Section 2

BOOSTER CHARACTERISTICS

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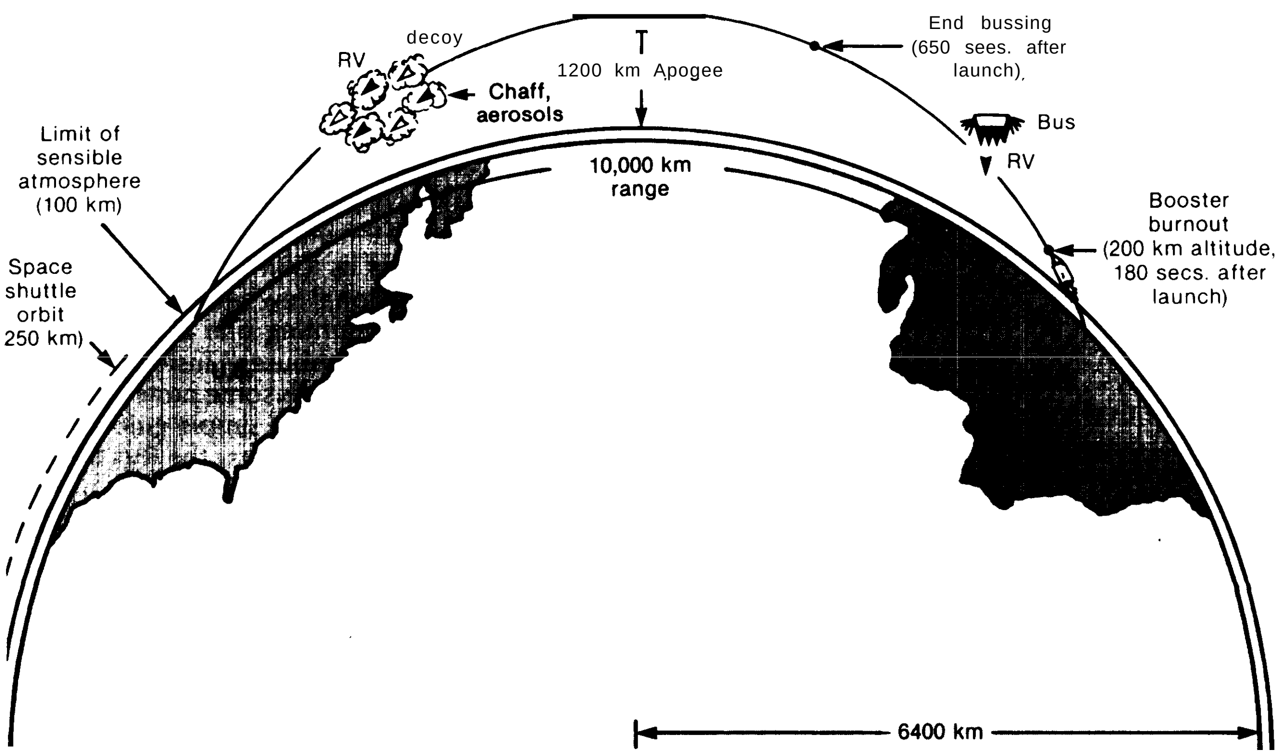
Intercept of ICBMs in their boost phase offers advantages and disadvantages relative to intercept of reentry vehicles (RVs) later in the trajectory. The boosters are fewer and generally more easily disrupted or destroyed than the RVs. Decoy boosters would have to match an ICBM's huge heat output, making this offensive tactic attractive only in certain circumstances. The disadvantages of boost phase intercept are that boost phase is only a few minutes long and comprises the earliest stage of an attack, and that sensing and intercept must be accomplished from outer Space and over enemy territory.

Figure 2.1 shows an ordinary (minimum energy) trajectory of a hypothetical future Soviet ICBM hat has been given, for illustration, the boost profile of the U.S. MX Peacekeeper. Pressure from a steam generator expel ls the missile from its storage cannister. Once clear of the cannister, the missile ignites its first stage motor. The first stage burns for about 55 seconds, burning out at an altitude of about 22 kilometers. The second stage also burns for 55 see, burning out at 82 km. The third stage burns for 60 sec and carries the remainder of the missile to about 200 km, the altitude of the lowest earth orbiting satellites.

