# Development Plan of Unmanned System and Development Status of UUV Technology in Foreign Countries

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***Abstract*—The future battlefield will be unmanned combat as the leading role, and the unmanned underwater vehicle (UUV) will play an important role in the future underwater battlefield. In order to maintain its maritime strategic advantages, the U. S. military has formulated a long-term development plan for the unmanned aerial vehicle (UAS) in recent years. The technology of unmanned underwater vehicles (UUV), which is characterized by strong endurance, high mobility, and high covert attack, has become the future development trend. In addition, Russia, with its strong industrial foundation and technical strength, has introduced its latest development status. At last, the latest research results of the new concept of surface/underwater cross-medium submarine were introduced. The results show that the new intelligent cross-medium submarine will become the mainstream of future development. The research provides a reference for the development of unmanned equipment in China.**

***Keywords—Unmanned System; Unmanned Underwater Vehicle; Research Progress; Latest Progress of Russian Research***

## I. Introduction

At the Defense Exhibition in London in 2019, a British speedboat manufacturing company launched a special combat submarine called “VICTA.” The submarine is about 11m long, made of carbon fiber, and weighs only 9t. It has the functions of a speedboat and submarine. It can not only sneak but also navigate at high speed on the water surface. The appearance of VICTA has a profound impact on the traditional amphibious operation mode and provides a new idea for the future underwater combat mode.

With regard to the research of unmanned underwater vehicles (UUV), scholars at home and abroad have carried out a lot of work [1-10]. Sands et al. [2] have studied the artificial intelligence decision-making technology of unmanned underwater vehicles. Hao et al. [3] studied the autonomous route planning method of unmanned underwater vehicles (UUV) in the presence of obstacles. Yao et al. [4] studied the UUV autonomous decision-making method based on dynamic response. Xue et al. [7] studied the dynamic position control of underwater vehicles based on energy consumption optimization. The appearance of "VICTA" technology is just a combination of surface and underwater vehicle technology. The new concept of vehicle technology has a profound impact on the future, which has attracted enough attention from developed countries led by the United States.

On April 14, 2020, the Atlantic Council, a US think tank, released a report entitled “emerging technologies and future US-Japan Defense Cooperation” (as shown in Fig. 1 (a)). It pointed out that under the background of China’s rising and China and the United States entering the confrontation between major powers, the United States and Japan should strengthen cooperation in such emerging technologies as unmanned systems, hypersonic weapons, artificial intelligence, so as to better confront China in the Asia Pacific region.

The US military believes that with the continuous rise of China and the entry of the era of great power competition between China and the United States, the geopolitical and security situation in the Indian Pacific region is constantly changing. The technological innovation related to the fourth industrial revolution accelerated development, interwoven with geopolitical changes, and jointly shaped the future military technology competition and new military operation mode. The rapid development of artificial intelligence, unmanned systems, hypersonic weapons, new materials, intelligent sensors, and neural and biological technology will bring great changes to the future military combat capability. Although there is limited understanding of the impact of emerging technologies and their military capabilities on the operational environment, there is no doubt that the development of these technologies is bringing new operational challenges and shaping a new strategic competitive situation. The United States and Japan face common security threats in the Indo-Pacific region, including China, which is constantly promoting military modernization, North Korea, which is developing nuclear weapons and missiles, and Russia, which is strengthening its influence in the Asia Pacific region. In order to ensure that the development of emerging technologies is conducive to the security situation of India and the Pacific region, the United States and Japan need to accelerate and strengthen defense technology cooperation. Specifically speaking, the five major fields, including UAV "bee colony" technology, unmanned underwater vehicle, anti-submarine combat capability, and anti UAV technology, are not only in line with the strategy of the United States but also in line with the regional interests of Japan. At the same time, it is also in line with industrial capabilities. These are the key points for the United States and Japan to strengthen technical cooperation.

As early as March 2018, the head of the U.S. Navy, James jewurtz, issued the "strategic roadmap for the Navy's unmanned systems," which provides a reference for the development of unmanned systems by the U.S. Navy and the Marine Corps. On August 30 of the same year, the U.S. Department of Defense released the "2017-2042 unmanned system integrated roadmap" (as shown in Fig. 1 (b)), which is the eighth version of the UAV / unmanned system integrated roadmap released by the United States since 2001, which guides the comprehensive development of military UAVs, unmanned underwater vehicles, unmanned surface vehicles, unmanned ground vehicles, etc. In order to meet the requirements of future joint operations, unmanned systems (UAVs) should focus on all operational domains rather than specific operational domains. Relevant technologies should support cross-domain command and control, cross-domain communication, and integration with joint forces. Interoperability, autonomy, network security, and human-computer cooperation are the four driving forces to accelerate the operational application of the unmanned system.

