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SECTION IV

SOVIET TEST FACILITIES

1. Solid Propulsion Testing

a. Introduction

Analysis of several Soviet test facilities has been conducted to determine the Soviet capability to provide solid propulsion units for ballistic missiles. This study is the direct result of analysis of several Soviet facilities that were revealed through photography which provided intelligence of a concerted Soviet effort to develop large solid-propellant rocket motors. (TOP SECRET DINAR RUFF)

b. Propulsion Test Facilities

The Soviet facilities of primary interest to this study are located near the cities of Krasnoyarsk, Perm, Sterlitamak, Kamensk-Shakhtinskiy and Biysk shown in Figure 3. In addition, facilities located near Leningrad and Sary Shagan are discussed; also a Chinese facility that is located near Tai Yuan. Each facility, excepting those at Leningrad and Sary Shagan, contain structures that are similar. Each is adjacent to a chemical/munitions plant. All have what appear to be horizontal static propulsion test cells. (TOP SECRET DINAR CHESS RUFF)

(1) Krasnoyarsk - This solid propulsion static test facility (Figure 4) is located five NM east of the city of Krasnoyarsk. It is apparently road served from the adjacent Krasnoyarsk Explosives Plant 580 Zlobino which has a probable nitroglycerin facility. The test facility is secured. Within the test area is a large and a small horizontal static propulsion test stand, each complete with apron and blast deflectors. (See Figure 5.) There is a revetted control bunker situated between and to the rear of the two test cells. This area contains the typical unique H-shaped building seen also at Biysk and Sterlitamak. In the plant area there are revetted buildings typical of those used for the production of nitroglycerin and unusually long buildings which are typical of facilities used for nitrocellulose production. It is important to note here that the facility suspected of nitroglycerin production and associated with the test area is new as is the case for the Biysk facility. (TOP SECRET DINAR RUFF)

(2) Perm - This solid propulsion test facility is located within the confines of Kirov Plant 98, Chemical and Munitions Combine. Plant 98 is located approximately 13 NM west of the center of Perm. The test facility is rail served, secured and identical in part to facilities found at Biysk, Krasnoyarsk, Kamensk and Sterlitamak. A capability of producing several explosive bases exists within the plant complex. (TOP SECRET DINAR RUFF)

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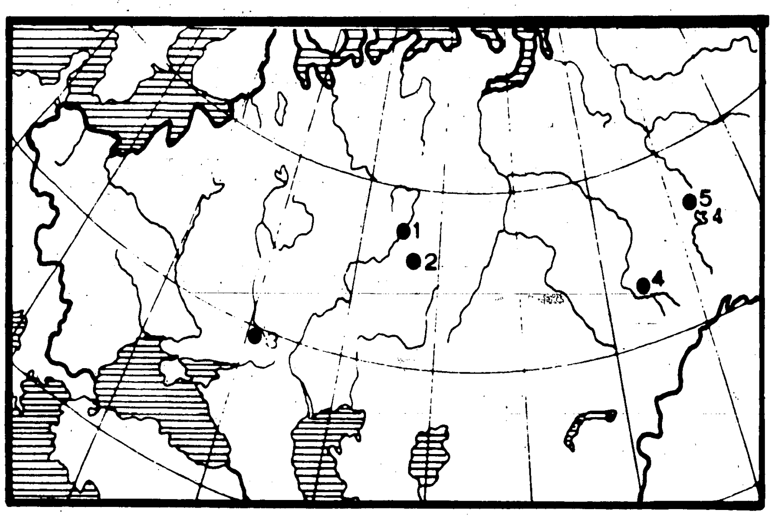

FACILITY	FIRST OBSERVED
1 PERM	1963
2 STERLITAMAK	1963
3 KAMENSK	1963
4 BIYSK	1963
5 KRASNOYARSK	1963

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Fig. 3 Probable Solid Rocket Test Facilities

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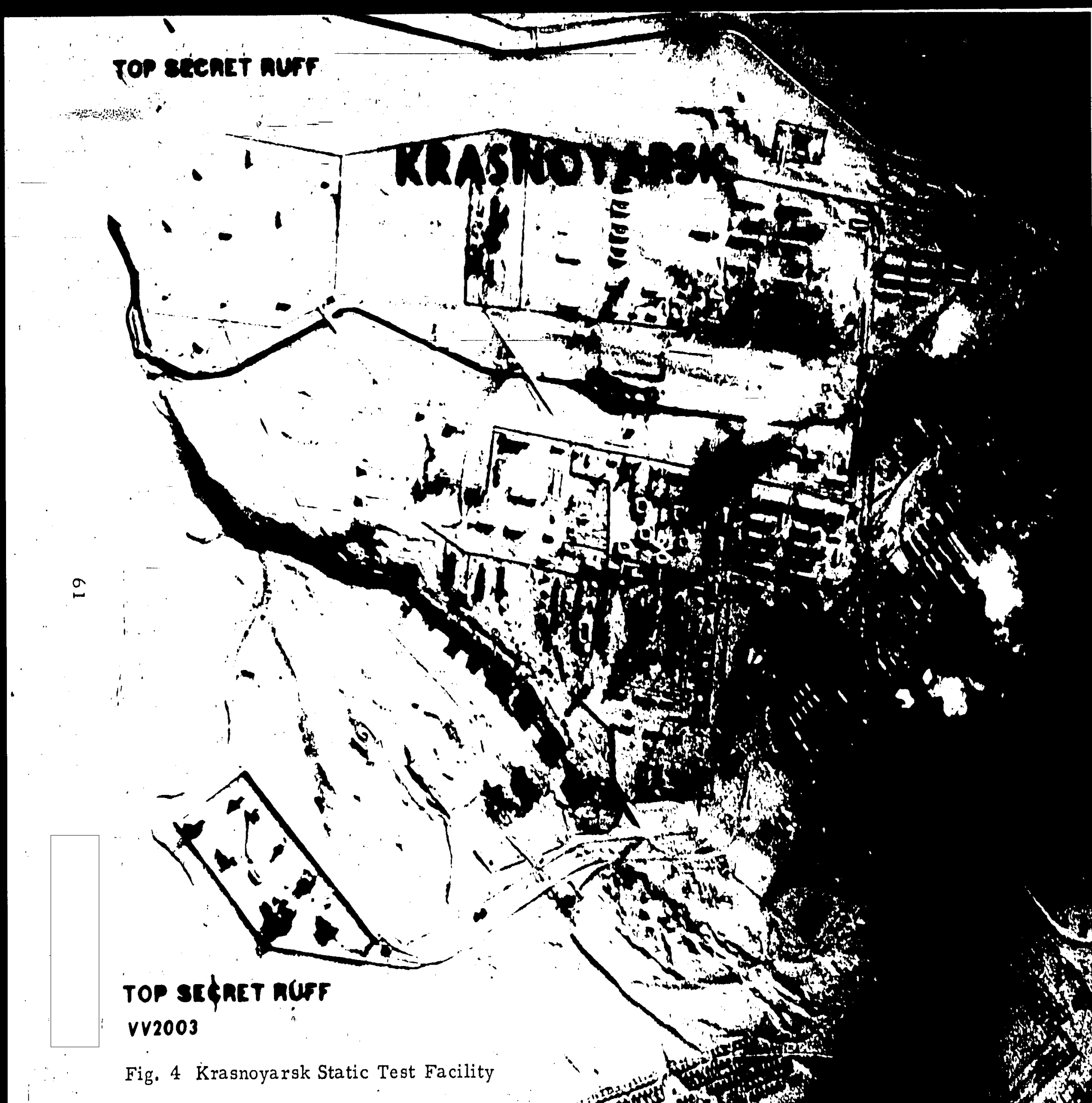

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Fig. 4 Krasnoyarsk Static Test Facility

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(3) Sterlitamak - This solid propulsion test facility is located approximately 7 NM north of the city of Sterlitamak, adjacent to Explosives Plant 850. Within the test area is a large H-shaped building that also exists at the Biysk and Krasnoyarsk facilities. As in the case of Perm, only one static test facility exists. (TOP SECRET DINAR RUFF)

(4) Kamensk-Shakhtinskiy - This solid propulsion static test facility is located adjacent to the Kamensk-Shakhtinskiy Chemical Combine 101 on the southwest side of the city of Kamensk-Shakhtinskiy. The test facility is secured. Within the test area there is one test cell which is separated from the deflector by a distance greater than the other four similar sites. (TOP SECRET DINAR RUFF)

(5) Biysk - This solid propulsion static test facility is located five NM west of the city of Biysk. This facility appears to be both road and rail served from the Biysk Explosives Plant and is secured by what appears to be a wall rather than fencing. The test area contains two horizontal test cells and a test position tentatively identified for small artillery rockets. In addition, this area contains the large H-shaped building also seen at Sterlitamak and Krasnoyarsk. Photographic coverage of the area now containing the facility typical of nitroglycerin production revealed that in December 1960 this facility was in early stage construction. Since then, the probable nitroglycerin processing area has been constructed. (TOP SECRET DINAR RUFF)

(6) Leningrad - This facility is located approximately 12 NM northeast of Leningrad. It is heavily secured and both road and rail served. Within the area are revetted buildings and widely separated buildings which could accommodate all of the phases of manufacturing of motors. This facility differs from the other five Soviet facilities in that there are no apparent nitroglycerin processing facilities. While there are apparently two horizontal static test cells at this facility, there is in addition a larger test facility located approximately 10 NM northeast of this area. Within this test area are five bunkered positions that appear to contain test positions. (TOP SECRET DINAR RUFF)

The Leningrad facilities have been discussed here primarily for reporting completeness. These do not appear to be associated in layout or function with the other five Soviet facilities discussed previously. (TOP SECRET DINAR RUFF)

(7) Sary Shagan - Analyses of the Sary Shagan test complex (Figure 5) indicate that this facility is designed for the development of antiballistic missile systems. Within this complex, the layout of certain areas, their building configurations, bunkering, and associated structures strongly suggest facilities devoted to the production of solid propellants and their eventual incorporation in a rocket motor. At present, identification of the possible type of propellant employed, i.e., double base or composite, is unresolved but the latter is more suggestive. (TOP SECRET DINAR RUFF)

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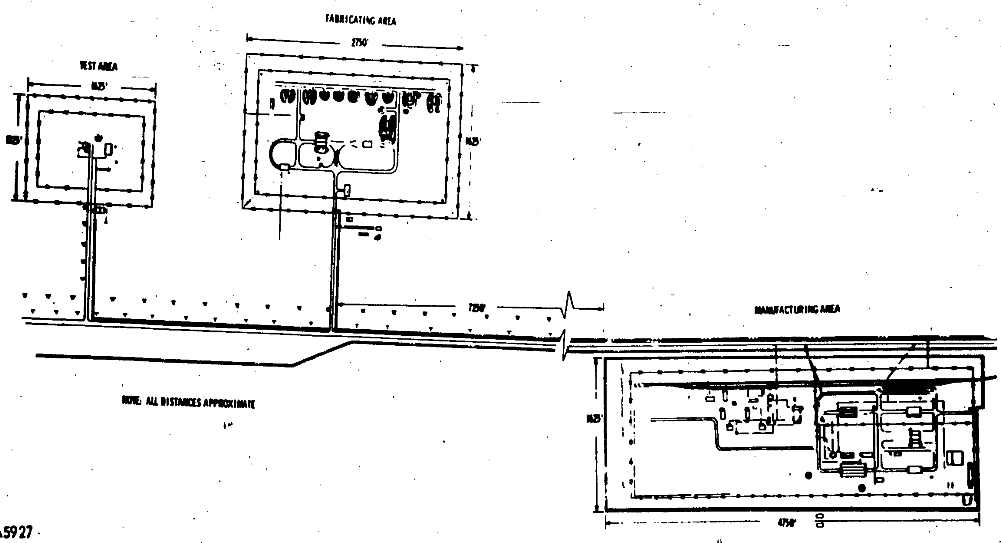

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Fig. 5 Suspect Solid Propellant Facilities at Sary Shagan

(8) Tai Yuan - This Communist Chinese facility is located just north of Tai Yuan and was previously targeted as "Tai Yuan Explosives and Ammunition Plant." Photography from [redacted] Mission 113, dated June 1962 revealed the existence of two new structures at the plant's test range, having the appearance of horizontal static propulsion test stands. Because of the quality of photography and the solid propulsion implication, a detailed analysis was made. (SECRET-NO FOREIGN DISSEM) 25X1

The plant area of this facility is complex and houses many functions. Of significance, however, was the facility typical of European type nitroglycerin processing with its system of bunkered buildings and cross-walks. Of added significance was the fact that Soviet participation in this venture became evident when photography of the five Soviet facilities became available. (TOP SECRET DINAR CHESS RUFF)

