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An Intelligence Assessment

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The Soviet Typhoon Submarine—A Radical Innovation in Submarine Design

Key Judgments

Information available as of 1 September 1985 was used in this report.

The Soviet Typhoon-class, nuclear-powered, ballistic missile submarines (SSBNs) are the world's largest submarines. They are the first class of submarines to be built using a radically different design concept, that of the very large submarine (VLSS). In contrast, the US Ohio-class SSBNs, though large, are designed with a more traditional arrangement. The VLSS is as major a design innovation as the VLCC, the super tanker, was in surface ships. Both exceeded established size barriers, using innovative approaches in design.

Typhoon has design characteristics difficult to attain in combination in a more conventionally designed submarine. Among these are:

- Extremely large volumes inside its outer envelope and very large, pressure-tight internal volume. It has reasonable and variable surfaced operating drafts.

[redacted]

- Capability of carrying both offensive (missile) and defensive (torpedo) armament totally within the submarine's outer hull envelope but external to its main pressure hulls. This allows the design to be developed for other purposes without disrupting the pressure hulls and with little or no change to the submarine's hydrodynamic characteristics.

By using the VLSS concept in Typhoon, the Soviets have produced a design with unusual potential for future development. Soviet open-source literature describes a number of unusual military applications for very large submarines. Included are oiler/supply ships and troop transports. The Soviets see such ships as particularly useful in the far north where port facilities are minimal and are iced in much of the year. We believe that the Typhoon design could also be developed into a naval staff command ship or a mother ship for minisubmarines.

The basic Typhoon design could be used with other types of missiles than those now carried. [redacted]

[redacted]

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Introduction

The Typhoon class, nuclear-powered, ballistic missile submarine (SSBN) was first seen [redacted] in September 1980 (figure 1). Since then the Soviets have launched three additional units, the latest in April 1985. Typhoon is the world's largest submarine. Its surfaced displacement is approximately 20,000 tons, about one and a quarter times that of the US Ohio-class SSBN. Surfaced displacement is an indicator of the pressure-tight internal volume of a submarine and is used most often as a representation of submarine size. However, another characteristic, full submerged displacement, which is the weight of seawater equivalent of the envelope volume (the total volume within the submarine's outer skin), better illustrates Typhoon's overall size. Typhoon has a full submerged displacement of about 48,000 tons, two and one-half times that of an Ohio-class submarine and about the same as the displacement of an Iowa-class battleship. Although Typhoon and Ohio are similar in length, Typhoon has greater beam and hull depth, which results in its larger envelope volume (figure 2

Figure 1. Typhoon-class SSBN

[redacted]

Typhoon is more than just big; it is very different in concept. Typhoon is an unusually arranged submarine (figure 3). It has two main pressure hulls in a "catamaran" configuration. Analysis of external features indicates that it also has a small pressure hull above the main hulls for submarine control functions and a small pressure hull at the bow for defensive (torpedo) armament. Its main missile armament is carried within the outer hull between the main pressure hulls, forward of amidships.

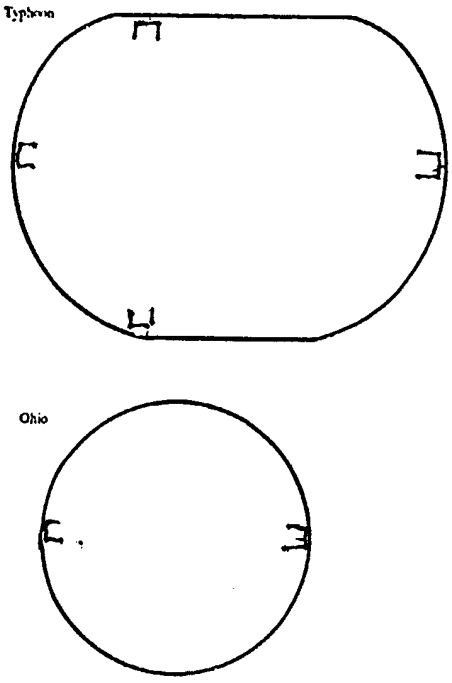
[redacted]

The Very Large Submarine Concept

In their 1960 treatise on submarine design,[1] Capt. Edward S. Arentzen, USN, and Phillip Mandel of M.I.T. stated, "There does seem to be a very real (surfaced) draft limitation for military submarines

[1] E. S. Arentzen and P. Mandel, *Naval Architectural Aspects of Submarine Design*, Society of Naval Architects and Marine Engineers, New York, New York, 1960

Figure 2
Comparison of Outer Hull Cross Sections of the Typhoon-Class and Ohio-Class SSBNs



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and this in effect sets an upper limit on the maximum beam. . . ." This beam limitation, about 13 meters, was based on the necessity for a military submarine to operate from bases having more or less normal channel depths and on the assumption that the submarine would have one hull of circular cross section, the most efficient way to "package" the volume for military purposes.