It can be seen that unmanned system [11-17] plays an important role in future land, sea, and air operations, and the Underwater Unmanned system has become one of the future strategic development directions of the US Navy. In order to deal with the future "asymmetric" underwater threats and ensure that the US military secretly infiltrates into the enemy's waters at the early stage of the war and that manned platforms cannot enter the exclusion area to carry out independent operations continuously, unmanned underwater vehicles are undoubtedly very suitable naval equipment to undertake such tasks [18]. In view of this, this paper summarizes the latest development of foreign Underwater Unmanned Underwater Vehicle Technology. In the current situation of rapid development of foreign naval unmanned equipment, China should combine its own national conditions, learn from foreign development experience and development ideas, and walk out the development path suitable for our country

## II. OVERVIEW OF THE DEVELOPMENT OF UUV TECHNOLOGY

The future war is an intelligent war. With the continuous development and wide application of intelligent level of information technology, unmanned intelligent equipment has become the protagonist of future war. An unmanned underwater vehicle (UUV) [19-26] is a kind of intelligent underwater device, which plays an extremely important role in Underwater Unmanned Combat, such as underwater search, surveillance, reconnaissance, mine hunting, communication, navigation, and anti-submarine warfare, etc. in recent years, it has attracted great attention of military powers in the world.

For a long time, the United States has been taking unmanned systems as one of the important technical means to maintain military superiority and as one of the important measures to promote the transformation of existing forces to distributed force structure. In recent years, the U.S. Navy has vigorously developed surface and unmanned underwater systems. Large unmanned surface vehicle (LUSV), medium unmanned surface vehicle (MUSV), and ultra-large unmanned underwater vehicle (XLUUV) are key models under development, which will bring significant capability improvement and operational flexibility to the US Navy in the future.

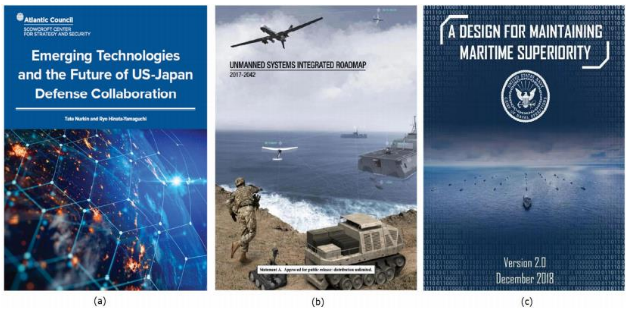


Fig. 1. A series of development plans issued by the US military (a): Emerging technologies and future US-Japan Defense Cooperation (b): An integrated roadmap for unmanned systems in 2017-2042 (c): Plan for maintaining maritime superiority

### US military unmanned system strategic development plan

In recent years, the U.S. military has attached great importance to the research of underwater warfare technology and has taken the technology of Underwater Unmanned Underwater Vehicle (UUV) as one of the key technologies of future underwater warfare. In the future, the U.S. military will focus on the development of unmanned underwater vehicles with covert strike capability, which can not only perform mine suppression tasks but also carry non-lethal weapons to carry out other operational tasks, and has good detection and avoidance capabilities.

As early as January 5, 2016, U.S. Navy Secretary of operations John Richardson released a new navy guide, the plan to maintain maritime superiority, which explained the strategic environment faced by the US Navy, pointed out that the US competitors had changed, China and Russia, as global powers, had enhanced their respective military capabilities and adopted coercion and competition measures, although these means did not break through the tradition The threshold of high-end conflict, however, still takes advantage of the weakness of existing norms in the fields of space, network and the electromagnetic spectrum. In December 2018, the US Department of naval operations issued the Navy's long-term guidance: plan for maintaining maritime superiority (version 2.0) (as shown in Fig. 1 (c)), which includes: (1) strengthening the underwater force in the national strategic deterrent force; (2) strengthening the underwater force in the national strategic deterrent force By 2019, the second fleet will be rebuilt and the overall combat capability will be realized; (3) the Navy's combat culture will continue to be revitalized and strengthened through the implementation of the "comprehensive review and Strategic Readiness Review" plan; (4) data driven decision-making will be taken as the basis for operational enterprise level system to achieve combat readiness; (5) the concept of "dynamic force deployment" will be improved through implementation and iteration; and (6) the "distributed sea" will continue to mature The concept of operation (DMO) and its main supporting concepts; (7) deploying logistics capabilities on the sea and on shore, so that the fleet can be deployed globally and continuously; (8) through the "Navy 2025" plan, continue to improve and modernize the management and training system of military personnel, and strengthen the construction of the future navy army.

In 2018, the U.S. Department of Defense released the latest unmanned systems integrated roadmap (2017-2042). The report shows that the office of the Secretary of Defense (OSD) has incorporated unmanned systems into its organizational structure, showing the overall importance of unmanned systems in the future.

Advances in unmanned systems technology highlight the need to shift focus from specific areas to unknowns. Future operations will rely heavily on multi-domain capabilities that must be seamlessly connected and integrated into the joint force structure. Underwater Unmanned System (UUS) is an important part of unmanned system construction in the U.S. Army and is one of the key development directions of the U.S. Navy in the future. As important support of Underwater Unmanned systems, Underwater Unmanned Underwater Vehicle (UUV) plays a very important role in the future construction of the Underwater Unmanned System.