Many of the Tai Yuan buildings in the plant area are similar to those in the five USSR facilities. Analysis of this facility was then broadened to determine this facility's function. (TOP SECRET DINAR CHESS RUFF)

The probable nitroglycerin area was evaluated in an attempt to determine process flow and output capability. The long buildings were assessed to produce nitrocellulose. These two products are then blended to produce the typical double base propellant typical of that known to be used in the Soviet Guideline missile. Scaling of the test facility indicates that motors of up to 290,000 pounds thrust can be tested at the large test range. Additionally, it was noted that scarring similar to a blast mark existed. This was scaled and resulted in a thrust level comparable to that of Guideline. Thus, this facility may produce the boosters for a Chinese version of the Soviet Guideline. (SECRET-NO FOREIGN DISSEM)

The capacity of this facility can be determined. However, it would have little or no value because the nitroglycerin produced here may also be used for many other applications. Were this plant assumed to use Biazzi nitrators, then it would produce about one ton of nitroglycerin per hour. There are three such nitrators located here; however, one is probably a standby. Assuming 40 percent nitroglycerin in double base propellant, the monthly capacity with no line loss would be approximately 3,750 tons and production about 2,500 tons. The booster for the Soviet Guideline requires about 500 pounds of nitroglycerin. Thus nitroglycerin production would be adequate for about 10,000 boosters per month, which of course is an extremely high number of boosters. (SECRET-NO FOREIGN DISSEM)

c. Propellant Identification

Soviet handbooks discussing missiles that have used solid propellants have provided knowledge of the use of double base propellants in motors of the unguided FROG artillery rockets and the booster of the Guideline. Five of Soviet solid motor manufacturing and static test facilities contain an area typical of that for nitroglycerin processing, identified by the system of revetted buildings and

[redacted] 25X1

system of cross-walks. Facilities such as these can be modified to some other propellant system. However, at both Krasnoyarsk and Biysk the probable nitroglycerin areas are new. Were some other propellant system being used in the motors being made here, other signatures would likely be evident. (TOP SECRET DINAR RUFF)

Soviet open literature reveals interest in the use of both the double base and composite propellants. Since double-base propellants are still a part of the Soviet effort, it is reasoned here that the motors currently being developed use the double base propellant system. It can, however, be postulated that if the Soviets were to encounter serious setbacks in the application of double base systems to large motors they would, with additional effort, be able to change propellant formulations. (TOP SECRET DINAR RUFF)

d. Initiation of Facility Construction

The five Soviet solid propellant motor manufacturing and static test facilities located near Perm, Sterlitamak, Kamensk, Biysk and Krasnoyarsk were first observed in mid-1963 through the recognition of a separately secured static test area. Since their discovery, it has been possible from previous coverage to determine roughly when construction was initiated. The Krasnoyarsk facility was started in 1960 and completed in 1961. The other facilities were probably started in 1961 and completed in 1963. Because of the similarity in plan layout, all appear to be under the control of a single agency such as the State Chemistry Planning Committee Nr. 3 as noted in the liquid propellant program. (TOP SECRET DINAR RUFF)

e. Analysis of Thrust Capabilities

Because all five of the facilities are similar the analysis of one may be regarded as representative of all. For purposes of orientation and demonstration of analysis technique, the Krasnoyarsk facility shown earlier was chosen. Figure 5 is a line drawing of the test area showing the blast deflectors and the H-shaped building which represented the principal identifier. Here is seen the large and small horizontal static test stand with their aprons and deflectors. Thrust capability of the facilities is based on the distance from the end of the test position to the face of the deflector and is shown in Figure 7. After determining the critical distance of each of the seven test positions, the method chosen to determine the thrust rating of the stand was applied. (TOP SECRET DINAR RUFF)

Thrust determination was based on general gas dynamic principles whereby the exhaust plume of a rocket motor has been well defined. This process of analysis is referred to as the "Exhaust Stagnation Pressure" method. It is recognized that the length of an exhaust plume of a rocket motor is primarily dependent on thrust. Within the plume there is a wide range of gas velocities,

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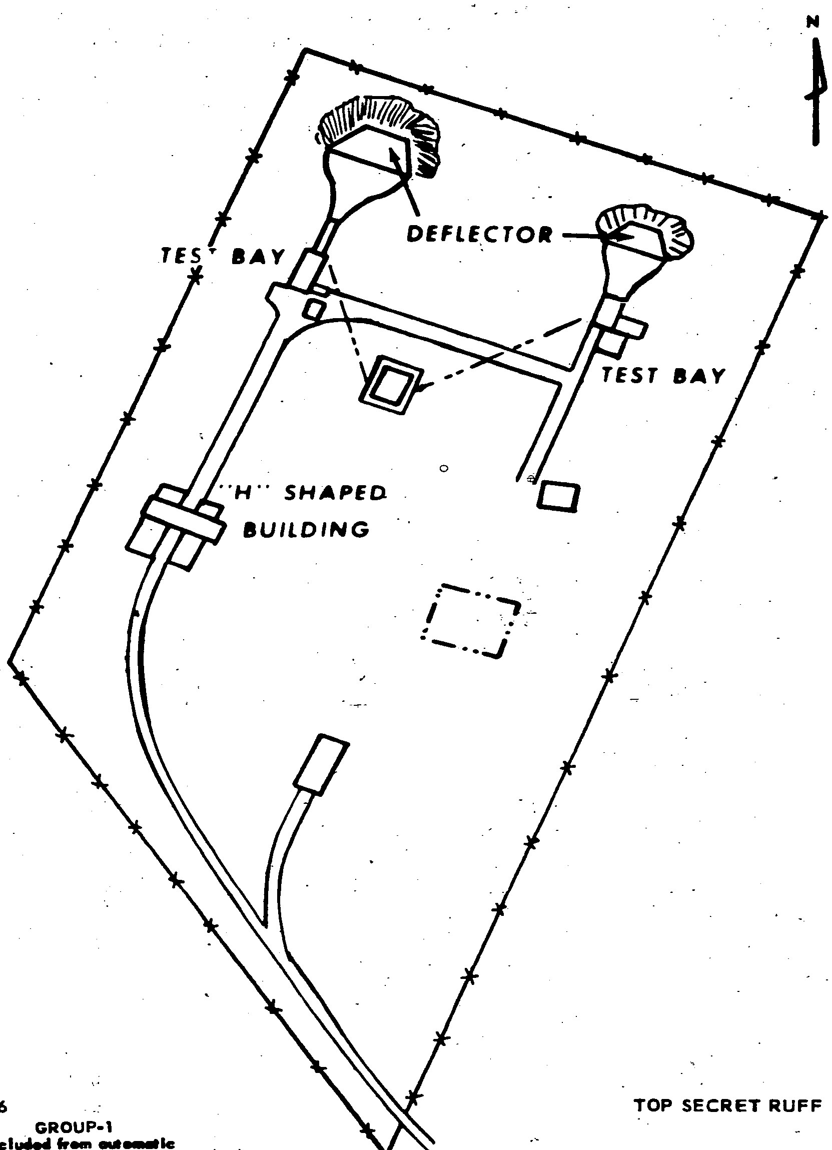

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Fig. 6 Krasnoyarsk Static Test Stands

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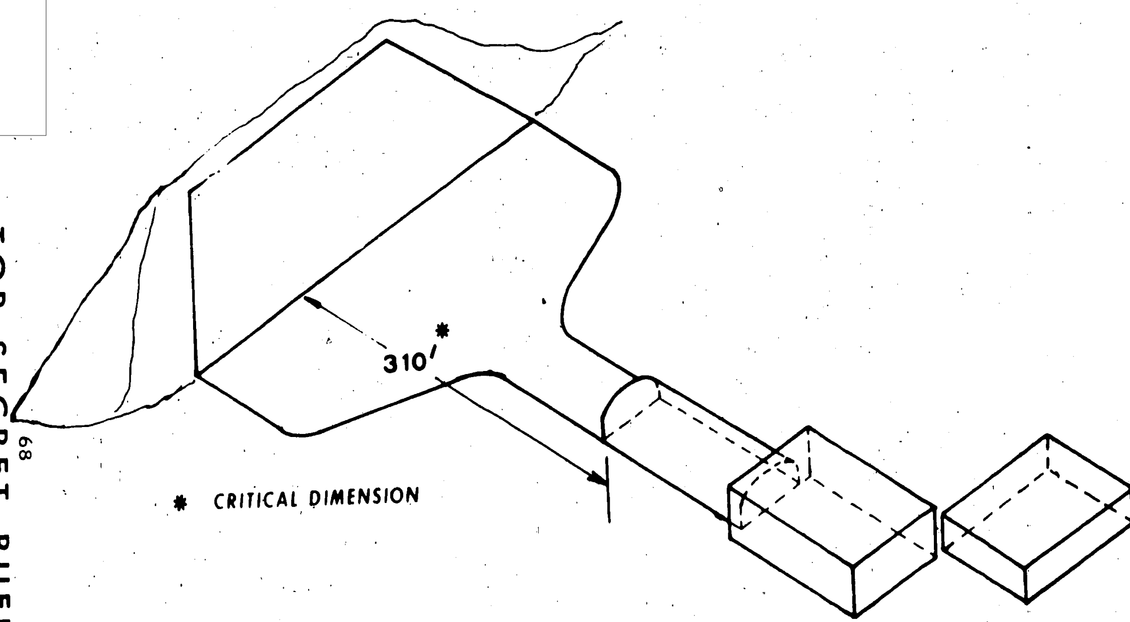

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Fig. 7 Krasnoyarsk Test Structure

pressures and temperatures. A typical stagnation pressure-temperature map for a sea level thrust of 1,500,000 pounds is shown in Figure 8. (TOP SECRET DINAR RUFF)

It has been well established by test stand and structural principles that the ideal point for a blast deflector is just beyond the last point where the exhaust plume remains supersonic. Many organizations in the United States who have studied this technology have established the 30 psia isobar as the critical stagnation pressure or that point where the exhaust velocity is down to Mach 1. Placing the deflector any closer than the 30 psia isobar places it in an area too destructive for conventional construction materials because of supersonic shock waves, overpressure and high temperature. The deflector can be located farther away, say at the 25 psia isobar; however, if the purpose of the deflector is to conserve space then it is not ideally located. Since the deflectors are located at several different distances from the test cells, it is assumed that they were placed by design rather than happenstance. Therefore, it was assumed that the deflectors were placed such that the 30 psia isobar of the motor being tested would be produced on the front face of the deflector. Several pressure maps such as the one shown here have been constructed for various thrust levels. Using these maps an empirical relationship between the critical distances and sea level thrust was developed for the 30 psia isobar and the 1000°F isotherm. The results of this analysis are presented in Figure 9. Using this correlation, the measured distance from the test cell to the deflector was the basis for determining directly the maximum sea level thrust limitations of the seven test cells. The distance between the static test cell and the deflectors is shown in Figure 10. These dimensions then have been correlated to thrust level which is also shown. (TOP SECRET DINAR RUFF)

f. Implied Applications

The thrust class of about 400,000 pounds associated with four of the seven test stands exceeds the requirements of unguided solid artillery rockets (under 100,000 pounds) or the boosters for surface-to-air missiles (about 60,000 pounds for Guideline to about 260,000 pounds for GRIFFON). Additionally, the four larger stands are in a later time phasing than is proper for the above applications. Therefore, it can be reasonably concluded that the four larger stands are part of a Soviet solid propulsion missile program that could lead to an ICBM capability. The three smaller test stands have a thrust class between 80,000 pounds and 200,000 pounds, and they could be tied in with upper stage static motor testing of a possible future solid ICBM. While this overall thrust determination analysis has been predicated on the discrete use of gas dynamic maps reduced to gas velocities, overpressure and temperature, [redacted] working with similar maps whose pressures and temperatures are presented in increments of pressure and temperature better suited to computer techniques quite independently obtained thrust levels comparable to those listed herein. (TOP SECRET DINAR RUFF)

