The development status and trends of ground unmanned combat platforms

H B Wang, Y Li*, K Ren, L J Yang and Zh H Han
Liaoshen Industries Co., Ltd, Shenyang 110045, China
E-mail: liyue04200@126.com

Abstract. Faced with the increasingly complex international situation and brutal military wars, the lives and safety of combat soldiers are greatly threatened. At this time, the unmanned combat platform is becoming increasingly important and has gradually become an important attack and defense force on the information battlefield. This article introduces the characteristics of the unmanned combat platform and its status quo of development at home and abroad, and combines the needs of future military wars to analyze the influence of ground unmanned combat platforms on combat capabilities and war patterns.

1. Introduction
In modern society nowadays, the struggle against the enemy’s nuclear, biological and chemical weapons has become an important part of warfare on land. The national science council has predicted that the core weapon in the 21st century would be unmanned combat systems [1-2]. At present, this prediction is gradually becoming a reality. With the advent of the intelligent age, unmanned warfare has gradually occupied the core of the war arena and guided the direction of future combat development.

With the development of science and technology and the upgrading of weapon systems, the lives and safety of combat soldiers on the battlefield has been highly valued. In order to protect the safety of combat soldiers, unmanned combat platform on the ground is essential, and equipment is developed in the direction of unmanned operations. The unmanned combat system consists of unmanned combat platform, mission load, and command and control system. Unmanned combat platform is an important part of an unmanned combat system, which can replace soldiers to complete special dangerous military tasks under various extreme conditions, such as replacing combat soldiers in the harsh combat environment to effectively complete the acquisition of intelligence, surveillance, reconnaissance, fire attack, transportation, search and rescue, mine clearance, protection of combat soldiers safely leaving the field and other important tasks. It can improve the survival rate and combat effectiveness of combat soldiers and complete the largest combat missions with minimum casualties. This unmanned technology has become the development trend of weaponry [3-5].

2. Characteristics of ground unmanned combat platform
The unmanned combat platform is a brand-new weapon system in which unmanned systems are further developed toward higher technology and stronger combat capabilities. It is a concentrated embodiment of the development of machinery, electronics, information, controlling and other
technologies [6]. Unmanned combat platforms are mainly divided into three categories: air, ground and underwater. Compared with air and underwater unmanned combat platforms, the environment faced by ground unmanned combat platforms is more complex and changeable, and there are many unknown obstacles, so its research and development is also more challenging.

The biggest feature of the ground unmanned combat platform is that it can carry certain weapons and equipment under the premise of unmanned participation, and be remotely controlled through the configured wireless communication equipment to conduct reconnaissance, surveillance, electronic interference, and direct combat. It has many advantages such as high degree of automation, good remote control, strong digital communication ability and anti-interference, excellent target detection and recognition ability, good concealment, and strong adaptability to the ground environment [7].

Ground unmanned combat platforms are mainly represented by unmanned combat vehicles, unmanned combat robots, and unmanned reconnaissance command vehicles. Among them, the unmanned combat robot is a machine that moves away from the direct control of humans and adopts remote control, semi-autonomous, and autonomous methods to move on the ground. Because unmanned combat robots have no emotions, no pain, no emotional fluctuations, no impact on combat due to fear, and extremely strong survivability, they will produce unexpected effects in war and have an impact on the enemy’s psychology and morale in the battlefield. Besides, it can obviously surpass traditional weapons. The investigation robot working in a complex and dangerous working environment is a collection of research results of many cutting-edge scientific theories and technical practices, and its research has great theoretical value and broad application prospects.

3. Development status of ground unmanned combat platform at home and abroad

3.1. Status of foreign development of ground unmanned combat platform

The origin of the ground unmanned combat platform can be traced back to the wireless remote control tank developed by the former Soviet Union in the 1930s. Then in 1939, the German military signed a contract to develop a wireless remote control blasting vehicle. The B4 remote control blasting vehicle is also called B4. The remote control blasting tank is a heavy-duty remote control blasting vehicle, as shown in figure 1. Nowadays, although the speed of this remote control blasting vehicle is slow, it was a highlight of the battlefield as a new weapon at that time [8].