**Development of UUV technology**

At present, unmanned combat equipment with unmanned underwater vehicle (as shown in Fig. 2(a) and unmanned aerial vehicle (UAV) as the main body is gradually emerging in marine military application, especially unmanned underwater vehicle (UAV) has become a key research direction of naval equipment in the world. Various military powers try to build or maintain underwater superiority and create a new underwater combat system by vigorously developing unmanned underwater warfare equipment with autonomous underwater vehicles as the main body.

At present, the U.S. anti-submarine equipment mainly includes marine surveillance satellites, fixed-wing anti-submarine patrol aircraft, anti-submarine helicopters, surface ships, nuclear submarines, underwater fixed sonar arrays, etc. After the deployment of new antisubmarine detection equipment represented by unmanned underwater vehicles, unmanned aerial vehicles, and unmanned vehicles, the composition of the U.S. anti-submarine equipment system will undergo a major change. Anti-submarine UAVs will be deployed in the air, unmanned anti-submarine vehicles will be added to the surface, and new equipment such as a submarine preset system, Underwater Unmanned Combat cluster, and underwater detection network laid out by other platforms will be arranged underwater. Through this round of reform, the U.S. anti-submarine equipment system is richer, the equipment types are diversified, the time density of normal anti-submarine patrol is increased, the granularity of environmental description of key waters is refined, and the existence time of American anti-submarine equipment in specific sea areas is prolonged, which can effectively deter other countries.

However, the fuel carried by the current unmanned underwater vehicle (UUV) cannot maintain a long endurance time. Frequent energy supply or recovery by the mother ship is not conducive to long-range combat. Especially when the opponent has high-performance and all-around anti-submarine means, frequent floating and recycling will lose the advantage on the battlefield.

**1) Research on endurance**

In terms of endurance capability, the United States has actively carried out a lot of research. In 2004, the U.S. issued the control of unmanned underwater vehicle (UAV) program, which proposed that in order to meet the needs of long-term intelligence surveillance and reconnaissance or combat, it is necessary to develop long-term endurance and high-reliability propulsion system and improve the underwater endurance of existing unmanned underwater vehicles from 10-40 hours to a few days or even weeks. In 2011, the U.S. Navy released the future Navy capability project of long-endurance unmanned underwater vehicle(LEUUV) [22], focusing on solid oxide fuel cells and proton exchange membrane fuel cells. The U.S. Navy requires that the power density of the power system (including hydrogen and oxygen sources) of the unmanned underwater vehicle (UAV) should reach 500wh / L and 500wh / kg in the medium and long term of the project, which meets the safety standards and will not cause any danger during storage, operation and maintenance. At the same time, the United States also carries out rapid research and development of complementary advantages by means of international cooperation. Taking advantage of the advantages of the United States in hydrogen storage research and Japan's advantages in power generation technology, the United States have jointly developed high-performance fuel cells for unmanned underwater vehicles, achieving a one-time battery life of 30 days. Japan has invested about 2.6 billion yen in the project (2014-2018 fiscal year of Japan's defense ministry). Japan's Yomiuri Shimbun even directly reported that the equipment would be used to collect technical information about Chinese Navy submarines.

It can be predicted that with the progress of fuel cell technology, the speed and endurance of unmanned underwater vehicles will be gradually improved, and the endurance time in a month will ensure that the UAV can be separated from the formation and realize the distributed C4ISR combat mission.

**2) Tactical research on mobility**

The hydrodynamic research shows that the speed of the underwater vehicle is doubled, and the energy required is increased several times. The limitation of performance improvement will lead to the speed of most unmanned underwater vehicles to maintain within 5kn. The slower speed obviously takes a longer time to reach the operation area. Similar weights need to optimize the relationship between energy storage and loads, such as size, power, and endurance. Although the battery of the unmanned underwater vehicle can last several hours or days, the specific value also depends on the sailing distance and load.

The power limitation of battery or fuel cell technology affects the speed and endurance of unmanned underwater vehicles (UAV), so gliding has become the current choice of an unmanned underwater vehicle. Two basic designs of underwater gliders have become the mainstream: one is to use a streamlined shell with low resistance and convert the work done by the underwater wing into forwarding motion; the other is that the floating attached to the submersible transports to the bottom by the expansion of seawater, and then uses the buoyancy generated by the wing to generate forward motion. Due to the simple use of buoyancy driving mode, the underwater glider can only make zigzag and spiral gyration trajectories under the water. Its track control and positioning accuracy are low, and the speed is slow. It may drift with the waves in the sea with large waves, which limits the application scope of the underwater glider.

