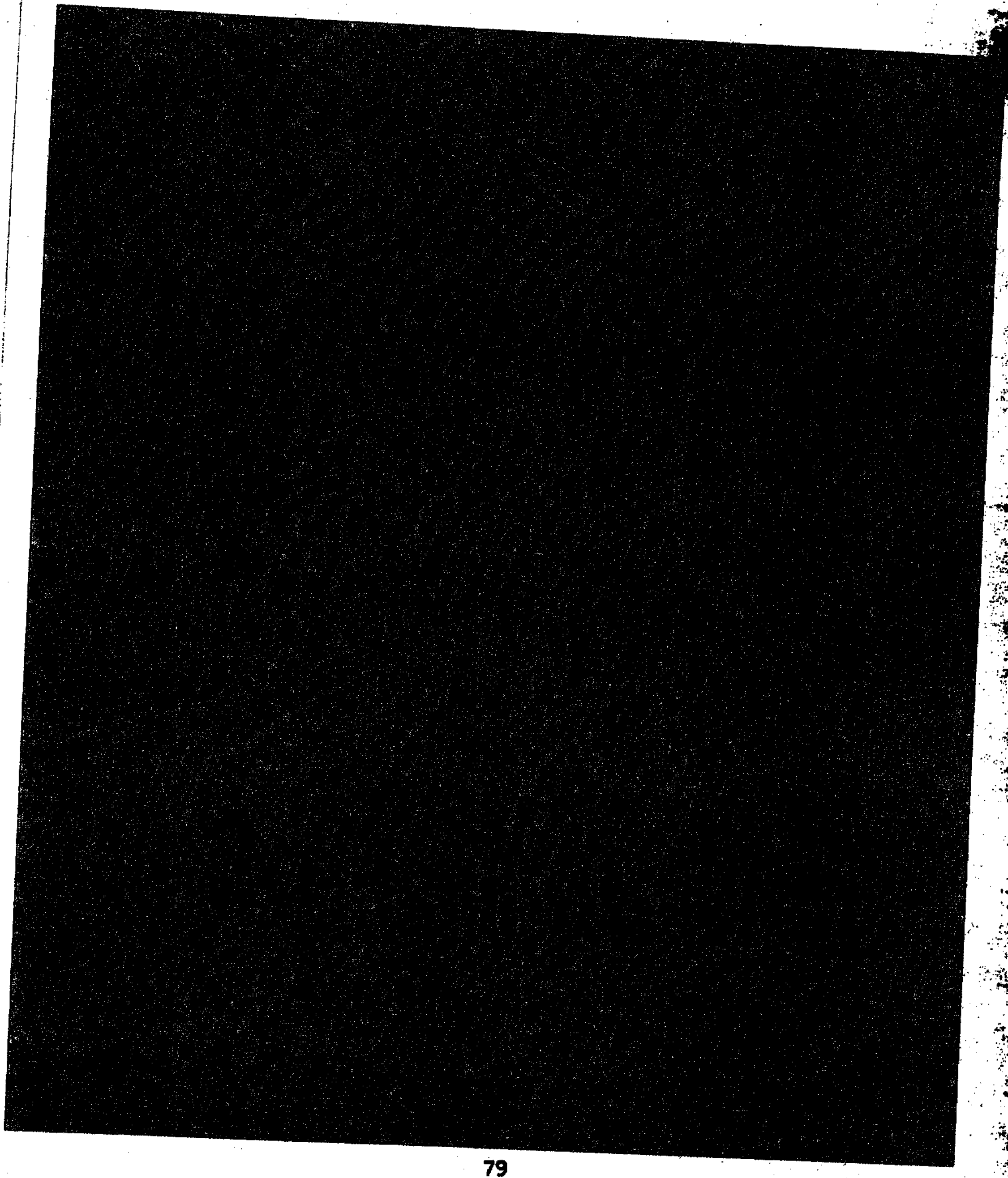
[redacted]