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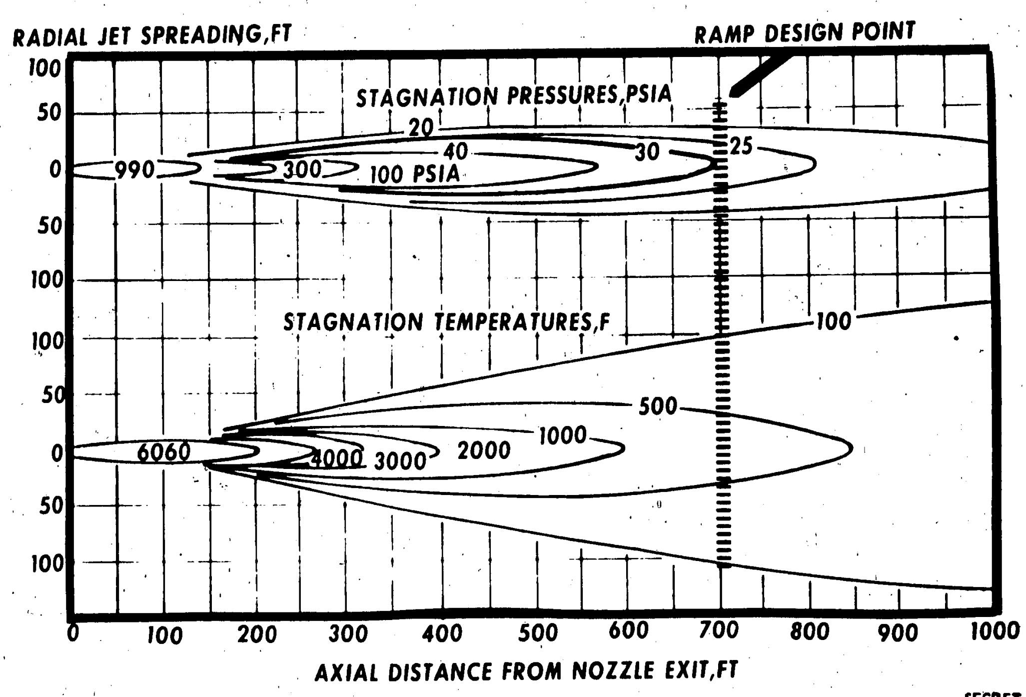

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Fig. 8 Sample Pressure-Temperature Map

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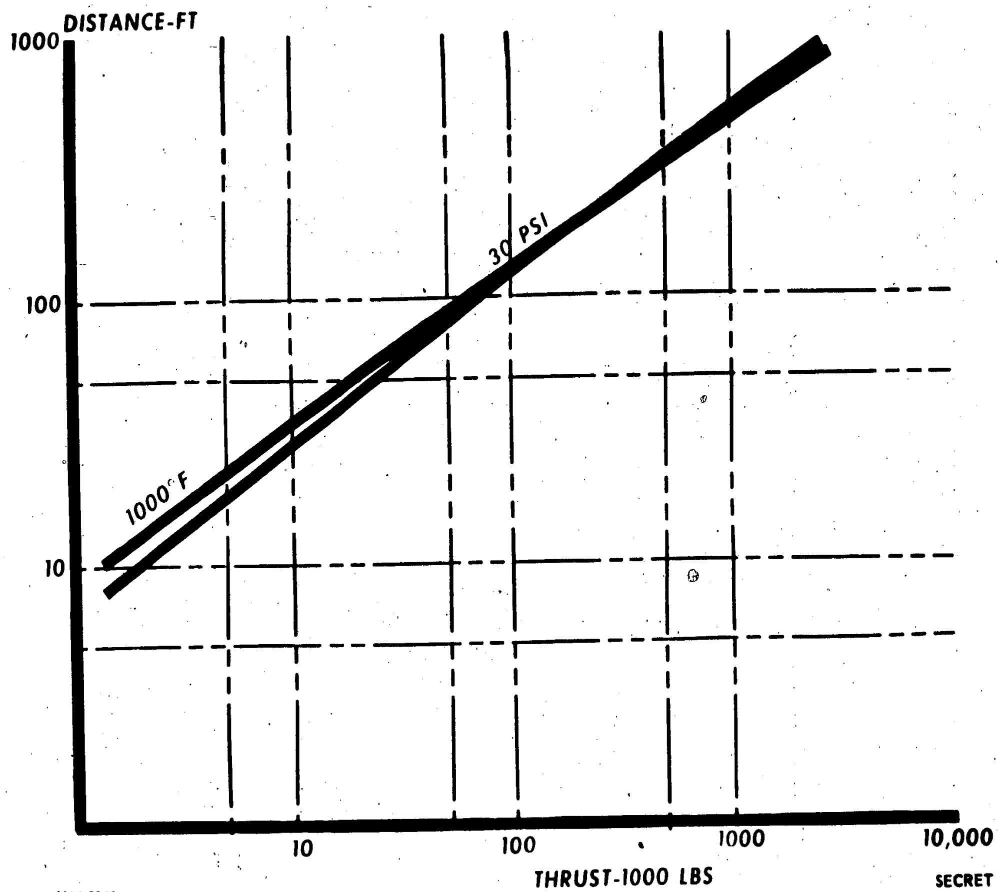

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Fig. 9 Thrust Determinations from Facility Dimensions

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FACILITY	DATE OF START	DATE OF FINISH	DISTANCE FROM TEST BAY TO DEFLECTOR	SEA LEVEL THRUST (10^3 LB)
KRASNOYARSK				
A (LARGE)	MAR. 1961	SEP. 1962	310	400
B (SMALL)	JAN. 1960	JUN. 1961	110	80
PERM	1961	1962 - 1963	335	450
STERLITAMAK	1961	1962 - 1963	200	200
BIYSK				
A (LARGE)	DEC. 1961	JUN. 1963	340	450
B (SMALL)	DEC. 1961	JUN 1963	150	125
KAMENSK	DEC. 1961	JUN. 1963	350	475

AVERAGE TIME OF FACILITY CONSTRUCTION: 1½ YEARS

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Fig. 10 Thrust Levels at Specific Soviet Test Stands

g. Solid Propulsion Development Program

To relate these facilities to a specific motor development program, a sample development schedule has been established as shown in Figure 11. Photographic intelligence of the Krasnoyarsk facility has established the construction time period and reveals the availability of the static stands for testing. This dates the achievement of certain mileposts in the basic technologies. Based on the information on the manufacturing and static test facilities from 1960 to 1963, it is believed that propellant energy improvement to the double base plateau (200 seconds of the basis of 1000 psi to sea level pressure) with the use of additives should have started in about 1957. It is probable that in early 1958 the Soviets committed themselves to a serious solid propulsion program. Motor designs would then have been chosen by 1959 to provide facility construction details such as process flow, motor sizes, facility equipment and the initiation of motor parts design that could be developed elsewhere. (TOP SECRET DINAR RUFF)

Assuming that the program went as planned, static testing of the small motors should have occurred in late 1961. Testing of the large motors could then have started in late 1962. Development testing would then continue until the design was proven. By mid-1964 motors could be available for flight testing. Static motor testing has just recently been detected at the test stand of the Kamensk facility. Additionally, it appears that testing of a motor has just recently been accomplished at the remote heavily bunkered area adjacent to the test facility at Perm. This testing which has occurred approximately one year after the facilities were apparently complete indicates that motor development is behind schedule as indicated by the Novikov reporting or that additional time was required to complete other portions of the facility germane to the motor development. (TOP SECRET DINAR RUFF)

Photographic evidence confirms all of the earlier studies that have been conducted which indicated the existence of a Soviet solid propulsion program. Based on the timing of facility construction the timing of the propulsion program can be reasonably well defined. Analysis of the static test facilities has revealed the thrust class of the motors under consideration. However, the actual design and performance of the solid propulsion subsystem is also required in order to determine effectiveness in a missile. The two most important motor parameters that must be determined in order to define a propulsion system are specific impulse and propellant weight fraction. Specific impulse is a measure of propellant energy. Weight fraction is the ratio of propellant weight in the motor to the overall motor weight. (TOP SECRET DINAR RUFF)

From the nature of these terms it can be readily realized that precise knowledge of actual performance is not known, nor is it readily available. These parameters will, however, become better defined when telemetry from flight vehicles is obtained and analyzed. (TOP SECRET DINAR RUFF)

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[redacted]

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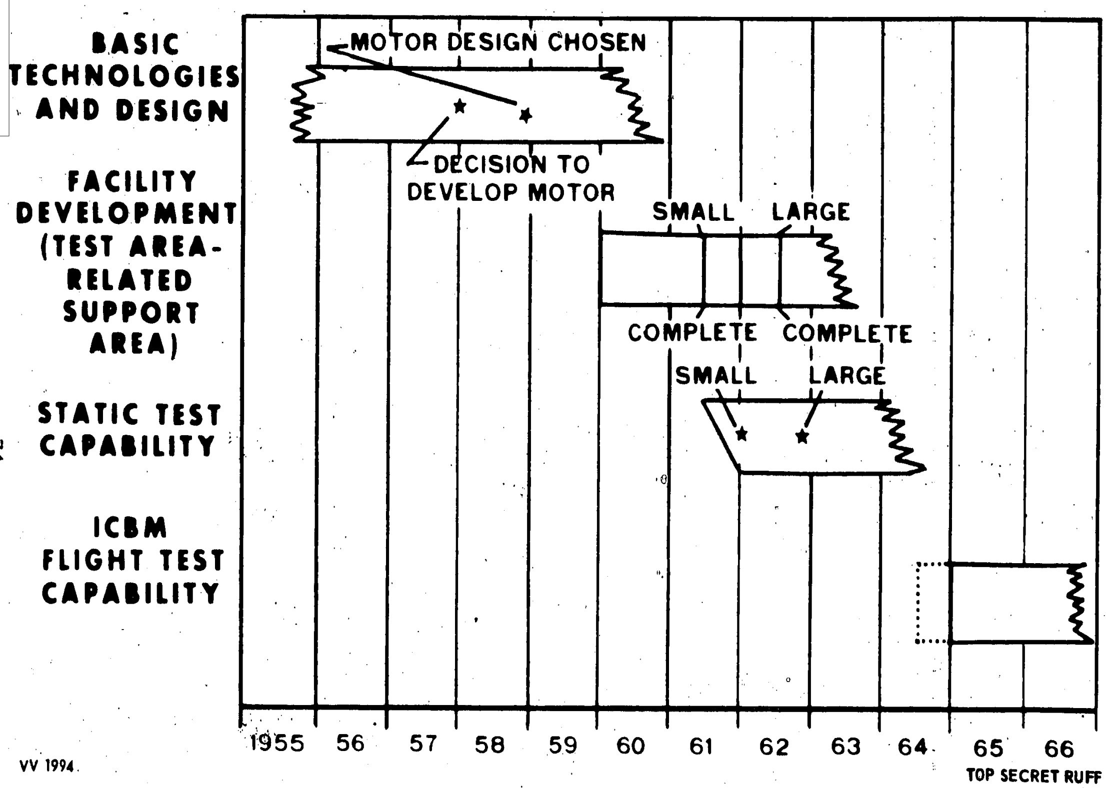

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Fig. 11 Sample Solid Missile Development Program - Krasnoyarsk

h. ICBM Implications

Based on these studies these parameters have been correlated with time and shown in Figure 12, in order to assess a Soviet ICBM capability. The specific impulse curve shows that in 1957 propellant performance was very low. This point is representative of unmodified double base propellants as identified through Soviet handbooks. Shown then is the improvement in performance that is both necessary and readily obtainable by first generally improving the double base energy by formulation changes, then by the use of additives. These changes are required to support high thrust, long duration motor development. Without this achievement the Soviets could not provide an effective large solid-propellant motor. Propellant weight fraction which is really a term that denotes metal parts efficiency must also be improved. The Guideline surface-to-air missile booster is known to have a propellant weight fraction of approximately 0.58. This means that the metal parts of the motor weigh almost as much as the propellant. This represents dead weight that must be carried. This motor has a volumetric efficiency of about 55 percent because the individual extruded grains are held in place in the straight portion of the case. If this propellant cast in the motor case were approximately 15 percent, more propellant could be loaded in the same case and the propellant weight fraction would then be approximately 0.63. Additionally, were the propellant cast in the motor case, the case steel thickness using the same steel could be reduced which would provide an additional improvement. Changing the steel to a higher strength type would effect another improvement. (TOP SECRET DINAR RUFF)

This type of improvement is not too critical to a booster such as the Guideline; however, for large motors of the ICBM class these gains must be made. The Soviets in 1959 developed a new high strength steel for application to solid-propellant motors. The Soviets have been assessed to have the capability to cast double base propellants. These factors then provide the improvement shown by this weight fraction curve to about 1965 where it is expected to level out at about 0.85. No further improvement is visualized because the Soviets have a tendency to overdesign their motors, the propellant they have apparently chosen is a hot burning propellant which will require heavy nozzles and there has been no firm indication of a Soviet program to develop fiberglass pressure shells for solid propulsion application. For comparison, propellant weight fractions achieved by the U.S. for upper stage motors exceeded 0.85 only when fiberglass pressure shells were introduced. (TOP SECRET DINAR RUFF)

These considerations form the bases for application of solid propellants to the Soviet ICBM capability. (TOP SECRET DINAR RUFF)

