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Soviet submarine detection

The ALFA Story

Gerhardt Thamm

"Better is the enemy of good enough" is an old Russian proverb that incorporates a philosophy both wise and true to the Russian heart. Those who have learned to appreciate the Russian character will agree that most Russians instinctively adhere to and follow that philosophy. To build, to create things good enough to do what they are meant to do is wise; to make them better than necessary is a waste of energy and precious resources. The proverb reportedly was inscribed on a plaque in the office of Deputy Minister of Defense and Admiral of the Fleet of the Soviet Union Sergei Gorshkov, who had guided the development of his navy since 1956.

Those of us who watched the building of the Soviet Navy from its humble beginnings as a coastal defense force after World War II to a powerful blue-water navy noticed long ago that the old proverb was true, even when it came to building submarines.

We knew that the Soviets did not follow our practice in building submarines; they did not incorporate edge-of-technology items in series-production models. And we saw Soviets building double-hull submarines long after we had discovered that the modern single-hull design had many advantages over the double hull, among them an improved speed/horsepower ratio. While the US Navy leaped decades ahead in submarine design, the Soviets plodded along by improving tried technologies. Our submarines not only looked better, they *were* better.

Yet the Soviets seemed satisfied with evolutionary advances in submarine design. Many US intelligence analysts were sure that the Soviets were never going to "put all their eggs into one basket." Soviet society punishes failure; designing high-risk submarines does not enhance one's career.