Almost as soon as marine nuclear power became practical, there were design proposals for nonmilitary submarines with deadweight (cargo) capacities too large to be built with single circular pressure hulls and still have surfaced drafts compatible with normal channel depths. In 1958 the Maritime Administration contracted with General Dynamics Company to study submarine tankers. General Dynamics developed several designs with deadweights ranging from 20,000 to 40,000 tons. In Japan, Mitsubishi, Ltd. developed a design for a 30,000-ton tanker; and, in England, Mitchell Engineering/Saunders-Roe advanced the possibility of a submarine tanker of 80,000 to 100,000 deadweight tons. None of these designs were ever built because of economic and nuclear safety considerations. Nevertheless, the design philosophy of these very large submarines, with unusual hull arrangements, became well known and was recognized early by the Soviets.

In 1964 Sudostroyeniy (Shipbuilding) Publishing House in Leningrad published a book on nuclear-powered submarine design.[2] The authors discussed the very large submarine in detail. They commented on both potential military and nonmilitary uses including ballistic missile carriers, aircraft carriers, transports, and oiler/supply ships, as well as merchant tankers and dry cargo ships. They commented on the economic infeasibility of the VLSS for merchant use, but they stated that "in wartime only submarine cargo carriers, possessing so important an advantage as secrecy, will be able to effectively supply . . . bases, operating forces, and individual combat ships with fuel, combat supplies, provisions, etc." They also commented on the usefulness of the VLSS in the Arctic: "to maintain year 'round navigation in ports, access to which is limited in wintertime for surface ships and, on the other hand, to reduce runs by using under-ice routes and, in particular, routes passing through the Northern belt." As is often the case, the emphasis of these unclassified Soviet writings can give clues to what the Soviets consider important. In retrospect, we can see in them the genesis of Typhoon.

[2] V. M. Bukalov and A. A. Narusbayev, *Atomic Submarine Design* (from foreign press materials). Sudostroyeniy Publishing House, Leningrad, USSR, 1964.

Advantages of the VLSS Concept in Typhoon's Design

Large Internal Volume at Reasonable Surfaced Draft

The most obvious advantage of the VLSS design is that the large usable internal volume coupled with reasonable surfaced drafts will allow free passage in channels and harbors. The maximum draft of Typhoon [redacted] about the deepest practical draft for any warship intended to operate from most ports [redacted]

Surfaced Draft Flexibility

Although the submarine normally operates surfaced at sea at or near its maximum draft [redacted] it can be brought to lesser drafts. Though we have no direct evidence, the ability to vary drafts suggests that a secondary ballast system is fitted. This ability to vary the surfaced draft can be of advantage in a critical situation when entering or leaving a base having marginal channel depths. It can increase markedly the usefulness of the submarine, opening ports to it which otherwise would be inaccessible

High Freeboard

Typhoon has a hull depth of [redacted] At its maximum draft, its freeboard [redacted]. This high freeboard means relatively dry decks when surfaced in rough seas, minimum icing in Arctic operations, and a good "height of eye" for its conning officer. The latter is of particular advantage when operating in areas of broken ice

Good Surfaced Stability and Resistance to Ice-Loading Effects

By spreading Typhoon's buoyancy transversely with parallel pressure hulls the Soviet designers have attained a high value of surfaced-stability. The analogy of a floating log illustrates this point. One floating log has little stability in roll; however, two logs, fastened together to form a raft, have much greater stability. So it is with Typhoon [redacted]

Disadvantages

High Hydrodynamic Resistance
The major resistance component of a submerged submarine is frictional drag. This varies approximately with the submarine's surface area. Typhoon's immense outer envelope implies high drag and, thus, high propulsion power requirements. There is an economy of scale, however, which favors a larger submarine. As hull volume becomes larger, surface area increases at a lesser rate.

Increased Mass
The submarine's large mass is a disadvantage for which there seems to be no compensating hydrodynamic advantage. A submarine traveling submerged at neutral buoyancy has a mass equivalent to the mass of seawater of its outer envelope. When the submarine changes speed, the entire mass must be accelerated. The "battleship size" mass of Typhoon implies that it is a very sluggish submarine. This is especially important when accelerating the submarin from rest, because marine propellers are inefficient at low speeds

Ship handling problems resulting from unusual size are not new. When the very large crude carrier (VLCC) came into being, experienced merchant masters assigned to them had great difficulty in ship handling. Special training facilities were established using miniature ship models capable of carrying one man. These models were "scale powered," using very low powered propulsion systems. The models were ballasted and their control systems were arranged to simulate as closely as possible the sluggish behavior of the VLCCs. Training with these models increased master confidence and provided hands-on experience in miniature before the masters faced the real world of VLCC operation.