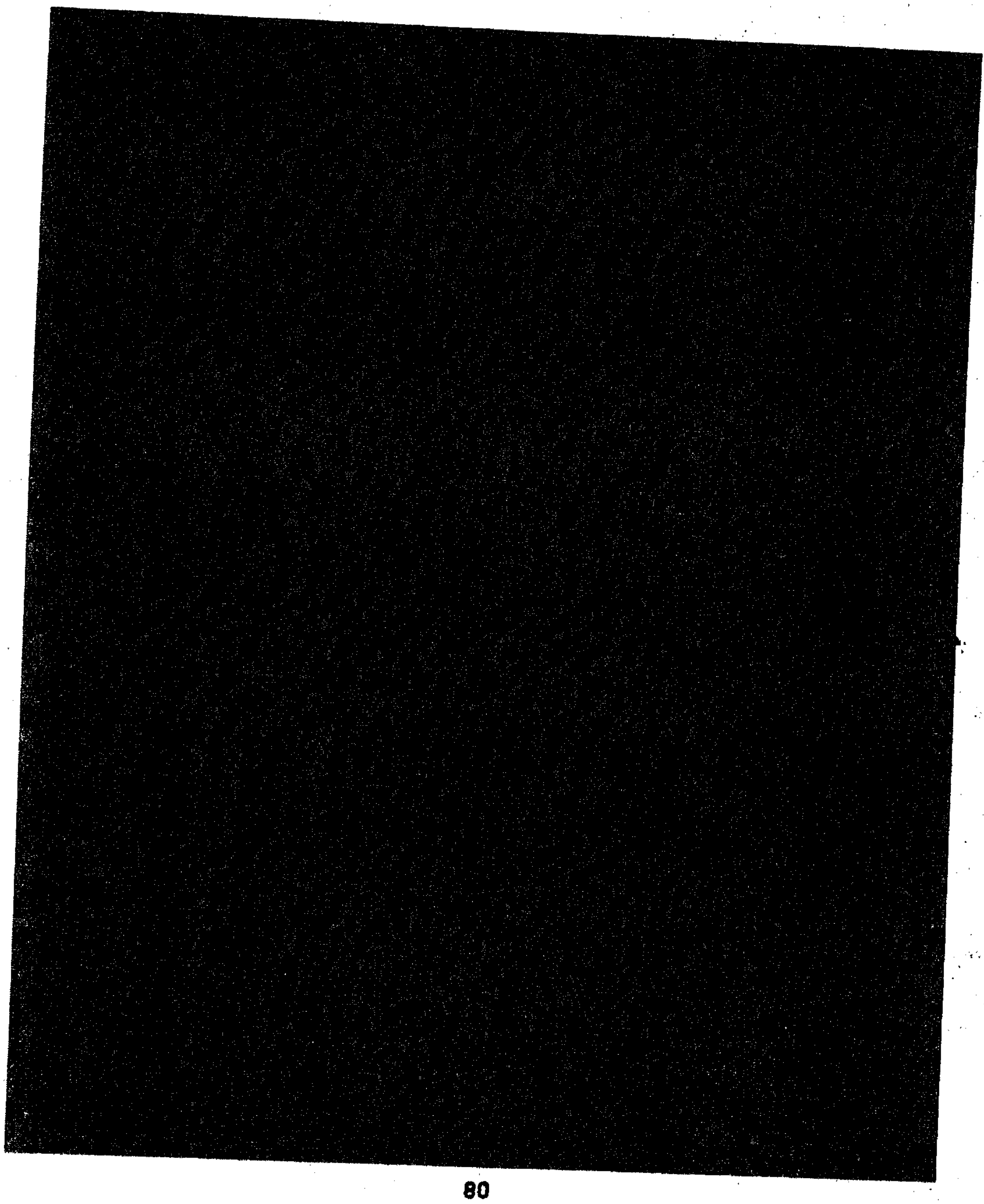
[redacted]

TABLE IV-4

SOVIET BALLISTIC MISSILES

	SS-1	SS-2	SS-3	SS-4	SS-5	SS-6
Range (NM)	150	350	700	1,100	2,000	6,500
Gross weight (1.000 lbs.)	10.8	42.0	66.0	76.4	124.0	450-530
Thrust (1,000 lbs.)	22.2	76.0	102.0	126.2	215.0	650.0
Estimated CEP (NM)	0.3	0.5	1.0	1.5	1 to 2	2.4
Warhead (lbs.)	1.200	2,000	2-3,000	2-3,000	4,000	6,000
Height (ft.)	31.8	52.6	68.0	73.3		
Diameter (ft.)	2.8	5.4	5.37	5.37		
Propellant	storable liquid	lox/ alcohol	lox/ c-stoff	lox/ amine	lox/ amine	
No. of States	1	1	1	1	1	1
Date operational	1956	1954	1956	1959	1961-62	1960
Guidance	radar-radio	radar-radio	radio-inertial	radio-inertial	radio-inertial	radio-inertial
Remarks	Mobile: self-propelled launcher			Moved by road, ship, or rail		