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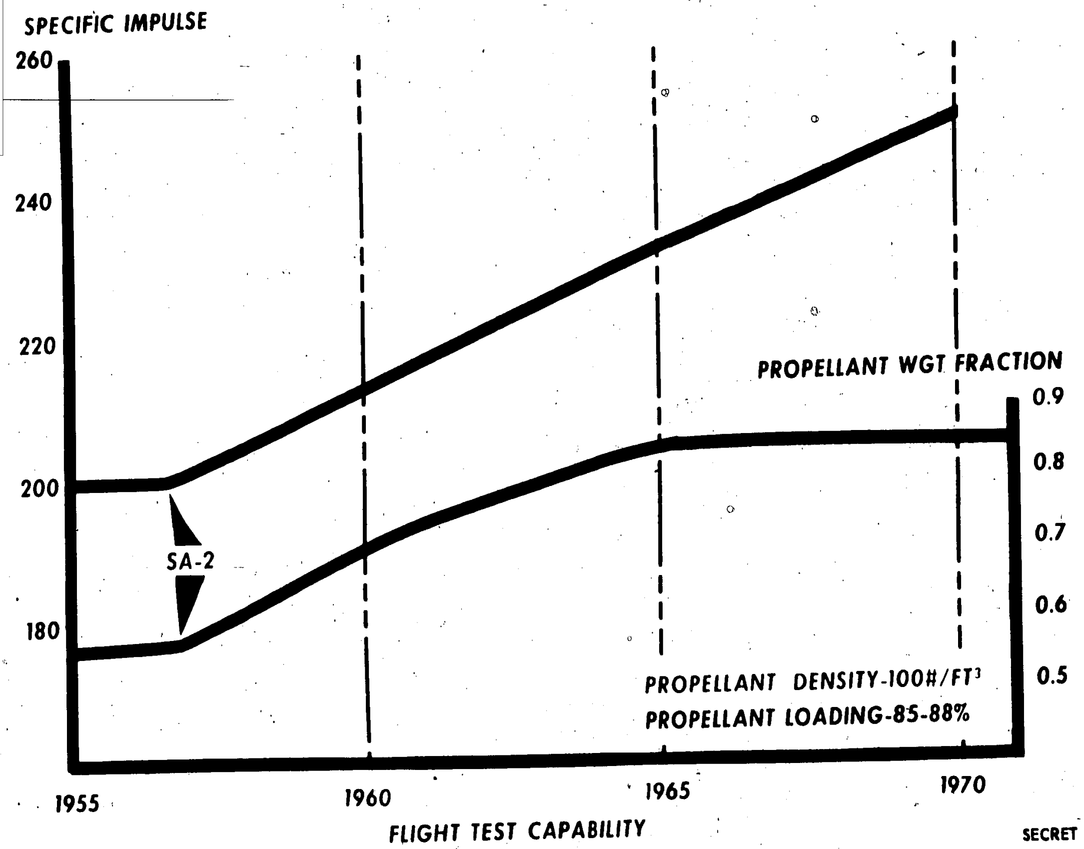

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Fig. 12 Soviet Solid Propulsion Parameters

2. Solid Propellant Missile Testing

a. Introduction

Subsequent to the completion of satisfactory tests at propulsion development facilities, motors developed at these facilities will be transferred to missile test facilities for stage mating, checkout and flight testing. Upon satisfactory completion of the flight testing, the motors developed or serially produced at these facilities will be transferred to operational sites for stage mating, checkout and storage in the ready condition. The Soviet facilities which would be used for the field testing of solid missiles would be either those at Kapustin Yar or Tyura Tam. These were studied to determine possible indications of the Soviet solid-propellant program. (TOP SECRET DINAR RUFF)

b. Kapustin Yar Missile Testing Facilities

A study of the Kapustin Yar test facilities eliminates from consideration all areas except the C area. The A and B areas are primarily associated with Soviet naval cruise and ballistic missile systems; the D area is associated with long range cruise systems; and the G area is associated with the shorter range systems such as the SS-1 and SS-2. The key factors on the C area are summarized in Figure 13. The only area that could be compatible with the possible Soviet solid propulsion missile program of 1963-1964 is the C-5A area, which is probably primarily a training area for soft SS-4 deployment. However, it was under construction up to the end of 1963, while the C-5B probable training area for soft SS-5 deployment apparently was abandoned in 1962. There is nothing in the C-5A area that can be uniquely associated with a solid propulsion missile; however, this is the only area at KYMTR which is in time compatibility with the possible solid propulsion missile program of 1963-1964. (TOP SECRET DINAR RUFF)

c. Tyura Tam Missile Testing Facilities

The Tyura Tam missile test center is the Soviet research and development facility for ICBM weapon and space systems. It is shown in schematic form in Figure 14. The SS-6 missile and space program was flight tested from Area A prior to 1961. After 1961 the SS-6 operational missile flight test program moved to Area B but the space flights using the SS-6 booster continued to use the A area. The SS-7 program has employed the C and D-1 areas at Tyura Tam, and these facilities have served as operationally configured prototype launch areas for soft and hard deployment, respectively. The SS-8 program has employed the E and F areas at Tyura Tam, and these facilities have served as operationally configured prototype launch areas for soft and hard deployment, respectively. The SS-9 program probably will employ the H area for a soft launch environment and the D-2 area for a hard launch environment. (TOP SECRET DINAR RUFF)

25X1

Fig. 13

KYMTR AREAS

- **C-1** MODIFIED IN 1962...KY COSMOS
- **C-2** 1960...SS-5 (NO CHANGE)
- **C-3** SS-3 AND SS-4 SOFT SITES
- **C-4** OPERATIONAL PROTOTYPE SILO SITES FOR SS-4 AND SS-5
- **C-5A** TRAINING SITE FOR SOFT SS-4 DEPLOYMENT CONSTRUCTION COMPLETED IN 1963; TIME COMPATABLE WITH NEW MRBM PROGRAM
- **C-5B** TRAINING SITE FOR SOFT SS-5 DEPLOYMENT ABANDONED IN 1962

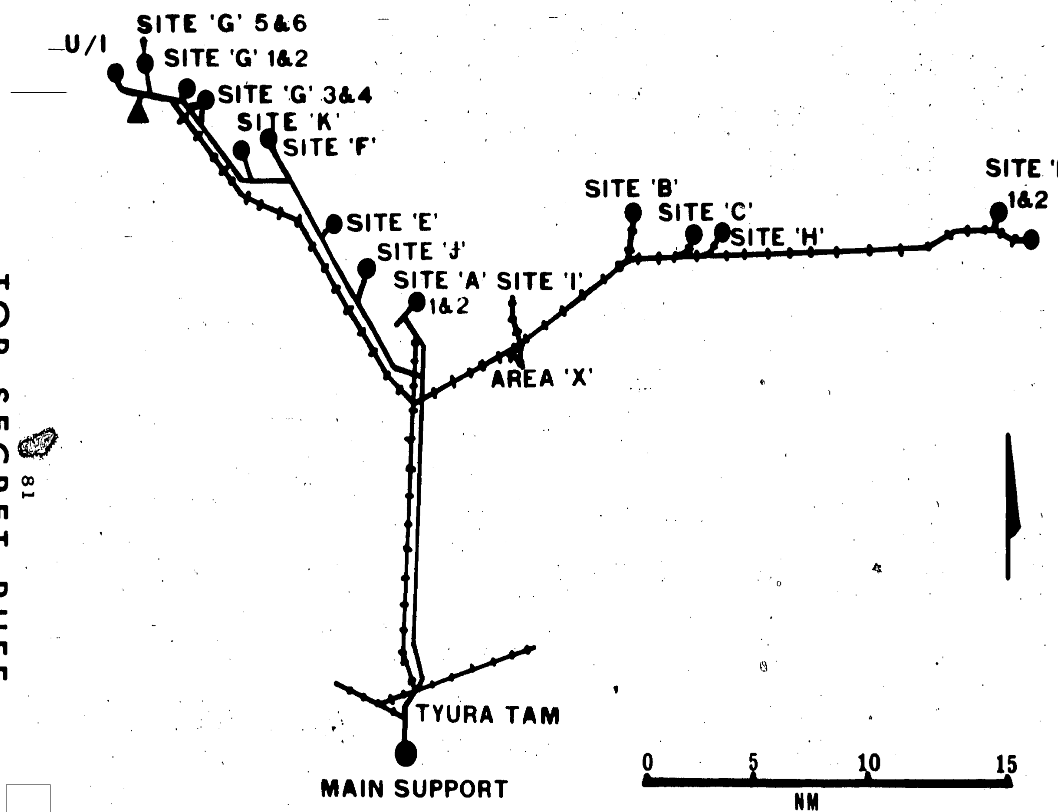

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Fig. 14 Tyura Tam MTR Areas

Of the newer facilities, some can be shown to be for larger systems and therefore would probably be tied in with liquid propulsion systems. Areas G-1 and G-2 can be positively associated with the new Soviet ICBM program which began in April 1964. Areas G-3 and G-4 and J are facilities that will probably support future large liquid propulsion systems. (TOP SECRET DINAR RUFF)

The smaller new facilities are suspect for a possible Soviet solid propulsion ICBM program. Area I is shown in the lower half of Figure 15. It consists at present of a single rectangular excavation for a probable silo launch site. There is road service into the area. Area K is shown on the upper part of Figure 15. It consists at present of two smaller rectangular excavations for probable silo launch sites. There is road service into the area. The K area also will use an L-shaped interferometer similar to the type used in the H area and D-2 area SS-9 facilities. Both the I and K areas could be for future solid propulsion ICBM programs, but no unique characteristics can be identified. (TOP SECRET DINAR RUFF)

A more probable solid propulsion ICBM facility at Tyura Tam is the area west of area G. It is shown in Figure 16. The left facility above the road had been initially evaluated by FTD as a possible soft launch area, but later coverage [redacted] The center area below the road is very similar to a solid-propellant motor storage area. The right facility above the road has just been recently identified on later coverage and the two launch points have been designated G-5 and G-6. However, it is not believed to be a part of the main G complex since the rail service for the main G complex is not intended for this new area, and since the pair of launch points form a smaller site than either G-1 and G-2 or G-3 and G-4. It is believed that G-5 and G-6 will be a road-served soft launch site. The two launch points are relatively close together, about 800 feet apart. (TOP SECRET DINAR RUFF)

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The association of the center facility below the road shown in Figure 16 with solid-propellant motor storage is based on a comparison of the revetted buildings in the area with the Polaris solid motor storage revetted buildings at Cape Kennedy. In Figure 17 the Soviet facility in the area west of the G area is compared with the Polaris facility using a common scale factor. The use of revetted buildings is common for safety and environmental handling of solid-propellant motors. (TOP SECRET DINAR RUFF)

The facility at Tyura Tam west of area G is therefore probably associated with a solid propulsion ICBM program, and will probably include a nuclear storage area, a solid-propellant motor storage area, and two soft launch pads. It could be completed in early 1965. (TOP SECRET DINAR RUFF)

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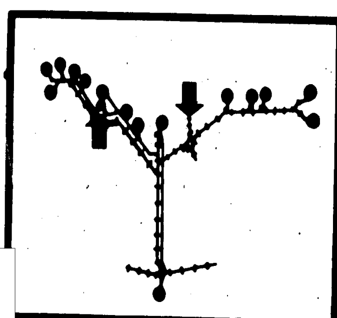
Fig. 15

TYURA TAM

MISSION 1006-1

JUNE 1964

SITE 'K' AND SITE 'I'



