TITLE: The Case Of The SS-6

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Growing pains in astronautics intelligence.

THE CASE OF THE SS-6

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The public display of a Soviet SS-6 rocket at the Paris Air Show in 1967 jolted the US scientific astronautics intelligence community into awareness of many weaknesses in its evaluative processes. These revelations were of much greater intelligence significance than the factual information gleaned from inspection of the missile itself.

The space rocket is one of the new intelligence targets to emerge in the past decade, and its unique character has necessitated the invention of new and comparatively sophisticated collection and analysis devices. To insure the effective operation of these extremely complex and expensive mechanisms, the results of their employment require continuous evaluation. A variety of intelligence inputs including telemetry and radar signature information had been available for a number of years on the Soviet SS-6 system, but it was not until the display of the SS-6 that the US intelligence community had a chance to assess Soviet rocket technology directly and extensively. Its appearance thus afforded the first real opportunity to evaluate the effectiveness of the collection and analysis efforts which had been directed against Soviet missile and space programs for a decade.

As a result it became possible to identify many shortcomings in the analytical phase of the intelligence cycle. Successful attempts have now been made to remedy most of these. The primary benefit to intelligence of the appearance of the SS-6 in Paris is thus not to be measured by what it revealed about the technical characteristics of the system, but rather by the subsequent improvements in our analytical processes.

In retrospect, it is clear that the principal shortcomings of our analytical cycle did not result from mistakes in the interpretation of the available data, nor from deficiencies in the quality or quantity of the data. Instead, error most frequently arose from attempts to relate Soviet technology directly to that of the United States. It is now evident that this approach involves a dangerous assumption, and that Soviet technological approaches in the field of astronautics often

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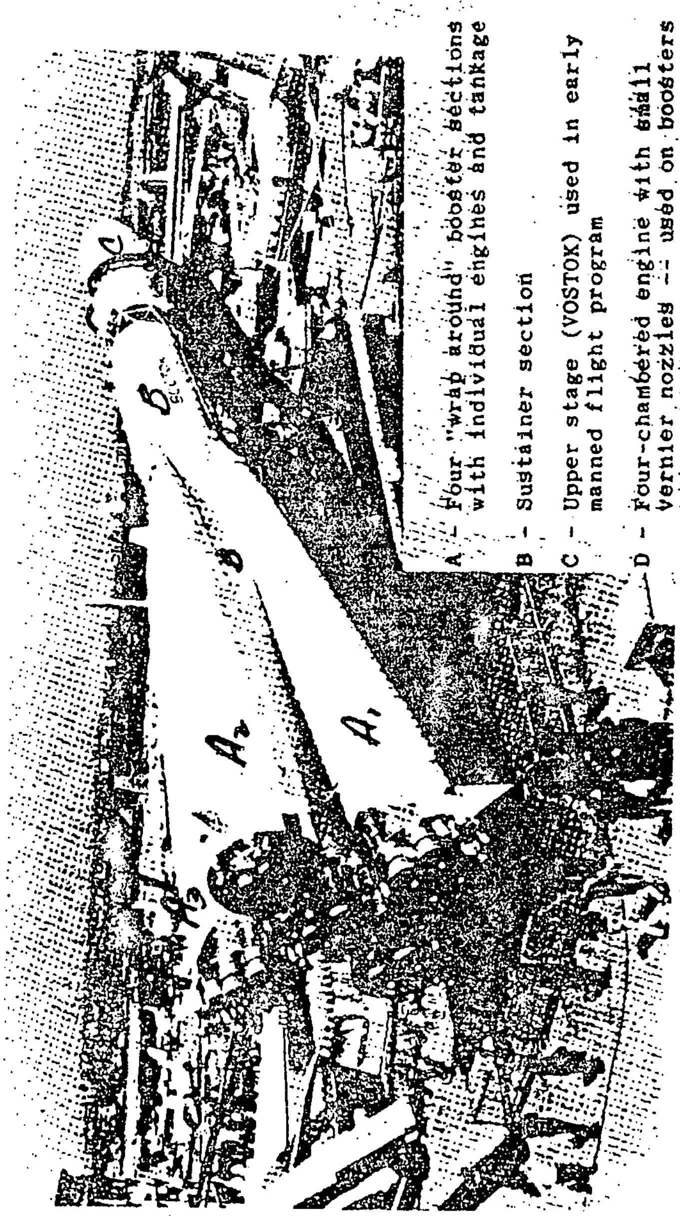
The SS-6



The SS-6 Rocket in Paris Air Show, May 1967

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differ significantly from those of the United States. Erroneous judgments reached by ignoring available intelligence because it gives answers seemingly inconsistent with "our way of doing things" have unfortunately been common in the scientific intelligence field.