The energy technology development of glider-type unmanned underwater vehicles has unlimited potential (as shown in Fig. 2 (b)). The endurance time can be extremely long, but the disadvantage is that the speed is slow, which limits its tactical effectiveness and is only suitable for ocean data acquisition and other tasks. The lack of tactical mobility makes the underwater glider unable to meet the requirements of a nuclear attack submarine. In the face of threat and threat symptoms, it can make a quick and decisive response, actively maneuver to change the enemy's strategy, limit its available resources, and prevent its action. The key is to improve the mobility of underwater equipment.

In order to solve this problem, in addition to providing a set of the power propulsion system for the unmanned underwater vehicle (for example, Russia's Poseidon unmanned underwater vehicle uses a nuclear power device, which greatly improves the speed and mobility), in addition, bionic technology can be used to enhance the mechanical ability of the unmanned underwater vehicle. For example, inspired by sea fish, researchers at the U.S. Navy laboratory have developed an active control curved mechanical fin, which can provide a new low-speed propulsion system for smaller autonomous underwater vehicles (as shown in Fig. 2 (c) and (d)). This artificial fin technology can adapt to various water flow environments, and provide necessary thrust control for low-speed maneuvering and precise positioning, so as to enhance the unmanned maneuverability and sensing ability of the submarine in the offshore combat environment.

3) Research on submarine preset weapon technology

As early as 2013, the United States carried out special research on preset submarine weapons. Submarine preset weapon [24] is a new kind of underwater equipment that can replace the submarine to be deployed on the seabed in key sea areas in advance for long-term standby. The U.S. Navy has developed two kinds of preset equipment, namely "floating payload" and "Hydra." The former is present in the deep sea, which is composed of a carrier, payload, and communication system. Through the deployment of surface warships, it can stand by for 5 years at a depth of 4 km. When necessary, it can wake up remotely, quickly release UAVs, sensors, missiles, and other loads to carry out intelligence surveillance, reconnaissance, and strike missions; the latter is present in the offshore area and can carry several small UAVs and unmanned underwater vehicles, including surface warships and submarines Launch the boat and aircraft, wait for several months underwater, wake up when necessary, and independently command the load to carry out the anti-submarine task.

**The latest research progress on the American submarine**

The submarine (as shown in Fig. 3) is a vehicle that can switch freely between the water surface and the underwater. In the future beach landing battle, it is a high-risk task to carry out the water attack. According to statistics, the process of troops marching from the water surface to the beach is the most dangerous moment in landing operations. The process lasts for a long time, and the landing is completely exposed to the enemy's artillery fire. The troops must charge in the rain of bullets, which is quite fragile. For many years, the U.S. Marine Corps has been studying how to deploy troops more safely from ship to shore, and the submarine is one of the feasible means (as mentioned above, the new concept submarine of "VICTA" of Britain (as shown in Fig. 3 (a)) will have a profound impact on the future sea crossing and landing operations).

On April 17, 2017, HSP technologies demonstrated its hyper-sub submarine (as shown in Fig. 3 (b)) at the shore-to-shore maneuvering detection and experiment of the 2017 advanced Naval Technology exercise ship held at Camp Pendleton, California. The ship is 13.7m long and has a displacement of about 13.6t. Two 480 HP diesel engines are installed inside the vessel to drive the speedboat at a speed of 27 kN / h with a load of 2.7t. After diving into the water, the hyper sub can be driven by two Innerspace electric thrusters at a speed of 6kn per hour. The battery and life support system on the boat can maintain underwater operation for an average of 12 hours. After the battery is exhausted, it can continue to sail in a semi-submersible model with a diesel engine and charge the battery at the same time.

According to a report on May 26, 2020, the U.S. Navy plans to invest more than $12 billion in unmanned aerial vehicles, unmanned surface ships, and Underwater Unmanned Systems from 2021 to 2025. This trend will accelerate as O & M costs increase, and defense budgets shrink. Robertson levint, a senior defense analyst at the Bloomberg News Agency, said senior Navy officials had made it clear that they wanted to achieve more than 355 ships, but unmanned systems "could be the future of the Navy.". Robertson Levent said that in the next few years, about $7.9 billion would be spent on UAVs, of which about $4.3 billion will be spent on the MQ-4c "Poseidon" unmanned reconnaissance aircraft, about $1 billion will be used for the MQ-25a "stingray" shipborne unmanned tanker, 2.2 billion will be used for unmanned surface vessels (USV), and $1.9 billion will be used for unmanned underwater vehicles (UUV). The Navy plans to spend $941 million on USV and UUV in 2021, an increase of 129% over 2019. It can be seen that the U.S. military has invested heavily in unmanned systems, with more than 30% of the total spending on unmanned surface vehicles and underwater vehicles.

It is reported that the US Navy plans to purchase nine ultra-large unmanned underwater vehicles (XLUUV) from 2020 to 2024 (as shown in Fig. 2 (E) and (f)), and Boeing's xluuv design will be based on echo traveler (echo) The UAV is 51 feet long, with a square section of 2.59 m × 2.59 m, with a weight of 50 t and a range of 6500 nautical miles. In addition, it can load a 35-foot-long module load chamber and provide an additional 2000 cubic feet (56.65 m3) of space.