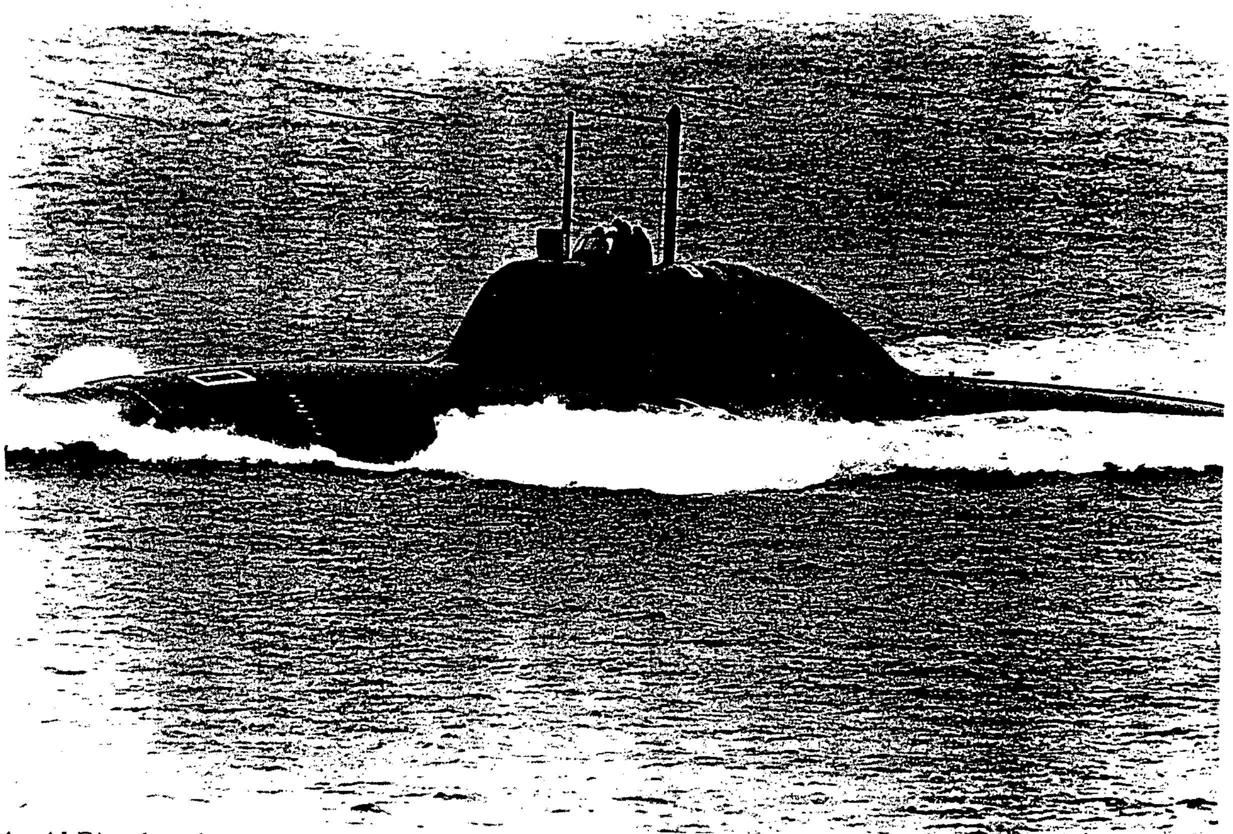
Phase One

This was the consensus of Western intelligence analysts, at least until one pleasant day in 1969 when strollers walking along the Neva River saw a modern-looking, small submarine tied up at the fitting-out quay at Leningrad's old Sudomekh Submarine Shipyard. It looked as if the submarine had just been launched from the old diesel submarine assembly shed. The assembly shed had seen little activity since the last Foxtrot-class diesel attack submarine had been launched there several years earlier. Naval analysts, following tradition and basing their analysis on previous launch histories, initially classified the submarine as a modern diesel-electric follow-on to a Foxtrot.

Further fitting-out activity, however, soon convinced at least one senior submarine analyst, Herb Lord, that this submarine was an SSN, a nuclear-powered attack submarine. It had a superbly streamlined hull and an overall length of about 79 meters.[1] Engineering calculations gave it a surfaced displacement of some 2,600 tons,[2] with a submerged displacement of about 3,700 tons.[3] Aside from the exceptionally streamlined hull form, this submarine had several other highly unusual features:

- In 1969, it was the world's smallest SSN.
- It had a rather high reserve buoyancy—a safety factor—of nearly 30 percent, in contrast to 8 to 11 percent for US SSNs.

The submarine received the NATO classification ALFA Class SSN. Lord, an experienced photointerpreter, alerted others to concentrate their efforts on the ALFA's construction and fitting-out pattern. The



An ALFA submarine.

analysts noticed something they had never seen before a "highly reflective" pressure hull section near the ALFA assembly area.

Lord then requested that he be point of contact for all reports that mentioned "highly reflective" or unusually colored submarine parts. During some eight years of examining photos of Soviet submarine construction yards, analysts assembled a construction history of a magnitude never before accomplished.

Periodically, and with ever increasing frequency, Lord received reports of "highly reflective" pressure hull sections associated with the ALFA fitting out at Sudomekh. Later, he also received reports of highly reflective pieces of hull sections, similar to those of the Sudomekh ALFA, at the Severodvinsk Submarine Construction Yard,[4] far to the north of Leningrad. He noted that these two yards were connected by an inland waterway, and he wondered whether both yards could be building this rather unusual class of attack submarine.

Lord subsequently conducted what is generally known as "look-back" analysis. All reports of "highly reflective" submarine hull sections at the two construction sites were collated, reviewed, and once again evaluated. It was a formidable, time-consuming task. There were reports of changes to the external appearance of the assembly halls; reports dealing with unusual submarine parts at storage sites near the halls; and reports on unusual railroad cars, tank cars, and increased production of titanium sponge. All were scrutinized. It took infinite patience to fit this miscellany into the ALFA submarine assessment. Although it was a most difficult challenge, it was a task in which most intelligence analysts excell.

After reviewing all the evidence and after long discussions with his fellow intelligence analysts, and with naval designers, engineers, and others in the Intelligence Community, Lord became even more convinced that the Soviets were indeed building a "special" type of super submarine, the first made of titanium alloy. Eventually, he concluded that he had to convince the US Navy that the Soviets were series-producing a highly modern, unusual SSN that, if fitted with advanced weapons, could seriously threaten US and allied naval operations.

Some analysts at CIA and the Defense Intelligence Agency (DIA) agreed. In fact, CIA had, as early as 1971, published analysis—*Use of Titanium by the Soviet Shipbuilding Industry*—that strongly supported the assessment that the otherwise conservative Soviets had conducted serious, long-time research on shaping and welding heavy titanium plates, and that they had in fact developed that capability.

Others were skeptical. They thought that the shaping and welding of heavy titanium hull sections, especially in the generally "dirty" shipyard atmosphere, was impractical, if not impossible. This, too, was a totally reasonable assessment, because titanium cannot be welded when exposed to air; welds have to be shielded, usually by argon gas. The consensus was that the Soviets could weld small parts of titanium, such as those for aircraft or missiles, in hermetically sealed chambers, but that it was impossible to weld huge submarine pressure hull sections.

Lord, however, could not be deterred. For nine years, he would be in the center of the battle over the "titanium submarine." During the early 1960s, little reliable, high-level scientific and technical information was available, and Lord had to rely heavily on photographic intelligence.