Estimated Design Characteristics

With Typhoon, the Soviets chose to enter the design regimen of the VLSS to gain characteristics difficult, if not impossible, to attain together in a more conventionally arranged submarine:

- An extremely large envelope volume and a large pressure-tight volume coupled with surfaced drafts compatible with operation from a number of ports and bases.
- Long endurance, requiring a large pressure-tight volume for stores and crew habitability.
- Space for both offensive (missile) armament and defensive (torpedo) armament totally within the submarine's outer envelope but outside the main pressure hulls. Armament can be altered or the space utilized for other purposes with no major disruption of the main pressure hull boundaries.

Typhoon Design Development Alternatives

On the basis of known and estimated parameters, we believe that, unlike the designs of older SSBNs, the Typhoon design can be modified easily in the future for purposes other than its initial SSBN service. The VLSS design concept used in Typhoon is economically suited only to military use, so future development of the design probably will be exclusively as a military submarine

Carriage of Minisubmarines. In about 1960 the Soviets were studying the concept of submarines carrying several minisubmarines under a project they called Little Mother. Typhoon, with its immense size and large free flood volume, has the characteristics necessary for a mother submarine. Advances in minisubmarine technology and in submarine quieting now make the concept more plausible. Capable minisubmarines deployed from a submerged submarine can be useful in a clandestine survey of potentially hostile coastal waters, in the recovery of sunken military equipment, and for evaluation of or interference with emplaced surveillance systems. Mother submarines also could be useful in the defense of secure sea areas such as bastions for ballistic missile submarines. Quieter attack submarines are harder to detect so sonar acquisition ranges are shorter. A screen of sonar-equipped minisubmarines deployed from a mother submarine could expand its sonar coverage.

The mother submarine, having data-processing capability, could receive sonar information from the mini-submarines and then vector defensive forces to counter an attacker.

Close Combat.

It is too cumbersome and too large a target for efficient use in a close-in, submarine-to-submarine combat role. Since 1983 the Soviets have launched the initial units of three new classes—Mike, Sierra, and Akula—of nuclear-powered attack submarines. These submarines are much smaller than Typhoon and are faster. They are better suited to the attack role than the Typhoon design.

Military Support Roles

Oiler/Supply Ship. Part of the present apparent free flood space inside Typhoon's outer envelope could be made into non-pressure-tight, cargo oil tanks. In a tanker role the submarine could carry a deadweight of at least 10,000 tons of fuel oil. This role, in effect, would be a further development of the "milch cow" submarine concept the Germans used advantageously during the battle of the Atlantic in World War II. According to Bukalov, the large volume already existing within Typhoon's pressure hulls could provide space for food, ammunition, and other "dry stores" needed to supply " . . . bases, operating forces, and individual combat ships. . . . " This could be especially important in a protracted war in the far north where weather and ice make the supply problem very difficult. The usefulness of Typhoon for this purpose becomes even more apparent by contrasting it with polar icebreakers available for Arctic resupply missions. The Soviet Yermak class has a deadweight (cargo) capacity of only 7,560 tons while the Kapitan Sorokin class has only a 4,225-ton capacity.

Staff and/or Troop Accommodation. Typhoon's large pressure-tight volume could be adapted to house and support a sizable "noncrew" contingent. Its size makes it a good candidate for submarine command and control missions, although the problem of reliable, sustained communications while submerged would be a deciding factor in assessing its feasibility. It also probably could be adapted to carry a "company-sized" contingent of assault or special service troops for missions in the far north in areas inaccessible by surface ships in winter and remote enough for only periodic access by air.

Projections

The Soviets have a very large resource investment in Typhoon. Development costs, using a different design concept, and setup costs for its production are much more than those of a more conventional submarine. This substantial investment and, above all, the design characteristics of Typhoon, lead us to believe that the Soviets probably will develop the design for other purposes—either for building new submarines or converting existing Typhoon SSBNs in the future.

third greater than the deadweight capacity of a Soviet Yermak-class Polar icebreaker, about 1,500 cubic meters of internal pressure-tight space would be needed as compensating tankage. This is equivalent to about 7.5 percent of the submarine's total "hard" volume. We do not know whether the existing Typhoons already have this large amount of compensating tankage. Apparently, they have room for it and still more than enough room for their SSBN role. The difficulty in converting existing Typhoon SSBNs would depend on what internal features the Soviets have chosen to build into them. Other military support uses would require less extensive rework of the design but would not use the submarines' characteristics to as good advantage.

Development of the Typhoon design as a mother ship for minisubmarines is a real, although less likely, possibility. Although the submarine's size and arrangement are suited to that use, the minisubmarine handling arrangements and access between the mother submarine and the "daughters" probably would require major pressure hull work; ballasting and trim problems also would be present. If the Soviets do pursue this design option, it is more likely that they will build a new Typhoon design variant than convert existing Typhoon SSBNs.

Design development as an oiler/supply ship for use in the far north would require extensive differences within the submarine's envelope outside its pressure hulls. "Soft" tanks would have to be provided. "Hard" pressure tight tanks would be required within the pressure hulls to compensate for the oil carried, which is about 15 percent less dense than seawater. Assuming an oil deadweight of 10,000 tons, about a