Appendix C

FAST, LONG-RANGE-ATTACK AIRCRAFT

In Chapter Five, we recommended a long-term stand-off option involving fast, long-range aircraft. In this appendix, we present an operational concept for long-range-attack operations to stimulate thought about, and a more thorough investigation of, such options available to the United States Air Force (USAF) in the early part of the next century.

WHY FAST ATTACK AIRCRAFT?

All other things being equal, if it is less expensive to develop and deploy sophisticated weapons than it is to develop sophisticated delivery platforms, then the USAF should adopt a combination of sophisticated, long-range weapons and relatively unsophisticated delivery platforms. An example of this approach to the long-range-attack problem might be thousands of advanced cruise missiles launched from Boeing 747 arsenal planes from outside the range of enemy defenses. However, if developing and deploying sophisticated launch platforms with less-sophisticated (and less-expensive) weapons is less costly than building thousands of advanced cruise missiles, then the best solution might be something like a Mach 2 penetrating bomber armed with accurate freefall weapons such as the Joint Direct Attack Munition (JDAM).

The arsenal plane concept has been explored by others.[1] The remainder of this appendix explores some of the technical issues surrounding the Mach 2 example given above.

OPERATIONAL CONCEPT

In the following analysis, we employ a force of supersonic bombers with a maximum unrefueled range of 3,250 nautical miles (nmi) to accomplish an 8,000-nmi combat mission in the following way. First, a force of tanker aircraft escorted by F-22s and the Airborne Warning and Control System (AWACS) departs an operating base. This base would be equipped with large, submunition-resistant shelters for all aircraft and personnel and be defended by anti–ballistic missile and anti–cruise missile systems.[2] Approximately 2 hours after that departure, the bomber force launches from the same base and proceeds to a rendezvous with the refueling force 2,250 nmi from base at Mach 2, at approximately 60,000 feet.[3] At this point the bombers descend to about 40,000 feet and slow to 500 knots for 30 minutes to refuel. Bombers and tankers are protected by F-22s during this delicate operation. Following the refueling, the bombers climb and accelerate to Mach 2, fly 1,500 nmi to their targets, then egress 1,500 nmi to a second refueling rendezvous with a different group of tankers, fighters, and AWACS. The second refueling would occur approximately 5 hours into the bomber mission (bombers maintain a 30-minute fuel reserve in case this second rendezvous is delayed). After refueling, the bombers again accelerate to Mach 2 and proceed back to base. Total bomber mission time is approximately 8 hours. The F-22 mission time is also approximately 8 hours (due to super-

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[1]The best exploration has been by The Boeing Company, *747 Air-Launched Cruise Missile System Concept,* Seattle, Wash., April 1974.

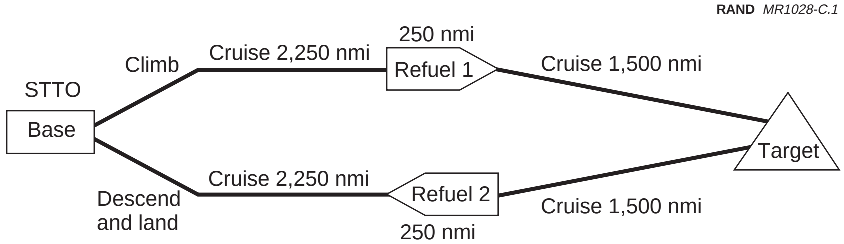
[2]The structures and systems at this base could also be designed to sustain operations under chemical and / or biological attack.

[3]For a given speed and size of aircraft, it is possible to calculate an optimal altitude for maximum range. The faster the aircraft, the more drag it produces. Air density and drag decrease with altitude. Therefore, the faster an aircraft flies, the higher the optimal altitude will be. Large aircraft capable of sustained Mach 2 speeds, such as the TU144 and Concorde, cruise at 60,000 feet, whereas the Mach 3+ SR-71 cruises at 80,000 feet or higher. Since our proposed aircraft are approximately the same weight as the Concorde, we used a similar flight profile.

cruise capability); tankers and AWACS are airborne for 10 hours. Figure C.1 illustrates this operational concept.

The unrefueled range of the aircraft proposed here is much shorter than the unrefueled range of current subsonic USAF bombers. For example, the B-52H has an unrefueled range of approximately 8,500 nmi and weighs about 500,000 pounds at maximum takeoff weight. Theoretically, it might be possible to build a Mach 2 bomber with a range of 8,000 nmi; however, it would be so big that it would be impracticable. Transonic and supersonic flight regimes have enormous drag, making the thrust requirements and, in turn, the fuel requirements for supersonic aircraft much larger than those for subsonic aircraft with comparable range. Due to the "spiral of requirements" described in the next paragraph, a supersonic bomber with an 8,000-nmi unrefueled range would be so large—much heavier than a Nimitz-class aircraft carrier—that it would be ridiculous to even consider building such an aircraft.[4]

RAND *MR1028-C.1*



NOTE: STTO = start, taxi, take off.