Lord remained certain that the collective evidence overwhelmingly supported his assessment of ALFA's titanium alloy pressure hull. He tried to convince the US Navy that the Soviets' research and development had advanced to such a degree that they were able to build submarines made of light-weight titanium alloy, and that their SSN would be able to dive deeper than any of our SSNs. In addition, a nonmagnetic titanium submarine would be most difficult to detect.

He tried to prove that the Soviets had digressed from their usual submarine building methods, and that they had combined several advanced technologies in a single class of submarine:

- A highly advanced, and possibly risky, pressure hull material (titanium alloy).
- An as-yet unknown, high-density nuclear power plant (high power concentration in a small hull).
- Possible automation to reduce the size of the crew.

It was an entirely unbelievable story.

The assessment was critical for US ship, submarine, and underwater sensor and weapon designers. After almost eight years of debate with Navy decisionmakers, Lord retired. He died a few years later, his enormous research effort never properly recognized by Naval Intelligence.

Phase Two

In a functional reorganization in Naval Intelligence the analysis of foreign submarines was divided into ballistic and cruise missile submarines, and attack diesel and nuclear attack submarines. The attack submarines were my responsibility, and in 1978 I became the ALFA Project Officer.

I agreed completely with Lord's analysis. Now it became my mission to convince the US Navy that the Soviets were building high-threat submarines using advanced construction technology. Also in 1978, CIA sponsored a meeting of [redacted] intelligence analysts, naval engineers, metallurgists, and submarine designers to discuss the "enigma" in Soviet submarine construction.

The great majority agreed that the "highly reflective" parts were submarine components. Most were certain that the components were not of conventional submarine steel. One[redacted]xpert presented several dozen formulae collected from published matter freely available to any serious researcher. He believed these open sources proved conclusively that titanium alloys dissolve in sea water. There were a few who suggested the whole "Sudomekh show" could have been a large-scale "disinformation" program, and that the highly reflective components were just parts covered with aluminum paint.

Many leading [redacted] metallurgists still believed it probably was impossible for the Soviets to have developed the capability to bend, shape, and weld thick titanium plates in a shipyard environment. The US submarine community, "the Rickover people," was happy with this assessment. It could not accept any possibility that the Soviets could series-produce such a sophisticated submarine.

These expert opinions made the ALFA submarine assessment inconclusive. On the one hand, I had the expert naysayers; on the other, I had some admirals asking, "What the hell are the Russians doing?"

Lord had rejected aluminum, stainless steel, and glass fibers. There remained the HY80, HY100, or possibly HY130 steels, and titanium. Except for stainless steel, steel turns a dark, almost black, color when exposed to the elements for extended periods. I still agree with Lord's analysis that a titanium alloy was the most logical material suitable for submarine pressure hulls.

As analysis continued, I perceived five essential problem areas, which I called "enigmas." These made my life difficult because they challenged traditional beliefs about the very nature of Soviet submarine construction.

- ***First Enigma:*** An apparent change in Soviet design and construction methodology.

  Advantage: Long-range gain.

  Disadvantage: Large investment of resources.

  Remarks: If successful, Soviet submarine designers and builders were making a quantum leap into modern technology.

- ***Second Enigma:*** Use of titanium alloy in pressure hull construction.

  Advantage: Titanium is stronger and weighs 33 percent less than steel; the pressure hull can be stronger without increasing displacement; its use gives a submarine a stronger hull for greater diving depth and increases resistance to explosives at lesser depths; and the submarine is essentially non-magnetic, thus decreasing the likelihood of magnetic anomaly detection (MAD).

  Disadvantage: Titanium is three to five times more expensive than steel; it needs a totally different manufacturing process; shipyard workers must be retrained; construction halls must be reconfigured; and bending and shaping of heavy plates of titanium alloy are far more difficult compared to steel.

  Remarks: Much evidence had been gathered that the Soviet Navy had ample research and development funds and that Soviet metallurgists had made remarkable advances in titanium manufacturing technology. Reports indicated that the Soviet Navy had conducted research in HY100 steel, aluminum, glass fiber, and titanium alloys for use in ship and submarine construction.

- ***Third Enigma:*** Apparent use of liquid metal reactor coolants.

  Advantage: Better horsepower to weight/volume ratio for higher speed.

  Disadvantage: The US Navy believed that a reactor cooled by liquid metal is less safe than the pressurized water reactor (PWR) in use by the US Navy.