In addition, according to a report on the US naval academy news network on May 22, 2020, the US Navy has issued a tender for the design, development, testing, and production of a medium-sized unmanned underwater vehicle (as shown in Fig. 2(g)), which uses an open architecture to replace the existing two types of unmanned submersibles (the king fish and the razor whale). MK 18 mod 2 "king fish" unmanned underwater vehicle is deployed and recovered by rigid inflatable boat, and the detection information is sent to the task processing module onshore for mine detection; and the razorback unmanned submarine is deployed by submarine, which can perform battlefield environment perception task. The new type of unmanned underwater vehicle (UUV) will have the functions of surface deployment and anti-mine of "king fish," as well as underwater fish detonator deployment and battlefield perception function of "razor whale."

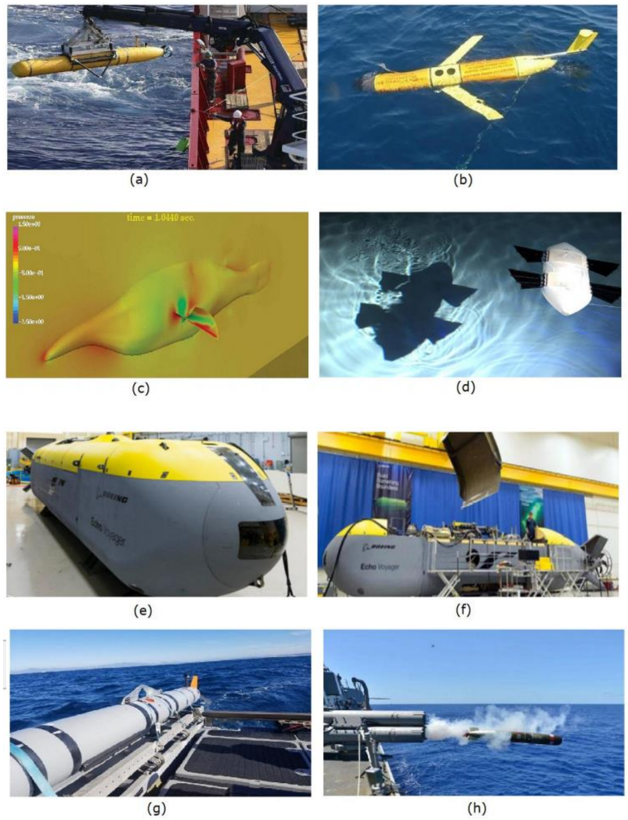


Fig. 2. Underwater Unmanned Underwater Vehicle (a): Unmanned underwater vehicle; (b) Glider type submarine; (c) Model of fish like a submarine in the naval laboratory; (d) Fish fin like a submarine; (e) and (f) Echo Voyager unmanned underwater vehicle; (g) Medium-sized unmanned underwater vehicle of the United States; and (h) Ultra-light torpedo (VLWT)

In May 2020, Northrop Grumman announced the successful completion of the first acoustic test of the ultra-light torpedo (VLWT) developed for US submarines (as shown in Fig. 2 (H)). The torpedo adopts a chemical energy storage propulsion system and a low-cost acoustic array. It is 2.15m long and only 99.8kg in weight, which is about 1 / 3 of the length and 1 / 16 of the weight of the heavy torpedo currently used by the US Navy. The length and weight of mk48 heavy torpedo are 5.8m and 1678kg, respectively, and the length and weight of the MK54 light torpedo are 2.72m and 275kg, respectively. The torpedo was developed under the U.S. Navy's compact rapid attack weapon (CRAW) program to provide anti-torpedo hard-kill weapons for submarines. It was first designed by the Applied Research Laboratory of Pennsylvania State University. In 2016, the Naval Research Agency awarded the contract to Norge to continue its research and development work. The U.S. Navy will continue to invest $49.1 million in the craw project in the fiscal year 2021 and plans to equip craw on the Virginia class block III and block IV attack-type nuclear submarines from October 2023.

In the future, the development trend of U.S. military submarines will be more unmanned, intelligent, precise, networked, collaborative, and clustered. The underwater equipment will show more technical advantages such as multi-task, intelligent, cooperative operation, precise navigation and positioning, and water air cross-medium navigation, especially the new concept of surface/underwater cross-medium submarine technology, which has been developed in recent years to lead the development direction of a future unmanned underwater vehicle.

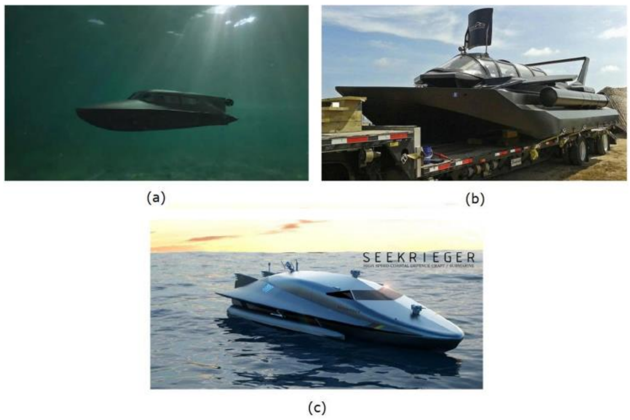


Fig. 3. Foreign new concept submarine (a) Victa submarine; (b) HyperSub submarine; (c) Seekrieger fast submarine attack vehicle.

