Russian Electronic Warfare

The role of Electronic Warfare in the Russian Armed Forces

Jonas Kjellén

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Cover: A Russian military truck with laser weapon *Peresvet* (date of photo 1 March 2018, TT Nyhetsbyrån)

Sammanfattning

Hur har rysk förmåga till elektronisk krigföring utvecklats de senaste tio åren? Vilka tendenser kan man se i dess fortsatta utveckling? Dessa två frågeställningar analyseras i denna studie. Att förstå de mest rudimentära tekniska förutsättningar och begränsningar som finns för att bedriva elektronisk krigföring är krävande, och överlåts därför ofta åt specialister. Den uppmärksamhet rysk elektronisk krigföring åtnjutit de senaste åren är därför mycket ovanlig. Grunden till denna uppmärksamhet är den utveckling som elektronisk krigföring genomgått i Ryssland de senaste tio åren. I synnerhet är det dess användning i framför allt östra Ukraina och Syrien som fångat omvärldens intresse. Denna studie visar att det alltför ensidiga fokus på de spektakulära förmågor som använts i dessa krisområden har lett till att andra viktiga faktorer har förbisetts. Det är framförallt offensiva förmågor inom rysk elektronisk krigföring som uppmärksammats – eller till och med överdrivits. De defensiva och preventiva åtgärderna har i hög grad förbisetts eller underskattats.

Nyckelord: telekrig, elektronisk krigföring, Ryssland, ryska Väpnade styrkorna, mikrovågsvapen, laservapen, signaturreducering.

Abstract

How have Russian Electronic Warfare capabilities developed, and what lies ahead? Because of its technical nature, Electronic Warfare is usually left to specialists. This is something that this report is attempting to change. The amount of attention that Russian Electronic Warfare has recently attracted is unusual. This awakened interest stems primarly from the Russian use of Electronic Warfare in eastern Ukraine and Syria. However, this study shows that the focus on high-profile use in these countries largely ignores Russian priorities and advances that are of equal of even greater importance. New offensive Russian Electronic warfare capabilities are often overemphasized or even exaggerated, while Russian efforts put into protective and preventive Electronic Warfare measures are more often overlooked and understated.

Keywords: Russia, electronic warfare, Russian Armed Forces, jamming, high power microwave, laser weapon, signature reduction

Preface

In recent years, Russian electronic warfare has attracted an unusual amount of attention. New Russian electronic warfare equipment in eastern Ukraine—and also in Syria – has caught the world's attention.

In his report, Jonas Kjellén demonstrates that the focus on eye-catching offensive electronic warfare weapon systems, has largely neglected other Russian priorities in the field of electronic warfare (EW) that are of equal or even greater importance. As important as supressing enemy command and control systems is enhancing the survivability of your own troops and critically important infrastructure through EW means.

Kjellén applies a systemic approach to analysing Russian EW. Examined are not only new EW systems, but also aspects such as organizational change, and industrial policy. In addition, more ambiguous factors could also be at play, such as an increased willingness to use EW measures in conflicts or a possible redefinition of when, where and how EW measures should be used.

The report is produced within the framework of the Russia and Eurasia Studies Programme (Russian foreign, defence and security policy) at the Swedish Defence Research Agency (FOI), which provides analyses for the Swedish Ministry of Defence. The programme focuses on research in Russian security studies, including Russia's neighbourhood, military, economic and domestic affairs.

A number of people have contributed with their knowledge and expertise to improve the report. First of all, we would like to thank Keir Giles, Conflict Studies Research Centre, UK, who read and commented on the entire manuscript. Furthermore, our gratitude goes to Per Sjöstedt, Pierre Keller, and Patrik Persson at the Swedish Defence Materiel Administration for providing photographs. They also read and commented on some of the more technical sections of this report. A special thanks goes to Per Wikström, FOI, who made the maps. In addition, we greatly appreciate Peter Johansson, Tomas Hurtig and Steven Savage at FOI for providing insights on technical matters. Last but not least I would like to thank Eve Johansson and Andrew Mash for improving the English.

Gudrun Persson

Head of the Russia and Eurasia Studies Programme

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Abbreviations[1]

AADA	Air and Air Defence Army
ABM	Anti-ballistic missile
AKP	*Avtomatizirovannyi kommandnyi punkt* (Automated Command Post)
ASAT	Anti-Satellite
Bde	Brigade
Btn	Battalion
BRESP	*Borba s radioelektronnymi sredstvami protivnika* (Combating Enemy Radioelectronic Equipment)
DEW	Directed-energy weapon
Div	Division
ELINT	Electronic intelligence
EMCON	Emissions Control
EMP	Electromagnetic pulse
EMS	Electromagnetic spectrum
EW	Electronic Warfare
FP	*Funktsionalnoe porazhenie* (Functional Attack)
FPI	*Fond perspektivnykh issledovanii* (Foundation for Advanced Research Projects in the Defense Industry)
FSB	*Federalnaia sluzhba bezopasnosti* (Federal Security Service)
FSO	*Federalnaia sluzhba okhrany* (Federal Protective Service)
GRU	*Glavnoe Razvedyvatelnoe Upravlenie* (Main Intelligence Directorate)
HF	High Frequency
HPM	High-power microwave
IED	Improvised explosive device
IMO	*Ispytatelno-metodicheskogo otdela* (Testing department)
JSC	Joint-stock company
KRET	*Kontsern Radioelektronnye tekhnologii* (Concern Radio-Electronic Technologies)

[1] Russian abbreviations that are commonly used and widely recognized in the EW literature are retained throughout this report.

KTK	*Kompleksnyi tekhnicheskii control* (Comprehensive technical control)
MD	Military District
MoD	Ministry of Defence
MR	Motorized rifle
NATO	North Atlantic Treaty Organization
NIIRTI	NII Radiopriborostroeniia (Scientific-research Institute “Radio Instrument Manufacturing”)
NIITs	*Nauchno-issledovatelskii ispytatelnyi tsentr* (Scientific Research Test Centre)
OKR	*Opytno-konstruktorskie raboty* (Research and Development)
OPK	*Obedinonnaia priborostroitelnaia korporatsiia* (United Instrument Manufacturing Corporation)
PD TSR	*Protivodeistvie tekhnicheskim sredstvam razvedki* (Measures against means of technical reconnaissance)
PGM	Precision-guided munition
PGS	Prompt Global Strike
R&D	Research and Development
REB	*Radioelektronnaia borba* (Electronic warfare)
REB-Atd	… *antiterroristicheskoi deiatelnosti* (EW units combating terrorist activities)
REB-K	... *s kosmicheskimi sredstvami* (EW units combating space based systems)
REB-N	... *s nazemnymi sredstvami* (EW units combating ground based systems)
REB-S	… *s samoletnymi sredstvami* (EW units combating airborne systems)
Reg	Regiment
RVSN	*Raketnye Voiska Strategicheskogo Naznacheniia* (Strategic Rocket Forces)
RWR	Radar Warning Receiver
SIGINT	Signals Intelligence
SDR	Software Defined Radio
SPS	Self-protection systems
STT	*Spetsialnyi tekhnicheskii tsentr*
TC	Training Centre

TNIIS	*Taganrogskii nauchno-issledovatelskii institut sviazi* (Taganrog Research Institute of Communications)
UAV	Unmanned aerial vehicle
UGV	Unmanned ground vehicle
USV	Unmanned surface vehicle
VDV	*Vozdushno-desantnye voiska* (Airborne Troops)
VKS	*Vozdushno-kosmicheskie sily* (Aerospace Forces)

1 Introduction

Russian electronic warfare (EW) has attracted an unusual amount of attention in recent years, most notably because of the well-documented presence, and use, of new Russian EW equipment in eastern Ukraine—and also since 2015 in Syria. Since the deterioration in Russia's relationship with the West, Russian EW has also attracted attention following a number of incidents. Examples include an alleged incident in 2014 involving the US destroyer *Donald Cook* in the Black Sea and, more recently, Russian jamming of western and NATO forces, as well as civilian air traffic and cellular networks during exercises. As these events unfolded they were closely watched and assessed by western military experts, and there is now widespread agreement that Russia has taken a giant, and somewhat unexpected, leap forward in terms of its EW capabilities. The details of this leap forward and how it was made possible, however, are less clear.

Following the showcasing of new Russian EW equipment in Ukraine and Syria, the most common supposition is that Russia has radically increased its EW capabilities thanks to the procurement of new and modern EW systems. This is a reasonable assumption, but the focus on recent combat operations and incidents has prioritized new offensive EW capabilities over other less conspicuous ones. I argue that any assessment of current and future Russian EW capabilities requires a systemic approach.

Beyond the study of new EW systems, aspects such as organizational change and industrial policy should also be examined. In addition, more ambiguous factors could also be at play, such as an increased willingness to use EW measures in conflicts or a possible redefinition of when, where and how EW measures should be used. Nor should the supposed increase in Russian EW capabilities and their use be seen only in the narrow context of the conflicts in eastern Ukraine and Syria. They are also means of bridging technology gaps with the USA and other NATO member states, in the context of the generally deteriorating relationship between Russia and the West. For this reason, EW should be aligned with notions such as *information warfare*, *cyberwarfare* and *network-centric warfare*, which means that conflicts and military operations should now be perceived in a new way that often stresses the need for, and the importance of, measures taken in the cyber and electromagnetic arenas. Admittedly, the perceived growth of Russian EW capabilities could also to some extent be an illusion. Some of the widespread claims made in both the Russian and the western media about this increase in capabilities are clearly exaggerated.

1.1 Purpose and Method

The purpose of this study is twofold: first, to study how Russian military EW capabilities have developed in the past ten years; and, second, to study the direction of the further development of Russian EW capabilities in the near future. In order to accomplish these two aims, a broad overview of Russian electronic warfare, covering its organization, purpose, tasks, procurement and technologies, is provided. This should also become a useful source of reference on Russian military EW for those who are studying the Russian Armed Forces more generally.

The heart of the study is the development of EW capabilities, which is here assumed to be dependent on a number of variables. Such development can comprise both qualitative and quantitative changes. First, the number of EW assets can grow, either by forming new units or by the further saturation of existing combat units and platforms with more of the same or new types of EW capabilities. Alternatively, existing EW assets can be improved in a qualitative sense through modernization or renewal of the EW inventory, or by improving specialist training and tactics. Furthermore, the boundaries of Russian EW capabilities, that is, the role and significance of EW within the Russian Armed Forces, could also be subject to change, due either to internal factors such as changes in priorities within the armed forces or to external factors such as new technologies leading the way to new opportunities—or, indeed, new threats.

The report takes three approaches to answering the research questions set for the study. First, the analytical underpinnings of contemporary Russian EW are studied, that is, their definition, terminology and evolution. Definitions and terminology ought to be resistant to short- to medium-term modification and, if reasonably up to date and modern, provide an idea of how the role and tasks of Russian EW will be perceived in current and future wars.

Second, an empirical approach is taken to the study of organizational development and technical procurement since 2008. In contrast to the analysis of definitions and terminology, this approach provides an understanding of the current weight given to EW in the military structure, for example, the number of units, their distribution across the Russian Federation, types of equipment, and so on. The development and procurement of new weaponry and equipment, as well as the dismantling of the old, is a slow process. The same is true of changes to organizational structures. Therefore, due to path dependencies, the study of organization and procurement involves depicting not just the current state of the Russian Armed Forces but also an idea of their EW ambitions.

The third approach is to track and discuss less tangible and long-term aspects of Russia’s EW ambitions. This includes statements of future ambitions in the EW domain, ongoing normative debates in Russia on the role of military EW and

technological advances that could, in the future, be converted into EW capabilities.

1.2 Limitations

The period of study of this report is limited to the ten years following the five-day war in Georgia in 2008. The object of study is the growth of Russian EW capabilities that has supposedly occurred during this period. There are two main reasons for this limitation. First, 2008–2009 was the starting period of the comprehensive military reform initiated by former defence minister Anatolii Serdiukov. This began a period of general modernization of all service branches and arms of the Russian Armed Forces. A basic assumption of the report is that the current state of Russian EW capabilities is largely a result of reforms and modernization efforts carried out during this period. Second, even though EW reform and experiences further back in time might have had an impact on current EW capabilities, it is reasonable to assume that this has been largely accounted for in how EW capabilities are organized and used today. Perhaps more troubling is that, despite the extensive renewal of the EW inventory over the past ten years, a substantial part of that inventory still consists of equipment procured prior to 2008, which is not analysed in this report. Some of these older pieces of equipment might continue to play a role in Russian EW in the coming years. However, equipment procured prior to 2008 is generally better known since these systems have been part of the Soviet and Russian EW inventory for a long time, and in some cases have also been exported. It is unlikely that details of the performance of an unmodernized older system will be completely unknown.

A great deal of knowledge about Russia's contemporary EW capabilities can be—and has been—extracted from analyses of recent and ongoing combat operations in eastern Ukraine and Syria. Such analyses are very useful and provide important insights on Russian EW tactics and validations of the performance of new, untested EW systems. Much of what is today publicly known about some of the new EW systems stems from analyses of their use in these combat operations, and this information is widely used in the descriptions of new Russian EW systems provided in this report. However, in-depth analysis of the use of EW in these combat operations is beyond the scope of this study. The same is true of a number of incidents involving Russian EW during this ten-year period that have received a great deal of attention, such as the downing of a US *RQ-170 Sentinel* reconnaissance unmanned aerial vehicle (UAV) in Iran in 2011 or the alleged jamming of USS *Donald Cook* in 2014 (see e.g. *Lenta* 2011 & *Interfax* 2014).

Given the relatively broad approach taken in this report to the study of Russian EW, it might be argued that there is a risk of the analysis being spread too thinly. To assess Russia's overall EW capability, however, there is no need to delve too

deeply into, for example, the configurations and technicalities of EW equipment. Descriptions of new equipment are therefore limited to a short description of what it is intended to do, its assessed capability, whether it represents a new type of EW capability and the extent to which procurement of the equipment has begun. Similar limitations confine the organizational description of the Russian EW architecture. Military secrecy makes it difficult to deduce an Order of Battle down to the tactical level, but this is not required for the overall analysis. The main focus is on describing the types of units that EW assets consist of and their distribution in the overall military structure.

Electromagnetic waves do not propagate well under water; instead, underwater reconnaissance uses acoustics. The Russian definition establishes acoustics (hydro-acoustics) as part of the EW domain (Guzenko & Moraresku 2017). This field plays an important role in submarine and anti-submarine warfare but, because of the special properties of the sea, is profoundly different to other areas of EW. Therefore, an analysis of Russia's hydro-acoustic EW capabilities is omitted from this report. In addition, non-acoustic EW systems fitted on board submarines, such as radar warning receivers and electronic intelligence (ELINT) capabilities, are also omitted.

1.3 Sources and Disposition

The report is based on primary and secondary sources. The sources used are articles in the Russian Ministry of Defence (MoD) journal of military theory *Voennaia mysl*, news articles mainly from Russian newspapers and magazines, and news articles as well as other information found on the Russian MoD webpage. The most important source of information on the contemporary state of Russian EW capabilities is, however, *Thematic Digest: EW in the Russian Armed Forces*,[2] which has been published annually by the Russian publishing company *Informatsionnyi most* since 2013. This consists mainly of articles written by people within the Russian military EW organization or closely linked to it, such as representatives of the EW industry. These articles provide valuable perspectives from within the Russian EW community, and are probably intended for that audience. Some articles are summaries of progress in the past year, written by the commanding officer or a company Chief Executive Officer. Claims regarding the excellence of the author's unit or company should therefore be treated with caution. Other features, such as presentations on an organization's role and function, are less problematic. Although these are primary sources and readily available on the company's website, these articles are largely overlooked by analysts studying Russian military EW capabilities.

[2] *Tematicheskii Sbornik: Radioelektronnaia borba v vooruzhennych silakh Rossiiskoi Federatsii.*

Chapter 2 analyses the newly updated Russian definition of EW as a starting point to provide historical context. Chapter 3 outlines the current organization of EW and provides an exposition of the new types of EW equipment procured in the period 2008–2018. Chapter 4 examines the trends in Russian EW development, including trends in the organization of EW Troops, industrial policy, EW exercises and technology. A brief discussion of the most important findings is provided at the end of each chapter. Chapter 5 presents the overall conclusions of the study.

1.4 A Note on Terminology

English-language terminology and abbreviations are predominantly used in cases where Russian and English terminology are roughly identical in meaning. The main term used for this study, electronic warfare, is a case in point. The Russian equivalent term, which has been used since the 1970s, is *Radioelektronnaia borba* (REB). Technology is an area where English and Russian terminology is often very similar. For example, using the English term electromagnetic spectrum, and its abbreviation (EMS), is unproblematic. In some cases, however, the Russian terminology and abbreviations are well established or denote something particular to Russia, such as a company name or a special trait of EW that does not have an equivalent in the Western EW tradition. Examples include Russian company names such as Concern Radio-Electronic Technologies (usually abbreviated KRET) or the distinct Russian EW discipline "comprehensive technical control" (KTK).

2 Electronic Warfare in Russia

This section examines Russia's current definition of military electronic warfare (EW). The fact that the Russian definition of military EW has been updated recently makes an examination of the definition and related terminology especially valuable. A comparable study of this new definition has, to my knowledge, not yet been carried out. In order to provide context for the new definition, older Soviet and Russian analogue definitions and terminology are briefly reviewed.

2.1 The Soviet definition of Electronic Warfare

The first specialized EW units were formed during World War II and, structurally, EW has been part of the Soviet armed forces ever since. However, according to histories often referred to by Russian EW representatives, the EW legacy goes further back, to the Russo-Japanese war of 1904–05. During the Japanese blockade of Port Arthur in April 1904, Russian forces were able to prevent the Japanese from providing radio artillery correction for their battleships (Kolesov & Nasenkov 2015). In commemoration, Russian EW troops celebrate "Electronic Warfare Specialist Day" (*Den spetsialista REB*) on 15 April.

Early definitions

The modern Russian equivalent of EW, *Radioelektronnaia borba* (REB), was not the only name used for electronic warfare in Soviet times. Depending on the current tasks and defined by the technical possibilities of the time, the Soviet EW capability had at least three different names after 1945 as the scope of Soviet EW expanded and the technology developed.

An article in the Ministry of Defence Journal of military theory, *Voennaia mysl*, written by EW Colonel Mikhail Liubin, outlines how the Soviet EW capability evolved between 1945 and 1991 (Liubin 2009). According to Liubin, in the 1940-50s, EW within the Red Army was simply known as Radio Countermeasures (*Radioprotivodeistvie*, RPD). As the term suggests, it was mainly about suppressing an adversary's radio communications and not much more. In the early 1960s, the term was changed to Combating Enemy Radioelectronic Equipment (*Borba s radioelektronnymi sredstvami protivnika*, BRESP). This change was very much led by the increased use of radar, so that electronic countermeasures were not restricted to radio communications. Nonetheless, the main focus was still on offensive capabilities, such as degrading radio communications or reducing the effectiveness of enemy weapon systems. In the late 1960s the contemporary term, REB, began to be used, introducing the novel idea that EW was a two-pronged struggle, involving both offensive and defensive capabilities (Liubin 2009).