  Remarks: The US Navy's safety record supported the PWR approach.

- ***Fourth Enigma:*** Seemingly large-scale use of automation and reduction of crew size.

  Advantage: Reduced the size of the boat and the size of its crew; lessened demand for electric power requirements; and relieved crew from mundane tasks, thus eliminating human errors caused by fatigue and boredom.

  Disadvantage: The US Navy believed automated controls to be less safe than hands-on control functions.

Remarks: Only by automating many control functions could the Soviets reduce the size of the submarine. This increased the ALFA's survivability in combat, because it became a smaller active sonar target. Furthermore, the low magnetic signature from a nonmagnetic titanium hull made localization of target by MAD difficult. Having unmanned engineering spaces also reduced personnel casualties should the liquid metal reactor malfunction.

- *Fifth Enigma:* Large rescue sphere in ALFA sail indicative of strong concern for crew survivability.

  Advantage: Provides safe exit for entire crew from maximum depth without external assistance. When the sphere is on the surface, it becomes a lifeboat; it protects the crew from the elements; and it has sufficient communications, emergency rations, and first aid on board.

  Disadvantage: Increases weight of the submarine.

  Remarks: The ALFA's high reserve buoyance, as well as a sophisticated rescue system, implied Soviet Navy concern for crew survivability. There were other indicators: the Soviet Navy had one India-class submarine rescue submarine each in Northern and Pacific fleet areas, had several "hard" compartments in submarines, and now had fitted a sophisticated survival system in the ALFA. This was another item that did not square with our view that the Soviets had little concern for human life.

Turning to HUMINT

Since Lord's ALFA SSN approach had failed, I believed that different collection assets had to be activated to convince the US Navy of a serious threat to our submarines. Under the guidance of an able Navy captain, I used my extensive experience as a HUMINT collector to tap these new assets.

With continuing support from CIA analysts, as well as the Agency's collection managers and collectors, several thousand reports were screened for information about titanium. To keep that collection current, photointerpreters spent considerable time briefing their assets in the technique of precision photography. For three years, I followed the unfolding of this dramatic change in Soviet submarine construction.

A fair number of HUMINT reports dating from the time ALFA was under construction alluded to a new submarine with a small crew. Some reports cited a crew of 15, and others indicated a crew of 18 to 45. Admiral Rickover's team believed that it was impossible to operate a nuclear submarine with such a small crew, and that it was irresponsible to automate the many vital control functions of a submarine. As a result, this information was temporarily shelved.

But the subjects of small crew and automation would not die, partly because some Western navies had already automated their submarines with considerable success. With strong support from the CIA, I collected and assembled information that supported Lord's original assessment of ALFA's small crew.

Periodically, CIA reported that the Soviets maintained a high interest in automating submarine maneuvering, propulsion power train, weapons loading, and fire control functions. The goal: small crew, small boat. Eventually, the evidence that ALFA was extensively automated convinced even the most skeptical.

A Key Report

Evidence continued to confirm Soviet concern with crew survivability. By pure luck, in 1981 someone walking along the Neva River saw a sphere being lowered into the area where an ALFA was being fitted out. Based on the description, analysts determined that the sphere was lowered into the ALFA sail. The source was able to estimate the diameter of the sphere. With that information, and based on my familiarity with West German submarines, I concluded that the Soviets had copied a submarine crew rescue sphere designed by Dr. Ulrich Gabler, the distinguished West German submarine designer.

By extrapolation, our submarine structures engineer calculated that 37 to 39 husky Russians would just fit into the rescue sphere. Careful examination of the sail revealed a continuous breakaway seam in the rubber antisonar coating of the ALFA sail. The assessment: the sphere, using part of the sail as a stabilizer and buoyancy tank, could be released to rise to the surface as a lifeboat. This report contributed significantly to solving the enigmas of crew size, automation, and crew survivability.

Accumulating Evidence

CIA also provided me with increasing evidence that appeared to confirm that:

- The Soviets had diverged from their pragmatic submarine construction modus operandi by combining at least three edge-of-technology items into a production-model submarine.

- Large, heavy, titanium alloy plates were shaped and welded at the Sudomekh and Severodvinsk shipyards. Almost all reports alluded to the many difficulties encountered when welding titanium.

- Liquid metal coolant was used to increase the horsepower over weight/volume ratio and thus to increase speed.