Figure C.1—Operational Concept for a Long-Range Supersonic Bomber Force

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[4]We used an aircraft-sizing model developed by one of our RAND colleagues, Dan Raymer, to estimate the size, weight, and amount of fuel required per mission for supersonic aircraft of various ranges and payloads. The model allowed us to input the desired range, speed, and payload, and used specific fuel consumption, aspect ratio, and lift divided by drag (L/D) to estimate the aircraft characteristics mentioned above. See Daniel P. Raymer, *Aircraft Design: A Conceptual Approach*, Washington, D.C.: American Institute of Aeronautics and Astronautics, 1989, for a complete description of equations and inputs to this aircraft-sizing model.

BOMBER CHARACTERISTICS

Figure C.2 shows the number of tankers required per bomber mission as a function of bomber range for bombers with 10,000- and 20,000-pound payloads. It is perhaps counterintuitive that bombers with longer ranges require more tankers per sortie than do those with shorter ranges. However, to achieve additional range, aircraft must carry more fuel. If we want to increase the unrefueled range of a 350,000-pound supersonic bomber with a 20,000-pound payload from 3,250 to 4,250 nmi, simply adding one-third more fuel will not do the job. Fuel is heavy—about 6.5 pounds per gallon—and takes up space within the aircraft. The additional weight and space mean a larger bomber is required to accommodate the extra fuel, and a larger wing and more power are required to compensate for the added weight and drag of the additional fuel and structure. Additional power means still more fuel is needed to achieve the increased range. This leads to yet more structure, drag, lift, power, fuel, etc. In

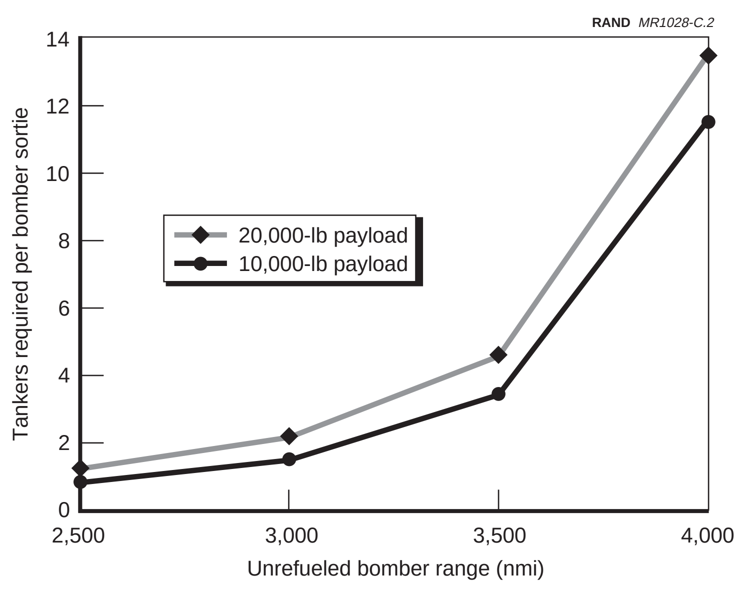

Figure C.2—Tankers Required per Bomber Sortie As a Function of Unrefueled Bomber Range

the end, this spiral of requirements leads to an increase in bomber weight from about 350,000 pounds to about 2,200,000 pounds—a 630-percent increase in weight to achieve a 33-percent increase in unrefueled range. The difference in fuel capacity is even greater. The 4,250-nmi-range bomber would have a fuel capacity of about 1,350,000 pounds, whereas the 3,250-nmi-range bomber would require a capacity of only about 197,000 pounds—a difference of 685 percent. Therefore, although the larger, longer-range bomber could fly a given mission with 33 percent fewer refuelings, each refueling would require far more fuel, necessitating more tanker support than the shorter-range bomber.[5]

Once we have established the desired range of our proposed supersonic bombers, payload drives bomber size. Obviously, the more each bomber can carry, the fewer bombers are needed to attack a given set of targets—an argument for very large payloads. However, as with long range, large payloads lead to large and expensive aircraft. In addition, there is a limit to the number of targets a crew can be reasonably expected to plan for and attack on a given mission. For example, Air Combat Command currently plans to have its B-1 and B-2 crews attack no more than 8 to 12 targets per mission.