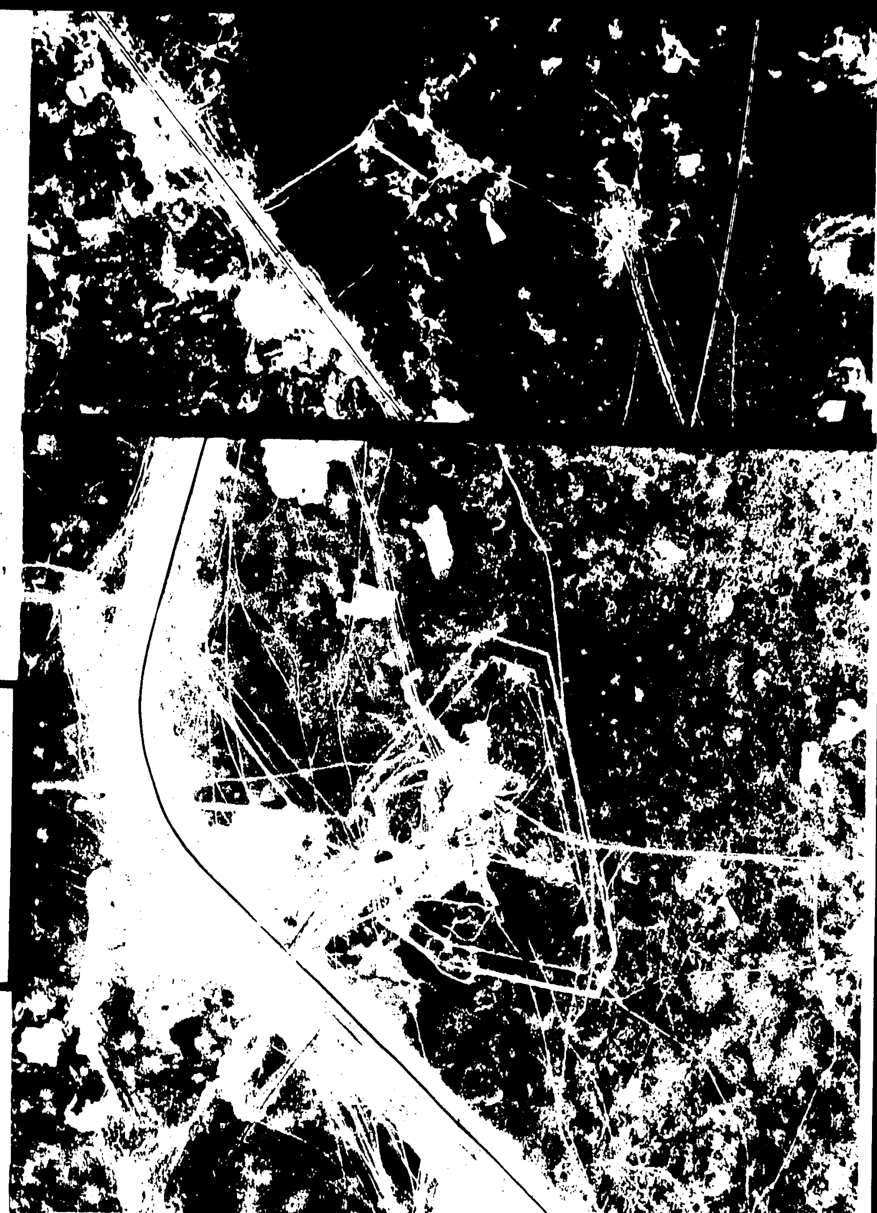


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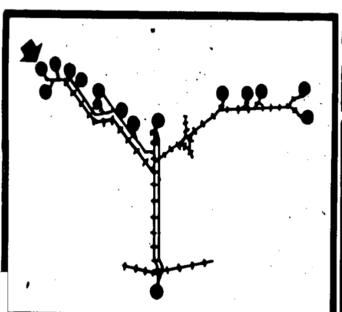
Fig. 16

TYURA TAM

AREA WEST OF 'G'

MISSION 1006-1

JUNE 1964



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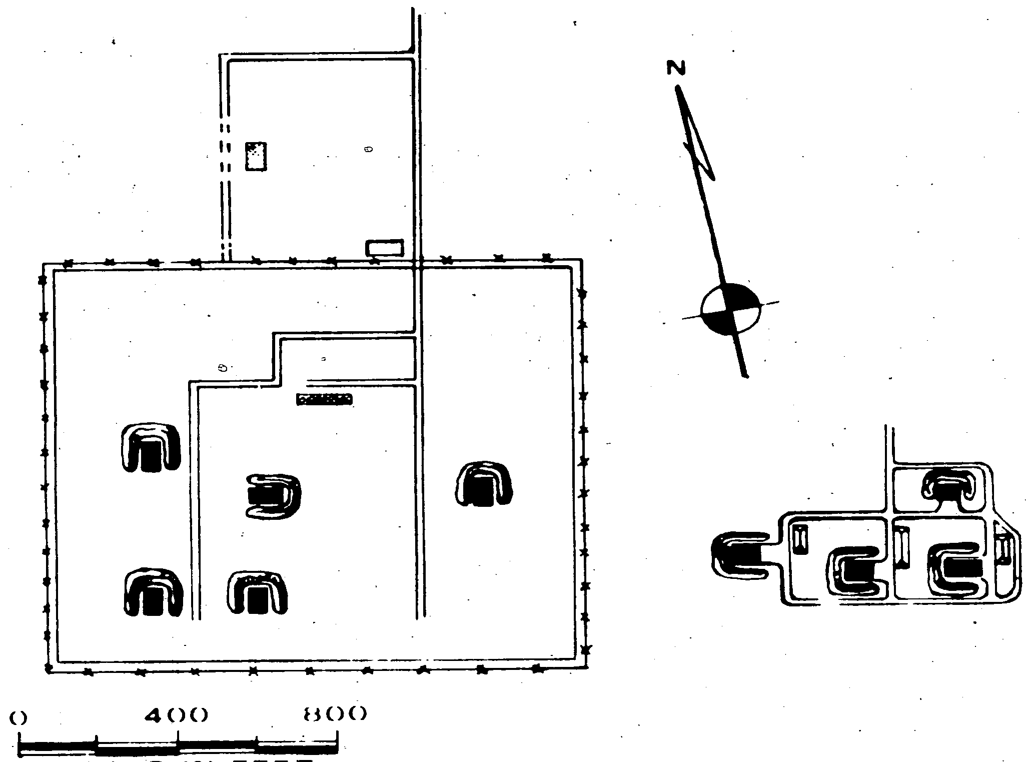

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Fig. 17 Tyura Tam MTR, Area G and Polaris Storage Area

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SECTION V

APPLICATIONS OF SOVIET SOLID PROPELLANTS

1. Introduction

a. Past

An early application of solid propellants by the Soviet Union was in the early 1930's. Using a concept patented by Alfred Nobel in 1888, the gelatinization of nitrocellulose by the explosive plasticizer nitroglycerin, the Soviets were able to refine the jelling process enough to develop a double-base solid propellant suitable for use in their "Katyuska" artillery barrage rocket. This rocket used a double-base propellant which contained 56.5 percent nitrocellulose, 28.0 percent nitroglycerin, 11.0 percent dinitrotoluene (another explosive less sensitive than nitroglycerin) and 4.5 percent ethyl centralite, a combustion stabilizer. (SECRET)

b. Present

Since World War II, the Soviets have given primary attention to the development of liquid fueled missiles; derivations from German technology acquired after World War II. The Soviet achievements with liquid fueled engines are widely known. (SECRET)

Because of this success and concentration on liquid fueled engines, Soviet use of solid propellants has been confined to aircraft takeoff boosters, short range air-to-air missiles, tactical missiles, and to first stage boost for surface-to-air and an antiballistic missile system. The majority of these solid propellants are believed to be double-base formulations. These propellants are referred to generically by the Soviets as "gunpowder." Known formulations of Soviet solid propellants were given in Table III. In two instances, the AA-4 and AA-5, the use of composite solid propellants is suspected because of the time of weapons systems development. (SECRET)

Similarities to the basic compositions were noted with refinements such as dibutylphthalate and nitrodiglycol as plasticizers, vaseline as an extrusion aid, magnesium oxide and chalk as burning rate modifiers, and the lead oxide as an approach to "plateau" catalyst to decrease the sensitivity of the burning rate-pressure relationship. (SECRET)

The Soviets are granted the capability to adapt this formulation to all of their known present-day, solid-propellant missile systems, within conceptions of using single or multiple extruded grains. (SECRET)

The Soviets are assessed to be using solid propellants in all five of their air-to-air missiles. They are not believed to be using solid propellants in any of their four air-to-surface missiles, although one of the air-to-air missiles, the AA-1, is granted a limited air-to-surface capability and one of the liquid-fueled air-to-surface missiles, the AS-4, might use a short-duration RATO unit. The major use of solid propellants by the Soviets is in their surface-to-air missiles as boosters burning for 4 to 5 seconds. Thrust of these boosters is from about 24,000 to 260,000 pounds. For application to surface-to-surface rockets, the Soviets are assessed to use solid propellants on six of their eight free-flight tactical artillery rockets (all of less than 30 NM range), for their two antitank wire-guided missiles, and for an ejection device for the SARK, an underwater submarine-launched liquid-fueled missile. In addition to these rocket and missile applications, the Soviets have boost-assist systems such as small RATO units and larger zero-length launch units. Completing the assessment of Soviet solid-propellant applications are less strategically significant devices such as seat ejectors, mortar launchers, ammunition, etc. (SECRET)

2. Current Applications

a. Air-to-Air Applications of Solid Propellants

Air-to-air missiles characteristically are small in diameter. The propellant in the Soviet AAMs is assessed to be a solid, and an extruded, double-base formulation seems most logical, especially for the earlier air-to-air missiles. Assignment of the propellant characteristics is predicated on expected developments within the time frame preceding the initial appearance of the missile. (SECRET)

(1) The AA-1 missile is a native Soviet development which had its inception around 1951-1952 and became operational in five years. It is believed to have a single extruded double-base grain slightly less [redacted] 25X1
The propellant is assessed to have a specific impulse of 195 seconds and a burn-time of 4 seconds. (SECRET)

(2) The AA-2, quite similar to the U.S. SIDEWINDER, became operational in 1959, two years after the AA-1. As with the AA-1, the AA-2 is presumed to have an extruded double-base grain. The grain is smaller in diameter [redacted] 25X1
[redacted] but has a shortened burning time - 3 seconds - and an improved specific impulse of 220 seconds. (SECRET) 25X1

(3) The AA-3 is believed to have become operational in 1961, two years after the AA-2. Again, the propellant is assessed to be a single extruded double-base grain with a specific impulse essentially the same as the AA-2, i.e., 220 seconds, but with a shorter burning time, 2.2 to 2.4 seconds, and an increased diameter [redacted] (SECRET) 25X1

[redacted] 25X1

(4) The AA-4 is believed to have become operational around late 1963 and was seen on a FLIPPER as early as 1961. It is also assessed to have used composite propellant which has a burning time of 4 seconds, an improved specific impulse, 230 seconds, and an increased grain diameter, [redacted] (SECRET) 25X1

(5) The AA-5 is thought to be slightly larger than the AA-4 in both length and diameter. Its propellant is presumably the same as the AA-4: a composite propellant; specific impulse, 230 seconds; but with a burn-time of 4 seconds. The improvement of the AA-5 over the earlier air-to-air missiles is in the use of lighter weight fabrication metals from which is expected a two-fold benefit. First, an increase of 50 percent in range; secondly, the possibility of a nuclear warhead. Although the AA-5 and the AA-4 were originally seen at the same time (at the Tushino Air Show in 1961), the AA-5 is expected to become operational sometime in 1964, about one year after the AA-4. (SECRET)

b. Air-to-Surface Applications of Solid Propellants

The Soviets are not believed to have any solid propellant missiles designed specifically for an air-to-surface mission. All known Soviet air-to-surface missiles have been assessed to be aerodynamic air-breathers using a kerosene-type fuel. However, the AS-4 might have a small liquid rocket boost. The AA-1 has recently been assessed to have an air-to-surface capability on a line-of-sight basis. No long-range air-to-surface missile using a solid propellant (akin to the SKYBOLT) has yet appeared. (SECRET)

c. Surface-to-Air Applications of Solid Propellants

No Soviet surface-to-air missiles use solid propellants exclusively. However, four such defensive missiles do use solid propellant boosters. (SECRET)

(1) The SA-2 missile, the Guideline, uses a solid propellant booster whose prototype was associated with vehicle of the late 1952 time period designated 32-B, of which about 50 were built. The Guideline itself became operational in early 1958 and has been in mass production since that time. It is widely deployed throughout the Soviet Bloc and also in Cuba. It is also deployed in Iraq, Indonesia, and India. Within the Soviet Bloc there are over 1000 SA-2 launch sites with at least six missiles at each site. The solid propellant in the booster is assessed to be 14 extruded double-base grains, each about 4 inches in diameter, which have a delivered specific impulse of 210 to 215 seconds. The weight of the combined grains is 1,210 pounds; burn-time, 4.3 seconds; and a total impulse of about 260,000 pounds-seconds. (SECRET)

(2) The booster for the SA-3 missile, the GOA, is estimated, from limited intelligence information, to have a delivered thrust of 24,400 pounds derived from a propellant with a specific impulse of 210 seconds. The total propellant

[redacted] 25X1

weight may be about 500 pounds, burning-time, 4.3 seconds. The booster is believed to have 14 extruded double-base grains, [redacted] The SA-3 system became operational in 1961 and is deployed at about 100 sites within the Soviet Union, primarily at coastal approaches. (SECRET) 25X1