## III. THE LATEST DEVELOPMENT OF RUSSIAN UNMANNED UNDERWATER VEHICLE TECHNOLOGY

In recent years, Russia, with its strong industrial foundation and technical strength, has vigorously developed unmanned underwater vehicle technology and has made remarkable achievements. Such as harpsichord-1r / 2R, Juno, amulet, marlin-350, etc. [25]. Among them, the most remarkable is the Poseidon strategic class, nuclear powered unmanned underwater vehicle under development. The fire incident of Russia's deep-sea submersible on July 5, 2019, did not prevent Russia from going into the deep sea and developing underwater equipment, including unmanned underwater vehicles.

The development of the unmanned system in Russia can be traced back to the former Soviet Union. The Soviet Union was the first country in the world to develop an unmanned underwater vehicle (UUV). The influence of the L-2 submersible with a depth of 6000m is almost equal to that of the first man-made satellite. After the disintegration of the former Soviet Union, Russia developed slowly in the field of unmanned underwater vehicles due to the limitation of funds and technology. Since the beginning of the 21st century, with the recovery of national strength, Russia has begun to strengthen the research and development of new concept weapons and try its best to narrow the gap with Western military technology. Relying on its strong industrial foundation and technical strength, Russia has made great progress in the field of unmanned underwater vehicles. According to the plan of the Russian Ministry of defense, the proportion of unmanned combat systems in the overall structure of Russian military equipment will exceed 30% by 2025.

At the Russian military exhibition in 2017, ruby Marine Engineering Central Design Bureau (Rubin Design Bureau) exhibited the amulet and Juno unmanned underwater vehicle (UUV) equipment (as shown in Fig. 4), which attracted the world's attention. Although the types and quantity of unmanned underwater vehicles in service of the Russian navy are not many, the growth rate of research projects is more obvious Obviously.

Juno is a torpedo-type unmanned autonomous underwater vehicle (as shown in Fig. 4 (b)). The length of the submersible is 2.9 m, the diameter is 200 mm, and the total weight is 80 kg. It is mainly composed of seven systems: detection system, buoyancy support system, battery, and power system, navigation control system, underwater searchlight and camera system, and propeller propulsion system. Compared with the active "diver," the performance of this type of submersible is significantly improved, the technology is more complex, and the

sensor carried is diversified, which fully reflects the new technology of Russia in the field of unmanned underwater vehicle technology. "Juno" has a diving depth of more than 1000 m and an independent working time of up to 6 hours. It can be equipped on Russian surface ships and submarines in active service and can be used for reconnaissance, mine clearance, ocean exploration, and other tasks. In particular, the "Juno" unmanned submersible vehicle is designed according to the characteristics of the Arctic sea area, which is specially used for information transmission and rescue in the Arctic Ocean. The future equipment of Russian nuclear submarines will play an important and positive role in improving the operational deployment and information transmission of strategic missile nuclear submarines in the Arctic Ocean, and its technical level is in the leading position in the world.

"Amulet" (as shown in Fig. 4 (c)) is different from the independently developed high-performance and high-end unmanned underwater vehicle "Juno." The length of the unmanned underwater vehicle is 1.6 m, the weight is 25kg, the diving depth is 50m, the maximum underwater speed is 3 kN, and the range is 15 Km, which is mainly designed and assembled by imported components, has the advantages of low cost, high-cost performance and miniaturization. The cost is only 112000 yuan, which is equivalent to 1 / 20 ~ 1 / 10 of the price of the same level unmanned underwater vehicle in Europe and America.

The head of the harpsichord 1R unmanned underwater vehicle is covered with a hemispherical fairing, with a length of 5.8 m, a diameter of 900 mm, a weight of 2.5 T, a depth of 6083 m, a speed of 2.9 kN, a range of 300 km and an autonomous working time of 120 hours. The length of Harpsichord 2r-pm is 6.5 m, the diameter is 1000 mm, and the weight is about 3.7 T. the sailing speed of 2r-pm is about the same as that of Harpsichord 1R, with a range of 50 km and a depth of 6 km. At the end of September 2016, the harpsichord 2r-pm completed the pool test and steam test and conducted a diving test in the Black Sea waters, with a diving depth of 500m.