The Soviet definition of electronic warfare in the 1980s

While the term electronic warfare has been used since the early 1970s, its meaning and content have continued to evolve, for reasons mostly linked to technological advances. This can be shown by comparing Soviet EW of 1980s–1990s with the definition of EW used in Russia today. The Soviet definitions studied here are those published in the Soviet *Military Encyclopaedia*, which is probably the most valuable official source from that time, as well as the most readily available. According to the *Military Encyclopaedia* in 1984:

> **Electronic warfare** is a set of measures taken in order to identify and subsequently use radioelectronic suppression on adversarial radioelectronic equipment and systems, and in order to protect own forces' radioelectronic equipment and systems (Military Encyclopaedia 1984: 615).

Soviet EW was at this time divided into offensive and defensive EW measures: "radioelectronic suppression" (*Radioelektronnoe podavlenie*) and "radioelectronic protection" (*Radioelektronnaia zashchita*). The process of detecting and locating a target was not omitted from the definition, but rather treated as inseparable from offensive and defensive EW measures. According to the definition, both enemy objects for EW targeting and Soviet assets in need of protection were "radioelectronic equipment and systems". By 1990, the EW definition in the Soviet *Naval Dictionary* had undergone some, mostly cosmetic, changes.

> **Electronic warfare** is an aggregate of measures and actions—interrelated in time and by target and tasks—taken by troops (forces) to detect enemy radioelectronic equipment and systems and ensure their subsequent destruction (using any type of weapon), elimination (take out of combat) or radioelectronic suppression, as well as the radioelectronic protection of forces' own radioelectronic equipment and systems; [electronic warfare] is a combat support function (Naval Dictionary 1990: 357).

There are very few differences in substance to be found between these two definitions. The main difference is that the latter puts more emphasis on EW's role as being one of combat support. As such, EW could, for example, suppress enemy communications to support combat operations, but its role in the destruction or elimination of enemy targets by other means would be limited to providing targeting and identification. This, however, is not excluded in the earlier definition, even if it is not explicitly stated. The basic provisions—the division into the two categories of radio electronic suppression and radio electronic protection, and that EW both targets and protects radio electronic equipment and systems—are alike. The EW definition found in the military encyclopaedia currently available on the Russian MoD homepage is principally the same as the one found in the Naval Dictionary of 1990. The only difference is an additional sentence, which states that "Radioelectronic and Informational Support Measures" are seen as a third component of EW. In the absence of a

comprehensive modernization of the Russian definition of EW, this addition was probably a way to update the definition, possibly inspired in part by the English-language tradition.

2.2 The Modern Russian Definition of Electronic Warfare

A large number of EW statutory documents have been revised since 2010, among them a document containing updated definitions and terminology in the field of EW (Doskalov 2013: 372). The document, *Radioelektronnaia borba: Terminy i opredeleniia* (Electronic warfare: Terms and definitions), was put together in agreement with the Russian technical standards body, Gosstandart Rossii (GOST R), which gives it authority and obliges both the Russian Armed Forces and the armaments industry to comply with it. The document is not publicly available, but has been summarized in an article from 2017 written by two colonels active within the EW troops and at the Electronic Warfare Division in the Air Force Academy in Voronezh (Guzenko & Moraresku 2017: 14–16). The article provides the following brief definition of EW, which in form and style follows its Soviet antecedents.

> **Electronic warfare** is a set of coordinated activities and actions encompassing radioelectronic attack on adversarial radioelectronic and information-technical objects, radioelectronic protection of radioelectronic and information-technical objects, countermeasures against technical reconnaissance and radioelectronic information support measures.

This definition differs from the earlier Soviet and Russian definitions in a number of respects. The first and most apparent difference is that it is divided into four areas, rather than the usual two, the additional two being countermeasures against technical reconnaissance and information, and radioelectronic information support measures. Second, the offensive side of traditional Soviet and Russian EW, "electronic suppression" (*radioelektronnoe podavlenie*), is replaced by electronic attack (*radioelektronnoe porazhenie*). In this way, the diversity of offensive EW weaponry has been broadened to include means capable of destroying electronic equipment. Correspondingly, the range of protective measures included in radioelectronic protection has also broadened. Third, by replacing the previous "radioelectronic equipment and systems" with "radioelectronic and information-technical objects", the types of enemy targets that can be subject to EW measures, as well as friendly systems in need of EW protection, have also been expanded. The targets of EW are thus not limited to equipment and systems directly active in the electromagnetic spectrum (EMS), such as radiocommunications equipment, radar, electro-optical sensors, and so on. Underlying systems such as computers, data storage and energy supply systems now also constitute viable targets for EW measures.

Components of modern Russian electronic warfare

In their article, Guzenko and Moraresku provide a basic overview of the content of the new definition and the relationship between its four subdivisions. This is probably inspired by the modern English-language definition of EW, which is usually segmented into the three subdivisions of Electronic Attack, Electronic Protection and Electronic Support Measures (Kolesov & Nasenkov 2015:17). This overview is shown in a somewhat summarized form in figure 1. The content and meaning of these four subdivisions of modern Russian EW are further discussed below. Even if the article does not provide any explanation of these terms, all four are used more or less consistently in the Russian EW literature.

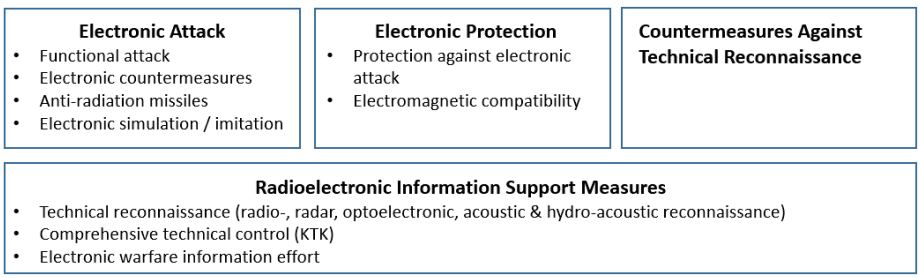


Figure 1: The modern Russian EW definition with its four subdivisions.
Source: Guzenko & Moraresku (2017).

2.2.1 Electronic Attack

As noted above, one major change in the new Russian EW definition is the inclusion of destructive EW weaponry, leading to a change of name for the offensive subdivision of EW from "electronic suppression" to "electronic attack". Nonetheless, the two basic and traditional tasks of Soviet and Russian offensive EW measures remain unchanged—to degrade the adversary's command and control, and reduce the effectiveness of its weapon systems. These tasks are carried out essentially through four different methods.

Functional attack

The first method, "functional attack" (*funktsionalnoe porazhenie*, FP), is a new term that describes EW weaponry that is able not only to suppress but also to destroy electronics. According to a number of different sources, such as a newly published dictionary on information security, this notion includes two main types of capabilities (Krylov et al. 2017: 126–127). The first is directed-energy weapons (DEW) such as laser or high-powered microwave (HPM) weapons. Because these use the EMS, this is a logical extension of traditional EW capabilities. The second capability concerns computer network operations. While this side of FP is often mentioned in the contemporary Russian EW literature, it

is rarely elaborated on. One exception is a 2016 article on "The role of EW in waging information war", written by Vladimir Ageikin, a senior researcher at the 46th Central Scientific Research Institute (46th TsNII) in Moscow. Ageikin stresses that Russian EW could significantly broaden its capabilities by introducing new ones able to execute software-based "functional attacks", such as virus attacks, on "radioelectronic objects". These objects should be understood as civil and military command infrastructure as well as military command and control systems (Ageikin 2016: 40). His article does not elaborate on what is meant by "civil and military command infrastructure" but, according to an article by two Russian EW colonels, serving at the EW Troops Directorate (General Staff) and VUNTs in Voronezh, attacking an adversary's defence industry is among the tasks of EW Troops and is included in the definition of "civil and military command structure" (Lakhin & Korobeinikov 2016). Hence, this definition would include computer network attacks against objects that are not limited to military targets.

Electronic countermeasures

The second area, electronic countermeasures, is probably the one most associated with the notion of electronic warfare. It includes both active and passive measures and covers, for example, suppressing enemy radio communications or radar. Even though destructive DEWs have been included in the EW definition, modern iterations of traditional jamming will probably continue to be the most essential offensive EW measure.

Anti-radiation missiles

The third area is the use of anti-radiation missiles. These were not previously considered EW weapons, which caused debate and frustration within the Russian EW community (Liubin 2009: 66–68). However, as shown in figure 2, anti-radiation missiles have now seemingly been included in the new definition. However, this should not be interpreted as a sudden win for the Russian EW community in a long-running debate. Nor does it represent a radical shift in how anti-radiation missiles are being used in the Russian Armed Forces. Rather, it reflects a change of view about the importance of the EMS—that it is a war fighting arena in itself where all military means that use the EMS are in need of coordination in order to work efficiently. Tactics and the use of anti-radiation missiles, and especially defence against them, have also been discussed more frequently of late in the Russian military EW literature (see e.g. Liubin 2009 and Zelenkov & Shevchuk 2016).

Electronic simulation and imitation

The fourth and final area of electronic attack is electronic simulation and the creation of a false electromagnetic environment (*Imitatsiia (sozdanie lozhnoi) radioelektronnoi obstanovki*). Radar jamming and deception are traditionally

linked to, or equated with, electronic countermeasures, but the fact that electronic imitation is given greater importance here may imply that imitative electronic deception will come to play a more prominent role in Russian EW tactics. Technical developments in the field of Digital Radio Frequency Memory,[3] and in EW command and control systems have enhanced the possibility not only of jamming single enemy radars, but also of creating a false, coherent electronic environment.

2.2.2 Electronic Protection

Electronic protection is often described as measures taken to ensure the functionality of radioelectronic equipment in a jammed environment (Kolesov & Nasenkov 2015: 17). In the Russian EW literature, two types of measures to ensure electronic protection are often discussed: electronic hardening and ensuring electromagnetic compatibility.

Electronic hardening

Electronic hardening is about increasing the resilience of electronics to different kinds of electromagnetic radiation. This is largely carried out by the MoD research institutes and laboratories connected to the EW Troops, in coordination with the EW industry (Bagramov & Shelamov 2014). Radioelectronic protection largely mirrors radioelectronic attack. The development of new types of destructive offensive EW weaponry has therefore led to a corresponding expansion of protective measures.

Electromagnetic compatibility

Ensuring electromagnetic compatibility is about reducing or eliminating harmful interference caused by a unit's own electronic equipment. This is becoming increasingly important due to the general increase in the use of electronics in military equipment (Krylov et al. 2017: 38 & 132). Operational planning and coordination between different types of systems that use the EMS is crucial in order to sustain electromagnetic compatibility.

2.2.3 Countermeasures against Technical Reconnaissance

Countermeasures against technical reconnaissance means (*protivodeistvie tekhnicheskim sredstvam razvedki*, PD TSR) have clearly been given enhanced importance in the new EW definition. Protecting troops or military objects against foreign technical reconnaissance has been a task of Soviet and Russian EW since at least the 1960s (Nepliuev 2014). The main way of providing such

[3] An electronic method of prompt reconstruction and alteration of an incoming electronic signal before its retransmission.

protection has been through self-monitoring, primarily in the EMS, to identify unintentional emissions that could reveal the location of a military object. This particular discipline of Soviet EW is known as *kompleksny tekhnicheskii kontrol* (KTK),[4] which can be translated as "comprehensive technical control".

Defining PD TSR as a subdivision has clearly elevated the status of countering foreign technical reconnaissance. The means of accomplishing this are not limited to self-monitoring through KTK capabilities, but also extend to the use of preventive measures and suppression. The fact that these means include both technical measures and organizational arrangements, and that it is about "safeguarding information about troops and their activities, military equipment and facilities" as well as "special protection of radioelectronic and information-technical objects", supports this hypothesis (Guzenko & Moraresku 2017: 16). The latter is about using technical solutions for the protection of objects and premises (buildings, structures, etc.) that contain confidential information (Krylov et al. 2017: 74). In this way, this notion also includes elements of information assurance.

2.2.4 Radioelectronic Information Support Measures

The subdivision Radioelectronic Information Support Measures enables the other three. For example, in order to be able to suppress radio communications or deploy countermeasures against an incoming missile, it is essential first to detect the radio signal or the missile homing in. This kind of electronic reconnaissance was simply assumed in Soviet definitions of EW. However, in the new Russian definition reconnaissance and awareness in the EMS are given their own subdivision, which much resembles the English-language tradition. It is suggested that Radioelectronic Information Support Measures consist of "a set of measures for identifying and controlling the functionality of radioelectronic objects as well as collection, analysing and generalization of data from the electronic environment in order to conduct electronic attack or signal Intelligence" (Krylov et al. 2017).

Comprehensive Technical Control

A traditional Russian and Soviet area of Radioelectronic Information Support Measures is KTK. As noted above, KTK is mainly emissions monitoring and control, and is an important component of reducing the effectiveness of foreign technical reconnaissance and targeting. It is important to bear in mind that KTK involves monitoring not just the EMS, but also a variety of other sources capable of disclosing information about the whereabouts of troops, military objects, and so on. These, for example, include acoustic, hydroacoustic, thermal and chemical

[4] The Russian abbreviation KTK (*kompleksny tekhnicheskii kontrol*) is well established and is used throughout this report.

attributes (Krylov et al. 2017: 165). The first KTK units were established in the 1970s within the Strategic Rocket Forces, but there are also KTK units protecting Moscow's anti-ballistic missile (ABM) facilities and other military objects of strategic importance. Some test sites, cosmodromes and exercise ranges also enjoy KTK protection.

Electronic warfare information effort

The "EW command organs information effort" (*informatsionnaia rabota organov upravleniia*, REB) essentially concerns the processing and systematization of the information needed as input data for Radar Warning Receivers (RWR), thereby enabling them to efficiently detect, and possibly identify, an electromagnetic emitting source (Razinkov et al. 2015).

2.3 Chapter Discussion

The above analysis presents a picture of a thorough transformation and expansion of the role of EW in the Russian Armed Forces. The role of EW is now much wider and introduces a broader set of means, including the use of anti-radiation missiles, DEW and cyber-capabilities, into the EW domain. This is highly significant for the status of EW measures in an operational context, as contemporary Russian EW possesses capabilities not only to temporarily suppress an adversary's electronic system, but also to inflict permanent damage. Of equal importance is the expansion of the types of target that are subject to EW measures. The former emphasis on targeting only the antennae and sensors of radioelectronic equipment has been extended to include the targeting of electronics not intended to interact with the electromagnetic environment, such as computers, data storage and energy supply systems. Another intriguing novelty is the elevated importance of "countermeasures against technical reconnaissance", which essentially cover a variety of EW means that, for example, include countermeasures against space-based reconnaissance assets or information assurance.

Based on the new definition, a number of aspects need to be taken into consideration prior to drawing conclusions regarding Russian EW capabilities. First, its adoption is probably first and foremost a modernization of the definition itself to cover already adopted tasks. Second, future-proofing, which does not exclude the possibility of unanticipated future tasks and technologies, may also have been an objective in devising the new definition. Thus, analysing the new definition does not reveal whether a certain capability is in the making or has already been created and implemented. Third, it is important to separate the definition of Russian EW and Russian EW assets from how EW capabilities are organized within the Russian Armed Forces. For example, the inclusion of anti-radiation missiles in the EW domain merely indicates that this type of weaponry is included in the operational thinking, the development of tactics and education

on EW. The physical control of these assets is another story, which is analysed and discussed further in chapter 3.

3 Electronic Warfare Troops

Obtaining an accurate overview of how Russian EW is organized can be very difficult. EW assets—that is, military EW systems and EW units—are dispersed throughout the military organization and often intertwined with other military capabilities. Equating the Russian military EW inventory with the organizational delineations of Russia's EW Troops is problematic for two reasons. First, many EW capabilities, such as aircraft self-protection systems (SPS), are highly automated electronic subsystems that are not handled by EW specialists. In addition, the EW Troops are not in physical control of the majority of the Russian Armed Forces' EW units (or its equipment), as they are most often subordinate to a Military District (MD) or a lower level formation within the MD. Second, there are EW units and functions that do not directly handle EW equipment, typically command units or educational facilities.

Thus, an overview of EW organization in the Russian Armed Forces might appear intricate and somewhat confusing and the following exposition of modern Russian EW equipment could be challenging to digest. Nonetheless, how EW assets are distributed, both qualitatively and quantitatively, is crucial to an overall assessment of Russia's contemporary EW capabilities. However, those readers unwilling to delve further into these topics might be advised to skip to the chapter summary (section 3.3).

This chapter treats EW organization and EW equipment separately. The distribution of EW units, and the various types of EW units, are discussed in section 3.1. The types of EW equipment, new or modernized, that have been procured in the period 2008–2018 are discussed in section 3.2. Section 3.3 highlights the most significant contemporary traits of Russian EW organization and EW equipment.

The formation of the EW Troops in 2009

Russian military EW has undergone substantial change over the past ten years. This was largely initiated in 2009 when the EW Troops was formed (*Izvestiia* 2009).[5] This increased the status of Russian EW, which is now on the same level as other combat support arms such as the Military Engineers or the Signal Troops. In Russian military operations theory, the change meant that the status of EW increased from a combat support element to a combat support arm (Donskov et al. 2015). The immediate and probably single most important result of this was the formation of a headquarters for the EW commander within the General

[5] Prior to the formation of the EW Troops in 2009, the highest coordinating body for Russian EW was the "General Staff EW Directorate" (*Upravlenie REB GSh*). Further back, in the late 1980s, EW was the responsibility of the "General Staff Main Directorate for automated command and control systems and EW" (*Glavnoe Upravlenie ASU I REB GSh)*, which implies an even more divided focus on EW (Informatsionnyi Most 2017: 6–7).

Staff.[6] Since 2009, this enlarged EW command structure has been essential for the general development of Russian EW forces. It has enhanced coordination within the EW domain, provided better means of integration with other force structures and facilitated the comprehensive rearmament programme. In a recently published book on Russian EW, edited by a former general director of the leading EW company, Concern Radio-electronic Technologies (*Kontsern Radioelektronnye tekhnologii,* KRET), this change is described as the most significant organizational change in Soviet and Russian EW since the creation of the first permanent EW units during World War II (Kolesov & Nasenkov 2015: 101–102). Forming the EW Troops, however, was only the starting point in a wide-ranging reform of Russian EW. Since 2009, new EW units have been formed, a large number of new EW systems have been procured, and new roles and tasks have been given to the EW Troops. Taken together, these form the "new look" of Russian EW capabilities which has been enthusiastically propagated by members of the Russian EW community.

Military electronic warfare assets

Figure 2 shows that Russian military EW capabilities come in a variety of forms. In Russian terminology, military assets are *voennye sily i sredstva*, or "military forces and means", a two-sided notion that includes both units and equipment (Toropin 2012: 51). To think of EW capabilities as military assets is therefore a good starting point in order to grasp the reach and duties of Russia's EW Troops.