Initial firings of the SS-6 occurred in late 1957. Although conceived as an ICBM, it was immediately adapted to serve as a space booster, and as such has been the workhorse of the Soviet space program for the past decade, being flown with a variety of upper stages on several different kinds of space missions. The frequency of its utilization afforded opportunities to collect a wealth of intelligence information about it during all phases of its flight. For example, telemetry was available on the ICBM version from a period well before lift-off until impact. It should have been possible to reconstruct the detailed anatomy of the launch vehicle with considerable accuracy. The intelligence assessment of the system, however, was disappointingly wide of the mark.

The Specific Analytical Illnesses

In particular, the specific propellant combination employed by the system was incorrectly determined because the volumetric ratio of the bi-liquid was derived from a telemetry interpretation which *assumed* the sustainer tanks were of the same diameter.

The most surprising feature of the SS-6, the use of multi-chambered engines, was not recognized. This was due to an adverse influence of US design practice on the thinking of intelligence analysts.

The specific impulse [1] of the first stage of the system, and the overall energy capability of the stage, were incorrectly derived; both because of the assumption that the area ratio of the first stage engines should be related to the area ratio of the sustainer engine in about the same manner as in engines of US design of the same type. Many intelligence officers within the community were correct in their assessment of the specific combination employed, but unfortunately their adversaries, guided by the "divine righteousness of domestic design concepts," overruled their superior technical judgments.

The weight and thrust of the system were incorrectly derived, first of all because of the error made in deriving the specific impulse of

[1] Specific impulse is a measurement of the energy potential of a given mix of propellant. Numerically, it is equal to the number of pounds of thrust developed per pound of propellant burned per second.

the first stage, and secondly, because structure factors, or structure weights, were assumed, based on comparable US state-of-the-art in vehicle fabrication and handling.

The detailed configuration of the four boosters was improperly interpreted, principally because of the erroneous assumption that liquid propellant tanks for large rocket vehicles would logically be formed from right circular cylinders. Additionally, the general configuration (parallel, or partial), was misinterpreted by many. This argument, incidentally, grew into one of the major intelligence controversies of the decade. Those who turned out to be wrong on this issue based their decisions upon "domestic logic" rather than objectively interpreting available intelligence information such as intercepted radio telemetry. The basic Soviet philosophy of building and handling large rocket vehicles was therefore misunderstood because of the foregoing errors.

On the other hand, there were some outstanding analytical achievements in the interpretation of the intelligence information collected from the SS-6. Although a number of errors were made in the overall assessment of the vehicle, the most important parameter, the payload weight capability, was, however, derived correctly. This was possible because the energy capability and major performance parameters of the second stage were interpreted correctly. There was some support for the view that the SS-6 employed a kerosene-base fuel, but the majority view that the oxidizer was liquid oxygen turned out to be correct. Although the number of combustion chambers was incorrectly derived, the presence of four engines in the first stage and one engine in the sustainer stage was correctly derived. The detailed plumbing of the propulsion system and the positioning of the propellant tanks were also correctly deduced.

The Diagnosis and Recommended Cure

An extensive investigation was undertaken into why incorrect results were achieved in our initial assessment of this rocket vehicle. It was first of all determined that the quality and quantity of the data which were collected on the system were indeed adequate to permit the analytical entities to accurately derive the performance, characteristics, and configuration of the vehicle. The mistakes were almost entirely the result of poor judgment.

First of all, the incorrect interpretation of the propellant combination employed in the second stage of the system gave our planners a false impression of the Soviet state-of-the-art in propulsion and propellants. The Soviet test engineers telemetered an instrumentation device from both tanks of the sustainer stage which gave a time history of the level of the propellant in each of the two tanks. Therefore, if the diameters of the tanks were the same, the relative rates at which the liquid surfaces were dropping in the tanks, as propellants were burned, would represent the volumetric ratio at which the propellants were being burned. The volumetric ratio of the propellants is thus a very important input in the determination of the specific propellant combination employed in a given missile. Considering the general characteristics of the SS-6 sustainer stage, and using US technology as a standard, the intelligence community assumed that the tanks were the same diameter. Unfortunately they were not. A mixture ratio of about 1:1 was derived from this assumption, and when considered with other pertinent inputs such as specific impulse, the specific combination was determined to be an amine-base fuel with liquid oxygen as the oxidizer.