In March 2018, Russian President Vladimir Putin disclosed an unmanned underwater vehicle named "Poseidon" (as shown in Fig. 5) in his state of the Union address. It is multi-purpose marine core equipment being developed by the Russian navy and has excellent nuclear strike capability. As a strategic campaign mission, the ultra-large nuclear-powered unmanned underwater vehicle (UUV) can go deep into the enemy's deep-sea waters and extreme waters without personnel to drive and operate so as to complete the established tasks remotely. Poseidon [25] submersible has a diameter of 1.8 ~ 2.0 m, a cruise distance of 10000 km, a maximum cruise speed of 60 kN, and a maximum depth of 1000 m. As an unmanned underwater vehicle, Poseidon can break through all kinds of limitations of traditional manned diving equipment. It can work in the harsh environment of high water pressure, no light source, large interference, and high-risk seabed environment, and complete reconnaissance, information collection, and other special tasks. To some extent, it is an epoch-making weapon system.

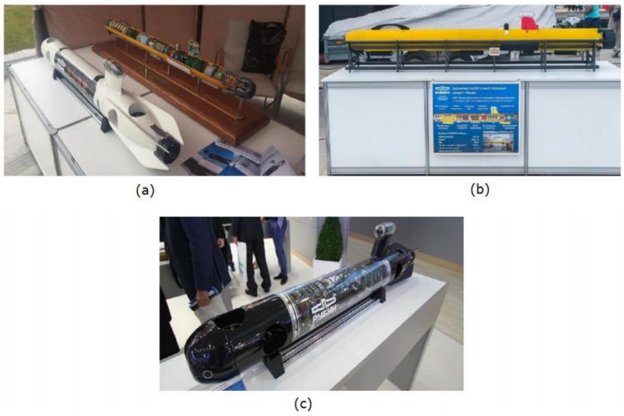

Fig. 4. The unmanned underwater vehicle developed by the Russian Srubin Design Bureau (a) Amulet (left) and Juno (right); (b) Juno unmanned submersible; (c) Amulet unmanned submersible

In December 2018, Poseidon's strategic unmanned underwater vehicle was launched for a test, the key components test was completed in February 2019, and the factory test was started in the summer of 2019. In addition, the 09852 Belgorod nuclear submarine launched in April 2019 will become the first submarine carrying Poseidon and can carry six Poseidons at the same time. The joint test of Poseidon and submarine will be conducted for two years, and the whole system is planned to be installed in the Navy from 2020 to 2021. The Khabarovsk submarine of 09851 projects is the second submarine carrying Poseidon. The submarine is expected to be launched in spring 2020 and put into service in 2022. Poseidon's research and development have been included in the Russian Federation's state weapons and equipment program from 2018 to 2027. It is planned to be put into service from 2027 to 2030, and the first batch of equipment will be 32.

It is the main reason for its excellent power performance. Compared with the nuclear power plant of the submarine, the nuclear power system has the advantages of compact design, fast start-up, ultra-high energy density, and high power proportion. The volume is only 1 / 100 of the original, and the working mode conversion time is 1 / 200 of the original, so it has excellent working performance. Yes.

As an Underwater Unmanned Combat Platform with both strategic nuclear strike and precision strike capability, the Poseidon submarine can be deployed in the enemy's coastal area, fleet assembly area, or other key waters through the long-range underwater maneuver and carry out a variety of operations and support missions. The submarine can even carry a warhead with an explosive equivalent of 10 million tons of TNT and carry out an attack by means of a tsunami triggered by an explosion in the offshore area. Its equipment will enable Russia to have a strong maritime countervailing capability and strategic deterrence capability against the United States.

To sum up, Russia has spared no effort in the development of unmanned system equipment. In the early days, the development of unmanned underwater vehicle technology was relatively slow. In recent years, with its own strong industrial foundation and technical strength, Russia's Underwater Unmanned Underwater Vehicle (UUV) technology level is at the forefront of the world, especially the submarine with nuclear strike capability, which has excellent combat performance, which can be applied to the U.S. military the sea confrontation has form obvious advantages.

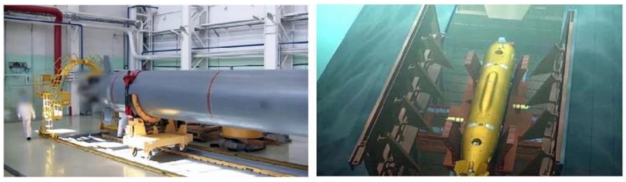

Fig. 5. Russian "Poseidon" nuclear powered unmanned underwater vehicle

## IV. RESEARCH PROGRESS IN OTHER COUNTRIES

The UK has made great progress in the research of unmanned aerial vehicles (UAV), such as VICTA's new concept submarine, ultra-large underwater unmanned underwater vehicle, etc. In addition, pap-104 of France, Pluto plus of Italy, and Pluto gigas [26] unmanned underwater vehicles are also typical representatives.