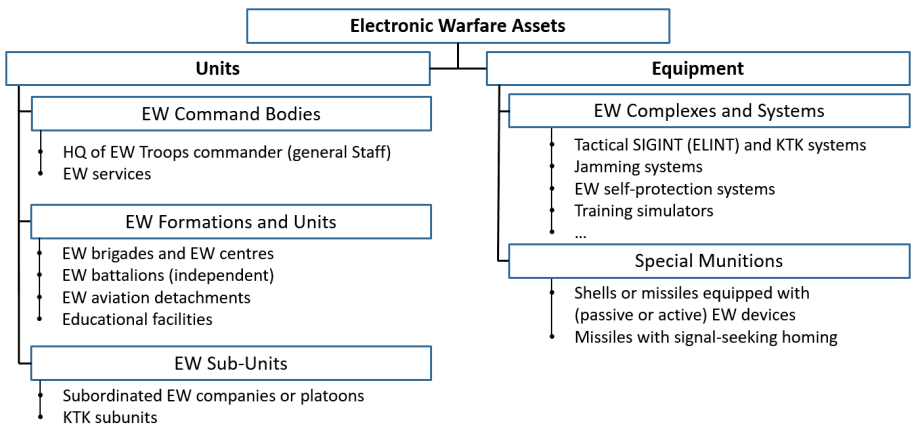


Figure 2: Examples of types of EW assets in the Russian Armed Forces.

As figure 2 shows, manned EW assets include independent units, subordinate units and command bodies (EW services) dispersed throughout the Russian Armed Forces. The types of EW equipment are plentiful and only a few

[6] *Upravlenie nachalnika voisk radioelektronnoi borby* (UNV REB).

examples are provided in the figure. These are discussed in further detail below, but a fundamental categorization is to separate EW systems from the EW capabilities of special munitions.

3.1 The Organization of Electronic Warfare

According to both a former and the current EW commander, military EW assets are roughly divided into three main organizational structures (Doskalov 2013; *Krasnaia zvezda* 2017):

1. EW assets of military districts, formations and units of the armed forces' services and arms.
2. EW assets in the single KTK system.
3. EW assets of the strategic radio jamming system.

The first structure covers EW assets usually associated with EW capabilities, for example, the independent EW brigades of the Ground Forces, the EW companies of the Airborne Troops, EW systems on board combat ships or aircraft, and so on. Above all, EW assets in this structure provide EW combat support to military units at the tactical or operational level. These units are discussed in detail below and summarized in map 1.

The second covers the system of KTK units that constitute a parallel organizational structure within the EW Troops. KTK units traditionally have two main tasks. The first is Emissions Control (EMCON), which is the management of electromagnetic emissions to ensure that no accidental use of electronics discloses the whereabouts of troops or military objects. The second is ensuring electromagnetic compatibility, in order to avoid situations where one electronic system causes interference, and thereby degrades the efficiency of, another electronic system. These tasks are carried out during exercises and military operations, often in coordination with camouflage measures taken by military engineers or chemical, biological, radiological and nuclear defence units, but also administratively as a peacetime control in order to reduce the signature of Russian units and military objects. A new role for KTK units is that of Information assurance, which is carried out together with the Service for Protecting State Secrets (*Sluzhba zashchity gosudarstvennoi tainy*). This involves measures to address the increased use of civil electronic devices, such as smartphones, as military objects (Stupkin 2018). Unlike the EW assets that belong within the first structure, the KTK units are organizationally divided into centres, nodes and groups, and thereby resemble the organizational structure of the Signals Troops (MoD 2017o). Since the 1970s, Soviet and Russian KTK

units have mainly been part of the Strategic Rocket Forces and the Space Troops.[7]

The third structure in which EW assets can be found is the Strategic Radio Jamming System (*Strategicheskaia sistema radiopomekh*). Exactly what this structure consists of is not clear, but in the Soviet Union the coordination of Red Army EW assets and the technical *Osnaz* units of the Main Intelligence Directorate (GRU) was designated the Strategic Radio jamming System (Gorbachov 2014). One of the new Russian EW systems that has attracted a great deal of attention is the *Murmansk-BN* "Strategic jamming complex",[8] which is intended to suppress the use of high-frequency radio communications across large areas (see 3.2.1). This new complex could be part of the strategic radio jamming system, but not its only component, as it is described as a structure that does not just consist of military EW assets (VPK 2017). The Strategic Radio Jamming System also existed prior to the procurement of the *Murmansk-BN* complex (Doskalov 2013), and therefore probably still constitutes the main means of coordinating strategic technical intelligence (SIGINT) and military EW.

Russian categorization of EW ground units

Irrespective of branch of service, many of the EW units are ground-based, which means that their equipment is either man-portable or fitted on to a wheeled or tracked vehicle. This is also true of the independent EW centres in the Russian Navy and the independent EW battalions of the Aerospace Forces. EW capabilities mounted on flying drones are found primarily in the Navy and the Ground Forces inventory—and not, as might be expected, in the Aerospace Forces. Thus, the kind of vehicle the EW equipment is mounted on cannot be equated with the three basic branches of service. A commonly used categorization in contemporary Russian EW terminology is to separate ground-based EW units, which have the greatest variety of EW complexes, based on the types of target they engage. The following five categories are the ones most used today:[9]

REB-N	EW combating ground-based systems (*REB s nazemnymi sredstvami*)
REB-S	EW combating airborne systems (*REB s samoletnymi sredstvami*)

[7] Since 2015, Space Troops have been part of the Aerospace Forces.

[8] The word "complex" is used in this report for a piece of EW equipment that consists of several systems. For example, the *Murmansk-BN* complex mentioned here consists of seven vehicles, four of which are used for the antenna while another is the command and control vehicle.

[9] The use of these abbreviations to denote a particular type of EW unit is found throughout the recent Russian EW literature. See for example Lokutov (2017) or Nezhivykh & Nogin (2016).

REB-K	EW combating space-based systems (*REB s kosmicheskimi sredstvami*)
REB-Atd	EW combating terrorist activities (*REB antiterroristicheski deiatelnosti*)
KTK	Comprehensive technical control (*Kompleksnyi tekhnicheskii kontrol*)

3.1.1 The EW Troops Headquarters and the EW Command Structure

At the top of the EW Troops is its headquarters, located within the General Staff in Moscow. With the creation of the EW Troops, EW Services, which are the EW command bodies found throughout the military organization, acquired a more central role. For example, EW matters in the Ground Forces were previously not a domain in their own right, but instead handled as part of the Ground Forces reconnaissance units. This changed with the reinstatement of the EW service in the Ground Forces in 2013 (Kalitikin & Strelka 2014). EW Services have also recently been created in the Airborne Troops (Leonov 2015). EW Services represent the main link between EW Troops headquarters and other subordinate EW assets. Very few organizations are directly subordinated to the EW Troops. In this category are the 1084th inter-service EW training centre (TC) and the 15th independent EW brigade, both of which are located in the city of Tambov (Shepeliov 2014; Chugai 2014).

At present, the tasks of the EW commander's headquarters are carried out by at least three directorates (*napravleniia*), one department (*otdel*) and one service (*sluzhba*) (Informatsionnyi Most 2017: 12–14). The main role of the EW Troops command structure is the long-term build-up and development of military EW assets. In addition, it administers everyday matters concerning EW and the EMS that are of importance to the Russian Armed Forces. These include organizing protection against foreign technical reconnaissance, ensuring electromagnetic compatibility, and responsibility for international legal issues concerning the protection of military radioelectronic systems (MoD 2017p). The current Head of the EW Troops is a two-star general, Lieutenant General Yurii Lastochkin.

Figure 3 is an overview of where EW units and subunits are found in all the branches of the service and the independent combat arms, and of their types. The distribution of EW units is multifaceted and there is no obvious way to categorize EW assets. There are EW units at all operational levels. Some have a multitude of EW tasks while others have a highly specialized role.

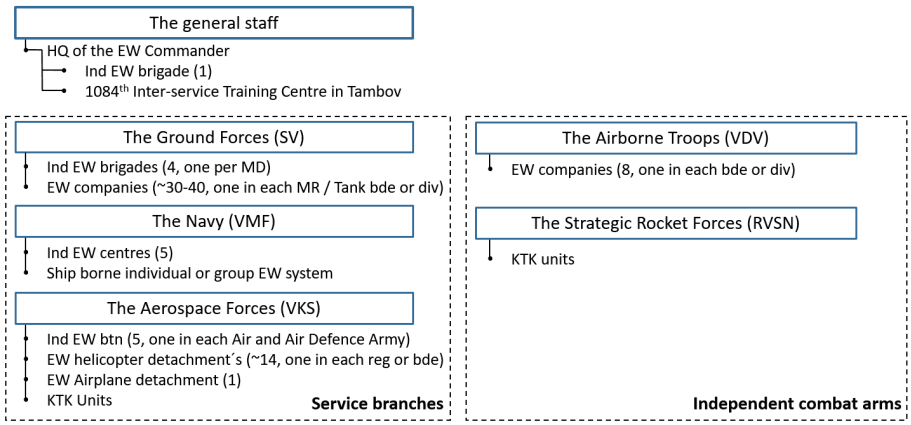


Figure 3: Overview of EW units in the Russian Armed Forces.

Manning

The overall number of soldiers serving in military EW units is relatively small, but the requirements asked of them are likely to be higher than the requirements placed on other troops. This is especially true regarding aptitude for technical skills, to enable the troops to complete EW specialist training. Despite an increase in the number of soldiers serving under contract, a substantial proportion of the soldiers serving in EW positions are conscripts (*Krasnaia zvezda* 2013; Malyshko 2018). The 1084th TC in Tambov is the main training facility for EW specialist training. In 2014, 3 600 servicemen, of whom approximately 900 were contract soldiers, underwent training at the centre (Gubskov 2015). In comparison, in 2017 approximately 2 000 conscripts were sent to the TC for four months of specialist training. Half of them entered training in the spring and the other half in the autumn (MoD 2017g & MoD 2017k). Thus, the number of conscripts has decreased in a period when new EW units, for example additional EW brigades, have been formed. This indicates an increase in the proportion of contract soldiers in the ranks of the EW units.

Conscripts are used to staff EW units in all services and arms, but the ratio of conscripts to contract soldiers varies. EW specialists serving in the Airborne Troops EW companies are more likely to be serving under a contract than those serving in the Ground Forces, and some Airborne Troops EW subunits are exclusively manned by contract soldiers (Fateyev 2018). The changes in Russian conscription policy, most notably the gradual decrease from 24 months to 12 months over the period 2006–2008, have probably had an impact on the training of EW specialists. However, according to a former EW commander, the shorter service time has been offset by more efficient training, largely because of the introduction of modern training simulators (Doskalov 2013). In a recruitment video for the 15th EW brigade in Tambov, special emphasis is put on the fact

that all the time spent serving in the brigade is used for training. Soldiers are not used as a grey labour force, and all the work that is not related to the service is outsourced (*Pochta polevaia* 2014).

The EW training and educational organization

The EW Troops headquarters plays a central role in the overall training of EW specialists and officers serving in EW units. Two organizations carry out the majority of EW training. The 1084th Inter-service EW Training Centre in Tambov is the main training centre for EW specialists, such as conscripts, professional soldiers and non-commissioned officers, as well as a small number of specialist officers and foreign servicemen. Retraining for units receiving new EW equipment is also carried out at the 1084th TC. In 2014 more than ten subunits, probably mostly at the company level, were retrained there (Gubskov 2015). EW specialists serving in the KTK structure are also trained at Tambov (Stupkin 2018). Other tasks for the TC include conducting scientific research on the tactical use of EW equipment, thereby supporting the EW industry on R&D and the modernization of EW equipment; conducting and participating in state trials of new EW equipment; and retraining EW units prior to rearmament. The TC also has a testing department (*ispytatelno-metodicheskogo otdela*, IMO), which participates in the evaluation of EW equipment that has not yet been adopted, conducts analyses of foreign EW capabilities and actively participates in the Russian scientific EW debate (Shepeliov 2014).

The Air Force Academy in Voronezh, and its fifth faculty for EW and information assurance,[10] is the main educational facility for commissioned officers, offering six main EW-related fields of study (REB-N, REB-S, REB-K, KTK and countermeasures against foreign technical reconnaissance, information warfare and EW methods). Computerized training simulators and some of the latest EW equipment are used in the teaching. Also located within the Air Force Academy is the EW scientific research test centre (*Nauchno-issledovatelskii ispytatelnyi tsentr REB*, NIITs REB). The main task of the NIITs, in close cooperation with the fifth EW and information assurance faculty, is to develop and evaluate new EW equipment (Khrolikov 2014).

Specific EW training is also carried out within other organizations, such as the Signals Troops Academy in St Petersburg (Kharchenko 2017), the Strategic Rocket Forces Academy in Balashikha (Aksenov 2017) and the Naval Academy in Petrodvorets (Malyshev et al. 2018). EW training in these organizations consists of either highly specific specialist training or supplementary courses for a small number of high-ranking EW commanders.

[10] *5 fakultet radioelektronnoi borby i informatsionnoi bezopasnosti.*

3.1.2 The Ground Forces

Five independent EW brigades were formed in the period 2009–2016. Four of these are subordinate to the Joint Strategic Commands (JSC) in each of the four MDs.[11] The fifth, the 15th EW brigade in Tambov, is directly subordinate to the General Staff and the headquarters of the EW Commander. The 15th EW brigade is sometimes referred to as a "mobile brigade", which is possibly something that distinguishes this brigade from the others (Yasinskii 2015). The brigade consists of four subordinate battalions, all with different roles and tasks (Kolesov & Nasenkov 2015: 103). The four include the REB-N, REB-S and REB-K battalions, whereas REB-Atd capabilities are of company size and subordinate to one of the battalions. REB-Atd units are found, as a minimum, in the independent EW brigades of the Eastern and Central MD (Makarchik 2015; Portnykh 2018). In the autumn of 2017, it was announced that the first company-sized unit designated for combating unmanned aerial vehicles (UAVs) had been formed within the 16th EW brigade in Kursk (MoD 2017l).

Table 1: The five independent EW brigades of the Russian Ground Forces.

Unit	Location	Line of Command	Comment
15th EW bde	Tambov	EW Troops HQ	Formed in April 2009 in the city of Tula, relocated to Tambov in 2011 (Chugai 2014 & VPK 2015c)
16th EW bde	Kursk	W MD	Brigade-sized unit since at least 2013
17th EW bde	Khabarovsk	E MD	Brigade-sized unit since at least 2011 (Portnykh 2014)
18th EW bde	Yekaterinburg	C MD	Created in September 2012 (Portnykh 2014)
19th EW bde	Kovalevka	S MD	Created 1 December 2015 (*Bmpd Livejournal* 2016)

Whereas the independent EW brigades possess a wide range of capabilities, the EW companies in the Ground Forces major combat formations have more specific tasks. They are tailored to provide EW combat support at the tactical level, such as providing overall situational awareness in the EMS, degrading enemy command and control systems, and providing protection against precision-guided munitions (PGMs) and remote-controlled improvised explosive devices (IEDs), and so on. All "New Look" (*Novyi oblik*) Motorized Rifle or Tank brigades/divisions supposedly have an EW company in their organization. This is a major change in comparison with the division system where it is probable that there was no EW capability at the regiment level, but an EW battalion was directly subordinate to the division (Kolesov & Nasenkov 2015: 103). According to Norberg & Westerlund, in 2016 there were approximately 40

[11] There is no independent EW brigade subordinate to the JSC of the Northern Fleet.

major combat formations within Russian Ground Forces (Norberg & Westerlund 2016: 28). There may also be some tactical SIGINT capabilities within the reconnaissance subunits of the Ground Forces formations (*Krasnaia zvezda* 2012). In addition to the EW assets within the Ground Forces, there are another four formations if Russian military bases abroad are included.[12] Of these, at least the 7th Military Base in Abkhazia and the 102nd Military Base in Armenia have EW capabilities (MoD 2015b & MoD 2017h).

3.1.3 The Navy

The main ground-based EW units within the Russian Navy are the independent EW centres, which were formed in 2009 out of the fleet's existing EW regiments. This reorganization was probably more a result of an ongoing general reorganization than an immediate effect of the creation of the EW Troops in 2009 (Kolesov & Nasenkov 2015: 177). There is one EW centre in each of the four fleets, apart from the Pacific Fleet which has two. The Caspian Flotilla does not possess an EW centre but has subordinate KTK units (Mazov & Lankin 2014). An EW centre consists of at least two EW battalions and possibly one independent EW Company. According to an article in the Russian military journal, *Krasnaia zvezda*, the first battalion carries out strategic tasks, while the second is responsible for tactical tasks (*Krasnaia zvezda* 2015). The Navy's ground formations, found in the newly formed Army corps, also have EW companies in their organization (MoD 2015a).

Table 2: The five independent EW centres of the Russian Navy.

Unit	Location	Subordination	Source
186th Ind EW Centre	Severomorsk	Northern Fleet	(Oreshkin 2014)
471st Ind EW Centre	Petropavlovsk-Kamchatskii	Pacific Fleet	(*Krasnaia zvezda* 2017)
474th Ind EW Centre	Shtykovo	Pacific Fleet	(Chichikailo 2017)
475th Ind EW Centre	Sevastopol	Black Sea Fleet	(*Telekanal Zvezda* 2016b)
841st Ind EW Centre	Yantarnii	Baltic Fleet	(*Voennoe obozrenie* 2012b)

The Russian Navy has EW assets on board ships and submarines. However, although the Russian definition of EW includes hydro-acoustics, submarine warfare using sonar is not covered in this report. Depending on the class of vessel and whether an individual ship has been modernized, the EW capability

[12]The 4th Military base in Tskhinvali (South Ossetia), the 7th Military Base in Gudauta (Abkhazia), the 102nd Military Base in Gyumri (Armenia) and the 201st Military Base at Dushanbe (Tajikistan).

on board probably varies. All Russian naval ships are likely to have some kind of Radar Warning Receiver (RWR) and EW countermeasures capability, but their level of modernity and performance and the degree to which the EW system also provides group protection vary greatly. There are no designated EW ships in the Russian Navy. There are however intelligence collection ships, such as the *Yurii Ivanov* class (project 18280), but these are not regarded as EW assets.

3.1.4 The Aerospace Forces

There are a number of different kinds of EW assets in the Aerospace Forces (VKS). First, there are independent EW battalions in at least four of the five Air and Air Defence armies (AADA) of the VKS (see e.g. Vovk 2014 or Krotov 2017). These are probably similar to the REB-S battalions in the Ground Forces' independent EW brigades. The battalions are probably highly integrated with the AADA's Air Defence Divisions, whereas the independent EW brigades REB-S EW battalions are probably adapted to work with the Ground Forces' Air Defence brigades.

Table 3: Independent EW battalions (REB-S) of the Air and Air Defence Armies. Note: NN = unknown ordinal.

Unit	Location	Subordination	Source	Comment
328th ind EW Btn	Pesochnyi	6th AADA (W MD)	(Gusarov & Ageyev 2018)	Possibly partly located in Kronstadt
2226th ind EW Btn	Engels	14th AADA (C MD)	(Balzhinimaev 2018)	
541st ind EW Btn	Artem	11th AADA (E MD)	(Krotov 2017)	Close to Vladivostok
504th ind EW Btn	Novomi-khailovskii	4th AADA (S MD)	(Malyshko 2018)	Close to Tuapse
NN ind EW Btn		45th AADA (Northern Fleet)		The unit's existence is assumed

EW helicopters are found within the Army Aviation structure, and helicopters are still seen as important carriers of EW capabilities. According to the then acting commander of the Aerospace Forces, General Colonel Viktor Bondarev, there will eventually be an Army Aviation brigade in every Military District and one helicopter regiment will be set up for every Ground Forces combined arms army (*Rossiiskaia gazeta* 2014). Since this statement was made in 2014, a number of organizational changes have been made that fit well with this ambition (see e.g. MoD 2017n). All these Army Aviation regiments and brigades will have an EW detachment (*Otriad REB*) (Denisentsev 2017).