When the third stage is jettisoned at the end of the 3-minute boost phase, the remainder of the missile consists of the post-boost vehicle (PBV) or ''bus" and its cargo of 10 reentry vehicles. At this point the bus and RVs are in ballistic free-fall flight to the United States. Even if they are disrupted in some way or destroyed, these objects or their debris will reenter the atmosphere over the United States. The last few seconds of third stage burn are crucial for giving the payload

Figure 2.1.–The Flight of a Hypothetical Future Soviet ICBM With the Booster Characteristics of the U.S. MX Peacekeeper, Drawn to Scale



SOURCE: Author

enough speed to reach the United States, so disruption of boost phase any time right up to burnout will cause the warheads to fall far short.

For the next 500 seconds or so after burnout—almost until it reaches apogee—the bus uses its thrusters to make small adjustments to its trajectory. After each adjustment, it releases an RV. RVs released on different trajectories continue on to different targets as multiple independently targeted reentry vehicles (MIRVs). Decoys and other penetration aids for helping the RVs escape defenses later in the trajectory are deployed during busing.

The bus itself is a target of declining value as it dispenses its RVs. Destroying it early in the deployment process would obviously be useful: the RVs not yet deployed from the bus would still arrive at the United States, but perhaps nowhere near their intended targets. If cities are the targets, relatively small aiming errors might be inconsequential. In any event, tracking the bus to allow some form of intercept requires a different type of sensor from that which tracks the booster for boost phase intercept, since the bus's thrusters are small and operate intermittently. Because of its small size, the bus (or at least critical elements of it) might be more easily hardened against directed-energy weapons than the booster. For all these reasons, the value of attempting bus intercept is very unclear, and it usually does not figure prominently in BMD discussions.

From apogee, the slowest point in their free-fall trajectory, the RVs and empty bus gain speed as they fall back to earth. RVs are more resistant to damage from directed-energy weapons than boosters, and they might be accompanied by many decoys. When these objects enter the upper atmosphere at about 100 km altitude somewhat over 2 minutes before impact, they begin to heat up, and the lighter objects slow down. Still lower, below 50 km altitude and less than a minute before impact, the objects undergo violent deceleration and the bus breaks up. The RVs, now glowing with heat, streak toward their targets at an angle of about 23 degrees to the horizontal.

The trajectory shape can be altered at the expense of payload (see Figure 2.2). A lofted trajectory takes longer but reenters faster, and a depressed trajectory can offer unfavorable viewing angles to defensive sensors late in the trajectory.