Data from USAF precision-guided-munition (PGM) attacks during Desert Storm indicate that, when the USAF attacked a target with PGMs, it used, on average, 1.6 weapons, or a total weight of 1,700 pounds per target.[6] If we assume that the USAF uses the same average number and weight of PGMs to attack targets in future conflicts as it did on average during Desert Storm, an aircraft capable of attacking 8 to 12 targets with PGMs would require a payload of between 15,000 and 20,000 pounds. Figure C.3 shows the predicted relationship between payload and bomber weight for 3,250-nmi-range

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[5]But only up to a certain point. As unrefueled bomber range decreases, the tankers must refuel the bombers closer to the target and farther from their base. As the tankers fly farther and farther from their base to make off-loads, more tankers are required to deliver a given amount of fuel to the bombers, since the tankers must fly farther both to and from the rendezvous.

[6]Eliot A. Cohen, ed., *Gulf War Airpower Survey* [GWAPS], Washington, D.C.: U.S. Government Printing Office, Vol. V, 1993, pp. 418, 467, 514, 606. These attacks include strikes using laser-guided bombs, Maverick missiles, and electro-optically guided bombs.

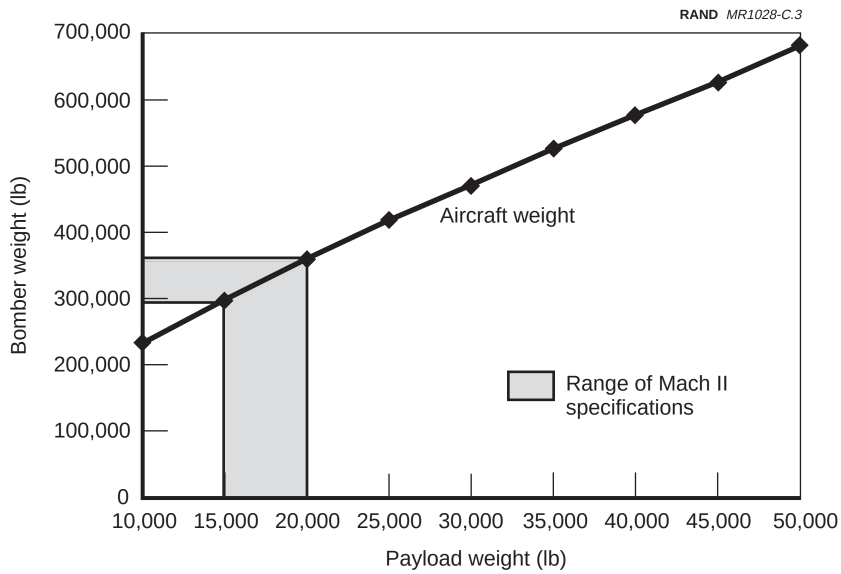

Figure C.3—Payload Versus Bomber Weight

supersonic aircraft. Aircraft capable of carrying 15,000 to 20,000 pounds of PGMs over this distance at Mach 2 would weigh between approximately 290,000 and 350,000 pounds—about 60 to 70 percent the weight of a B-2.[7]

SURVIVABILITY

We need to emphasize here that our reason for suggesting supersonic bombers has more to do with increasing the survivability of the aircraft, facilities, and support personnel on the ground than with increasing the survivability of the aircraft during the course of their

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[7]By the time the proposed bomber reaches initial operating capability (IOC), the USAF may have fielded the family of small, smart munitions that is currently on the drawing board. If the proposed bomber used these weapons, which purport to provide the punch of a 2,000-pound bomb in a 500-pound package, it would need only a 4,000–5,000-pound payload to attack 8 to 10 targets. A supersonic bomber with 3,250-nmi range and a 5,000-pound payload would weigh only 154,000 pounds—about half as much as the aircraft under discussion here. This reduced size would lead to marked reductions in initial cost and tanker support requirements, among other things.

combat missions. This is a very different motivation from the one that led the USAF to develop supersonic bombers such as the B-58 and XB-70 in the late 1950s and early 1960s: overcoming increasingly sophisticated and capable Soviet interceptors and surface-to-air missile (SAM) systems by dramatically increasing the cruise speeds and altitudes of its bomber force. In the era before the advent of stealth technology, the Soviets showed that they could build radar-guided SAM systems capable of intercepting any high-performance bomber the United States could possibly develop. As a result, the XB-70 was canceled and the B-58 withdrawn from service.

To survive adequately against future surface-to-air and air-to-air defenses, our proposed long-range strike aircraft would have to incorporate features that minimize its radar and infrared signatures. With the F-117, B-2, and F-22 behind it, the Air Force and the U.S. aircraft industry probably possess most of the expertise needed to ensure the requisite degree of radar stealthiness. However, managing the infrared (IR) signature of an aircraft cruising at Mach 2 will present some new challenges.