Russian Armed Forces EW aircraft are subordinate to the 117th Transport Aviation Regiment in Orenburg (Revenko & Grigorenko 2017). In 2009, the

regiment was reorganized into the 6956th Aviation Base, but the 117th Transport Aviation Regiment was reinstated in 2014 (*Izvestiia* 2017).

Other objects of strategic importance have also enjoyed the protection of KTK units. The Aerospace Forces 9th Missile Defence Division located in Sofrino, north-east of Moscow, which operates the *A-135* anti-ballistic missile system, including the *Don-2N* battle managing radar, is one example. The unit has an EW service under it and a KTK structure that is supposedly one of the largest EW organizations in the Aerospace Forces, consisting of a KTK node at the division level and KTK groups at a lower level. Their main objective is to protect the division from foreign reconnaissance means and ensure its functioning in a highly contested electromagnetic environment (Chugunov 2015). A similar KTK unit is subordinated to the 1st State Test Cosmodrome located in Plesetsk, which is also part of the Aerospace Forces (Chugunov 2014). In order to protect sensitive flight and weaponry tests from foreign technical reconnaissance, the 929th State Flight Test Centre, located at Akhtiubinsk, also has KTK units within its organization (Borshchev 2014).

3.1.5 The Airborne Troops

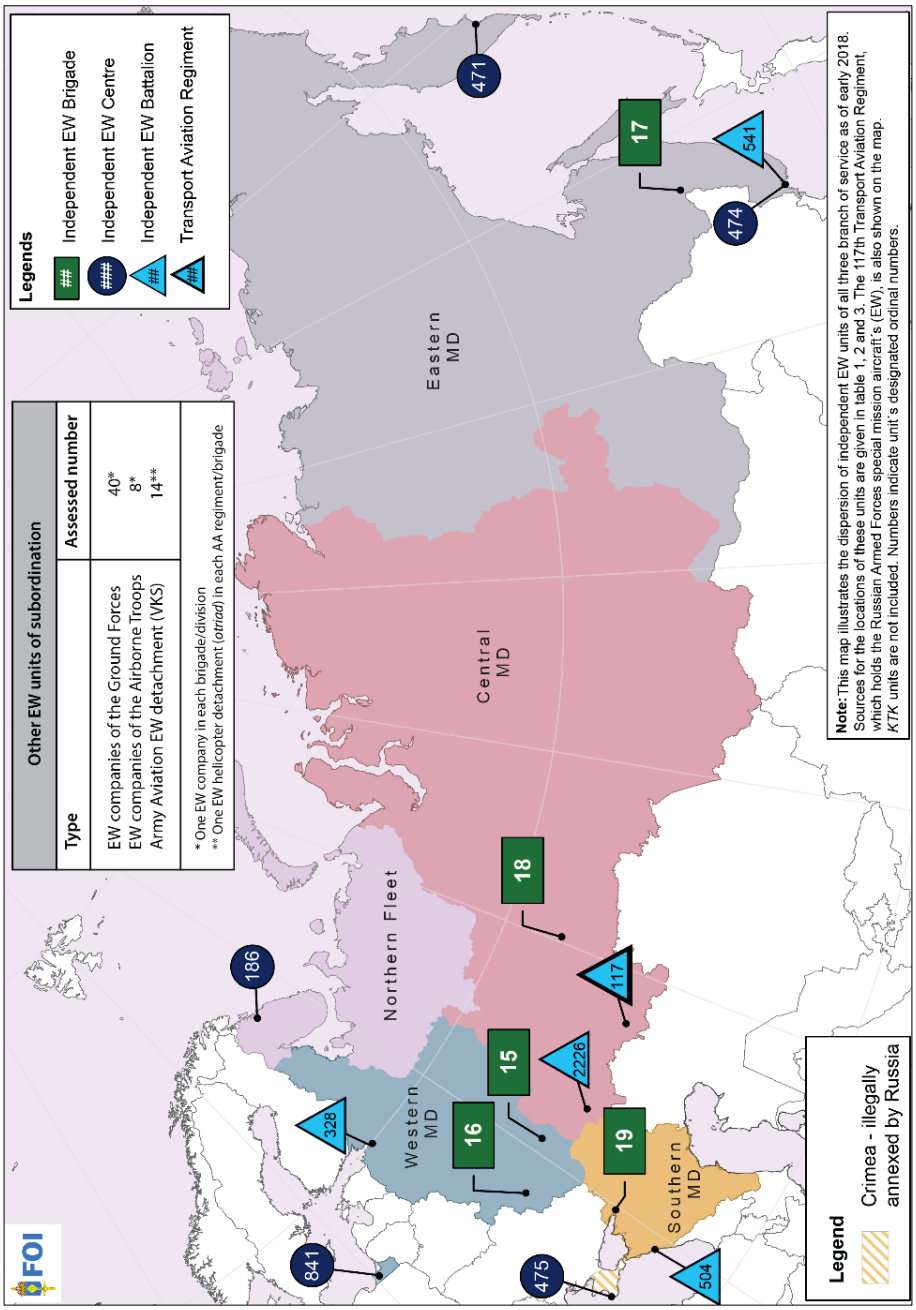
Until the end of 2016, the EW capability of each airborne formation consisted of a few independent EW platoons.[13] However, in late 2016 the individual EW platoons were reformed into an EW company and EW services were reinstated at the division and brigade levels (Leonov 2015). As the overall number of *vozdushno-desantnye voiska* (VDV, Airborne Troop) formations increased from five to eight in 2013, the number of EW subunits in the EW Troops also increased. These organizational changes followed a few years of intensive procurement. In 2015 alone, five Airborne Troops formations received new EW equipment (MoD 2015i). The Airborne Troops units have fewer large jamming systems than the Ground Forces EW companies. Instead, the emphasis is on small, or even portable, systems with predominantly tactical electronic surveillance capabilities.

3.1.6 The Strategic Rocket Forces

The EW assets of the Strategic Rocket Forces are predominantly KTK units. This capability has been in the Strategic Rocket Forces since the 1970s, and still today there are KTK units at all three levels of the organization: army, division and regiment (VPK 2017). Its principles of organization are similar to those of the

[13] Radio control, direction finding and jamming platoons (*vzvod radiokontroliia, pelengovaniia i podavleniia*, RKPP).

Signals Troops as its units and subunits are structured into centres, nodes, units and groups.



Map 1: Russian military EW units and their distribution in the military districts.

3.2 Electronic Warfare Equipment

When the EW Troops was formed in 2009 a large proportion of the existing EW systems possessed by the Russian Armed Forces had been developed and produced in Soviet times. Since 2009, an extensive rearmament programme has been initiated to radically alter the EW inventory. This section briefly describes the new Russian EW systems. The systems of interest and defined as new are either brand new or thoroughly modernized systems, the procurement of which began no later than 2009. The greater part of this section is devoted to describing which EW systems have been, or are thought to have been, procured since 2008. Details such as the frequency ranges covered by individual systems are deliberately omitted. Instead, capabilities and configurations are described. Nonetheless, this exposition of new Russian EW systems might be of most interest to specialists. Readers with a more general interest are advised to skip section 3.2. and go straight to the chapter discussion (section 3.3).

Extensive rearmament

The procurement of new EW equipment is the feature of recent Russian EW developments that has attracted by far the most attention. The EW Troops are planned to reach a 70 per cent level of technical modernity by the end of 2020, which is also the overall goal of the GPV-2020 armament programme (MoD 2017c). By mid-2013 the modernity level of EW equipment in the Russian Armed Forces had reached 35 per cent (*RIA Novosti* 2013), the EW commander stated in early 2016 that this level had risen to 45 per cent (VPK 2016) and a February 2018 statement by Defence Minister Shoigu revealed that the proportion of modern equipment in the EW Troops had reached 67 per cent. All this was made possible by the procurement of more than 600 EW complexes in the period 2013–2017 (*RIA Novosti* 2018). Other figures on the retraining of units and subunits at the TC in Tambov, prior to the delivery of new EW equipment, give a sense of how substantial this rearmament has been. In the period 2006–2017, five REB-N battalions, 34 EW companies and 20 other lower-level subunits had undergone retraining in Tambov (Sirota 2017).[14]

New types of systems

Not only have new pieces of EW equipment been procured in large numbers, but the number of different systems and complexes developed is also high. In an interview in 2014, the EW commander disclosed that 18 new EW complexes had completed state trials in the period 2010–2013, 14 of which were mentioned by name: the *Borisoglebsk-2, Alurgit, Infauna, Krasukha-2O, Krasukha-S4,*

[14] The lower-level units probably include EW units/subunits subordinated to naval EW centres, Special Forces units, Russian foreign military bases and most of the Airborne Troops subunits since Airborne Troops EW companies were first formed in 2016.

Moskva-1, Parodist, Lorandit-M, Leer-2, Leer-3, Lesochek, Less, Magnii-REB and *Pole-21* (VPK 2014a). How much detail is known about the specification and performance of these varies, but none of these complexes are completely unknown. In addition to these 14 complexes, around ten new complexes have completed state trials since 2013, or are as yet unfinished projects that are publicly known about. It is also quite possible that recently fielded EW equipment exists that is not known about for reasons of greater secrecy or because numbers are low.

Scrapping of old equipment

Despite this substantial procurement of new systems, there are good reasons to believe that not insignificant amounts of older equipment are still in the EW inventory (Korolev et al. 2016; Brazhnikov 2018). A small proportion of these older EW systems will, after modernization, probably be kept and used well into the 2020s. A large amount of old EW equipment has been dismantled and scrapped, however, or is to be scrapped in the near future. Old EW equipment is transported to and stored in Tambov prior to scrapping. This has posed a special challenge for the Eastern MD due to the distance from the Far East to Tambov. To make scrapping feasible in financial terms, old EW systems from the Eastern MD are scrapped in the Siberian city of Ulan-Ude (Brazhnikov 2018).

3.2.1 Ground-based EW Systems

Tactical EW systems for Ground Forces subunits (REB-N)

The *Borisoglebsk-2* is the latest Russian iteration of the Soviet *R-330 Mandat* complex (Kalitkin & Strelka 2014). The complex consists of a number of EW systems fitted on nine MT-LB armoured tracked vehicles, which together provide a tactical SIGINT and jamming, targeting radio, satellite communication and navigation system. It is probably the main tactical EW system of the Russian Ground Forces EW subunits, which are company-sized units in motorized rifle and tank formations (MoD 2015d).


Figure 4 & 5: A vehicle of the *Borisoglebsk-2* complex and the *R-330Zh Zhitel* system, part of the *Diabazol* complex.
Sources: mil.ru, licensed under CC BY 4.0 (left) and Vitaly Kuzmin, licensed under CC BY 3.0 (right).

As of early 2018, a large number of *Borisoglebsk-2* sets had been delivered to Ground Forces formations in all MDs (see e.g. MoD 2015b; MoD 2015j; MoD 2015a; MoD 2016a). According to the Sozvezdie corporate magazine, *Sviazist*, development of the system began as early as 2004, state trials were initiated in 2009 and serial production started in 2011. The system is mainly produced by the Sozvezdie company, *Efir*,[15] in Tambov, but some subsystems are probably produced by subcontractors. It is very much the result of a number of different R&D projects (*opytno-konstruktorskie raboty*, OKR), which have in turn resulted in other EW systems and subsystems (*Sviazist* 2009). For example, a wheeled EW complex known as *Diabazol*, produced and marketed by the scientific innovation enterprise (*nauchno-vnedrencheskoe predpriiatie*) Protek, located in Voronezh, was probably put in serial production earlier than the *Borisoglebsk-2*, but has probably been procured and delivered to the Russian Armed Forces in much smaller volumes. It is possible that the complete *Diabazol* complex is seldom procured but that parts of it are procured separately. For example, the *Altaets* and *Zhitel* systems are part of the inventory of the EW brigades' REB-S battalions, and are used for jamming an aircraft's communication and satellite navigation (GPS, Galelo, BeiDou, etc.). The *Zhitel* system attracted an extraordinary amount of attention in 2015 when it was reported by the Organization for Security and Co-operation in Europe to have been used in eastern Ukraine, supposedly to impede the use of drones by suppressing GPS signals (OSCE 2015). The *Altaets* jamming system has also been used, seemingly on its own, in exercises (MoD 2017a).

[15] NIIR "Efir".

Table 4: Systems of the Borisoglebsk-2 and Diabazol EW complexes.
Sources: Mikhailov (2014); Kolesov & Nasenkov (2015: 168); and www.protek-vm.ru.

Function	***Borisoglebsk-2* (MT-LB)**	***Diabazol* (Ural-43203)**
Command and control	R-330KMV	P-330KMA
Automated jamming system	R-378BMV	R-378UM
Automated jamming system	R-330BMV	R-330Zh *Zhitel*
Automated jamming system	R-934BMV	R-934UM *Sinitsa*
Automated jamming system	R-325BMV	*Altaets-AM*
Service & repair vehicle	ATO-40	*NA*

EW companies in the Ground Forces have also received the *Rtut-BM* system, which is described as a thoroughly modernized multifunctional ground-based jamming system (*mnogofunktsionalnyi nazemnyi stantsii pomekh*) based on the Soviet *Rtut* system. It is designed first and foremost to protect soldiers and equipment from proximity-fused artillery ammunitions by making them detonate prematurely. According to KRET, the *Rtut-BM* has been in serial production since 2011, and is able to cover and thereby protect troops in an area of up to 50 hectares for up to 6 hours (KRET 2017c). Deliveries of the *Rtut-BM* system have been taking place in parallel with the procurement of the *Borisoglebsk-2* system and probably to the same types of units—EW companies in motorized rifle and tank formations (see e.g. MoD 2016a).

Figure 6 & 7: *Rtut-BM* proximity fuse jamming system.
Source: The Swedish Defence Material Administration.

A system that has probably not yet been procured, but was shown at the *Armiia-2016* military expo, is the new mobile ground-based EW system, *Palantin*. It is produced by the United Instrument Manufacturing Corporation (*Obedinennaia priborostroitelnaia korporatsiia*, OPK) and was supposedly specifically designed to suppress communications systems working at the operational-tactical level based on Software Defined Radio (SDR) technology. The system is also described as having a "system-forming" (*sistemoobrazuiushchii*) capability in the sense that it can tie together several jamming systems to make them work more efficiently together (*Lenta* 2016). Development of the system was completed in 2016 and serial production was planned to begin in 2017 (*RIA Novosti* 2016a). The first prototype of this system was probably truck-based, but there are plans to fit the *Palantin* EW system on to the new *Kurganets-25* infantry fighting vehicle (Timofeev & Sarantsev 2015; *Lenta* 2016). This new system is probably intended for both the Ground Forces and the Airborne Troops EW companies.

Figure 8: *Kurganets-25* infantry fighting vehicle.
Source: The Swedish Defence Material Administration.

Portable and multifunctional EW systems (REB-N)

In addition to large jamming systems based on vehicles, smaller portable electronic reconnaissance and jamming systems with direction-finding capabilities have been developed, primarily to meet the needs of the Airborne Troops and reconnaissance units. There are two families of modern portable EW equipment: the *Lesochek*, developed by Sozvezdie; and the *Lorandit*, developed by the NIIDAR-SFERA company, located in Moscow.

The *Lesochek* system is a highly portable jamming system that can be carried in a backpack or installed in a truck. Deliveries to Airborne Troop formations began in early 2013, and 1 150 units had been delivered by 2015 (RVO 2016c: 23). Some deliveries of the *Lesochek* have also been made to the Ground Forces

(MoD 2015h). In addition to being able to suppress communication channels, it provides the capability to jam radio-controlled IEDs. As such, the *Lesochek* is also the basis of the IED jamming capability in the *Infauna* system, a "multifunctional electronic reconnaissance and jamming system" based on the K1Sh1 BTR-80 armoured personnel carrier. The alleged multifunctionality entails, in addition to the capability to jam radio-controlled IEDs, radio communication and optical jamming in order to protect soldiers, military equipment and objects from guided weapons equipped with video or laser homing. Development began in 2005 and ended with state trials in 2010–11 (Kolesov & Nasenkov 2015: 168). Procurement by the Russian Armed Forces has been ongoing since at least 2012, when deliveries of the systems to formations within the Airborne Troops began (MoD 2012a). Since then the *Lesochek* system has been delivered to a large number formations in the Ground Forces and the Airborne Troops. As with the *Rtut-BM* proximity-fuse jamming system, on several occasions procurement of the *Infauna* has taken place alongside deliveries of the *Borisoglebsk-2* complex (see e.g. MoD 2015k).

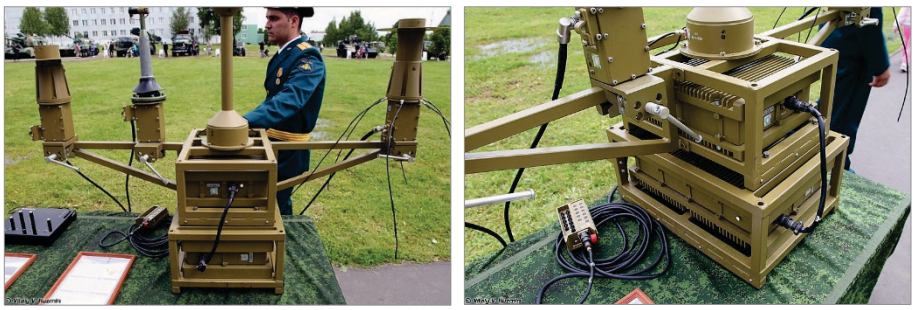


Figure 9 & 10: The portable *Lesochek* EW system from two different angles.
Source: Vitaly Kuzmin, licensed under CC BY SA 4.0.

The *Lorandit* is primarily a KTK and electronic reconnaissance system but also has jamming capabilities. As with the *Lesochek* system, it can be carried in a backpack or fitted on to a vehicle (Lobov et al. 2014). The *Lorandit* EW system is also the basis of the *Leer-2* EW system, based on a *Tigr-M* infantry mobility vehicle. The *Leer-2* is described as a mobile automated KTK, radioelectronic imitation and jamming system (*mobilnyi avtomatizirovannyi KTK, radioelektronnoi imitatsii i postanovki pomekh, MKTK REI PP*). It underwent state trials in 2011 and has been delivered regularly to Airborne Troop formations, the Navy's EW centres, the Strategic Rocket Forces and possibly Ground Forces units since late 2012 (MoD 2012b; MoD 2017e). According to the Airborne Troops commander, General Colonel Andrei Serdiukov, deliveries of a version capable of being air-dropped from aircraft, the *Lorandit-AD*, will begin in 2019 (*Telekanal Zvezda* 2017c).

Figure 11 & 12: The *Leer-2* EW system from two different angles.
Source: mil.ru, licensed under CC BY 4.0.