(3) The AM-1 missile, the GRIFFON, appears to be a scale-up of the Guideline. The solid-propellant booster is believed to be of increased size, having an assembly of 12 extruded double-base grains, [redacted] The propellant is assessed to have a specific impulse of 215 to 225 seconds, a 4-second burning time, and a total weight of 4780 to 5420 pounds, delivering a thrust of around 260,000 pounds. Apart from the fact that this booster has grains about twice the diameter of those in the Guideline booster, it is not significantly different from the Guideline booster, whose development began more than 11 years ago. (SECRET) 25X1

(4) A new missile, as yet undesignated, which was first shown in the 1964 May Day parade uses 4 small solid-propellant boost devices, which are essentially RATO boost units. Each unit is assessed to have an extruded double-base grain with a specific impulse of 205 seconds, a burning-time of 3 seconds and a propellant weight of 340 pounds. (SECRET)

d. Surface-to-Surface Applications of Solid Propellants

(1) Free-Flight Rockets - There are seven artillery rockets in use by the Soviet Army. Six of these use extruded double-base grains. [redacted] 25X1 [redacted] high-explosive rocket contains a 42-pound extruded double-base grain. The 25X1 [redacted] high-explosive rocket contains a 163-pound grain. The [redacted] 25X1 [redacted] high explosive rocket has a 138-pound grain. The FROG-1 ("3R2" or "Eagle Owl") uses 8 extruded double-base grains, totaling 3682 pounds, having a specific impulse of 221 seconds, and producing 79,000 pounds of thrust. The FROG-2 ("3R1" or "Mars") uses 2 extruded double-base grains, each approximately 10 inches in diameter, totaling 1094 pounds, having a specific impulse of 224 seconds, and producing 41,572 pounds of thrust. The FROG-3 (or FROG-4 identical except for warhead) is also believed to use multiple extruded double-base grains, although their exact characteristics are undetermined. (SECRET) 25X1

(2) Antitank Missiles - The Soviets possess 2 wire-guided antitank missiles, designated the SNAPPER and the SWATTER. Both are assessed to use around 4 pounds of double-base propellant for propulsion. This propellant has a specific impulse of 183 seconds. In addition, the SWATTER is believed to use a short boost from another small solid charge. (SECRET)

(3) Strategic Surface-to-Surface Missiles - Only one other surface-to-surface missile is believed by FTD to use a solid propellant. The SS-N-5, or SARK, is assessed to be a liquid-fueled, submarine-launched missile with 7 small solid-propellant ejection devices at the aft end. Their purpose is to expel the

[redacted] 25X1

missile from its launch tube. Each of these devices is believed to contain an extruded double-base solid-propellant grain about [redacted] which burns for 1.72 seconds, delivering a thrust of 21,000 pounds per second. The propellant selection is predicated on the initial appearance of the missile and estimated design and development time. (SECRET) 25X1

(4) Recent Developments - Now under study is unusual telemetry data acquired from 4 flights early in 1963. These flights ranged from 650 to 1000 miles. One possibility of the unique telemetry data is that it represents flights of dubious success and is suggestive of a solid-propellant MRBM. Another possibility is that the missile was liquid-fueled and that the unusual flight characteristics are associated with solid propulsion guidance checkouts. There are still other unresolved assessments as to the function and success of these four flights. Intelligence analyses continue in hope of resolving contrasting opinions. (SECRET)

e. Boost-Assist Applications of Solid Propellants

The Soviets have released pictures of 3 boost-assist systems which presumably use solid propellants. These are a rail-launch booster for fighter aircraft, a zero-length launch booster for fighter aircraft, and a RATO unit which is seen on the FISHBED fighter aircraft. All three of these systems are believed to use extruded double-base solid-propellant grains. Picture quality of the rail-launch booster is insufficient for sizing, but the thrusts and probable burn-times have been extrapolated from the other two photographs. The zero-length launch booster is believed to provide 73,500 pounds of thrust for a 3.6-second burning-time. The FISHBED ATO unit is assessed to deliver 10,750 pounds of thrust through 6.6 seconds of burning-time. (SECRET)

f. Miscellaneous Applications of Solid Propellants

The devices discussed (for inclusiveness) in this section are ancillaries having much less mass than those in the preceding five sections. A list of the compositions of captured Soviet devices is given at the end of this section. (CONFIDENTIAL)

In general, a solid propellant (a controlled explosive) is used in applications where compactness and simplicity of function are desired, occasionally at the expense of energy. Bullets, artillery and mortar shells, and shrapnel or fragments are propelled by a solid explosive. Pilots and bombs are ejected from aircraft by solid propellants, flares are fired into the air, rescue signals are fired from submarines, ropes are fired from ship to ship, torpedoes are ejected and propelled, fire extinguishing streams are propelled, all by solid propellants. Aircraft engines use solid propellant starters. (UNCLASSIFIED)

[redacted] 25X1

The use of solid propellants to energize hydraulic and pneumatic systems (such as the one that slides back the top of a Minuteman silo) is common throughout the world. However, the gas generators for turbine drive in Soviet missiles are fueled by liquid monopropellants such as hydrogen peroxide and isopropyl nitrate or by bleed-off from the main engine fuel lines or combustion chamber. The Soviets have a known capability and use of solid propellants to initiate gas generators. They probably also use solid propellants to effect pressurization of liquid-propellant tanks. The Soviets use explosive bolts at stage-separation and are also believed to use solid-propellant retrorockets to separate the main stage of the SS-7 from the second stage. (SECRET)

A Soviet ammunition item captured from the Viet Cong in analysis of the powder was found to be 96 percent nitrocellulose, 3 percent diphenylamine and 1 percent dibutylphthalate. (SECRET)

Soviet primer powder is based exclusively on mercury fulminate. Samples have been analyzed and found to contain from 21 percent to 25 percent mercury fulminate, 35 percent to 45 percent potassium chlorate, and 33 percent to 40 percent antimony sulfide. (SECRET)

Only one Soviet high explosive filler has been analyzed; it was found to contain 75.1 percent RDX, 20 percent aluminum and 4 percent binder. The detonator for this mixture was one-third each lead styphnate, antimony sulfide and barium nitrate. (SECRET)

Soviet primers for grenades are usually 9.7 percent to 17.2 percent mercury fulminate, 46.5 percent to 48.8 percent potassium chlorate, 36.2 percent to 36.3 percent antimony sulfide and up to 5.3 percent ground glass. (SECRET)

Soviet delay fuses are made of black powder. (SECRET)

Soviet detonators are either two-stage or three-stage, the final stage being tetryl in each case. The two-stage initiator is mercury fulminate. The three-stage initiator is lead styphnate with an intermediate stage of lead azide. (SECRET)

Soviet high explosive charges are TNT, the only exception being the latest HEAT grenade whose formulation has been reported to possibly be either TNT/PETN or TNT/RDX. (SECRET)

Soviet mines have primary charges of TNT, amatol, dynammon, ammonite, or picric acid. Mine detonators are usually TNT and, occasionally, picric acid. (SECRET)

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PETN is used as the detonator for mortar, rocket, and artillery rounds; RDX is used as a sub-booster, booster and bursting charge. A high-explosive warhead filler consisting of 60 percent TNT, 24 percent RDX and 16 percent aluminum (covered by a 5 percent addition of chloronaphthalene) is used in two surface-to-surface missiles. (SECRET)

Soviet small arms propellants are nitrocellulose usually stabilized by diphenylamine (acetanilide and dinitrotoluene also are used). These propellants also contain small amounts of modifiers: sodium, potassium, and calcium salts, camphor and graphite. (SECRET)

Soviet propellants for larger caliber ammunition are of either the single-base (i.e., nitrocellulose) or double-base (i.e., nitrocellulose gelled by nitroglycerin) type, as in other countries. Other stabilizers such as dinitrotoluene, diphenylamine, acetanilide, or dimethylene glycol dinitrate are added, as well as the conventional modifiers: methyl and ethyl centralites; various phthalates; potassium, sodium and calcium salts; camphor, and technical vaseline. (SECRET)

3. Future Applications of Solid Propellants

Future solid propellant applications by the Soviets are speculative but possibilities are:

a. Air-to-Air Solid Propellant Applications

The new long range air-to-air missile, AA-6, expected in 1965, should be a follow-on of the design concept initiated in the AA-4 and AA-5. This missile, as speculated, will have an increased range, around 30-40 miles, and a nuclear warhead capability. It will also have the capability of being used with an all-weather fighter aircraft. The composition of this propellant should approximate that of its forerunners, and be of the composite formulation. (SECRET)

Past improvements on air-to-air missiles have been directed toward optimizing warhead packaging, with an eye toward eventual nuclear warheads and toward optimizing reliability and accuracy of guidance and control systems. Expected developments of the future air-to-air missiles will appear in these same fields. Propellant improvement for air-to-air missiles, per se, is less likely, but fall-out from future propellant improvement specifically directed toward larger missiles should be immediately adaptable to air-to-air missiles. (SECRET)

b. Air-to-Surface Solid Propellant Applications

As with air-to-air missiles, improvements in propellants which are to be used with larger missiles could be adapted to air-to-surface missiles. Most solid propellant air-to-surface missiles are relatively short-range, medium-speed,

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modified air-to-air missiles with heavier warheads. The development of long-range, high-speed, air-to-surface missiles involves unique problems and depends more on satisfying operational constraints such as minimizing size for internal storage (in supersonic aircraft) and accurate geodetic survey of launch points or long-range guidance and control of the air-to-surface missile from an airborne platform. Because of these special problems associated with long-range air-to-surface missiles, and since advanced propellant work is not the limiting constraint, development of such air-to-surface missiles will probably trail that of equivalent surface-launched weapons. (SECRET)

c. <u>Surface-to-Air Solid-Propellant Applications</u>

Defensive missile systems that will be developed by the Soviets through the early 1970's will require a progressively improved solid-propellant propulsion capability. The trend to smaller, lighter, more compact missiles with an increasing degree of mobility will require solid-propellant motors with lighter inert parts weight, higher specific impulse, and higher volumetric loading. Similar performance increases will be required in the ABM systems. The solid-propellant facilities observed at Sary Shagan are more advanced than the state-of-the-art of the GRIFFON (AM-1) missile, and could provide a solid-propellant propulsion capability to support future ABM developments, i.e., the AM-X incorporating a higher velocity missile or the AM-Y incorporating a long-range, high-altitude interceptor missile. (SECRET)

d. <u>Surface-to-Surface Solid-Propellant Applications</u>

In view of U.S. success with solid propellants in the Polaris and the Minuteman, it should be expected that the Soviets would show equivalent interest in solid-propellant developments, in spite of their success with liquid-fueled long-range surface-to-surface missiles. It is significant to note that so far the Soviets, in order to obtain thrusts over 50,000 pounds with solid propellants, have had to cluster either grains, as in the GRIFFON, or motors, as in the SARK. (SECRET)

The Soviet publications in areas relevant to solid propellants have become more frequent since 1958-1960 suggesting that this propulsion medium is receiving more objective attention. Although confirmation is not yet evident, it is speculated that a Soviet 1,000 NM range missile would be a stepping-stone to the ICBM category. Presuming the latter is the Soviet objective and that it has and will be given adequate support to proceed in an orderly fashion, it is considered likely that small scale tests would be accomplished in the 1961-1963 period. Larger scale tests and an overlapping prototype development could now be current and extend up to 1965-1966. Operational status may be attained in the 1967-1969 period. The future Soviet solid-propellant ICBM capability is discussed in Section VI. (SECRET)

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e. Solid Propellants for Space Applications

Solid propellants for use in space require even more refining than they do for long-range missiles. Long-range missiles require a propellant of at least a certain homogenity, web size, integral strength and specific impulse. Solid propellants for use in high vacuum of space require all this and, in addition, either hermetic sealing of the motor or meticulous preparation of the binder (to prevent inclusion of low molecular weight fractions that would evaporate out and leave a porous propellant). Also, the effects of radiation on solid propellants must be worked out well in advance of use in space (although it is expected, for example, that current U.S. solid propellants would be able to withstand 10 to 20 million Roentgens, i.e., 10 years in the Van Allen belt). There is no direct indication of Soviet work in such space-related fields, although facilities for high vacuum and 2-25 mev betatron radiation testing exist at numerous locations in the Soviet Union. (SECRET)

f. Miscellaneous Solid-Propellant Applications and Associated Problems

High-performance propellants generate the requirement for hardware suitable for long-term use in a high-temperature environment, e.g., valving for thrust vectoring by hot injection (from a solid-propellant gas generator). (UNCLASSIFIED)