With the increasingly complex international situation, the ground unmanned combat platform gradually changes from remotely controlled ground unmanned combat platform to semi-autonomous and autonomous ground unmanned combat platform. Nowadays, the technology of remote-controlled ground-based unmanned combat platforms has matured, and there are large-scale products used in the battlefield. Among them, small unmanned platforms for reconnaissance and strike missions, medium- or heavy-duty platforms for mine clearance and channel opening missions are the focus. Most of the
semi-autonomous ground unmanned combat platforms are in the research and development stage, and a few are already in use by the troops. Fully autonomous ground unmanned combat platform research still focuses on breakthrough key technologies [9].

In the 1980s, the United States and the Department of Defense specifically formulated an unmanned combat system development plan, successively formulated joint robot plans, Demo plans, ground unmanned combat vehicle plans, off-road robot perception and other plans to form unmanned combat systems [10].

In 2001, the United States designed a "spider" unmanned ground tank. The structure of this tank can provide a large-capacity load cabin and can change four weapon stations. In 2005, in the Ground Unmanned Combat Vehicle Program, the National Robotics Engineering Center (NREC) of Carnegie Mellon University in the United States developed an unmanned combat vehicle, the Crusher, as shown in figure 2. Compared with the "Spider" unmanned ground combat vehicle, the "Crusher" unmanned vehicle adopts a new vehicle body system and carries out several new technical improvements. This unmanned chariot is a next-generation unmanned high-mobility platform for a large range of complex off-road roads. This chariot is durable, self-controlled and capable of performing autonomous search, reconnaissance, and combat tasks within 1km. Can adapt to complex ground environment, even if it encounters obstacles such as fences, trees, rocks, etc., it can pass easily and at high speed [11-12].

There are many types of iRobot security defense robots in the United States, such as detection robots for reconnaissance, tactical mobile robots and load-bearing robots for transportation. PackBot is a small teleoperated crawler unmanned platform developed by iRobot. Allow personnel to complete operations beyond a safe distance, perform reconnaissance and surveillance, explosive detection and processing, route clearance and other tasks, as shown in figure 3. PackBot510 is an upgraded version of the bomb removal robot. On the basis of PackBot, the overall mass is lighter and the power drive is stronger. This robot has significantly improved in driving speed, reliable stability, ability to remove obstacles, etc., and this robot can Equipped with other intelligent equipment to adapt to various combat environments and requirements [13-14], as shown in figure 4.
In 2006, the Boston Dynamics Engineering Company of America developed the Bigdog quadruped bionic unmanned platform. The unmanned platform can confirm the target through the laser scanner and the stereo camera, and can follow the soldiers on complex terrain [9], as shown in figure 5.

![Bigdog quadruped bionic unmanned platform.](image)

The Andros series of anti-detonation robots of the American Remotec company have been unanimously praised all over the country. The Chinese domestic market mainly uses the Andros series of F6A robots. This robot is equipped with a six-degree-of-freedom robotic arm. The horizontal arm fully extends up to 122cm and the vertical arm fully extends. Up to 213cm, equipped with a variety of remote control methods to adapt to the complex working environment. Since then, Talon and "Sword" unmanned chariots have appeared in the United States. The Talon unmanned chariot (TALON) began to be used in the Afghan war in 2000. Its main task is to drill into the mountains of Afghanistan Look for the enemy's hiding place in a dangerous cave. In the Iraq War, the "Sword" unmanned chariot became the life-saving straw of the US military. It was small and only 0.9 meters high. It could be remotely controlled and easily passed through difficult areas such as rocks and barbed wire. The car can be equipped with guns and shells, which can fire hundreds of shells continuously with high accuracy [15-17].