KTK and electronic reconnaissance systems

In addition to the *Leer-2* small hybrid KTK and jamming system, a number of other KTK and electronic reconnaissance systems have been developed and procured in recent years. The truck-based *Dziudoist* is an automated truck-based KTK system and a further development of the *Plavsk* system, which was fielded in the early 2000s (Lobov et al. 2014). The Airborne Troops started to receive *Dziudoist* complexes in 2012, and by 2013 the Strategic Rocket Forces had received eight *Dziudoist* complexes and 40 *Lorandit systems* (MoD 2012b; MoD 2013; RVO 2013).[16]

Figure 13 & 14: The *Dziudoist* (left) and *Svet-KU* (right) KTK systems.
Source: Vitaly Kuzmin, licensed under CC BY SA 4.0.

Svet is another recently developed family of KTK systems designed to monitor the EMS, and conduct automated signal analysis and direction finding on objects of interest. It is also designated to work together with similar stationary or mobile electronic reconnaissance or KTK systems. The *Svet* family comes in a number

[16] It is uncertain whether "40 *Lorandit* systems" refers to the portable system or to the Lorandit fitted on a *Tigr-M* chassis (the *Leer-2* system).

of different models. The Russian Armed Forces have had a *Svet-KU* system based on a Kamaz truck since 2012. A *Svet-KU* based on a civil Ford Transit truck was launched in 2015 (Timofeev & Sarantsev 2015 & *Voennoe obozrenie* 2015a). Finally, there is also a stationary version of the *Svet* KTK system called the *Svet-VSG* (Lobov et al. 2014).

Perhaps the most interesting new *KTK* complex is the *Less* automated mobile system. It is designed to collect and process information but also to act as a command and control system for KTK units and subunits. The system is said to be one of the main components providing information about events in the EMS to the EW situational awareness centre at the General Staff. The *Less* was one of the new EW systems that completed state trials in 2010–13. It has since been procured by the Armed Forces (see e.g. MoD 2017m).

The *Torn* mobile electronic reconnaissance system has been in the EW company inventory of at least one motorized rifle brigade in the Southern MD since 2012 (*Krasnaia zvezda* 2012). There is information that the system has been procured not by EW companies of the Ground Forces major combat formations but by their reconnaissance subunits (*Vesti* 2013). Since at least 2017 the EW training centre in Tambov has been conducting training on a probably modernized version of the system, the *Torn-MDM* (Sirota 2017). The *Torn* system is reported to have been used by Russian forces in Donbas, eastern Ukraine in 2015 (*Informnapalm* 2015).

Drone-based jamming (REB-N)

The introduction of unmanned EW systems as a mean to advance an EW combat operation on to enemy territory is a stated objective of the EW Troops by 2020 (*Krasnaia zvezda* 2017). The *Leer-3* is probably the first system of its type to be widely procured by the Russian Armed Forces. The system, introduced in 2015, is produced by *Spetsialnyi tekhnicheskii tsentr* (Special Technical Centre), a company in St Petersburg. It consists of three *Orlan-10* UAVs and a truck-based command and control post, and provides capabilities mainly to suppress cellular communications base stations and replace them by acting as a virtual cellular base (RUVSA 2017). The system has probably been procured primarily for the independent EW brigades, where the *Leer-3* complex is operated at platoon level (Nikulin 2016). The Russian Ministry of Defence has stated that it has also been delivered to at least one Russian military base abroad, the 4th Military Base in South Ossetia (MoD 2015f). *Spetsnaz* (special forces) units also operate the *Leer-3* complex (*Telekanal Zvezda* 2017e).


Figure 15 & 16: The *Leer-3* command vehicle and *Orlan-10* type EW drone.
Source: Vitaly Kuzmin, licensed under CC BY SA 4.0.

Strategic jamming systems

The *Murmansk-BN* complex, often described as a "strategic jamming system", is another complex that has attracted a lot of attention, this time because of its sheer size. It has been developed and produced by KRET and is mounted on seven Kamaz or Ural trucks, four of which have 32-metre telescopic masts, which together hold up a vast high-frequency antenna net. The other vehicles include a command post and a power generator (*Rossiiskaia gazeta* 2016). The power supply is said to be able to provide up 400 kW of power, thereby enabling the *Murmansk-BN* complex to suppress high-frequency signals over an area of 640 000 km^2 (*Krasnaia zvezda* 2016). It is described as an asymmetric response to the USA and NATO's lead in "network-centric warfare", by denying the US Air Force use of the High Frequency Global Communications System network at the theatre level (*RIA Novosti* 2016b).

Procurement of the *Murmansk-BN* complex has been relatively well covered in the Russian media. The complex will probably be exclusively part of the inventory of the Ground Forces EW brigades and the Navy's EW centres, and procurement of the complex to the Baltic, Northern and Black Sea fleets has been prioritized, but at least one of the two EW centres of the Pacific Fleet received two *Murmansk-BN* complexes as early as 2014 (MoD 2015g; *Rossiiskaia gazeta* 2016; *Krasnaia zvezda* 2016). At least four, and probably all, of the Ground Forces EW brigades had received the *Murmansk-BN* complex by 2018 (MoD 2015g; MoD 2016c; Gusarov 2016; Nikulin 2016). It is probably operated by a company in the REB-N battalion of the independent EW brigades.

According to its annual report, the company NTI Radiosviaz in St Petersburg is also involved in the development of the *Murmansk-BN* (NTI Radiosviaz annual report 2012). It has also been involved since in the development and delivery of a new "stationary coastal jamming complex" known as *Samarkand*, which is probably a stationary version of the *Murmansk-BN* complex (Malyshev et al. 2018). The *Samarkand* complex has recently been delivered to at least the Northern and the Baltic fleets (MoD 2017d & *Telekanal Zvezda* 2017d).

There are also indications that an EW command and control system for the *Murmansk-BN* has been developed within the framework of the *Bylina* brigade-level command and control system project, allowing several *Murmansk-BN* complexes to work in coordination and feed into the overall EW command and control system. As of the autumn of 2017 the complex, which goes under the name of *Bylina KV KRET,* had been ordered by the Russian Armed Forces but had probably not yet been delivered (TASS 2017b; Simonov et al. 2017).

EW command and control systems

In September 2017, during the Belarusian-Russian strategic exercise, *Zapad-2017*, the new *Bylina* Russian EW automated command post (*avtomatizirovannyi kommandnyi punkt*, AKP) was used for the first time (MoD 2017j). The *Bylina* complex consists of five trucks, not including troop support vehicles, able to field a main command post and a reserve command post. Serial production will begin in 2019, and all the independent EW brigades will be equipped with the *Bylina* complex by 2025. It is not the first EW command post to be procured but earlier complexes and systems have all been designed to support just one specific domain of EW, whereas the *Bylina* ties together all the different EW domains of the EW brigade (REB-N, REB-S & REB-K) (Simonov et al. 2017).

A stationary EW command and control system for the higher command structure has also been developed, and was probably delivered and installed before 2016—possibly in 2014 when the EW situational centre within the General Staff was formed. It does not have a system label, but is distinguished from the *Bylina* system by its article designation (*izdelie*) *RB-108S* (Simonov et al. 2017).

EW systems against airborne systems (REB-S)

The capability to detect and suppress aerial onboard electronic systems such as radar, airborne communications systems or cruise missile homing, are all important tasks for Russian EW. These capabilities are found in particular in the *REB-S* battalions subordinated to the Ground Forces EW brigades or the independent *REB-S* battalions subordinated to the Air and Air Defence armies of the Aerospace Forces. Systems for jamming airborne communications and satellite navigation are primarily found in the *Borisoglebsk-2* and the *Diabazol* complexes, whereas the EW command and control complex *Moskva-1* and the radar-jamming complexes of the *Krasukha* family, *Krasukha-2* and *Krasukha-4*, are intended to suppress airborne and space-based radar systems. These systems target on-board radar systems of all kinds, but the role of reducing the effectiveness of aerial warning and control (AEW&C) takes special precedence. All three of these complexes are more or less further developments of earlier ones that have been in the Soviet and Russian EW inventory since the 1970s and 1980s. Systems specially designated to combat UAVs have also recently been launched.


Figure 17 & 18: Jamming system *Krasukha-2O* and *Krasukha-4S*.
Source: The Swedish Defence Material Administration.

The *Moskva-1* complex, produced by Kvant, is sometimes described as a passive radar (*passivnyi radar*). However, this should probably not be confused with passive radar in the sense of systems that use reflections from existing sources of illumination in the environment. Instead, its description as "passive" concerns its alleged capability to provide the location of emitting flying objects through electronic intelligence (ELINT) without revealing its own position, as a radar system would. The *Moskva-1* is mainly a command complex with some ELINT capabilities that is able to link together up to nine *Krasukha*-type jamming systems located at different sites, and transfer target data to Air Defence command and control systems. The *Moskva-1* is able to triangulate the position of the emitting aircraft or cruise missile at a distance of up to 400 km (MoD 2017i). The complex consists of three systems based on as many Kamaz trucks. One truck holds an ELINT system and the other two trucks are command vehicles (KRET 2016). Deliveries of the complex began in 2014, and in 2015 nine *Moskva-1* complexes were delivered to the Russian Armed Forces (*RIA Novosti* 2015). The *Moskva-1* complex has been developed as a replacement for the *AKUP-1* system, which was developed in Soviet times (Siliuntsev et al. 2016).

The *Krasukha* family of jamming complexes consists today of the *Krasukha-2O* and the *Krasukha-4S*. Development of both systems began early in the 1990s, with the larger *Krasukha-2O* system mounted on a BAZ-6910 vehicle and the *Krasukha-4S* on a Kamaz-6350 truck. The *Krasukha-2O* is designed to suppress primarily airborne early-warning aircraft ,[17] such as the *Boeing E-3 Sentry* or the *Northrop Grumman E-8 JSTAR*. It is largely a more mobile and modern version of the Soviet *Pelena-1* jamming system. It is probably usually procured together

[17] *Dalnee radiolokatsionnoe obnoruzhenie* (DRLO).

with the *Moskva-1* complex, and possibly also together with *Krasukha-4S* (MoD 2017i).

The *Krasukha-4S* is mainly designated to suppress the airborne interception radar[18] of fighter and interceptor types of aircraft, but also drones, reconnaissance aircraft and satellites in low earth orbit. Development of the complex began as early as 1994, but state trials did not end until 2009. Serial production began in 2011 and the first deliveries took place in 2013 (*Lenta* 2015; RVO 2016a). According to some sources, the system was first ordered by the Strategic Rocket Forces (RVSN) to provide a means of jamming US *Lacrosse*-type radar-imaging reconnaissance satellites (*Nezavisimoe voennoe obozrenie* 2014). In 2015 Interfax reported that the RVSN had received an EW system matching that description (*Interfax AVN* 2015). There is not much information on the rate at which the complex has been procured. According to one Russian military magazine (*Nezavisimoe voennoe obozrenie* 2014), 18 systems were delivered in the period 2014–2015 (nine complexes, as each complex consists of two vehicles/system). The *Krasukha-4S* is largely a successor of the *SPN-4* jamming system, with reduced deployment time and a range that is three times longer. At the *MAKS-2017* Russian arms fair in Moscow, the KRET representative, Vladimir Mikheev, stated that KRET had just started testing a newly developed successor to both the *Krasukha-2O* and the *Krasukha-4S*. The new system is supposedly able to block threats regardless of whether they are from an aerial or a space-based system (*RIA Novosti* 2017b).

The *Krasukha* and *Moskva-1* complexes are the most recently developed Russian EW complexes against aerial targets, but older systems are still being modernized in large numbers. In 2014, one-third of the total production capacity of EW systems against aerial targets was used for modernization (*Nezavisimoe voennoe obozrenie* 2014). The *Avtobaza-M* ELINT system and the *SPN-4M* jamming system are both modernized versions of older systems. Both are intended for the Russian Armed Forces as well as the export market (Gubskov 2016).

Parodist is another newly developed radar and communications jamming system against aerial targets (REB-S). Compared to the *Krasukha* complexes, it has been less talked about. It is supposedly a multifunctional jamming system (*mnogofunktsionalnyi kompleks radiopodavleniia*) designed to counter the *Northrop Grumman E2 Hawkeye* airborne early-warning system (Siliuntsev et al. 2016:49). The extent to which this complex has been procured is unknown.

State trials of the new EW system, the *Shipovnik-AERO*, developed by OPK, ended in 2017. The system is intended to combat an enemy's UAVs by attacking its control transmission, but is also able to locate where the UAV's control signal

[18] *Bortovaia radiolokatsionnaia stantsiia* (BRLS).

is transmitted from. The system provides different solutions for attacking the UAVs. One is to first analyse the control signal, then suppress and replace it, thereby taking control of the UAV. Another is to force the UAV down by creating an area with fake navigation signals (GPS). The system can also attack cell phone communications, as well as Wi-Fi and Wimax networks (*Telekanal Zvezda* 2017b).

EW systems against space targets (REB-K)

The *Krasukha-4S* is partly designed to suppress reconnaissance satellites in at least low earth orbits. Other Russian systems for suppressing foreign military satellites are also under development. This was underscored in August 2017 when the KRET Vice-General Director, Igor Nasenkov, stated that as the United States is developing new military space-based systems, Russia has to have an adequate answer by developing EW countermeasures against those systems, and that prototypes of such EW systems were being developed (VPK 2015a). There is generally less information about EW systems designated to suppress space-based military assets, but some new systems and modernizations of old ones are known about.

Jamming devices for suppressing satellite communications were being developed in Soviet times. One such system is the *Tirada* family, development of which began in the late 1970s (*Gazeta 2000* 2017). In November 2017, a representative of the 46th MoD Scientific Research Institute (46 TsNII) announced that a new ground-based, mobile iteration of the *Tirada* system was under development. Like earlier versions, the new system, *Tirada-2S*, is designed to suppress satellite communications. It is a further modernization of the *Tirada-2* system, development of which began in 2001. The 2S version of the system may have been tested at the 186th Ind. EW centre within the Northern Fleet in 2014 (Oreshkin 2014). The *Tirada* EW system is being developed as part of a wide variety of new Russian anti-satellite (ASAT) capabilities, as part of the forthcoming State Armament Programme (*Rossiiskaia gazeta* 2017b; *Interfax* 2018).

Another REB-K project, *Divnomore-U*, is an EW system under development by KRET. According to the KRET annual report, published in a Russian military defence blog, the system is “a *Krasukha* type system” (*Bmpd Livejournal* 2015). Not much is known about this system apart from the fact that it is designed to suppress space-based radioelectronic assets. The system has probably not been fielded yet.

EW protection of stationary objects

A number of stationary EW systems designed to protect important military, and civilian, objects have been procured in recent years. These EW systems are above all protective systems designed either to reduce the efficiency of precision-guided munitions or to avert foreign technical reconnaissance.

The *Pole-21* is a system developed by the Nauchno-tekhnicheskii tsentr radioelektronnoi borby (NTTs REB), a company in Moscow. One of the systems that completed state trials in 2010–2013 (VPK 2014a), it is designed to enhance the protection of an object or facility from precision-guided munitions. By jamming radio navigation systems such as GPS, Galileo or Beidou, *Pole-21* reduces the precision of an incoming missile and, in this way, increases the survivability of the object. The system has similarities with the *R-330 Zhitel* EW system, which is part of the *Diabazol* complex, and is designed to protect, for example, brigade- or division-level command posts against PGMs. The *Pole-21* system was agreed for procurement by the Russian Armed Forces in 2016 (*Voennoe obozrenie* 2016).

Zaslon-REB is an EW system that monitors flows of information within and around a critical object in order to stop unsanctioned flows of information. State trials of the new system were completed in 2016 and it has been installed at a number of the Aerospace Forces assets. Through a number of antennae and up to 11 jamming devices, the system monitors and blocks all common cell phone Wi-Fi frequencies and creates up to four controlled virtual cell phone base stations. Cell phones used within the perimeter of the system must be approved by the *Zaslon-REB*, or they are automatically blocked (*Voennoe obozrenie* 2017a). The system has been criticized for being based on old technology, however, and it only deals with the problem of servicemen carrying and using cell phones in very limited areas, such as garrisons, training fields, and so on (*Nezavisimaia gazeta* 2017).

Lastly, and as mentioned above, there is also a newly developed KTK system from the *Svet* family, the *Svet-VSG*, which has been developed for installation on immobile objects. Like other systems in the *Svet* family, it provides surveillance of the EMS and direction-finding capabilities.

Electronic warfare training simulators

The increased use of training simulators has been put forward as one of the main reasons for the efficiency of the EW Troops' training system, especially at the inter-service EW training facility in Tambov, which in 2016 received a new EW training simulator designated the *Intellektualnogo trenazhorno-obuchaiushchego kompleksa* (ITOK).[19] The new simulator is modular and can be used for training

[19] The ITOK EW training simulator is sometimes mistakenly also called *Itog* (MoD 2016b).

in defined aspects of EW (Gubskov 2016; MoD 2016b). A training simulator known as *Magnii-REB* has also been delivered to major combat formations in the Ground Forces and the Airborne Troops. Deliveries of *Magnii-REB* seem to be carried out in conjunction with procurement of *Borisoglebsk-2* complexes and *Infauna* systems (MoD 2015e & RVO 2016d: 35).

3.2.2 Aerial Systems

Aerial on-board EW systems come in roughly two types: self-protection systems (SPS), which are often miniaturized in order to provide protection but not affect the main tasks of the aircraft; and systems that constitute the main task of the aircraft, that is, surveillance and jamming capabilities in support of other military aircraft.

The new *Khibiny* EW pod, manufactured by the KNIRTI company in Zhukov, is a multifunctional SPS that was developed in parallel with the Su-34 multi-role fighter-bomber aircraft, on which the *Khibiny-10V*[20] complex was first mounted. Versions of the *Khibiny* have also been developed for the Su-30 and Su-35 fighter aircraft. The *Khibiny* on-board defence complex attracted special attention due to the infamous *USS Donald Cook* incident in the Black Sea in April 2014 (*Nezavisimoe voennoe obozrenie* 2017). The *Khibiny* pod is designed to provide EW defence capabilities on an individual aircraft or for a small group of aircraft (Kolesov & Nasenkov 2015:36). The system consists of a, probably automated, ELINT awareness capability and jamming system able to duplicate and slightly alter the adversary's radar signal in order to create a large number of fake targets (KRET 2017b). It also provides protection against incoming missiles with radar and infrared homing, and aids the pilot in making tactical decisions (Turishchev 2015).

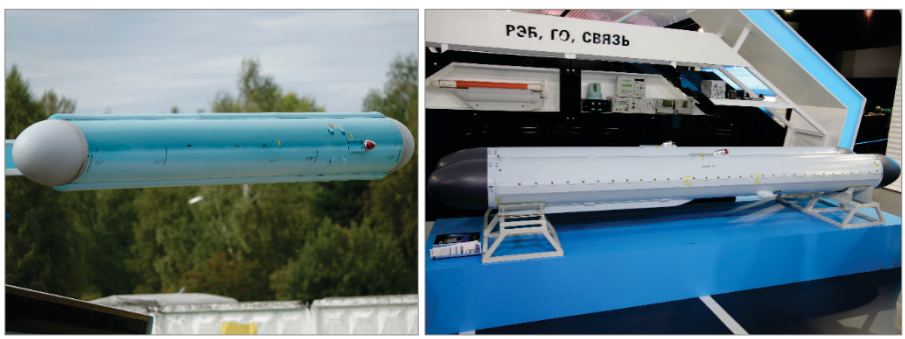


Figure 19 & 20: *Khibiny* SPS-system mounted on wing-tip of a Su-34 and at display. Source: The Swedish Defence Material Administration.