Advanced solid-propellant motor design anticipates the demand for stop/restart motors, or command-delivered, fixed-impulse shots, or thrust modulation. Work on these three problems appears to take a course designed to separate fuel and oxidizer components, e.g., the hybrid, reverse hybrid and solid/solid hybrid concepts. (UNCLASSIFIED)

In the more usual motor (with the fuel and oxidizer together in the grain), these three problems are attacked by attempting to regulate pressure (and hence, combustion) by valving. Valves may be fabricated for small grains, but size scale-up entails special development problems. (UNCLASSIFIED)

Successive ignition by repeatable igniters and a means of extinguishing combustion, or a motor unit containing a series of separate small propellant and igniter water packages are two other concepts that have been suggested. (UNCLASSIFIED)

Small packaged units (with very fast acting valves) that contain sublimating solids of high vapor pressure, which would not be useful for propulsion under atmospheric pressure, become very worthwhile in the vacuum of space. In addition, no demand is placed on the associated hardware for resistance to high temperatures, as with more conventional combustive propellants. (UNCLASSIFIED)

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A long tape with attached packages of propellant, to be fed at variable speeds into a continuously ignited combustion chamber, is another idea that has been suggested. (UNCLASSIFIED)

An outer sheet of styrofoam banked with small amounts of propellant, each quantity supplied with an individual ignition wire to be fired in groups and directions as desired, is yet another concept proposed to satisfy the demand for command delivered fixed-impulse shots. (UNCLASSIFIED)

Interest of the U.S. in all of the above concepts has appeared in open literature. Any indication of Soviet interest in any of these areas should be expected to be indicative of concomitant interest in improved solid-propellant grain development; as yet there is none. (SECRET)

Of special interest is the problem of thrust modulation (all U.S. suggestions for attempting thrust modulation of solid propellants have involved the use of high temperature valvage). The current and highly reliable inertial guidance systems of all Soviet liquid-fueled missiles of over 500 NM range are described as using, in the pitch plane, programmed thrust modulation. This imposes the requirement for repeatable burnout parameters for any given predetermined trajectory. In other words, a major constraint of current Soviet guidance systems is the ability to control thrust. The other Soviet alternative is to develop an entirely new guidance system.

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TABLE V

SOVIET SOLID PROPELLANT ROCKETS AND MISSILES

NAME	DESIGNATION	NUMBER OF GRAINS	TYPE OF PROPELLANT	BURNING TIME (seconds)
ALKALI	AA-1	Single	Extruded Double-Base	4.0
ATOLL	AA-2	Single	Extruded Double-Base	3.0
ANAB	AA-3	Single	Extruded Double-Base	2.2 - 2.4
AWL	AA-4	Single	Composite	4.0
ASH	AA-5	Single	Composite	4.0
GUIDELINE	SA-2 Booster	14	Extruded Double-Base	4.3
GOA	SA-3 Booster	14	Extruded Double-Base	4.3
GRIFFON	AM-1 Booster	12	Extruded Double-Base	4.0
NEW SAM	SA-4? Booster	4	Extruded Double-Base	2.8
"MARS" FROG-2	3R1	2	Extruded Double-Base	5.1
"EAGLE OWL" FROG-1	3R2	4	Extruded Double-Base	4.6
SNAPPER		Single	Cordite Double-Base	
SWATTER		Single	Cordite Double-Base	
SARK	SS-N-5 Ejector	7	Extruded Double-Base	1.72

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TABLE V (Cont)

NAME	TOTAL WEIGHT PROPELLANT (lb)	SPECIFIC IMPULSE (sec)	THRUST (lb)	SYSTEM IOC YEAR
ALKALI	44	195	2,145	1956-1957
ATOLL	38	220	2,787	1959
ANAB	165	220	1,650	1961
AWL	305	230	17,360	1963
ASH	305	230	17,360	1963
GUIDELINE	1210	210-215	60,000	1958
GOA	500	210	24,000 (to 100,000)	1961
GRIFFON	4780-5420	215-225	257,000 (to 305,000)	1964-1965
NEW SAM	340	205	23,200 (for 10 inch throat) 20,900 (for 9 inch throat) (3.2 sec burning time)	1961
"MARS"				
FROG-2	1094	224	41,572	
"EAGLE OWL"				
FROG-1	3682	221	79,000	
SNAPPER	4	183		
SWATTER	4.5	183		
SARK	945	220	146,000	1962-1963

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SECTION VI

FUTURE SOVIET SOLID-PROPELLANT ICBM CAPABILITY

As discussed earlier, the Soviet manufacturing and static test facilities were ready for testing of fairly large double-base solid-propellant motors in the 1962-1963 time period. Motors from these facilities could appear in flight test as early as 1964. However, the suspect area at Tyura Tam (the area west of the G area) that is probably associated with a solid propulsion ICBM program will not be completed until the first part of 1965. Figure 18 shows two possible future Soviet solid-propellant ICBM systems. The first would enter the flight test phase in early 1965, reaching initial operational capability (IOC) in 1967. A second generation solid propulsion ICBM system could enter flight test in 1967, reaching IOC in 1969. (TOP SECRET RUFF)

The two key factors in determining the performance of possible Soviet solid propulsion ICBM systems are the specific impulse and propellant weight fractions. The specific impulse is a measure of the energy of the propellants and the weight fraction is the ratio of propellant to total motor weight. Both of these factors have been estimated as a function of time for the Soviet Union as discussed earlier. In Figure 19 two curves are shown for 6500 NM, three-stage, solid-propellant ICBM systems, one available for flight test in 1963 and the other in 1965. Two stage solid propulsion designs are not shown because they are grossly inferior to the three-stage designs. Also shown on this payload versus gross weight correlation is the U.S. Minuteman, which was first flight tested in 1961. Due to the estimated poor performance of the postulated 1963 flight test design, it would have been over three times as heavy as the Minuteman if it had been designed with the payload capability of the Minuteman. The first possibility of a three-stage solid propulsion ICBM is 1965 as discussed above, and even in that time period the estimated performance of the postulated 1965 design would allow a design for the Minuteman payload of about 100,000-pound gross weight as opposed to about 70,000 pounds for Minuteman. (SECRET)

The curve for 1965 flight test capability of a three-stage solid propulsion ICBM system is repeated in Figure 20, but the IOC date of 1967 is reflected so that comparisons can be drawn with the Soviet liquid propellant ICBM systems. The SS-6, SS-7, SS-8, and SS-9 design points are shown in Figure 20. As can be seen, the early design of the SS-6 which reached IOC in 1960 is superior to what the Soviets could achieve in a solid propulsion ICBM in the 1967 time period. In addition the SS-7 which reached IOC in early 1962 also is slightly superior to what the Soviets could achieve in a solid propulsion ICBM in the 1967 time period. While a low ratio of gross weight to payload weight is not the sole consideration in effectiveness of an ICBM system, it should be pointed out that the second generation systems, the SS-8 as a second generation to the SS-6 and the SS-9 as a second generation to the SS-7, represented major advances in efficiency when compared with the SS-6 and SS-7. The SS-8 reached IOC in late 1963, and the SS-9 is expected to reach IOC in early 1965. While one cannot discount completely that the

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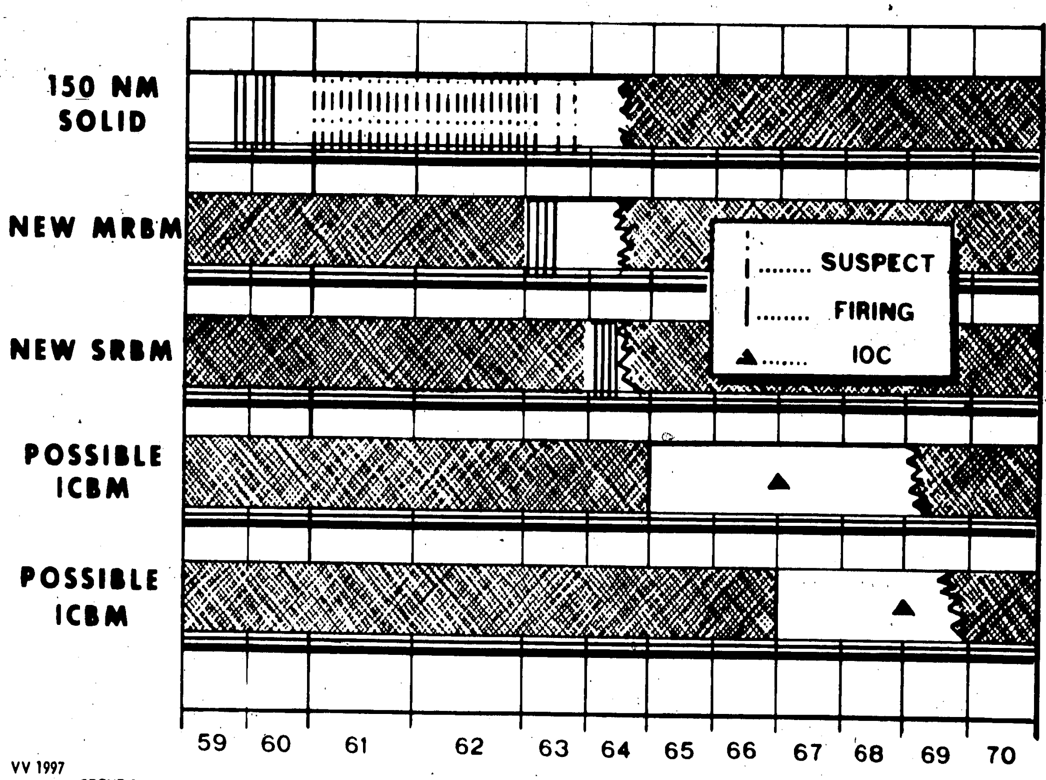

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Fig. 18 Possible Solid Missile Program

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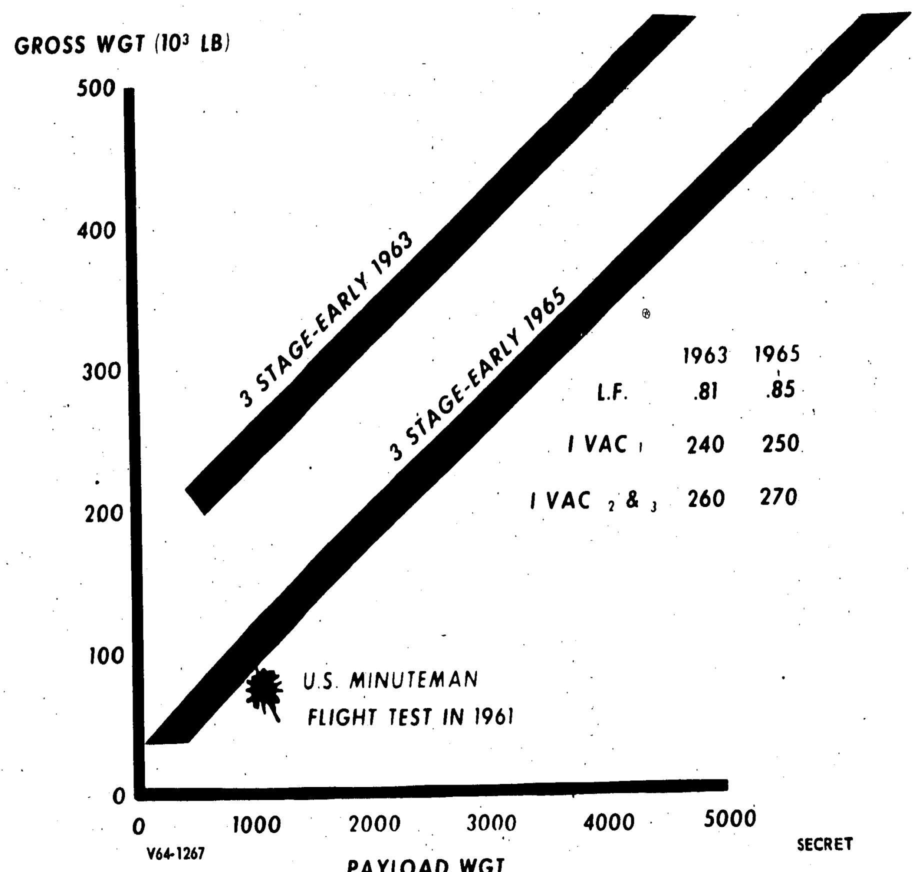