In addition, CIA reported that the first ALFA had suffered a catastrophic failure during sea trials in the Barents Sea, when the liquid metal coolant spilled from the reactor containment vessel into the bilge. Indeed, as later reported in *Jane's Defence Weekly*, the "first ALFA suffered a reaction meltdown in 1970."[6] The submarine was towed to an isolated corner in Severodvinsk shipyard. Eventually, the bow and amidships sections appeared once again at Sudomekh. The pieces were left in open view on the quay for many years. Nevertheless, ALFA prototype's trial run, even with its disastrous aftermath, must have produced some encouraging results, because series construction continued.

Renewed Production

In mid-1974, one ALFA was launched from Sudomekh, and in early 1976 one was launched from Severodvinsk. The class was back in series production, and intelligence collection again went into high gear. After more than a year of collection, the results were assembled and examined. The reports confirmed the previous assessments that the Soviets had encountered seemingly insurmountable problems when welding titanium. The first boat of the class had been on the ways for about seven or eight years, instead of the normal one to two years. Fitting-out periods were also much longer than those of other SSNs.

The old and new supporting evidence was presented to another panel of experts convened by CIA to assess whether the Soviets could weld heavy plates of titanium alloy in a shipyard atmosphere. Again, most of the experts opined that the Soviets most likely could not series-produce titanium pressure hulls for SSNs. But this time, Naval Intelligence, with support from CIA analysts, disagreed with the experts. The mutually supportive evidence from all assets had convinced the Technical Director of the Naval Intelligence Support Center that the Soviets had made a quantum leap in submarine technology by combining several high-risk options in one class of submarine.

Consequently, it was critical for US Navy decision-makers to learn that:

- The Soviets were building submarines with hulls made of lightweight, nonmagnetic titanium.

- The most streamlined hull shape ever produced by the Soviets was designed for speeds over 40 knots.[7]

- These high-technology submarines could dive below the effective range of US antisubmarine weapons.

- These units, probably fitted with advanced weapons, posed a serious threat to US and allied naval forces.

The Director of Naval Intelligence, confident that his analysts had made the correct assessment in the face of aggressive opposition, invited me to present the assessment to the Vice Chief of Naval Operations. The evidence convinced him, and he decided that the information had to be disseminated to the Navy as soon as possible. Naval Intelligence published the ALFA assessment in record time.

Postscript

In March 1979, technical assets detected the second ALFA making trial runs in the Barents Sea. An analysis of the data indicated that the ALFA had exceeded 40 knots while submerged in moderately deep water. In 1978,* after two decades of effort, the ALFA class had reached Initial Operational Capability, and was in series production. (In 1985, the Soviets had at least six operational ALFAs.)

On 19 January 1979, the commander of the US Naval Sea Systems Command wrote Naval Intelligence that CIA's extraordinary collection and Naval Intelligence's timely analysis of the ALFA Class SSN threat had saved the Navy $325 million in new torpedo designs. It was the first time in history that this type of intelligence collection and analysis had ever been officially credited with saving such a large sum of money.

Tenacity Pays Off

The R&D and manufacturing efforts for the ALFA SSN are difficult to estimate. Two construction sites were tied up for excessively long times with this project. The first sea trials far exceeded Moscow's expectations. Then, even with a catastrophic failure in the engineering spaces, the Soviets continued the ALFA project with tenacity unmatched by Western navies.

There is little doubt that the Soviets have incorporated these technological gains in follow-on nuclear-powered submarines. After all, the Soviet R&D community, submarine designers, and builders had, at almost prohibitive cost, accomplished what their Western counterparts thought impossible: the production of a titanium submarine that surpassed all others in speed and diving depth.

There was at least one commonalty between the Soviet ALFA construction program and the US Navy's intelligence effort against the submarine: in tenacity the Soviet Navy had been matched by that of one senior US Naval Intelligence analyst. We had learned once again that nothing can be taken for granted. Most important, we learned that the Soviet Navy did not always follow old Russian proverbs. We also learned that US intelligence was "right on the money," and that the Soviets had indeed built a submarine that was "better than good enough."

NOTES

1. *Soviet Military Power*, Office of the Secretary of Defense, 1985.

2. *Understanding Soviet Naval Developments*, NAVSO P-3560 (Rev. 1/81) p. 86.

3. *Soviet Military Power*, 1990

4. Norman Polmar, *Naval Institute Proceedings*, October 1991, p. 122.

5. *Jane's Defence Weekly*, 18 April 1987, p. 715.

6. *Ibid*.

7. *Soviet Military Power*, 1983.

8. *Soviet Military Power*, 1985.