The American "Black Knight" unmanned combat vehicle is an intelligent unmanned combat vehicle developed by BAE Systems [18]. It uses advanced robot technology, has automatic driving capabilities, and flexibly avoids obstacles. It is an important part of the US Army's "Future Combat System" (FCS). The main tasks are to carry out forward reconnaissance, gather intelligence, and survey dangerous areas. It can also accompany infantry operations and provide fire support, as shown in figure 6. But at the same time, there are still many bottlenecks in the technology of the American "Black Knight" unmanned combat vehicles that need to be overcome. For example, the reliability of unmanned combat vehicles can pose a great threat to the enemy’s infantry, but once it loses control, the consequences are disastrous. Therefore, this type of technology is like a double-edged sword, but it does have a very broad military application prospect.

!["Black Knight" unmanned combat vehicle.](image)
The United States is in the front of the world in the research of ground unmanned combat platform, and its practical value is increasing. In addition to the United States, the research of ground unmanned combat platform has also attracted the attention of Israel, Russia, Germany, Italy and other countries.

Israel's development focuses on the field of medium-sized autonomous unmanned vehicles, and its equipment and development level are at the forefront of the world. Guardium is a kind of autonomous navigation vehicle launched by Israel, which represents the highest level of autonomy of foreign active ground unmanned system [19]. The guardian has a strong off-road function. The maximum driving speed can reach 50km/h, and it can work continuously for 24 hours. The guardian can independently detect and detect hazards and obstacles, and can automatically identify road traffic signs. If there is a danger, it can send a warning to the operator.

At EADS 2016, IAA launched a heavy-duty, high mobility, unmanned combat and support robot system vehicle, the ronattle unmanned combat vehicle [20], as shown in figure 7. The ronattle is equipped with an ultra light remote control station called pitball, which has a unique sensor system that can accurately detect enemy fires and make judgments within seconds. The ronattle unmanned combat vehicle has high intelligent mobile driving performance, and can travel across obstacles as if on the ground, meeting the needs of different regional environments. Support a wide range of missions including intelligence, surveillance and armed reconnaissance, as well as escort, decoy, ambush and attack.

![Figure 7. Ronattle unmanned combat vehicle.](image)

2015 is the year of the rise of Russian military equipment. A large number of new weapons and equipment were displayed at the Moscow military parade. "Uran"-9 multi-functional unmanned combat vehicle is a kind of unmanned combat vehicle satisfactory to the Russian military [21]. In 2014, it has been ordered dozens of vehicles by the Russian army. "Uran"-9 multi-functional unmanned combat vehicle has many functions, such as all terrain mobility, real-time autonomous obstacle detection and avoidance, remote control or semi self-help control. The "Uran"-9 multi-functional unmanned combat vehicle is equipped with a turret, which is mainly equipped with a 2a42 30mm automatic gun, which can deal with light armored targets at 1500-2000m and helicopters within 4000m, as shown in figure 8.

![Figure 8. “Uran”-9 multifunction unmanned combat vehicles.](image)

In 2016, Russia demonstrated three new types of "Uran" series of ground unmanned vehicles,
namely, "Uran"-6 type MRTK-R multi-functional unmanned mine sweeping vehicle, "Uran"-9 type unmanned combat vehicle, "Uran"-14 type MRTK-P unmanned fire-fighting /mine sweeping vehicle [22-23].

In 2015, the first batch of "Uran"-6 type MRTK-R multi-functional unmanned mine sweeping vehicle mass production model was delivered to the engineering force of the southern military region of the Russian army. The roof of the unmanned mine sweeping vehicle is equipped with 4 cameras (covering 360 degrees of full view), antennas and other equipment, equipped with a very complete set of mine sweeping tool components. The main task is to search for mines and unexploded ordnance, which can detonate 59kg TNT explosives, with a maximum remote control distance of 1500m [24], as shown in figure 9.

![Figure 9. "Uran"-6 multifunction unmanned mine clearance vehicle.](image)

In 2015, Russia's defense industry company developed the "Uran"-9 unmanned combat vehicle, which is now the Russian army's active service system equipment, and was first made public at the "Army 2015" exhibition [25]. The overall design of "Uran"-9 armed unmanned combat vehicle is basically similar to "Uran-6", but it is not an engineering auxiliary unmanned vehicle, but a combat type unmanned vehicle, as shown in the figure. "Uran"-9 can be regarded as a light tank equipped with unmanned turret guns. Its firepower performance is the same as that of the current infantry combat vehicles, even higher than that of the mainstream Western infantry combat vehicles. The vehicle mainly provides long-range reconnaissance and fire support for army infantry units, airborne units, special forces, etc. as shown in figure 10.