Fig. 19 Soviet Solid ICBM Flight Test Capabilities

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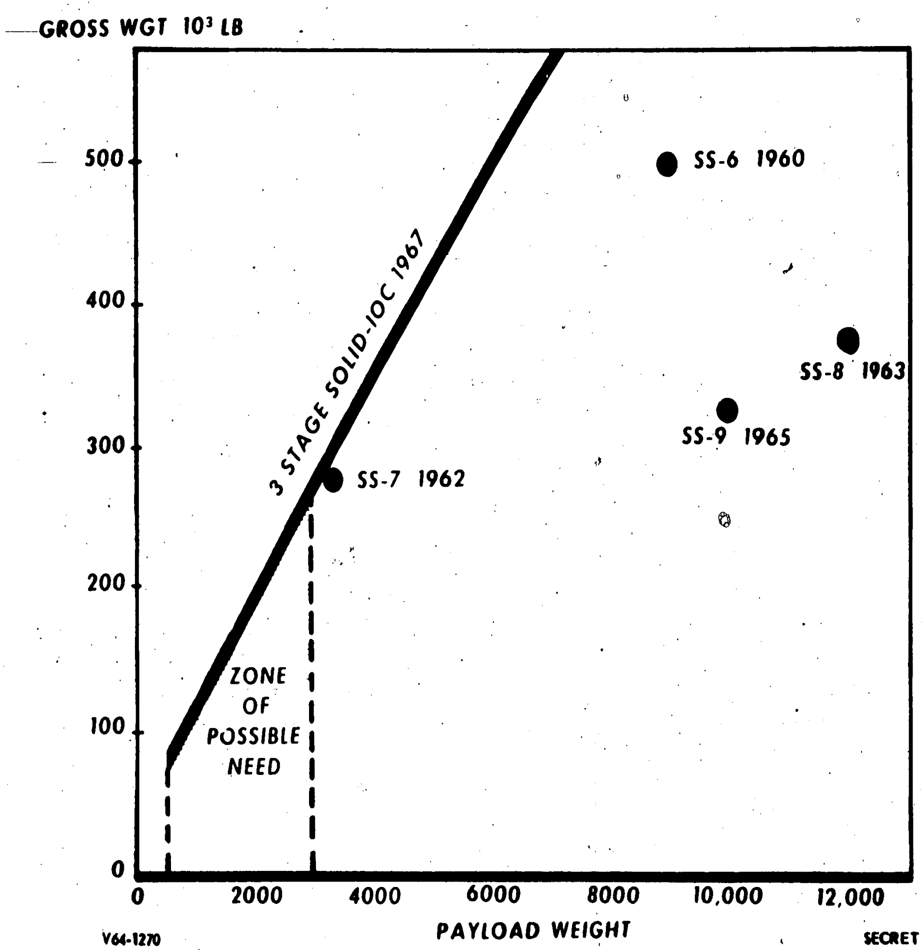

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Fig. 20 Soviet Liquid and Solid Capabilities

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Soviets will design a first generation solid propulsion ICBM system in the range of payloads above 3000 pounds, it is felt that this is unlikely due to the heavy investment and experience in rather efficient large liquid propellant systems. Hence, it is believed that the area of possible Soviet need for a solid propulsion ICBM system is in the payload class between 500 and 3000 pounds, where the requirement for a rather inexpensive system for mass deployment could exist. (SECRET)

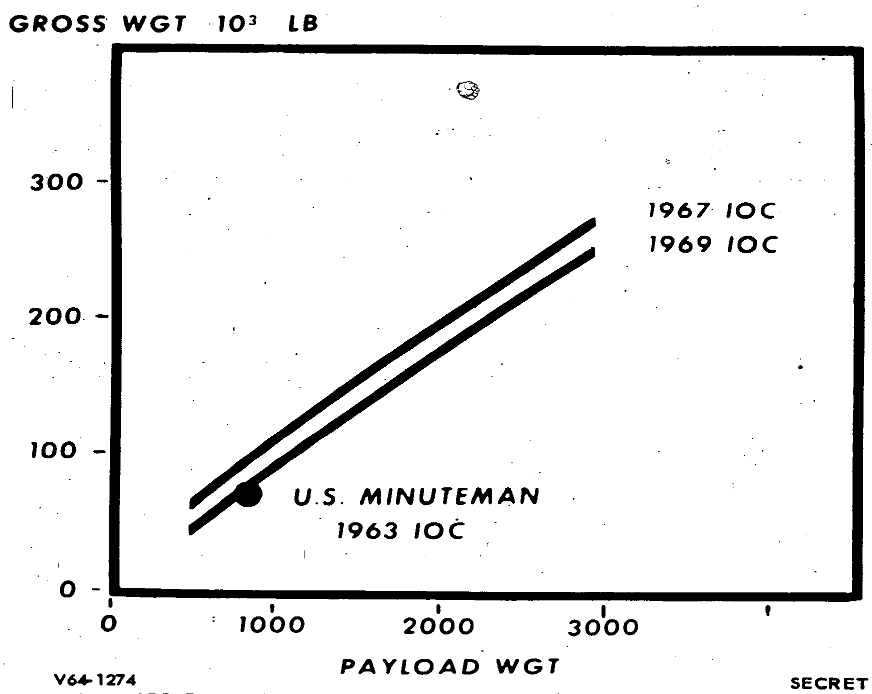
The evaluation of the Soviet solid ICBM systems that could reach IOC in 1967 and 1969 are shown in Figure 21. The improvement evaluated from 1967 to 1969 is again based on the estimated performance parameters of specific impulse and propellant weight fraction. For the payload range of 500-3000 pounds, gross weights would be between 50,000 and 275,000 pounds, and takeoff thrusts would be between 125,000 and 700,000 pounds. If the need exists for takeoff thrusts of over 400,000 pounds, then the Soviets could cluster two or more of the postulated solid motors being developed at the static test facilities. The comparison between the possible future Soviet solid ICBM systems and Minuteman is shown in Figure 22. For the Minuteman payload, the 1967 IOC design would be definitely of lower efficiency than the Minuteman (1963 IOC), and the 1969 IOC design could approach Minuteman efficiency. (TOP SECRET DINAR RUFF)

Another important aspect of possible future Soviet solid propulsion ICBM systems in addition to weight, thrust, and specific impulse is the guidance subsystem. In the past the Soviets have developed and used on all known liquid propulsion ballistic systems a "fly the wire" guidance concept. No airborne computer is used. A taped program for velocity gain is carried on the airborne missiles, and acceleration sensing instruments are used to compare actual velocity gain with programmed velocity gain (on the taped program). Errors in velocity gain are remedied through the use of a thrust control system which regulates gas generator pressure, turbopump speed, pump discharge pressure, engine chamber pressure, and consequently engine thrust. This concept has been improved with time on the generations of Soviet liquid systems, and it is evaluated from detailed studies that the Soviets could achieve overall ICBM system accuracies at IOC of between one-half and three-fourths NM in the 1967-1969 time period. The possible future Soviet solid propulsion ICBM system would require the development of a new guidance system, since it is not probable that thrust control of solid motors could be used in the 1967-1969 time period. This new guidance system would require an airborne computer or a ground control system so that the trajectory can be recomputed and modified as required to achieve proper target impact. Hence, the overall accuracy of possible Soviet future solid propulsion ICBM systems in the 1967-1969 time period is evaluated as being between three-fourths and one NM. (SECRET)

In conclusion, the Soviets could achieve an initial operational capability with a solid propulsion ICBM system as early as 1967. The probable payload class is between 500 and 3000 pounds. The associated system accuracy would be between three-fourths and one NM. With the combination of payload weight and accuracy

25X1

W_G	50,000-275,000 LB
W_{PL}	500-3000 LB
T	125,000-700,000 LB



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GROUP-3
Downgraded at 12 year intervals;
Not automatically declassified.

SECRET

Fig. 21 Soviet Solid ICBM Capability for 1967-1969

25X1

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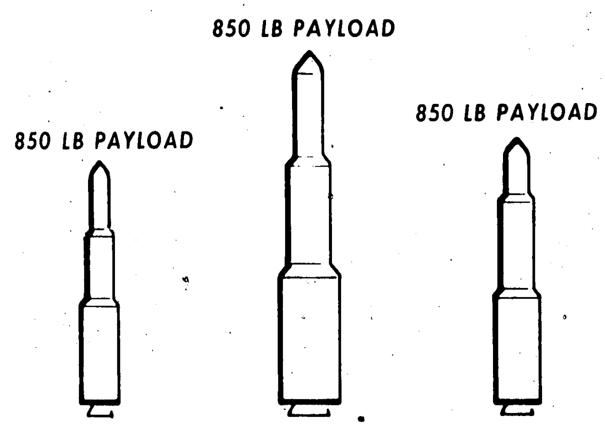

	MINUTEMAN	SOVIET	SOVIET
FLIGHT TEST	1961	1965	1967
IOC	1963	1967	1969
GROSS WGT,LB	70,000	100,000	75,000

V64-1272

Fig. 22 Possible Future Soviet Solid ICBMs this system would have very limited capability against hard targets, but it could fulfill a future Soviet need for an inexpensive soft target weapon system for high deployment in the 1967-1969 time period. The essential conclusion items for the future Soviet solid ICBM systems are summarized in Figure 23. (SECRET)

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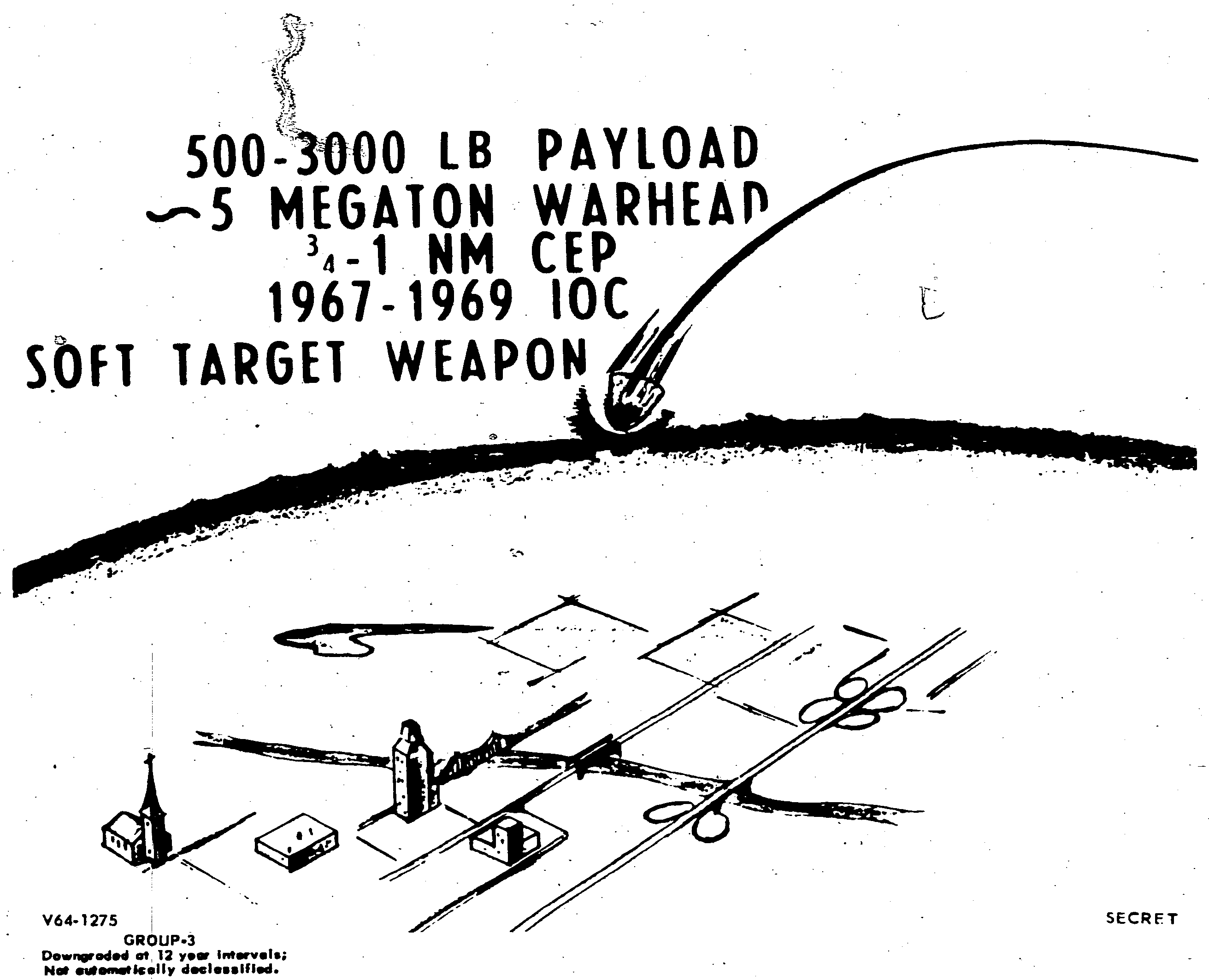

Fig. 23 Summary Soviet Solid ICBM Capability