It was immediately obvious upon seeing the vehicle in Paris that the lower tank of the sustainer had a significantly smaller diameter than the upper tank, as a consequence of the manner in which the first stage sections were faired into the sustainer section. Because of this, the volumetric ratio of the propellants was really about 1.60:1, in contrast to the 1:1 ratio which had been derived from telemetry. The propellant combination in the case of the 1.60:1 ratio would logically be kerosene for fuel and liquid oxygen as the oxidizer, consistent with the Soviet announcements at the time. Thus, an erroneous assumption overemphasizing the importance of comparable US practices, led the community astray. This was the first lesson learned from the reassessment, and an important one to consider in future efforts of this type.

Since we were absolutely confident of the scale factor of the accelerometer telemetered from the sustainer stage of the SS-6, determined through a study of on-pad telemetry, we were certain of the derived specific impulse of the second stage. Although a great deal of acceleration information was available on the operation of the first stage of the vehicle, from which a specific impulse value of that stage could have been independently derived, deficiencies in our analytical methodology limited this direct derivation. In the absence of a direct computation of the first stage specific impulse, the intelligence community again turned to US technology for an indirect derivation of this energy value. It was correctly assumed that the first and sustainer stages of the SS-6 employed the same propellant combinations. Thus, by "scaling down" the sustainer specific impulse value, according to US optimum design, the SS-6 first stage value was determined.

Again, we went astray. As is typical of the Soviets, they adapted a single rocket engine for use on both the first and sustainer stages of the vehicle. Consequently, the area ratios and the vacuum specific impulse values were nearly the same in both stages. Intercepted telemetry from engine parameters gave this indication of common engines in both stages. However, rather than believe this direct evidence, the community once again erroneously relied too heavily on US design precepts. Thus, lesson number two was that the Soviet approach to rocket engine design can be radically different from that of the US, and that a direct comparison of the type made above can be dangerously misleading. The community should have attempted to remedy the deficiency in its analytical capability, in order to solve for the specific impulse of the first stage directly.

The failure of the intelligence community to recognize that a multi-chambered engine was employed in the SS-6 was embarrassing. In this instance a lack of telemetry from the early firings of the system contributed significantly to the failure. Considering the other indicators available, however, the engine configuration should have been recognized. When the Soviets fly multi-chambered engines they generally employ special instrumentation to monitor the pressure trail-offs of the individual chambers. This special monitoring is easily recognizable, but is generally carried only on the earlier flight tests of a system. The community was denied this initial indicator because powered flight telemetry was not intercepted from these early firings of the SS-6.

A combination of the comparatively high specific impulse and thrust level of the SS-6 engine, considering the 1957 time frame when it was being initially flown, however, should have alerted analysts to the fact that something was amiss. In addition, the strategic system which preceded the SS-6 in research and development flight testing, the SS-4, as well as systems which immediately followed it, such as the SS-5 and SS-7, incorporated multi-chambered engines. Analysts within the community were reluctant to accept the multi-chambered engine configurations of both the SS-4 and SS-5, even in the light of evidence that such was the case. Although the tendency was not as clear as in the case of the SS-6, it seems rather certain that the analysts were reluctant to accept these indications because of the radical disagreement with US design philosophies.

The error made in the derivation of first stage specific impulse, combined with the failure to recognize that the same engine was used in both powered stages, resulted in a poor assessment of the structure weight of the first stage of the system. Although this was not of serious consequence to intelligence consumers, a more accurate assessment would have been of considerable help to analysts in their overall interpretation of the vehicle. The vehicle also turned out to be much more rigid than had been deduced by relating it to comparable US vehicles. Other incorrect findings in the analysis of the SS-6, including the thrusts and weights of the stages and the true configuration of the booster stage, were also principally prompted by undue stress on analogies in US rocket technology.

The combination of several incorrect results thus gave planners an erroneous concept of this highly significant Soviet system. In matters of space research, this may not be considered wholly intolerable. If the intelligence target in this instance had been an intercontinental missile delivery system, however, the consumers might not have been disposed to be so charitable.

The episode of the SS-6 thus illustrates the familiar tendency of the constituents of our analytical machine to get locked into inflexible departmental attitudes. It shows that these can be mistaken, and it shows the difficulty of making corrections. From the point of view of the individual analyst, the lesson is clear. He should by all means be very much aware of domestic technology associated with his assignment, but he should never feel safe in assuming that the Soviets are necessarily taking the same route as the US in their solution of related technological problems. Assumptions which must be made in the interpretation of the data should be based upon previous design philosophies of the target nation, or upon general indications available from the data base, and seldom, if ever, upon domestic philosophies. And finally it goes without saying that the analyst should also remain aware of his grave responsibility for being objective in his interpretation of the data, particularly in his dealings with counterparts in other analytical entities of the government.