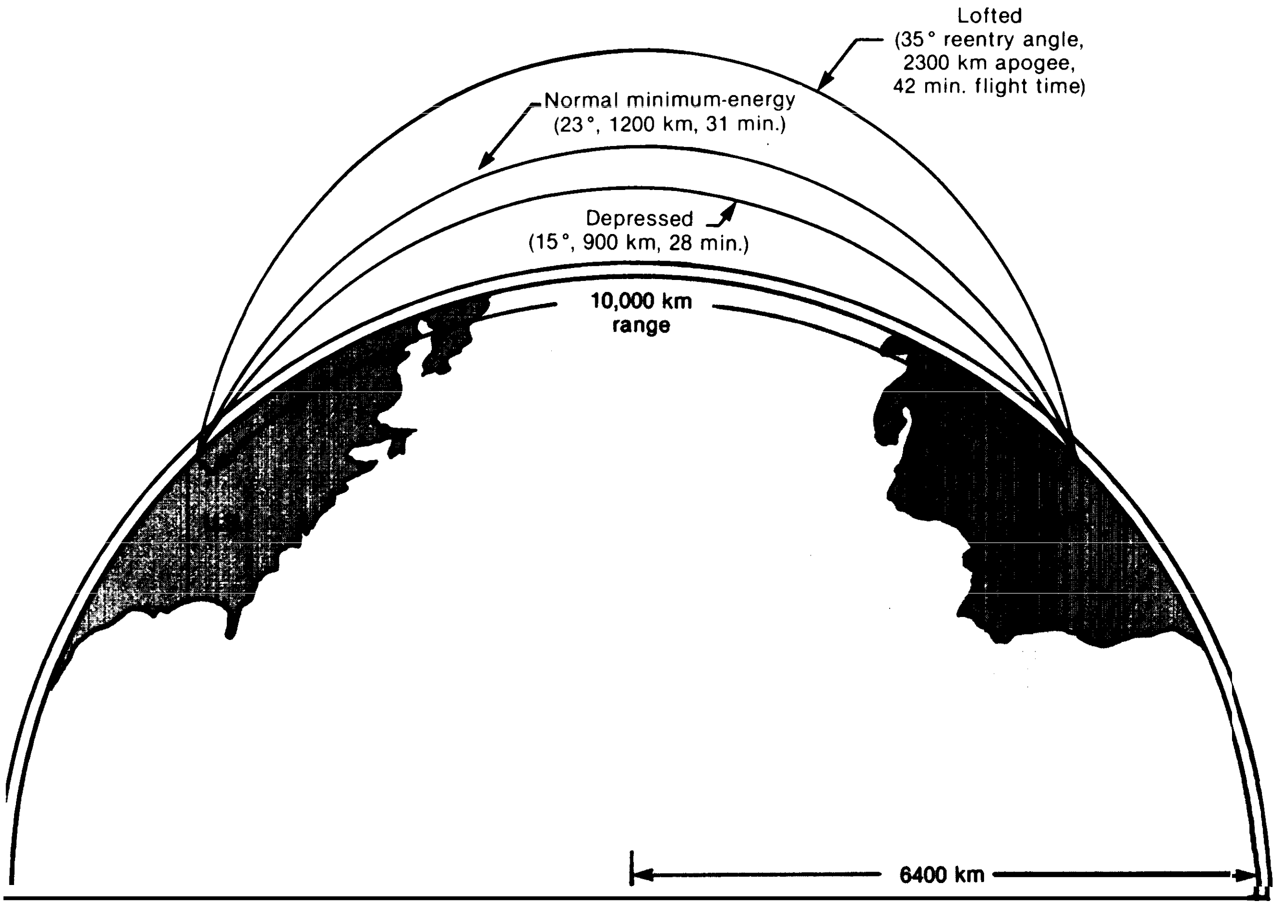
The most important trajectory variations from the point of view of boost phase intercept are variations in boost profile. Boosters like MX were designed with no regard for boost phase BMD, and optimizing their design gave rise to rather long boost times. But boost phase can be shortened–giving less time for boost phase weapons to act–and accomplished within the atmosphere—where certain directed-energy weapons cannot penetrate–with relatively little reduction in payload or increase in missile size. Fast burn is accomplished most easily with solid-fueled rockets. Liquid-fueled boosters like the Soviet SS-18s and SS-19s burn more slowly and burn out at higher altitudes. Thus while MX burns out at 200 km after 3 minutes of boost, the SS-18 burns out at 300-400 km after 5 minutes. The next generation of Soviet ICBMs will reportedly employ solid propellants.

Studies performed for the Defense Department showed that with a 25 percent reduction in payload, a booster about the same size as MX could be built which would burn out in less than 1 minute at only 80 to 90 km, well within the sensible atmosphere. At 90 km the atmosphere is still too dense for extremely accurate RV deployment or for deployment of lightweight RV decoys and other penetration aids aimed at later defensive layers: these functions require an additional 10 to 15 seconds of precision deployment betweer 90 and 110 km. If the offense needs precision ac curacy for some of its ICBMs but fears intercept during these additional few seconds of high-alti tude operation, mounting one or two RVs or each of several "microbuses" instead of all the RVs on a single bus affords some protection. Each microbus would contain a simple guidance sys tern only good enough to carry the RVs from up per stage burnout to 110 km. Instead of present ing one target above 90 km, therefore, such booster would present several targets.