![Figure 10. "Uran"-9 unmanned combat vehicle.](image)

In the same year, the "Uran"-14 type MRTK-P unmanned firefighting / mine sweeping vehicle was developed, which is basically the same in appearance as the "Uran"-6 type MRTK-R multi-functional unmanned mine sweeping vehicle, but its size is larger than the "Uran"-6 type MRTK-R, which is mainly a kind of unmanned vehicle system specially used for fire-fighting in areas with life-threatening environment and inconvenient traffic. "Uran"-14 type MRTK-P unmanned
The 2020 International Conference on Defence Technology (Autumn Edition)  
Journal of Physics: Conference Series 1721 (2021) 012065  
doi:10.1088/1742-6596/1721/1/012065

The fire-fighting / mine sweeping vehicle can work normally in large area forest fire, night, low visibility and other extreme environments, as shown in figure 11.

Figure 11. "Uran"-14 type MRTK-P unmanned firefighting / mine sweeping vehicle.

In addition to the above-mentioned countries, the unmanned combat vehicles developed in Ukraine are equipped with visible light, infrared, laser and other systems, which can search, detect, identify, locate and track targets in complex battlefield environment, and transmit information to the command post in real time [4]. The "Demis" tracked unmanned combat vehicle developed by the UK is equipped with a central loading cabin, which is loaded with a variety of weapons and equipment, and can detect and accurately locate dangerous objects on the battlefield in time [26].

3.2. Domestic development status of ground unmanned combat platform

Compared with the rapid development of ground unmanned combat platform in recent years, the development of the ground unmanned combat platform in China is relatively slow. Armament experts have long predicted that unmanned combat vehicles will play an important role in the future military. When carrying out such dangerous tasks as bomb dismantlement, the unmanned combat vehicle will be the extension of soldiers' hands, eyes and ears. However, due to the limitation of technical level, unmanned combat vehicles have not been supplied to the military in large quantities. In order to be the leading role in the battle, the autonomous navigation of the unmanned combat vehicle must be improved.

June 2014, the R&D center of weaponry ground unmanned platform was established in the North China Vehicle Research Institute of the China Ordnance Industry Corporation. It was established mainly for the rapid development of a series of products and equipment for land, sea and air forces, public security, armed police, etc. Now China has made rapid progress in the system design, product integration, technology development, basic process platform construction of unmanned vehicles. China has driven the R&D depth and speed of relevant domestic fields and products. Among a large number of new weapons and equipment displayed by China, "five tigers" unmanned combat vehicles: all-terrain vehicle, indoor monitoring robot, modular explosive disposal robot, field reconnaissance robot, mini tank and other aspects are outstanding.

All-terrain vehicles have been widely used in military field, they are also very suitable as the basis of large unmanned vehicles. All-terrain vehicle (GHRYSOR) has a net weight of 950kg, the maximum load on the ground is 680kg, maximum load on water is 300kg. There is a high-performance on-board artificial intelligence computer in the middle of the all-terrain vehicle (GHRYSOR). This computer is responsible for processing the data, finally designing the driving route and adjusting the speed, sending out the control and execution instructions.

MOSRO is a robot for indoor monitoring, it is 0.36m long, 0.48m wide and 1.18m high, and it is equipped with a variety of sensors, which can automatically sense and detect obstacles around, in order to walk freely. The maximum traveling speed is 4km/h. It can also perform dangerous tasks in special occasions, such as inspection in ammunition depots. MOSRO reduces the workload of logistics
personnel and ensures their safety.

Modular explosive removal robot (ASENDRO EOD) is 0.6m long, 0.4m wide and 0.4m high. Its control station and operation interface are convenient and practical, and its effective radius can reach 2km in the field of radio remote control. ASENDRO EOD can also be used in the detection and disaster relief of complex environment.