[20] "10V" is the article number (*izdelie*) for the Su-34 aircraft.

Along with the *Khibiny* system, an EW system with enhanced capabilities for providing protection to a larger group of aircraft has been developed for the Su-34. This system probably fills the gap between an on-board defence system and specialized EW aircraft or helicopters. The system, *Tarantul*, has been in development by the KNIIRTI company since 2007 (*RIA Novosti* 2017a). According to Igor Nasenkov, the first systems were delivered to the Russian Air Force in late 2015 (*Voennoe obozrenie* 2015b).

The company NII Ekran in Samara has developed the *Vitebsk* onboard defence complex, which provides self-protection for military helicopters such as the Mi-8, Mi-26, Mi-28 and Ka-52, and to the Su-25 close support aircraft. The first orders were placed by the MoD in 2011, and deliveries began in early 2013. The system is a combination of subsystems that together provide awareness, through both radar and laser warning receivers, as well as passive and active countermeasures, including both optical and radar jamming, against a number of threats (*Izvestiia* 2012).

The *President-S* "on-board protection system" is an SPS that is intended for both civilian and military aircraft. The system is automated and provides protection from air defence systems, including Manpads. It has been developed by NII Ekran, which also produces the *Vitebsk* helicopter SPS (Vladimirov & Petrov 2016).

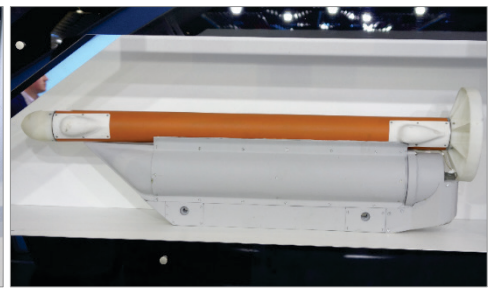


Figure 21 & 22: Missile Approach Warning System, the EW decoys (left) and towed EW decoy (right) of the *President-S* system.
Source: The Swedish Defence Material Administration.

The *Gimalai* on-board EW defence complex is an SPS developed for the new fifth-generation fighter aircraft, the Su-57.[21] It was developed by NIIRTI in Kaluga and is produced at the Signal plant in Stavropol. The first prototype was delivered in 2014 and serial production was planned to start in 2017 (*Lenta* 2014). The new Tu-160M2 strategic bomber, which flew for the first time in early 2018, will also get a modified version of the *Gimalai* SPS (*Telekanal*

[21] Also known as the T-50 or *Perspektivnyi aviatsionnyi kompleks frontovoi aviatsii* (PAK FA).

Zvezda 2017a). Not much is to be found in the EW literature on the performance of the *Gimalai* complex.

New specialized aircraft that have EW as their main function have also been developed recently. A new EW helicopter, the Mi-8MTPR, fitted with the *Rychag-AV* or *Rychag-BV* EW system is designed to provide group protection for helicopters, aircraft, drones, ships and ground-based systems against attacks from different types of strike systems (Vladimirov & Petrov 2016). It has been in testing with an Army Aviation unit of the Western MD since at least 2015 (Timofeev 2016). A new specialized EW aircraft, the Il-22PP *Porubshchik*, has also been developed. The first three aircraft were delivered to the Russian Armed Forces in the second half of 2016. The aircraft was commissioned in 2009 and the first prototype was completed in 2011. Like earlier EW aircraft, it is based on the Il-18 air frame (*Izvestiia* 2017).

Figure 23: Antenna of the *Rychag-AV* helicopter EW system.
Source: The Swedish Defence Material Administration.

3.2.3 Naval Systems

As with aerial EW systems, naval systems are above all designed to provide self-protection through a combination of active and passive countermeasures. Ships' EW systems are not limited as to weight and size, so there is less need for specialized EW platforms such as EW aircraft or helicopters. The only exception is intelligence ships. All combat ships are equipped at least with an RWR and decoy launchers, but the EW capabilities mounted on board tend to increase with

ship size. A number of new or modernized naval EW systems have been procured the past decade.

The *TK-25* is a new "ship radioelectronic suppression complex"[22] developed by the Taganrog Research Institute of Communications (*Taganrogskii nauchno-issledovatelskii institut sviazi*, TNIIS) in Taganrog. It is mainly intended for self-protection, and builds on an earlier system known as the *MP-405*. Depending on role and displacement, different versions of the system have been installed on the project 11356 Grigorovich class frigate and project 20380 Steregushchii class corvette. It provides capabilities to detect and analyse threats, for active jamming of air- and shipborne radar systems and against incoming missiles (KRET product information 2016).

Figure 24 & 25: The EW *TK-25* system on board the Grigorovich class frigate Admiral Makarov (left) and another configuration of the same system on board the Steregushchii class corvette Stoikii (right).
Source: The Swedish Defence Research Agency.

The project 1144 Kirov class cruiser, *Admiral Nakhimov*, which is undergoing modernization at the *Sevmash* shipbuilding company in Severodvinsk,[23] is to have the TK-28 multifunctional radioelectronic suppression complex installed (Kolesov & Nasenkov 2015: 178–179). The new project 22350 Admiral Gorshkov class frigate has been fitted with both the TK-28 multifunctional radioelectronic suppression complex and the *Prosvet-M* EW protection suite. One component of the *Prosvet-M* system is probably the passive decoy launching

[22] *Korabelnyi kompleks REP.*
[23] OAO PO `Sevmash` (Northern machine building enterprise).

system. The KT-308, developed and produced by *KB Mash* in Moscow,[24] completed state trials in 2009 (*Voennoe obozrenie* 2012a).

Also developed by TNIIS is the MP-411 system, which is described as a "container active jamming station" that is designed to simulate fake targets in order to confuse enemy radar and radar-guided missiles. The system is intended for mounting on small military ships and civilian ships, as well as in harbours and on other critical infrastructure (KRET Product information 2016).

Countermeasures against laser and optical-electronic guided missiles is one area in which a number of new Russian systems have been demonstrated. One is the MDM-2 "shipborne optical-electronic deflection system",[25] a laser warning and decoy system that has been installed on the new Admiral Gorshkov class frigate. Another is the *Grach* shipborne dazzling system,[26] developed by Vega, which is part of the JSC "Morinformsystem-Agat" company. The *Grach* system is designed to suppress optical sights with multi-spectral high-intensity light (VPK 2015b). It is installed on the project 21980 Grachonok class anti-saboteur ship as well as the Admiral Gorshkov class frigate.

Figure 26 & 27:The *MDM-2* laser jamming system (left) and the *Grach* dazzling system (right).
Source: The Swedish Defence Research Agency.

There are also ongoing developments in the field of large inflatable radar decoys. Since 2008, the company NIIRPI, located in St Petersburg, has been developing the *Ugolok* large radar decoy, which is intended to provide combat ships with a rapidly inflatable decoy as protection against anti-ship missiles with radar homing.

[24] AO NPK `KB Mashinostroeniia`.
[25] *Korabelnyi kompleks optiko-elektronnogo podavleniia.*
[26] *Korabelnaia stantsiia vizualno-opticheskikh pomekh.*

Figure 28: The *Ugolok* radar decoy.
Source: The Swedish Defence Research Agency.

3.3 Chapter Discussion

Russian military EW assets consist of both organizational structures and an inventory of EW equipment. The newly formed EW Troops is responsible for the operational and long-term development of military EW assets, but does not necessarily wield physical control over them. Rather, EW assets are highly distributed, present in all service branches of the armed forces and in all geographical locations. The formation of EW Troops has led to a number of significant changes to the overall EW capability of the Russian Armed Forces. The two most important are an enhanced ambition to wield control of the EMS, that is, to coordinate EW measures and to ensure electromagnetic compatibility, and an increased status and prominence for the role of EW in the military operational art. Apart from the strengthening of the EW command bodies, the weight of EW capabilities, especially in the Ground Forces and the Airborne Troops, has significantly increased as EW brigades have formed along with EW companies at the brigade and division levels.

The Armed Forces EW inventory has also been transformed substantially since 2008. There has been procurement of new equipment in large numbers, with a diversity of new systems and virtually all military domains affected. However, the notion that all these newly procured EW systems are fundamentally “new” is

not entirely accurate. A large number of the new systems are modernized versions of earlier generations with enhanced capabilities or general improvements, such as digitization, automation or miniaturization. Others are essentially the result of revived Soviet projects that were halted in the 1990s. Thus, the impression, often provided by Russian media outlets, that this new Russian EW inventory is almost entirely based on “new physical principles” needs to be taken with a pinch of salt. There have also been very few examples of fielded EW systems that have shown any real progress in the field of DEW, such as lasers and HPM.

There are, however, newly procured—or anticipated—pieces of equipment that present new EW capabilities in terms of mobility and range. Example of these are drone-based jamming capabilities, air-droppable systems and High Frequency (HF) jamming systems able to suppress HF communications over vast areas. There is also an emphasis, demonstrated in a number of systems, on increasing capabilities to supress space-based assets and UAVs.

In terms of fundamentally new capabilities, a number of areas stand out. One is the introduction of EW systems designated to increase the survivability of troops and military facilities against PGMs, which include offensive capabilities to reduce the efficiency of PGMs by suppressing their guidance systems. Another area is the introduction of a number of EW command and control systems that enhance the capability to coordinate measures taken in the EMS and enable sharing of situational awareness.

4 Russian Electronic Warfare Trends

This chapter studies trends in Russian EW in four different areas. In contrast to the more physical objects of study in chapter 3, more uncertain aspects such as ongoing debates, the impact of western sanctions and technology readiness levels are elaborated below. More precisely, the trends discussed are trends in organizational change, exercises and training, the development of the EW industry and, finally, trends in Russian EW technology development. There are arguably other trends, or possibly even areas of trends, that could be of importance to the development of Russian EW capabilities. However, in the light of the long-term strategy document on EW adopted in 2012, it is reasonable to say that all the trends discussed below fit well with its five main strategy directions.

The Electronic warfare strategy documents adopted in 2002 and 2012

In 2002, President Vladimir Putin signed a long-term EW strategy and policy document, *Osnovy politiki Rossiiskoi Federatsii v oblasti razvitiia sistemy radioelektronnoi borby na period do 2010 goda i dalneishuiu perspektivu* (Fundamental policies for development of the Russian Federation electronic warfare system until 2010 and beyond) (Yefimov et al. 2005: 23). The document resulted in the adoption of a partial contract manning system for the EW units, launched a technical modernization of EW equipment through the armament programme and led to the creation of the EW Troops in 2009 (*Izvestiia* 2009). In February 2012, this strategy document was renewed and signed by President Putin. The new document is now valid "until 2020 and beyond" (Doskalov 2013).

In 2013 the five main directions of the then newly adopted strategy document were revealed by the former commander of the EW Troops. These are: first, improving state control over the functioning and development of EW; second, integrating the military EW domain with other state domains significant for national security; third, exploiting accomplishments in R&D in order to procure a new generation of EW systems; fourth, further development of the EW educational and scientific research system; and, fifth, expanding military-technical cooperation and increasing the export potential of EW systems (Doskalov 2013).

The most noticeable feature is that the strategy covers not only the development of the Russian Armed Forces EW Troops, but also the promotion of the EW industry and EW capabilities with other security authorities. The strategy document provides some idea of the general direction of development, but the specific concept documents and short-term goals that the strategy document is broken down into are not publicly available. Two possible ways round this are to study what representatives of the Russian EW community are saying about the

future, and to study the actions that have been taken to further develop, dismantle or change the role and place of EW in the Russian Armed Forces.

4.1 Development Trends for the EW Troops

Reorganization of the force structure was probably a major priority in the years immediately following the formation of the EW Troops in 2009. There have been EW brigades in all the MDs since 2016 and the formation of EW companies in the Airborne Troops has made considerable progress, while consolidation of these new combat units and subunits will continue in the coming years. Other organizational reforms have attracted less attention but are defining in terms of the role of the EW Troops in the Russian Armed Forces, now and in the future. In addition to organizational development, there is an ongoing debate about further enhancing the status of the EW Troops. As destructive means of EW warfare are included, the prospects of EW being used to degrade or destroy enemy information objects, not just on the front line but across the full depth of the battlefield, are increasing in a way that resembles the use of precision-guided missiles (PGMs) (Lastochkin 2015). There are a number of examples of this ongoing expansion of the role and place of Russian EW, some of which are discussed below.

Electronic warfare command and control

Creating an automated electronic warfare command and control system is a key goal in the long-term Russian strategy for the development of EW. This is also an area in which a specific concept has been hammered out: the "concept for developing an EW command and control system up to 2025" (Doskalov 2013).[27] The main purpose is to increase the combat efficiency of EW units through information sharing and automated processes, but the aim is also to increase coordination of surveillance in the EMS in peacetime. This is an area that relies on technological capacities to create and field such EW command and control systems, but it is largely also an organizational issue that implies closer interaction among EW assets at different levels of subordination.

The guiding principles for what this EW command and control system will look like have been thoroughly described in an article by three leading representatives of the 5th EW department at the Air Force department in Voronezh. The goal is to unify the work of EW systems of different types and at different levels, by sharing information and coordinating their work in the EMS (Reshetniak et al. 2017). The backbone of the EW command and control system will be the *RB-108S* EW command and control system at the General Staff level, the *RB-109A*

[27] *Konseptsiia razvitiia sistemy upravleniia voiskami radioelektronnoi borby Vooruzhennykh Sil Rossiiskoi Federatsii na period do 2025 goda.*

Bylina system at EW brigade level and the *RB-105B Less* system at the KTK formation (KTK nodes) level (see figure 4). The EW command and control systems will also be able to feed into, and retrieve information from, the non-EW command and control systems within the different branches of service and independent combat arms.

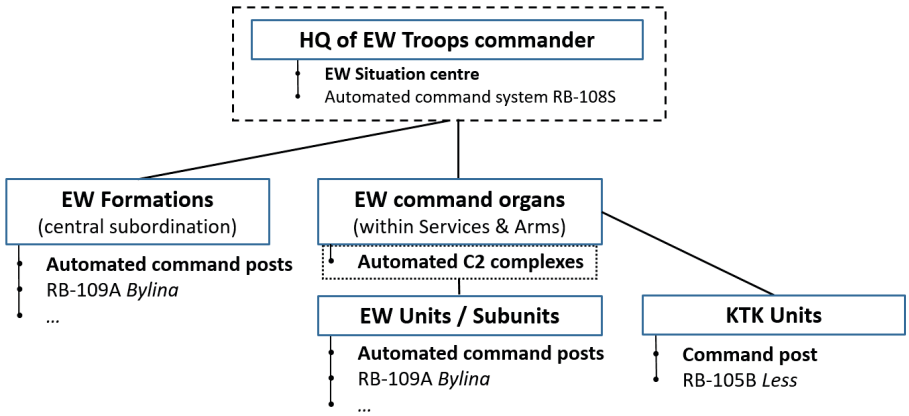


Figure 29: The future Russian EW command and control (C2) system.
Source: Reshetniak et al. 2017.

However, other lower-level EW command and control systems under development or newly developed are also designed to feed into this overall EW command and control system. According to an article by the deputy EW commander, there are a number of new systems that, apart from their main task, are also lower-level command and control systems. These include, for example: the *Moskva-1*, an Elint and command and control for *Krasukha*-type jamming systems; the *Silitsii-2*,[28] a lower-lever command and control system; the *Palantin*, a Ground Forces jamming system; the *Bylina-KRET*, probably an EW strategic command and control system; the *Murmansk-BN* HF jamming system; and the *Tirada-2S*, a jamming system for use against space targets.

Some of these systems have probably not yet completed state trials while others have only recently started the procurement process. The first deliveries of the RB-109A *Bylina*, which is perhaps the most important complex for linking together EW systems working in different domains, have only recently taken place, and it will be at least 2025 before all five EW brigades are equipped (Simonov et al. 2017).

[28] State trials were conducted in 2011, but state orders for this Ground Forces battalion or company level EW command and control system were halted due to the reorganization (Sozvezdie Press Service 2011).

The creation of a unified EW command and control system will enable the Russian Armed Forces to conduct coordinated EW operations, while also providing the means to share information and coordinate action with other military capabilities. A highly automated and integrated EW command and control system is also crucial to the ability to generate a false electromagnetic environment by imitation and creating false targets, which is a long-term objective for the EW Troops (VPK 2017).

Increased importance of electronic warfare in Air Defence

One of the most discussed topics in the Russian EW literature is the role of EW in modern air defence. The increased use of UAVs, PGMs and stealth technology has changed the preconditions for an air defence based around air defence missile systems. Aircraft and missiles flying at either very low or high altitude, at hypersonic speed, or which come in very large numbers (swarming) are particularly difficult targets (Nezhivykh 2014). The discussion has mainly been about how EW can provide complementary means to offset the shortcomings of traditional air defence, and there are discussions about strengthening the Armed Forces Air Defence divisions with complementary EW means (Romanov 2018).

Voennaia mysl, the MoD journal of military theory, has long been used as a forum for conveying these ideas. Even though the status of EW has increased, not least with the creation of the EW Troops, there is an ongoing debate over enhancing its status in Ground Forces operations, especially in relation to air defence. A *Voennaia mysl* article from 2015 argues that the view of EW in Ground Forces operations should change in the light of new aerial threats, such as drone warfare and long-range missiles. Further integration of EW and Air Defence, the article argues, is needed to address the limitations of traditional air defence against these types of threats (Donskov et al. 2015). In a *Voennaia mysl* article from August 2017, the current EW commander, General Lieutenant Yurii Lastochkin, takes an even more offensive stance. He argues that the development of EW capabilities, on account of their ability to physically destroy and eliminate enemy electronic systems, means that the status of EW units in Ground Forces operations should not be one of combat support. Instead, their role should be made equal to the four main combat arms: motorized rifle, tank, artillery and air defence (Lastochkin et al. 2017). Thus, in Ground Forces operations EW should not been seen as complementary to air defence capabilities, but as a capability in its own right.

Russian and Belarusian cooperation on Electronic warfare

Russia and Belarus initiated cooperation on EW in 2009. The agreement covers, for example, arranging joint exercises in the field of EW, coordinated distribution of military frequencies,[29] and increased cooperation in EW R&D

[29] Probably to avoid frequency conflicts between the two states' armed forces radio and radar use.

(*Interfax* 2011). Earlier the same year an agreement was also signed on creating a single, regional air defence. However, air defence integration was slow to develop for a number of reasons, among which were Belarus resistance to a Russian proposal for a permanent Russian airbase on Belarusian soil and Russia's refusal of Belarusian requests to purchase modern aircraft. At this stage, the air defence and EW agreements were closely interlinked and cooperation on EW was limited too.

The air defence integration process was restarted in 2015–16. In April 2016 the Belarusian Chief of the General Staff declared that implementation of the single air defence agreement signed in 2009 had been completed. Following the creation of the Russian Aerospace Forces in 2015, the text of an updated agreement was rushed through the State Duma, and ready only a week before the start of the Russian-Belarusian joint strategic exercise, *Zapad-2017* (*Rossiiskaia gazeta* 2017a). According to the Belarusian Chief of the General Staff, the single Russian and Belarusian Air Defence comprises 15 radio-technical units, nine air defence divisions and three EW units (MoD Belarus 2017).