The heat generated by flight at Mach 2 might make it impossible to produce a Mach 2 aircraft with a low-IR signature (the Concorde's nose cone reaches 260°F during Mach 2 cruise at 60,000 feet). It might be possible to design and build a long-range, high-altitude SAM system using an Infra-Red Search and Track System (IRSTS) to detect and track the bombers and IR guidance for the missiles. However, no such system currently exists, and the maximum detection range of such a system would be limited by atmospheric absorption of the bomber's radiated heat. If effective detection range is short, the number of SAM sites required to construct an effective barrier would be large. SAMs used as point defenses could be defeated by equipping the bombers with stand-off weapons with ranges that allowed them to attack targets from outside the range of the defenses.

HOW MANY BOMBERS?

How many supersonic bombers might it take to replicate an offensive air campaign of the size and intensity of operation Desert Storm? During the course of the 43-day conflict, USAF aircraft conducted

28,295 strikes—an average of 660 strikes per day. Only about 7,800 of these attacks—about 28 percent—were made with PGMs.[8] However, to maximize the impact of our bomber force, we propose to attack the same number of targets using only PGMs. As mentioned in the preceding section, the USAF used 1,700 pounds of PGMs in each PGM strike. To attack 660 targets per day with 1,700 pounds of PGMs each, our supersonic bomber force would need to deliver about 560 tons of PGMs per day. With each aircraft carrying between 7.5 and 10 tons of PGMs, an effort of this size would require 56 to 75 bomber sorties per day.[9] Figure C.4 summarizes this information. Maintaining a ready strike force of 56 to 75 bombers while allowing for training aircraft, test aircraft, aircraft in depot maintenance, etc., would probably require a total force of 80 to 105 aircraft.

SUMMARY

For the supersonic bomber concept described here, a total inventory of approximately 80 to 105 Mach 2 bombers with the following characteristics could deliver enough PGMs (about 560 tons per day) to replicate the USAF Desert Storm effort:

- an unrefueled range of 3,250 nmi
- a weight of 290,000 to 350,000 pounds each
- a payload of 15,000 to 20,000 pounds
- support of 37 to 40 percent of the current USAF tanker fleet and 100 air superiority fighters.

In addition, Mach 2 bombers could attack targets almost anywhere in the world while operating from well-protected, permanent bases on U.S. and UK territory.

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[8]Cohen, GWAPS, 1993, Vol. V, p. 418. We use the same definition of a *strike* as presented in Cohen, GWAPS, 1993, Vol. V, p. 403: an attack by a single aircraft on a single target. The aircraft may use one or more weapons in its attack and, if it has enough weapons, may conduct multiple strikes in a single sortie.

[9]On the basis of KC-135R and KC-10 mission profiles computed from their respective flight manuals and assuming an 80-percent tanker mission-capable rate, we estimate that sustaining this level of bomber activity would require the commitment of between 37 and 40 percent of the USAF's total existing tanker capacity. Additional tankers would be required to support escorting fighters, AWACS, etc.

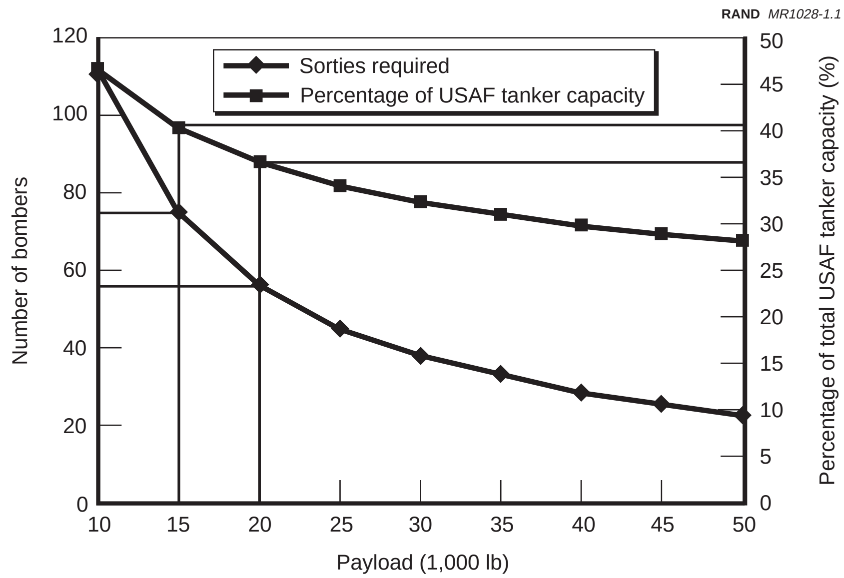

Figure C.4—Bomber Sorties and Tanker Capacity Required As a Function of Bomber Payload