The basic structure of the field reconnaissance robot (ASENDROSCOUT) is the same as that of the modular explosive discharge robot (ASENDRO EOD). ASENDROSCOUT is equipped with a wide foot color and thermal imaging camera. This reconnaissance equipment also has motion recognition function. To make it easier to perform tasks in the field, its walking device can also be quickly switched to four wheels. In anti-terrorism, explosive ordnance disposal, reconnaissance and disaster relief operations, ASENDROSCOUT can make great efforts, and can also complete tasks such as mine detection and rescue.

The mobile reconnaissance vehicle (OFRO) is 1.12m long, 0.7m wide and 0.4m high. It's like a mini tank. OFRO is equipped with ultrasonic ranging sensor, infrared sensor, DGPS receiver and other equipment, which can be controlled remotely or patrol autonomously. It is equipped with a gas detector, which can detect all the toxic gases for military and industrial use at present, and give the exact analysis results in a few seconds.

In 2014, China debuted a new type of combat reconnaissance unmanned combat vehicle UGV. This unmanned combat vehicle is a "Sharp Claw I" combat reconnaissance small unmanned combat vehicle developed by China North Industry Corporation [27], as shown in figure 12. It is a typical small tracked unmanned combat vehicle, with a length of 70cm, a width of 60cm, a total weight of 120kg and an operating range of 1km. "Sharp Claw I" can perform short-range reconnaissance, detection and surveillance tasks in the battlefield. It can change weapons flexibly according to the requirements of the mission. In the case of fire assistance, it can carry 7.62mm machine gun on the platform and walk independently. "Sharp Claw I" combat reconnaissance UAV and "Sharp Claw II" transport UAV can cooperate. During transportation, "Sharp Claw I" can be carried in the cabin of larger "Sharp Claw II". After entering the battlefield, "Sharp Claw I" unmanned combat vehicle can drive down from the back plate of "Sharp Claw II" and quickly put into the war.

![Figure 12. "Sharp Claw I" unmanned combat vehicle.](image)

Now China has officially entered the "countries with unmanned combat vehicles in service" club which has only a few members. The Chinese army has basically realized mechanization. In the future, the Chinese army will surely transform to information technology. With the deployment of unmanned combat vehicles, the technical and information level of the Chinese army will be greatly improved.
4. The influence and development trend of ground unmanned combat platform on combat capability

The unmanned combat system, as a subversive technical equipment that changes the rules of future wars, has developed rapidly around the world, and has become an important force in military games between countries. Large unmanned tanks charge in battles, small robots obtain and transmit intelligence from the enemy, and fewer personnel gives orders in safe places. The equipment of the unmanned platform gives the infantry detachment a stronger combat capability [28-29]. Compared with traditional army operations, the military equipped with an unmanned combat systems will have significantly improved reconnaissance, situational awareness, and firepower on the battlefield. Many countries have invested a lot of material, human, and financial resources to carry out research on ground unmanned combat platforms. Ground unmanned combat platforms will develop around the following points.

(1) Maneuverability and concealment latency of ground unmanned combat platforms

Due to the special military application value, higher requirements have been placed on the miniaturization of ground unmanned combat platforms. The miniaturization of the unmanned combat platform on the ground can prevent the enemy from quickly discovering us, realize maneuvering flexibility and long-term lurking, and can greatly reduce support and research and development costs. It is believed that the ground unmanned combat platform will play a vital role in war.

(2) Expand the use of ground unmanned combat platforms

For ground unmanned combat vehicles, different weapons can be equipped to form a variety of unmanned combat platforms. This variety of ground-based unmanned combat platforms can effectively reduce costs and improve combat capabilities in specific environments, and has important social and economic significance.

(3) Development from semi-autonomous to autonomous ground unmanned combat platform

At present, ground unmanned combat platforms mainly include remote-controlled ground-based unmanned combat platform and semi-autonomous ground-based unmanned combat platform. At present, the unmanned ground unmanned combat platform is difficult to achieve in theory and technology. In order to improve the efficiency, environmental adaptability, and autonomous learning capabilities of ground unmanned combat platforms, with the rapid development of the information age, research on autonomous ground unmanned combat platforms is imminent.