The VICTA New Concept Submarine (as shown in Fig. 3 (a)), launched by the British company at the London Defense Exhibition in 2019, is powered by two diesel engines, with a maximum speed of 40 kN and a range of 250 nautical miles. When diving and sailing, the power is provided by lithium batteries, the deepest diving depth is 30m, the maximum speed is 8kN, and it can submerge for 25 nautical miles. With oxygen, eight crew members can breathe underwater for 4 hours. In combat, VICTA can approach the war zone at high speed from the water surface and then dive into the water after entering the enemy's range. It has good concealment and can greatly reduce the threat of enemy fire. In addition to the traditional landing operations, the VICTA can also be lifted by a CH-47 helicopter, and it is compatible with three penetration modes of air, water, and underwater. It is very suitable for carrying special combat personnel to carry out secret reconnaissance and other tasks.

On April 16, 2019, the UK Ministry of Defense announced that it would provide 2.5 million pounds (US $3.3 million) for the design, modification, and testing of ultra-large Underwater Unmanned Underwater Vehicles (also known as xluuvs). The purpose of the test is to test the ability of the ULV to autonomously navigate 3000 miles (2600 nautical miles), collect intelligence and perform other missions. The UK also decided to explore the use of xluuvs after the US Navy awarded Boeing a contract to manufacture, test, and deliver four ultra-large unmanned underwater vehicles. Boeing, based on the echo Voyager demonstration boat, beat its rival, Lockheed Martin, for a $43 million grant, which will be delivered in 2022.

At the international maritime and Aerospace Exhibition in Langkawi in 2019, DK Naval Technology Company of Singapore launched a conceptual model of a submarine fast attack ship called seekrieger (as shown in Fig. 3 (c)). Seekrieger fast submarine attack craft is designed with a triangular streamline and a fully enclosed structure. The retractable three-body sliding structure is adopted to improve the seakeeping performance and sliding stability of the small hull. The two pontoons on both sides can be retracted to the hull when diving. Once the seekrieger fast submarine attack vehicle becomes a submarine, it can quickly recover the equipment outside the boat and go underwater. The maximum underwater speed can reach 30 kN, and the surface information can be detected by the photoelectric sensor mast. At the same time, the seekrieger fast submarine attack boat is equipped with three remote control weapon stations of small-diameter mechanism guns and two torpedo tubes, which have the ability of rapid attack on the surface and underwater.

With the improvement of technical level, European countries' autonomous underwater vehicles and remote-controlled submarines can efficiently perform a series of important tasks, including searching, discovering, identifying, and destroying a large number of triggered and non-triggered mines; implementing underwater acoustic reconnaissance; collecting hydrological information; detect the enemy's anti-landing and anti-submarine defense systems in combat waters; and detect underwater hydraulic facilities and garrisons Basic facilities of berthing, ship hull survey, etc. Navy personnel can be liberated from various dangerous and arduous tasks. Among the equipment development directions determined by the navies of European countries, autonomous underwater vehicles and remote control submarines still occupy the priority position to help surface ships and submarines to carry out their tasks.

In addition, European countries carry out multinational cooperation technology, and no member state can be alone in an environment of increasing world instability and cross-border threats to European security. In February 2019, the European Commission began to work with the Member States to implement the first European joint defense project funded by the EU's future budget. The budget for European defense cooperation is EUR 590 million (R & D in 2017-2019 is EUR 90 million, and in the period 2019-2020 is EUR 500 million). The project brings together 42 partners from 15 EU countries. The research content includes supporting marine surveillance tasks and integrating UAVs and unmanned underwater vehicles into fleet operations to achieve this goal.

Compared with the United States and Russia, the development of unmanned underwater vehicle technology in other countries is also very rapid. For example, the new concept submarine of British VICTA and seekrieger of Singapore has realized the interactive navigation on the surface and under the water, thus realizing the effective avoidance of the enemy. The emergence of cross-media navigation technology will cause a new revolution in underwater warfare.

## V. Conclusions

The progress of unmanned system technology highlights the need to shift the focus from specific areas to unknown areas. The progress of unmanned systems in any field will promote the progress of other fields. Future operations will rely heavily on multi-domain capabilities, which must be seamlessly connected and integrated into the joint force structure. Unmanned underwater vehicle (UUV) [27-29] belongs to the subsystem of the unmanned system. Although it can realize many tasks, such as minesweeping, anti-submarine, underwater rescue, seabed survey, wreck salvage, and so on, it is an underwater network-centric warfare efficiency multiplier and an underwater multi-faceted hand. However, the volume of the unmanned underwater vehicle is limited, and the power of the power plant is limited. In addition, the detection and searchability, positioning accuracy, and maintenance of the UAV are low. There is still a lot of room for improvement in interception rate and range, and there is a long way to go for future development [26]. This paper summarizes the long-term development plan of unmanned systems formulated by the US military in recent years to maintain its maritime strategic advantage, the technology of unmanned underwater vehicles, which is characterized by strong endurance, high mobility, and high stealth attack, has become the trend of development in the future, the latest development status of Russian UUV technology was studied, and the latest achievements of the new concept UUV in Britain, France, and Italy were presented. The results show that the new type of intelligent controlled trans-medium vehicle will become the mainstream of the future development, which provides a reference for the development of our navy unmanned equipment.

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