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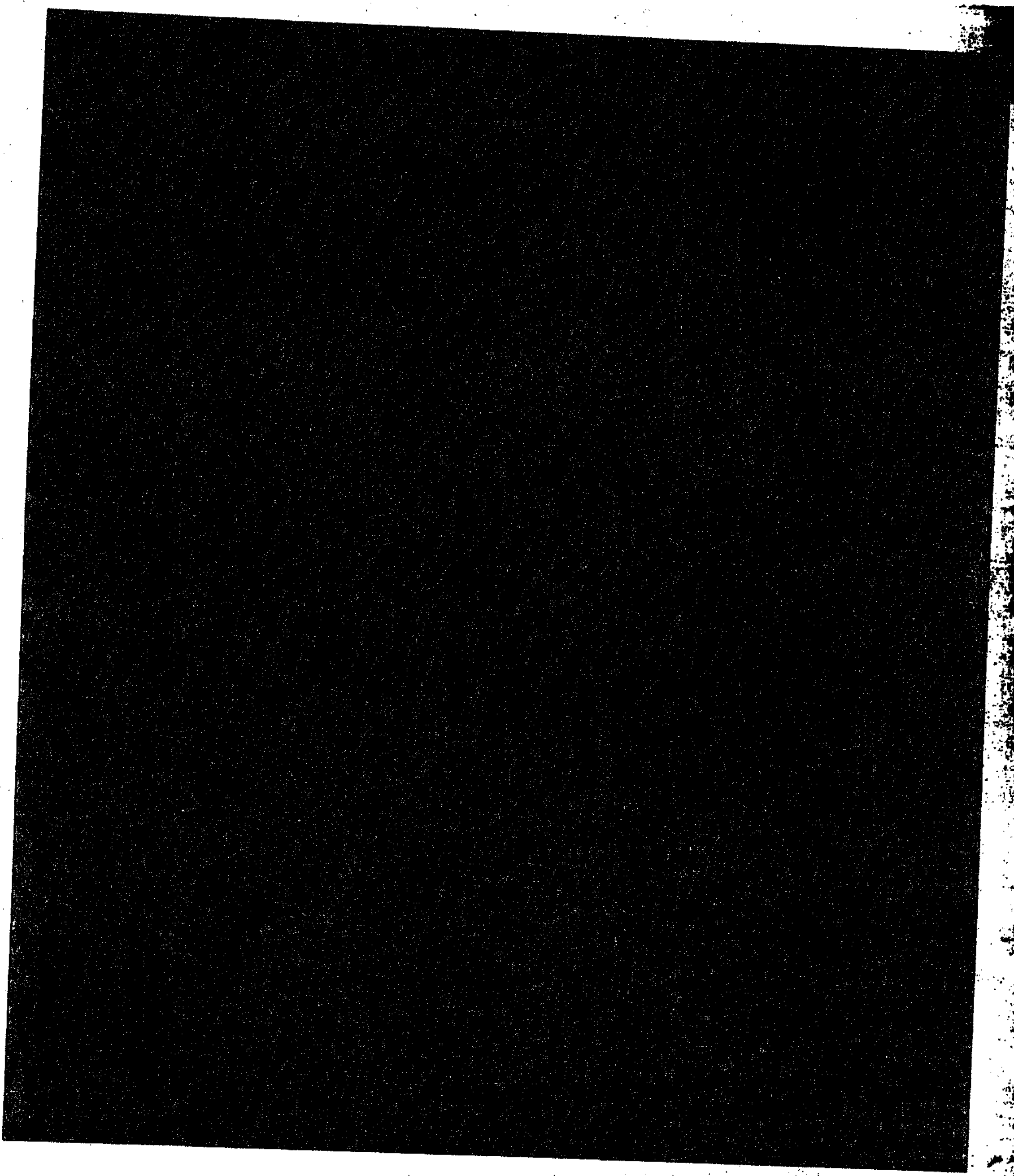

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Impending production of an improved type of submarine was reported in 1960, but did not materialize after the withdrawal of Soviet technical personnel.