(4) Increase the interoperability of different unmanned combat platforms

In view of the complex combat environment, the tasks of the ground unmanned combat platform are relatively simple at this stage. If unmanned combat platforms of the air, water, and ground are used in conjunction to form a sea, land, and air combat system, a significant effect can be achieved.

5. Conclusions

Political and military needs are the direct driving force for the development of unmanned combat systems, and the development of science and technology provides technical support for unmanned combat platforms. Although the international situation has no hidden dangers of world wars, local conflicts occasionally occur, and the anti-terrorism situation remains severe. Unmanned combat robots and other unmanned equipment have developed rapidly, and are used in actual combat. It has become an inevitable trend for military ground unmanned platforms to enter the battlefield on a large scale. Ground unmanned combat platforms are increasingly favored by the military because of their superior ability to perform special operations missions. Many developed countries have been devoted to the research of ground unmanned combat platforms and have achieved remarkable results, but ground unmanned combat platforms still have great potential for development. In terms of the development and application of unmanned platforms, there is still a certain gap between China and advanced countries. Therefore, China should accelerate the research and development of related equipment to improve military attack and defense capabilities.
References

[1] Boyd R S.U.S. 2003 Army works on robot soldiers Knight Ridder Tri2bune Business News 2-6
[2] FAROOQ W, KHAN M A, REHMAN S AMVR 2017 Applied Sciences and Technology (IBCAST) 14th International Bhurban Conference on IEEE 699-706
[3] JIN P, PANG XB. 2010 Acta armamentaria 32 163-6
[4] LI YX, LI ZY, XU HB, et al. 2017 Journal of Ordnance Equipment Engineering 12 124-30
[5] Citation format, LI YX, LI ZY, et al. 2017 Journal of Ordnance Equipment Engineering 12 124-30
[6] LU GD, ZHANG DF. 2009 Technology Information 36 354-6
[7] LU LN, HU Y, CAI XY. 2016 Curriculum Education Research 24 22-3
[8] SUN ZP. 2013 National Defence Science and Technology 34 12-6
[9] MENG H, ZHU S. 2014 Acta Armamentaria 35 (S1) 1-7
[10] ZHANG JM, FANG DX, XIAO AN. 2017 Light weapon 17 10-3
[11] YOUNG S H, MAZZUCHI T A, SARKANI S A 2017 IEEE Transactions on Systems, Man, and Cybernetics: Systems 47(6) 1192-206
[12] WANG GZ, SHEN W. 2017 Robot Technology and Application 6 23-5
[13] Brooks R, Angle C. PackBot: a complete system solution from the innovators at iRobot [EB/OL]
[14] YANG XB.2010 Light Weapon 8 16-9
[15] Endo Y, Balloch J C, Grushin A, et al 2016 International Society for Optics and Photonics 98(3) 558-71
[16] FU HL 2016 System Design of Ground Mobile Detection Robot Shanxi North University of China
[17] ZHANG FY 2012 Youth Science Park 3 38-9
[18] DU M, WANG W. 2008 Weapon Knowledge 7 53-5
[19] ZHU F 2010 Weapon Knowledge 3 61
[20] XIAO X 2015 Electronic Warfare 6 46
[21] SHI Z.2016 Foreign Tank 3 49-55
[22] ZI W. 2017 Ordnance Material Science and Engineering 40(1) 114
[23] WANG JL.2016 Foreign Tanks 8 5
[24] GAO M, ZHOU F, CHEN W. 2019 Modern Defence Technology 47(3) 9-14
[25] TIAN Z. 2017 Russian “Uran”-9 unmanned chariots heading for Syria China National Defense News
[26] ZHAO DY, LIN L.2016 Light weapons 0 (021) 30-1
[27] ZHAO Y.2011 Business Culture 5 310
[28] Patle B.K., Babu L G, Pandey A, et al 2019 Defence Technology 15(4) 582-606
[29] Rath A.K., Parhi D.R., Das H.C., et al. 2018 Defence Technology 14(6) 677-82