EW cooperation also took off in 2015-16. In August 2015, Belarusian EW units participated for the first time in the Russian *Elektronnyi rubezh* EW competition held in Tambov. Since then, Belarusian units have participated regularly in similar events. Joint exercises in the field of EW have also intensified, such as Belarusian participation in the Russian *Elektron-201*6 large-scale EW exercise and a joint exercise in Belarus in May 2017, which was said to be the first joint EW exercise of its kind since the 1980s (VSR 2017).

This exercise was partly a rehearsal for the *Zapad-2017* strategic joint exercise, which was carried out in September the same year. Evaluation of the ability of the Joint Regional Air Defence to protect the Russian Central Economic Region[30] from airstrikes was a key goal of the joint *Zapad-2017* exercise (*Vedomosti* 2017). The role of EW during the exercise was well covered in both the Russian and the Western press. It was also well noted that the Russian jamming operations affected not only the Latvian and the Swedish cellular networks, but also Norwegian air traffic control (*Washington Post* 2017).

In addition to Russian-Belarusian military cooperation, consolidation of military cooperation between Russia and a number of Central Asian countries is also ongoing. There has been air defence integration within the CSTO framework, as well as bilateral integration with the Armed Forces of Kazakhstan and Armenia in order to form joint regional military forces (*Novaia Gazeta* 2017 & *The Diplomat* 2017). However, this integration has not progressed as far as that with

[30] *Tsentralnyi promyshchlennyi raion*, the greater Moscow region, including adjacent subjects of the Russian Federation.

Belarus, partly because Moscow probably perceives the threat from modern strike weapons in this region to be lower.

Creating a single KTK system

KTK capabilities were initially limited to the Strategic Rocket Forces, but later also extended to military objects belonging to the Space Troops[31]. Numerous articles have covered the strengthening of the military KTK system over the past ten years, as well as the creation of a single federal system encompassing both military KTK and civilian assets for surveillance in the EMS. One objective has been to dramatically increase the number of military and civilian facilities that enjoy KTK protection. The motive is the increased threat from PGMs and the growth of electronics that use the EMS in military systems, which increases the risk of unintentional interference. This was articulated in an article written in 2013 by a former EW commander, which outlines the roadmap and objectives of a strengthened KTK structure (Doskalov 2013).

A transitory intergovernmental commission active in the period 2008–10 concluded that Russian KTK should be more integrated. In order to increase the level of integration and information sharing of observation in the EMS, a single military KTK system in the Armed Forces (*Yedinaia Sistema* KTK, ES KTK) was set up in the period 2011–2015. To achieve this, an EW situational centre was set up in the General Staff in 2014, and every MD has a KTK Centre (MoD 2017m). A new generation of KTK equipment has also been procured in order to create this integrated system, and the introduction of KTK command and control systems such as the *Less* (RB-105B) was probably essential to achieving the single KTK system. In addition, a cross-government KTK system has been created within the framework of the single military KTK system. This integrates military KTK capabilities with the non-military capabilities for monitoring the EMS belonging to other executive government bodies, such as the Ministry of Internal Affairs (*Ministerstvo Vnutrennykh Del*, MVD), the Ministry of Telecom and Mass Communications (*Minkomsviaz*) and the Federal Protection Service (*Federal Sluzhba Okhrany*, FSO) (see e.g. Lobov et al. 2014; Petrovskii & Kravtsov 2016; Lobov et al. 2017).

Civil use of military EW capabilities has probably increased. KTK assets from the Southern MD, for example, were involved in providing security at the Winter Olympic Games and the Paralympics in Sochi as well as the Fourth Caspian Sea summit in 2014 (Mazov & Lankin 2014). During the 19th St Petersburg International Economic Forum, EW units monitored the EMS as a part of overall security arrangements (Timofeev 2016).

[31] The Space Troops were merged with the Russian Air Force in 2015, creating the Russian Aerospace Forces.

The coordinating role of the EW Troops in signature reduction

In October 2014 the EW Troops were made the coordinating MoD body for efforts in signature reduction (Mikhailov 2016). This field is only loosely related to EW, but the move is fairly logical due to the traditional emphasis on KTK in Russian EW that dates back to the 1970s. It also fits well with the enhanced focus on countermeasures against technical reconnaissance (PD TSR). Much of the focus in signature reduction concerns the development of new materiel, ranging from heat-resistant radio-absorbing coatings for aircraft to hydroacoustic noise reduction coatings for submarines, but also the development of non-EW countermeasures, such as aerosols. The main role of the EW Troops is one of coordinating these efforts, involving a large number of state research institutes and companies in the arms industry. The initial task was to set up a single military certification system for the comprehensive assessment of the signature qualities of military equipment, while also working out methods and developing laboratory technical means for measuring signatures. As with KTK, the assessment of signature covers a wide range of means of detection, including optical, acoustic and infrared detection. Much of this work is concentrated around the Research Centre for EW and Assessing the Effectiveness of Signature Reduction Measures,[32] at the Air Force Academy in Voronezh (Mikhailov & Ponkin 2018; Mikhailov 2016).

4.2 Electronic Warfare Military Exercise Trends

Military training of EW units largely follows the general trends within the Russian Armed Forces. Examples of this is are enhanced efficiency of military education through the use of modern training simulators, training in unfamiliar terrain, military competitions, snap exercises, and so on. It is hard to assess the extent to which the number of exercises has increased but, according to the EW commander, the number of tactical EW exercises doubled in the period 2013–17 (*Krasnaia zvezda* 2017). According to the Russian Defence Minister, the 2017 training programme for the EW Troops involved 220 EW exercises, including ten brigade-level exercises (*RIA Novosti* 2018).

In addition to the greater number of specific EW exercises within the Russian Armed Forces, in recent years training in an electromagnetically challenged environment has been included in all types of military exercise and at all levels (*Krasnaia zvezda* 2013). Another general feature is that a great deal of emphasis is put on training EW officers to work out "non-standard solutions" for achieving military tasks (Portnykh 2018).

[32] *Nauchno-issledovatelskii tsentr radioelektronnoi borby i snizheniia zametnosti.*

The use of training simulators has also been increased in recent years. The ITOK computerized training simulator is used regularly in the basic training of EW specialists, which starts at the training centre in Tambov. Another automated training system—*Mauzer*, which imitates the operator station of an EW system—is also used. According to an article written by a representative of the 1084th training centre in Tambov, there are plans for an improved version of the ITOK system, VITOK, which has additional virtual reality capabilities (Malkov 2018).

In common with many other military domains of the Russian Armed forces, the use of army competitions has increased in the EW Troops. The time allocated for these competitions is considerable and they are a not insignificant part of specialist training. The *Elektronnyi rubezh* (Electronic boundary) contest, which is carried out annually, often at the training centre in Tambov, involves a large number of EW disciplines. The final competition is preceded by qualifying rounds in all MDs (MoD 2017b).

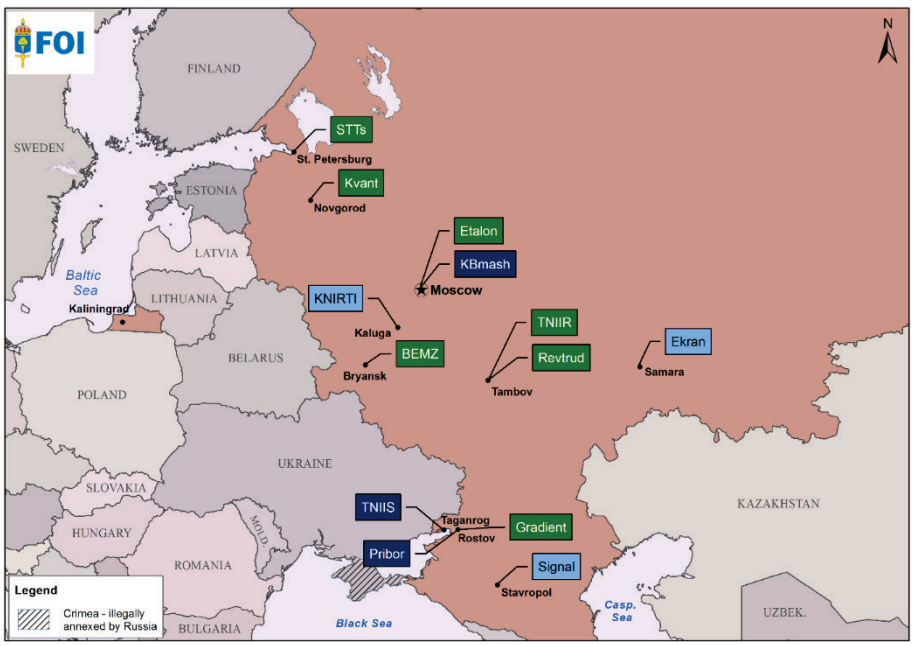
According to Russian MoD press releases, EW units regularly conduct training together with other types of unit, such as Signals Troops units and Air Defence radiotechnical units (see e.g. MoD 2017j). It is also becoming more common for EW units—together with chemical, biological, radiological and nuclear units, and Engineers units—to be used in protection and concealment against air strikes. For example, in a Western MD exercise in July 2017, EW and engineering methods of jointly providing concealment and camouflage were worked out and used as measures against massive attacks from the air (MoD 2017f). EW assets are also used for psychological operations during exercises. For example, use of the Leer-3 to send out text messages requesting adversarial units to retreat prior to artillery shelling has been trialled in exercises at the Prudboi range in the Southern MD (KRET 2016).

In August 2016, the Russian Armed Forces commenced the first strategic-level EW exercise (KRET 2016). The exercise, *Elektron-2016*, was carried out at a number of training ranges in the Southern MD, as well as the Crimean Peninsula. It comprised 30 military units and approximately 460 units of EW equipment (*RIA Novosti* 2018). The Russian Defence Minister noted that this was the first exercise of its kind in modern times, and that in order to find one of corresponding size and complexity one would have to go back to the Soviet EW exercises of the 1970–1980s, such as *Elektron-75* or *Dozor-86*. According to the EW commander, one of the main aims of the exercise was to explore new ways of conducting EW operations at the strategic level (VPK 2017).

The Russian Armed Forces KTK units have also started joint exercises with other state authorities, such as the Federal Security Service (FSB) and the FSO, under the auspices of the “single KTK system”. In June 2016 a joint exercise was held in the illegally annexed territory of Crimea, with the goal of enhancing the combined capability for monitoring the EMS (Lobov et al. 2017).

4.3 Electronic Warfare Industry Development Trends

The EW sector in the Russian defence industry has a long legacy that goes back to Soviet Red Army procurement and the Cold War arms race. Like the Red Army, the Russian Armed Forces rely heavily on the ability of domestic industry to provide them with modern EW equipment. According to a former commander of the EW Troops, in 2010 more than 120 Russian companies were involved in the development and production of EW systems (*Krasnaia zvezda* 2010). However, around ten of these companies are responsible for the lion's share of EW equipment output. Map 2 shows the location of 13 of the most important EW companies.



Map 2: Key KRET and Sozvezdie EW companies and their location, by branch of service
Key: naval equipment = dark blue; aerial equipment = light blue; ground-based equipment= green.

Table 5: Russian EW companies: full name and example of products, by type of EW system produced.

Company	Full name	Products (examples)
	Aerial Systems	
KNIRTI	JSC "Kaluga Research Institute of Radio Engineering"	*Khibiny, Tarantul* etc.
Ekran	JSC "Samara Plant 'Ekran'"	*Vitebsk, President-S*
Signal	JSC "Stavropol Plant 'Signal'"	
	Ground based systems	
Kvant	JSC "Research-Production Association 'Kvant'"	*Krasukha-2/4, Moskva-1*
Gradient	JSC "All Russian Research Institute 'Gradient'"	*Rtut-BM*
TNIIR	JSC "Tambov Radiotechnical Research Institute"	*Borisoglebsk-2*
Revtrud	JSC "Tambov Plant 'Revtrud'"	*Rtut-BM, Borisoglebsk-2*
BEMZ	JSC "Bryansk Electromechanical Factory"	*Krasukha-2/4*
Etalon	JSC "All Russian Research Institute 'Etalon'"	*Leer-2, Dziudoist, Shipovnik-AERO*
STTs	JSC "Special Technology Centre"	Leer-3
	Naval Systems	
TNIIS	JSC "Taganrog Research Institute of Communication"	TK-25, MP-411
KBmash	JSC "Research-Production Corporation 'KB Mashinostroeniia'"	KT-308
Pribor	JSC "Rostov Plant 'Pribor'"	

The majority of these EW companies are located in western and southern Russia, especially in an area south-west of Moscow and in the *Krasnodar krai* (Rostov area). The companies are often specialists in either R&D or production, and tend to focus on the supply of EW equipment in just one of three domains: aerial systems, naval systems or ground-based systems. Most of these companies are subsidiaries of either the Joint Stock Company (JSC) Ruselectronics (KRET) or the JSC *Sozvezdie*, both of which are part of the Russian state corporation *Rostec*, which was formed in 2007. Together, *Sozvezdie* and KRET have approximately 80 per cent of the Russian EW market share, in terms of state orders (*Kommersant* 2017). *Sozvezdie* companies mainly produce EW equipment for the Russian Ground Forces, whereas KRET companies produce for the needs of the Air Force and the Navy. Apart from these two giants, there are also a few smaller companies that make a substantial contribution to providing EW equipment for the Russian Armed Forces. One of these is the St Petersburg-based company STTs, which produces the *Leer-3* UAV-based EW complex. In addition to

companies in the armaments industry, a number of military state research institutes play an important role in the R&D of EW equipment.

The Russian EW industry suffered heavily in the 1990s due to the lack of state orders and the absence of government subsidies. Nonetheless, a large number of Soviet-era development and production entities survived, and often go by the same name today as they did in Soviet times (see e.g. Kolesov & Nasenkov 2015: 43–83). Thus, when state spending was radically increased, especially through the GPV-2020 armament programme, initiated in 2010, the industrial infrastructure was more or less already in place. However, the Russian EW industry of today also faces a number of challenges. The three discussed below involve the entire military industrial complex, but some of the impacts and strategies for dealing with these are particular to the EW Troops. The first is the challenge of how to attract young, talented people to work on the development and production of EW equipment. The second is how to increase innovation in the field of EW. The third is how to manage the consequences of Western sanctions and the export embargo, linked to events in Crimea and Ukraine, respectively.

Attracting young talented people

One major challenge facing the EW industry in Russia is the need to find and attract engineers, especially young ones. In an interview in 2013, the Deputy Director of KRET, Yury Maevskiy, argued that the number of technically skilled people had been eroded over the past 15–20 years, partly because young people "prefer to study for a law or economics degree" rather than aspire to be a technical designer or engineer (*RIA Novosti* 2013).

One way to counter this trend is the creation of "scientific companies", which have been set up to attract young, technically talented people to military service. They are also a source of recruitment of talented people to the EW industry. The 9th Scientific Company in Tambov is engaged in a number of EW research efforts. According to an article in *Moscow Defence Brief*, these mainly consist of researching solutions for assessing and increasing the effectiveness of EW systems in three main areas: technical information assurance systems, the general effectiveness and use of EW systems, and the training of EW specialists (Boltenkov 2017: 10–12). This system of scientific companies also served as the model for the creation of research and production companies, which are staffed with conscripts who have been assigned to a defence industry company. The first three research and production companies were set up in 2015. The 2nd research and production EW company was set up at AO Revtrud, the radiocommunication and EW equipment production company in Tambov, which is a subsidiary of Sozvezdie (MoD 2015c & *Kommersant* 2015). According to the current EW commander, there are plans to set up two additional EW scientific companies (VPK 2016).

In addition to the scientific companies, other initiatives include the recently announced creation of the *Era* military innovation centre (*voennyy innovatsionnyy tekhnopolis*), which was launched by Defence Minister Shoigu in October 2017 (*RBK* 2018). It is hoped that this military innovation centre, located in the city of Anapa, will attract talented people who have already served in the military scientific companies (*Telekanal Zvezda* 2018).

The creation of EW industry clusters

In May 2017 KRET announced plans to boost its production of naval and ground-based EW systems by creating two separate industry clusters. The first will focus on naval EW systems and be created around the TNIIS company, located in Taganrog. The second will be formed around VNII Gradient, located in Rostov-on-Don, and focus on developing and producing ground-based EW systems for targeting aerial and space-based targets. This follows the creation in 2016 of an industry cluster for aerial EW systems around the KNIRTI company in Kaluga, which has developed, for example, the *Khibiny* protection system for individual aircraft and the An-22PP EW aircraft. KRET believes that this organizational reform, which is intended to shorten the lead times between development, creating a prototype and serial production, will make it possible to increase the production rate by 20–30 per cent (KRET 2017a). The production of the *Krasukha-4S* jamming complex offers an illustration of the complexity of the Russian EW industry: the complex was developed by VNII Gradient, the first prototype was built by Kvant and serial production was undertaken by BEMZ (RVO 2016a).

The Ukrainian export embargo and Western sanctions

The sanctions imposed on Russia following its illegal annexation of Crimea and Ukraine's exports embargo have affected the Russian defence industry in different ways. The embargo has had a distinct impact in some specific areas. By preventing deliveries of ship gas turbines and helicopter engines from Ukrainian producers, the embargo has in some instances halted production (Malmlöf 2016: 154). The restrictions imposed by the sanctions have had a more general impact on the Russian Defence Industry. Here, the challenges are especially acute in areas such as dual-use products and electronic components, which are potentially of greater concern for companies producing EW equipment.

While the halting of deliveries of Ukrainian-made ship gas turbines and helicopter engines caused considerable challenges for Russian shipbuilders and the helicopter industry, the procurement of new EW equipment seems to have been less affected. In 2014, when the first sanctions and Ukraine's export embargo were imposed, it is unlikely that there were any major contracts between Ukrainian producers and the Russian MoD for EW equipment. Both the Ukrainian and the Russian EW industry have the same Soviet EW technology

legacy. Unlike other defence industry domains, however the EW industries of both countries seem to have been less interdependent.

Modernization and further development of the Soviet-era Ground Forces *R-330 Mandat* jamming system took different directions in Russia and Ukraine. The Ukrainian equivalent of the Russian *Borisoglebsk* and *Diabazol* complexes, the *Mandat-B1E*, has been developed and produced by the Topaz plant in Donetsk. However, there have been reports, mainly in the Ukrainian press, but also picked up by western newspapers such as the *New York Times*, that equipment was taken from the Topaz plant and put on board Russian humanitarian convoys to Russia (Higgins & Herszenhorn 2014). Other sources claim that the Topaz plant was successfully evacuated to other parts of Ukraine at the beginning of the war (*Interfax Ukraine* 2017).

The lack of solid domestic production of electronic components has probably caused a bigger challenge for the EW industry than the Ukrainian export embargo. According to the Russian general designer of EW, Yurii Maevskii, however, dependence on foreign electronic components for EW equipment was very low even before the sanctions. The real challenge is therefore not so much to substitute imports as to further enhance the performance of domestically produced electronics. According to Maevskii, it is this and not sanctions that is the most important prerequisite for achieving series production of some of the advanced EW projects currently under development (*Gazeta.ru* 2017).