No Chinese work with naval missiles of any kind has been reported. The possibility exists, but is relatively slight, that the Soviets would furnish either cruise missiles or the design specifications for cruise missiles that can be launched from modified present submarines. Chinese independent development of a submarine-launched cruise or ballistic missile could scarcely be achieved before the 1970s, and the cost in scarce resources would adversely affect other advanced weapons programs.

As can be seen by their 1,300-ton displacement, the W-class vessels now built in Communist China are not large submarines. By way of comparison, US nuclear submarines are between 2,300 and 7,000 tons displacement, while those carrying Polaris are in the 5,400 to 7,000-ton range. With shipyards and construction experience already acquired, however, the Chinese should be able to build larger vessels on their own within perhaps three or four years. Submarines can be very expensive, because of their modern equipment and materials requirements. In the United States, conventional submarines cost at least $8,000 per standard displacement ton--about $13,000, if designed to carry missiles.

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In some respects, a solid rocket is a very simple device. There are, however, severe engineering problems which must be solved. precision casting or assembly of the solid propellant; designing a nozzle chamber capable of withstanding the heat and pressure for the number of seconds required until burn-out; building the main pressure chamber of sturdy heat-resistant material such as stainless steel or fiberglass; controlling the thrust vector by aiming the nozzle; and properly igniting the propellant. Guidance depends both on thrust-vector control and precision quality-control manufacture of the solid propellant blocks, so that they will burn completely in a carefully determined length of time. Making a missile system that can be hardened requires all-inertial guidance rather than the radio-inertial guidance used with Soviet MRBMs.

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INTERCONTINENTAL CRUISE MISSILE

A cruise or air-breathing missile is essentially a pilotless aircraft, the prototype being the German V-1. A cruise missile does not require an airfield, and, being initially boosted by a liquid or solid-propellant booster, it is potentially mobile and survivable.

Compared to a ballistic missile, however, an unsophisticated cruise missile is highly vulnerable to air defense. Over long distances there are severe guidance problems (the inertial error tends to be proportionate to time in flight), and the sum of these shortcomings makes cruise missiles unsuitable for flexible military uses. Their inaccuracy makes imperative warheads of maximum possible yield. Used in large numbers, cruise missiles could be designed to explode upon interception or impact and could rely on a fallout attack to eliminate shortcomings stemming from inadequate geodetic surveys and targeting. But this would call for large thermonuclear warheads.

US intercontinental cruise missiles include the Snark, which weighs 45- to 60-thousand lbs. at launch, and also, although never made operational, a smaller, simple, decoy missile known as Goose. Snark is sophisticated and expensive--mainly because high accuracy and performance were required. Goose would cost less than $100,000 a unit, being made entirely of fiber-glass and other cheap materials. A relatively small solid-propellant booster would be required. The pay load over a range of 5,000 NM, however, would be only 1,000 lbs. for Goose, instead of Snark's more than 6,000 lbs. For China this would be discouragingly small.[1]

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[1] At one time the manufacturer did propose to convert Goose into a highly mobile purely deterrent system, relying on fallout for its effect, with probable circular errors [CEPs] on the order of 100 nautical miles.

It appears that little advantage in time would accrue to China from a decision to build cruise-type missiles instead of ICBMs, and there would be severe penalties in loss of capability and in requirements for scarce fissionable material. It must therefore be assumed that the Chinese will not follow this road unless they encounter severe and unpredicted obstacles in the development of ICBMs.

SUMMARY

Nuclear delivery systems are particularly expensive for Communist China; its resources are not equal to simultaneous development of more than a handful of different systems at most.

From now until 1966 or 1967, the only nuclear delivery threat is likely to be the presently obsolescent Beagle light bomber force, plus (for possible clandestine delivery) the submarines and ships already in existence--unless the Soviets provide Badgers or other sophisticated vehicles.

Starting some time between 1966 and 1968 the Chinese will probably have the capability to deploy at least a few nuclear-tipped medium range (700 to 1,100 NM) ballistic missiles of their own, copied from Soviet missiles. Given a strong economic recovery, independent production of medium jet Badgers would probably be feasible in roughly the same time period, but missile and bomber efforts together might be beyond Chinese capacity.

The regional threat could reach the vicinity of 100 fairly accurate thermonuclear MRBMs, supplemented by bombers, by 1970 at the earliest.

ICBMs cannot be deployed by China until the early 1970s, and quite possibly not until the mid-70s or later.

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