The United States is studying a "Midgetman" missile endorsed by the President's Commission on Strategic Forces (the Scowcroft Commission

[1] "Short Burn Time ICBM Characteristic and Considerations," Mar tin Marietta Denver Aerospace, July 20, 1983 (UNCLASSIFIED).

Figure 2.2.—Normal (Minimum-Energy), Lofted, and Depressed ICBM Trajectories, Drawn to Scale



SOURCE : Author

with weight 15 to 25 percent that of MX and carying one warhead. Midgetman's warhead and ›us are combined in one hardened structure. "able 2.1 shows the characteristics of Midgetman ariants designed to face a boost-phase intercept ystem. The fast-burn version burns out at 80 km fter 50 sees of boost. With a 10 percent increase 7 weight, the fast-burn version can carry a substantial payload of penetration aids. A low-flight-profile version is intended to stay within the atmosphere until burnout, protecting it from some types of directed-energy weapon. In the hardened version, one gram of ablative or other hielding material has been applied to each quare centimeter of the entire booster body (if ıe boost-phase intercept system did not begin operation until a minute or so after launch, the first stage might not have to be hardened). These mall boosters are all estimated to cost $10 to $15 million per copy, assuming a buy of 1,000 boosters. Costs for the second and subsequent thousand would of course be substantially smaller. These costs are two to three times higher per RV than MX.

The Soviet ICBM arsenal today comprises about 1,400 boosters, more than two-thirds of them MIRVd. Most are slow-burning liquid-fueled boosters. The U.S. arsenal contains about 1,000 faster-burning solid-fueled Minuteman boosters, about half of them MIRVd. Both sides are adding solid boosters to their arsenals in the 1980's.

The geographic distribution of offensive boosters can also be important to space-based boost-phase defenses. The number of satellites required in a defensive constellation usually increases if all opposing ICBM silos are concentrated in one region and decreases if the silos are spread over

Table 2.1.—ICBM Booster Characteristics

	Gross weight (kg)	Length (m)	Width (m)	Type	Booster burnout time (seconds after launch)	Booster burnout altitude (km)	End bussing time (seconds after launch)	End bussing altitude (km)	Comments
SS-18	220,000[a]	35.0	3.0	2-stage liquid	~300	~400	—	—	—
MX Peacekeeper	89,000	21.3	2.3	3-stage solid	180	200	650	1,100	**Carries 10 RVs on a single bus**
MIRVd fast-burn booster	87,000	22.9	2.1	2-stage solid	50	90	60	110	**Deploys several "microbuses" carrying RVs and decoys**
Midgetman	19,000	2.1	.5	2-stage solid	220	340	—	—	Carries one accurate RV
Midgetman fast-burn	20,000	13.8	5	2-stage solid	50	80	—	—	Carries one accurate RV
Midgetman fast-burn with midcourse penetration aids	22,000	4.3	1.5	2-stage solid	50	80		—	Carries one RV plus decoys
Midgetman with low flight profile	25,000	3.4	1.5	1st stage solid, 2nd liquid	220	100	—	—	Carries one accurate RV
Hardened Midgetman	30,000	15.1	1.5	1st stage solid, 2nd liquid	220	320	—	—	Carries one accurate RV; entire booster covered w th 1gm/cm² shielding
Pershing	7,500	10.5	0	2-stage solid	100	—	—	—	—