Export ambitions

Even though one of the five long-term development directions of the EW strategy adopted in 2012 is to raise the export potential of Russian EW systems, only a small number of new or modernized export versions of Russian EW systems are listed on the *Rosoboroneksport* homepage.[33] Two systems explicitly listed are the *Avtobaza-M* modernized ELINT complex and the *R-330 Zhitel* satellite navigation jamming system. Russia's export ambitions in the field of EW are not limited to these systems. It is highly likely that export versions of SPS are regularly being fitted on to Russian export versions of fighter jets, military helicopters and combat ships. Other systems, such as the *Krasukha-2* radar jamming system, the *Moskva-1* EW command and control and ELINT system, and the *Rtut-BM* proximity-fuse jamming system, have all been mentioned as possible exports (*Lenta* 2018; *Sputnik News* 2015).

According to Sergei Denisentsev, an expert at the Moscow-based think tank CAST, Russia would like to have a larger share of the world market in military EW systems, which was worth approximately USD 9 billion in 2014, and is expected to be worth USD 16 billion by 2020. Denisentsev identifies two reasons

[33] See http://roe.ru; *Rosoboroneksport* is Russia's sole state intermediary agency handling Russian exports of military and dual-use products.

for this projected increase. First, EW is a necessary military means for combating modern military airborne capabilities, which constitute the most important strike weapon in modern warfare. Second, EW equipment is not subject to export regulation in the same way as strike systems, something which is even true of the new Arms Trade Treaty which entered into force in 2014 (VPK 2014b).

4.4 Electronic Warfare Technology Development Trends

A number of general technical trends are frequently referred to by leading representatives of the EW Troops and the EW production industry. Some of these are almost a matter of course, such as striving to develop small, light and highly automated performance systems with fast processing capabilities. One of the clichés most used in Russian military R&D over the past ten years—the development of new weaponry based on "new physical principles"—is often used in the EW context. This and a number of other technical development trends are worth examining, since they tend to provide a glimpse of the kind of EW systems and capabilities that are being prioritized for the near future.

Destructive electronic warfare means

There are ongoing Russian research projects in the field of Directed-Energy Weapons (DEW), such as laser, High Power Microwave (HPM) and Electromagnetic Pulse (EMP) weapons. Depending on the distance to target, the power generated and the targets' electromagnetic shielding, HPM and EMP weapons could inflict suppressive or even destructive effects on electronic systems. Lasers can be designed to merely dazzle optical sensors or to inflict damage on them. HPM can be used as "backdoor penetration", that is, not exploiting antennae and sensors but rather inducing electric currents into cables and circuits, and so on, thereby interfering with or even overheating electronics. It is seldom possible to say with certainty whether a laser or an HPM system is intended to destroy or merely suppress sensors or electronic systems.

The Soviet Union initiated an airborne laser programme in the late 1970s, and tests of an on-board modified Il-76 transport aircraft, the A-60, were carried out throughout the 1980s and early 1990s, before the project was mothballed. The programme was revived early in the 2000s with the project title *Sokol-Eshelon* (*The Aviationist* 2016). In May 2016 the Russian Vice-Defence Minister, Yurii Borisov, stated that the modernized version of the A-60 had successfully completed ground testing (*Telekanal Zvezda* 2016a).

An article from 2014 revealed some of Russia's DEW projects. In the early 2000s, the Russian arms industry was showing, and marketing, a ground-based HPM system known as the *Ranets*. It was developed by the Ioffe Institute

together with the company NIIRTI,[34] which is part of the Almaz-Antey air defence corporation, and was shown at the LIMA arms expo in Malaysia in 2001. A project known as *Alabuga* was also mentioned, which aims to create munitions able to generate an EMP (*Voennoe obozrenie* 2014). There are however no reports of Russia having fielded such a weapon.

A prototype of an HPM weapon mounted on the tracked vehicle of the *Buk* surface-to-air missile system, developed by the United Instrument Manufacturing Corporation (*Obedinennaia priborstroitelnaia korporatsiia*, OPK), was allegedly shown at the *Armiia-2015* expo. According to OPK, the weapon is intended to be used against aerial threats (REB-S) and has an effective range of ten kilometres. The article concludes that there are at least two ongoing Russian HPM projects, one ground-based (REB-S) and one aerial-based (*Voennoe obozrenie* 2017b). There are reports that Russian EW units in eastern Ukraine have used HPM systems not only to jam, but also to destroy the on-board electronics of surveillance drones (Blank 2015). However, these claims have not been satisfactory backed up, and lack details of, for example, what HPM equipment was used and why the downing of drones was not caused by traditional jamming.

According to KRET, it is in the early stages of developing airborne HPM and laser capabilities intended for the sixth generation of Russian fighter jets. This scientific work is being conducted together with the Foundation for Advanced Research Projects in the Defense Industry (FPI)[35] (TASS 2017c).

In his presidential address to the Federal Assembly on 1 March 2018, President Vladimir Putin unveiled a number of weapons systems. On the theme of new weapon systems based on new physical principles, he discussed a laser system, procurement of which the Russian Armed Forces began in 2017 (President of Russia 2018). The system, known as the *Peresvet*,[36] is intended for air and anti-ballistic-missile defence and uses a small nuclear reactor in order to create laser pump power (*Rossiiskaia gazeta* 2018).

[34] NII "Radiopriborstroeniia" (Moscow).
[35] A Russian equivalent of the US Defense Advanced Research Projects Agency (DARPA).
[36] It was named Peresvet following a competition for a name held on the MoD homepage in March 2018 (TASS 2018).

Figure 30: Russian laser weapon *Peresvet*.
Source: TT Nyhetsbyrån.

Electromagnetic hardening

In relation to other fields of research, means of further enhancing the resilience of electronics to withstand jamming and DEW have had less coverage in the Russian media and the EW literature. According to Director Maevskii, KRET is currently working on projects aimed at further enhancing the protection of aircraft and cruise missiles against HPM. How this will be done, however, is not elaborated on (TASS 2017c).

Another field of research is the development of ferrite fibres, a material that can be used to shield electronics from EW countermeasures, and to create a fabric that can be used to reduce radar signatures. In an interview with the General Director of the Russian holding company *Ruselektronika,* the use of ferrite fibres was exemplified in connection with the S-500 missile system and the Armata battle tank (RVO 2016b: 19). Procurement of these systems has not yet begun, and it is not clear from the article whether ferrite fibre is used for electromagnetic hardening or signature reduction in these two weapon systems.

Electronic warfare to counter ABM defence systems

One of the main directions of development for the period 2016–2020 is to take delivery of and field EW systems intended to counter anti-ballistic missile (ABM) defence systems (Lakhin & Korobeinikov 2016). The kinds of systems and methods these systems use is not further elaborated, but the development of EW means to reduce the efficiency of ABM systems is an important field of

study at the Military Academy of the Strategic Rocket Forces, and has intensified in line with the fielding of ABM radar systems in Eastern Europe (Aksenov 2017). Mechanisms to suppress the radar systems located in Eastern Europe and space-based reconnaissance are two methods of EW that are probably being explored.

Unmanned electronic warfare systems

"Moving the battle on to the adversary's territory" is a tactical principle that has frequently been articulated by EW representatives in recent years. This lessens the exposure of EW personell and the risk of signal-seeking missile strikes, since the more powerful jamming signal is administered at a distance. The term *zabraseyvaemyi peredachik pomekh*, that is, "launched" or "thrown" jamming devices, is frequently used in this context, often to denote the new *Leer-3* jamming complex, which consists of EW jamming capabilities mounted on a Russian-built *Orlan-10* drone. In 2017, the developer and producer of the *Leer-3* system, *Spetsialnyi tekhnicheskii tsentr* (STTs) in St Petersburg, was in the initial phase of developing an EW drone to be based on board Russian Navy combat ships (Chichikailo 2017).

An article from 2018, written by representatives from the EW Troops and the Air Force Academy in Voronezh, discusses the future use of UAVs, unmanned ground vehicles (UGV) and unmanned surface vehicles (USV). Three major development directions are outlined. The first is to continue further development UAVs, and adopt UGV concepts, as a platform for conducting EW operations on the territory of an adversary. These systems are to be small in size with limited range (up to 10 kilometres) and are intended to carry out electronic reconnaissance and jamming. The second is to develop and adopt medium-sized (<3 500 kilo) UGVs designed to operate within combat units in order to provide protection against reconnaissance and PGM strikes, and to conduct jamming. The third is to develop large UGVs, and possibly USVs, (>3 500 kilos) that use "new physical principles" to protect objects of critical importance from adversarial technical reconnaissance and PGM strikes (Balybin et al. 2018).

Another area where use of UAVs in EW is being explored is the use of quadcopters as antennae for ground-based EW systems. An article from 2017, also written by representatives from the EW Troops and the Air Force Academy in Voronezh, outlined a number of reasons why research in this field looks promising. First, unlike a winged UAV, the quadcopter allows the use of a non-aerodynamic antenna, thereby opening up a wide range of different configurations for jamming and direction finding with higher payloads. Second, a quadcopter antenna can shift between operating at very low to very high altitude. In addition, the time of deployment decreases as an antenna supported by guy lines does not need to be set up. The quadcopter antenna might also be able to operate at low speed (Shirokov et al. 2017).

EW Munitions

Although the focus has been on air-launched EW drones, there is some information on the development of new EW munitions. This kind of EW asset may also play a role in moving the battle on to the adversary's territory.

Munitions with an unspecified EW capability are under development for the new AGS-40 *Balkan* automatic grenade launcher (*Lenta* 2018). According to the General Director of KRET, an EW warhead fitted on to a cruise or air-to-air missile is under development. Instead of an explosive charge, the warhead will carry an EW device that imitates the flight of a group of missiles in order to confuse enemy radar (TASS 2017a).

4.5 Chapter Discussion

Some of the Russian EW trends discussed in this chapter closely follow the general tendencies and ambitions of the Russian Armed Forces as a whole, while others are more specific to the EW domain. Examples of the former are both technical and organizational, such as the efforts to enhance military command and control capabilities and improve military training, and to seek new ways for industry to enhance EW R&D and increase production output, and to promote exports.

Some of the EW trends described in this chapter seemingly fall back on a few common objectives or concerns regarding EW development. The three highlighted here are the increasingly prominent role of EW in air defence, the ambition to achieve greater coordination in EW operations and the efforts to address the challenge of sustaining high levels of innovation and production in the EW industry.

The most conspicuous example is the more significant role anticipated for EW means in future air defence. Combating UAVs and cruise missiles with Air Missile Defence Systems, for example, is perceived as too slow, too costly and above all too inefficient. This growing emphasis on EW in Air Defence is apparent in Russian-Belarusian Air Defence Cooperation and the development of DEW capabilities, and is the main argument among the Russian EW community for a further increase in the role of EW in the Russian Armed Forces. The enhanced role of EW in air defence in not just limited to combating these types of new threats head on. The role of EW means is also highlighted in reducing an adversary's surveillance and targeting capabilities as well reducing the signature of troops and objects.

Further increasing coordination of and command over EW measures is a second area that receives a lot of attention. This includes internal coordination of EW capabilities of different types at different levels, but also externally with other non-EW capabilities. Among the main objectives are to be able to carry out

complex and coordinated EW operations at both the operational and the strategic level at the same time, and to ensure electromagnetic compatibility with other non-EW military assets such as radar or radio communications. The organizational prerequisites for increasing the EW command capacity were provided by the formation of the EW Troops. However, the procurement of EW command and control systems, as well as establishing structured interaction for information sharing and coordination, are still ongoing, both within the armed forces and together with non-military actors.

A third main area of concern is ensuring technical innovation long term, and continual modernization and renewal of the EW inventory. As demonstrated in chapter 3, a not insignificant number of the recently procured EW systems are essentially revived Soviet-era projects or based on Soviet innovations. This is of concern to the Russian Armed Forces as a whole but, due to its high-tech nature, is most worrying for EW modernization. A number of general, as well as EW-specific, measures have been adopted to enhance innovation and production. These include the formation of EW scientific companies, the creation of production and innovation clusters and the nurturing of the EW industry by promoting exports.

5 Conclusions

This study has examined how Russian military EW capabilities have developed in the past ten years. This was done by analysing how EW is currently defined in Russia, its strength and importance, and its distribution across the Russian Armed Forces. The study also sought to identify trends in the field of Russian EW.

A principal conclusion of this study is that the claims that Russia has expanded its EW capabilities over the past ten years are essentially correct, but that these miss important aspects. There are plenty of pitfalls in studying Russian EW capabilities, and an immense risk that capabilities will be either overstated or understated. Much of EW is often shrouded in military secrecy and the often complex technological nature of EW breeds misconceptions that occasionally create and fuel myths. The deterioration in relations between Russia and the West, involving both deliberate Russian disinformation and a "Russia scare", has added to this problem. An excessive focus on Russia's recent military operations as well as its extensive rearmament has provided a not entirely flawed but somewhat uneven picture of the role and purpose of EW in the contemporary Russian Armed Forces.

The development of Russian EW capabilities, 2008-2018

Soviet and Russian EW terminology and definitions have evolved over the decades, to slowly incorporate technical advances and thereby widen the role of EW within the country's armed forces. The most recent update, completed somewhere between 2013 and 2015, represents one of the most comprehensive changes in Soviet and Russian military history. The introduction of destructive means, such as directed-energy weapons and cyber-capabilities, a wider set of conceivable targets and the reintroduction of anti-radiation missiles into the EW domain all represent major shifts of the role of EW in military operations. This provides a picture of a thorough transformation and enhancement of the role of EW in the Russian Armed Forces.

Changes in organization also support the view that EW has increased in status in military operational thinking. The formation of EW Troops is the most important factor, but the weight of EW in the Russian Armed Forces has also generally increased. There are now larger and more capable EW subunits in both the Ground Forces' and the Airborne Troops' major combat formations. Denying a hi-tech adversary the ability to make use of its command and control system undisturbed is now perceived as crucial to modern warfighting, at both the tactical and the operational level. Moreover, the creation of large EW formations and an expanded EW command structure represent an unprecedented capability for the Russian Armed Forces to conduct EW combat support operations at the war theatre level.

The area that has attracted most attention is the extensive procurement of new EW systems in the past ten years. It is not possible to compare the extent of these deliveries with, for example, the period 2001–2010, but it is safe to say that the increase has been substantial. Not only have new systems been delivered in quite large numbers, but the EW inventory has been renewed in practically all military domains. This extensive renewal was made possible partly because several of the new pieces of equipment built, to varying degrees, on Soviet-era research projects.

However, the focus on eye-catching offensive EW weapon systems, many of which have been used in eastern Ukraine and Syria, has largely neglected other Russian priorities in the field of EW that are of equal or even greater importance. As important as supressing enemy command and control systems is enhancing the survivability of your own troops and critically important infrastructure through EW means. The approach required is multifaceted and the means include a broader distribution of, for example, GPS-jamming capabilities, which reduce the precision of GPS-guided munitions, and the introduction of improved emission control capabilities (KTK) to a larger number of military and civilian structures. The importance of survivability is also emphasized by the special coordinating role in signature reduction that has been handed over to the EW Troops.

Perspectives on the further development of Russian EW capabilities

The Russian objectives for enhancing their EW capability have been set for the long term, with no explicit end-state in mind. In addition to what has already been accomplished, there are ongoing efforts to further develop capabilities, some of which look more promising than others.

One area that often attracts much interest is the development of Directed-Energy Weapons (DEW). The updated Russian definition of EW clearly includes DEW but even though a number of concepts have been presented over the years, the Russian Armed Forces are yet to demonstrate an operational and effective DEW system that can be procured in large numbers. Even less elaborated on are cyber-capabilities, which under the new EW definition are also defined as EW weaponry. What these EW cyber-capabilities look like, whether such capabilities are already in place and operational, and how they relate to other Russian cyber-capabilities is yet to be revealed. Nonetheless, the successful incorporation of effective DEW and cyber-capabilities into the Armed Forces' EW inventory will continue to be important subjects for further study, as they would embody and justify a further enhanced role for EW in the armed forces, which is coveted by representatives of the Russian EW community.

More significant for the further enhancement of Russian EW capabilities in the short term is whether the Russian Armed Forces will be successful in their objective of enhancing coordination and sharing information on activities in the

EMS through an integrated EW command and control system, as well as increased coordination with other military capabilities and non-military organizations. These are all in their early stages but if they prove effective, the capability to conduct large-scale EW operations will be substantially increased. In addition, a more prominent role for EW in air defence, as anticipated in numerous articles by representatives of the Russian EW community, requires effective means of seamless exchange of current situational EMS data with radar and air defence units.

The likelihood that the Russian Armed Forces will be able to sustain an EW modernization rate comparable with the one seen for the past ten years is low. The high renewal rate was largely made possible through the revival of Soviet-era projects that were halted in the 1990s, and this source will eventually be depleted or become obsolete. The long-term impact of sanctions on the level of success in promoting exports, as well as the effectiveness of measures already taken in order to promote technical innovation, attract young people to the EW industry and increase production efficiency, are all factors that will determine the success of future renewal and modernization.

Regardless of whether the Russian Armed Forces manage to achieve individual objectives in further developing their EW capabilities, the increased significance of EW as a crucial combat support element of Russian military thinking will not be rolled back. There are essentially three key reasons for this.

First, the ever-increasing use of electronics in military systems presents vulnerabilities as well as opportunities in military operations. Automation and the increased number of interdependent systems have had a radical impact on the effectiveness of modern combat systems. However, the effects operate in both directions, as they imply a greater need to provide protection for the country's own electronic systems. The evolution of the role of EW in Soviet and Russian military thinking shows that technological development is, not surprisingly, a key driver of the ever-increasing importance of EW.

Second, general technological advances have altered the efficiency of traditional military means. The introduction of "new physical principles" to military strike systems, as well as information warfare have introduced new arenas for waging war and new means for doing so. At the same time, the introduction of UAVs and high-speed cruise missiles, and the increased use of space-based military assets for targeting and surveillance, and so on, have altered the parameters for a number of important military capabilities, such as the efficacy of Air Defence missile systems and how to counter adversarial reconnaissance operations.

Third, asymmetric means are effective if an adversary has advantages in technology and/or resources. EW is frequently put forward as an effective asymmetric means in areas where Russia's contemporary capabilities are inferior to those of the USA and NATO. This is typically UAV warfare, network-centric

warfare and space-based reconnaissance, as well as projects such as Prompt Global Strike (PGS) and the NATO Anti-ballistic missile defence system in Europe.

There is no sign that there will be any change in one of these conceptions any time soon. The reliance on electronic systems in military equipment will continue to increase, and EW measures will certainly continue to be a solution for addressing shortcomings in Russia's traditional military means. More importantly, with President Vladimir Putin winning another five-year presidential term in 2018, there are no immediate signs of Russia stepping back from its great-power ambitions. Given Russia's partly dysfunctional economy, lack of innovation and reliance on sales of oil and gas, there is also no immediate sign that Russia will be able to bridge the economic and technical gap with the USA, the Western European countries or even China. Hence, Russia is bound to continue its striving for a role as a military great power from an underdog position, compelled to use asymmetric means such as EW to maintain its ambitions.

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