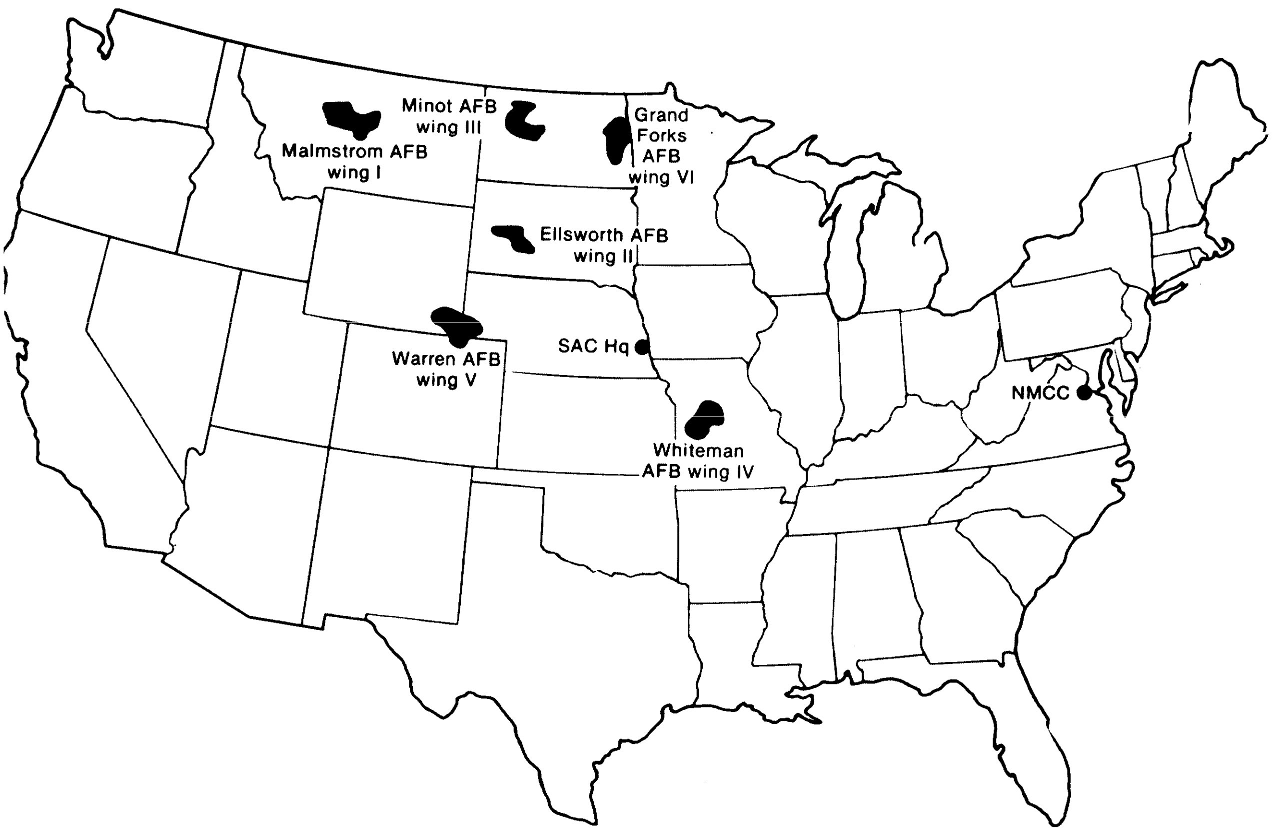
[a]*Soviet Space Programs 1976-1980* (Committee on Commerce, Science, and Transportation, U.S. Senate, December 1982), Part 1, p. 63.

SOURCE: Except where indicated, "Short Burn Time ICBM Characteristics and Considerations," and accompanying backup, presented to DTST, July 20, 1983, by Martin Marietta Denver Aerospace (UNCLASSIFIED).

wide land areas. (On the other hand, too much concentration allows defensive satellites to be focused on one region by choosing the orbits ju- viciously.) Soviet SS-18 ICBMs, their largest MIRVd missiles, are organized into 6 wings of about 50 missiles each, spread out over a large region of the U.S.S.R. U.S. Minuteman missiles are organized into 6 wings of about 150 missiles each. Figures 2.3 and 2.4 show the geographic distributions.

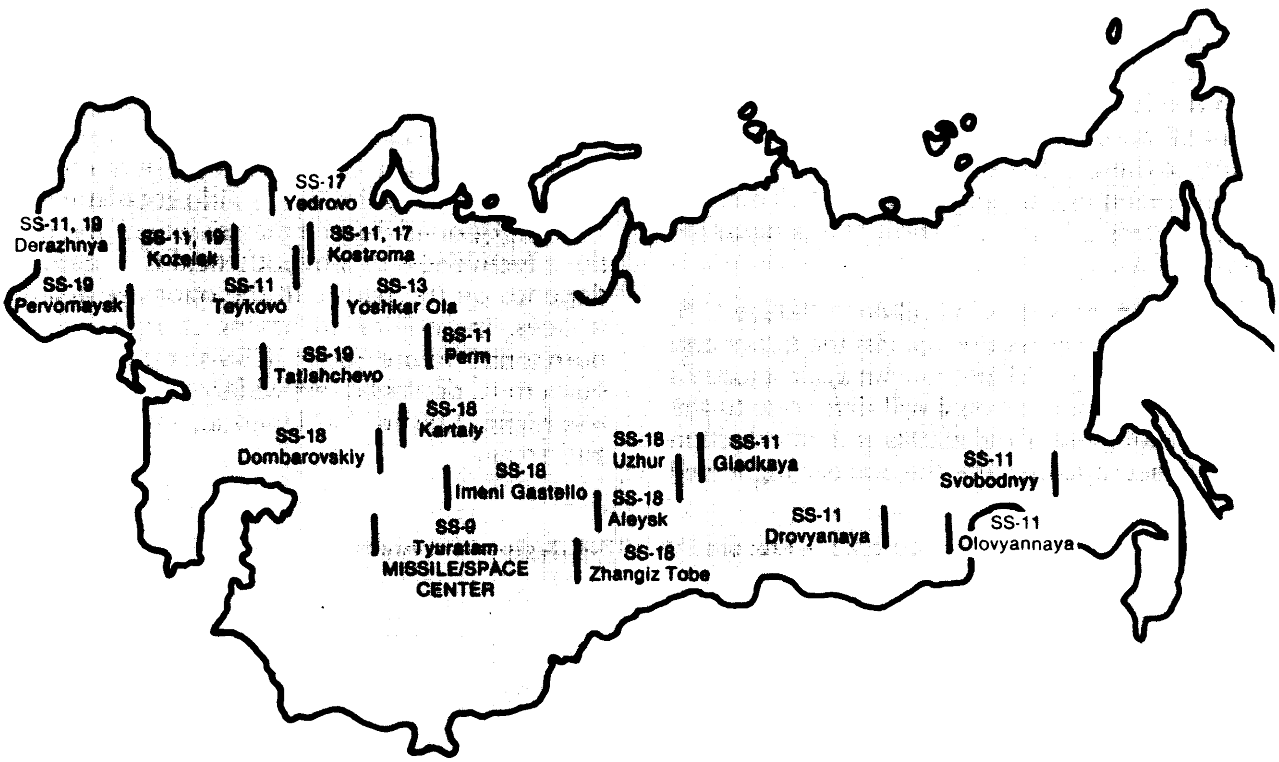
The capabilities of a hypothetical future U.S. BMD should be measured against the ***future*** and ***potential*** Soviet ICBM arsenal, not against today's arsenal. The future arsenal will differ due to the natural retirement of old ICBMs and introduction of new ones, and because the Soviets might well react with new and different deployments when they learn of any U.S. plans to deploy defenses. It is impossible to project Soviet deployments far into the future. A reasonable "baseline' estimate for the Soviet ICBM arsenal 15 to 20 years from now might assign them the same number of boosters they have today, but with burn charac- teristics similar to the U.S. solid-propellant MX. This Background Paper indicates where and how the effectiveness of a hypothetical U.S. defense depends on the nature of the offensive arsenal it faces. In addition to having shorter average burn times, future Soviet ICBMs could be more numerous, deployed less widely geographically, less highly MIRVd, hardened against intercept, and so on.

Figure 23.— Present U.S. ICBM Deployment **Areas**



SOURCE: OTA, MX Missile *Basing,* p *274*

Figure 2.4.—Present U.S.S.R. ICBM Deployment Areas



Type	ICBMs Number
Ss-11	550
SS-13	60
Ss-17	150
SS-18	308
SS-19	330
Total	1398

SOURCE: U.S. DOD Soviet Military Power, 2nd cd P. 14.