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REVIEW OF CONTEMPORARY SYSTEMS FOR AIRCRAFT SELF-PROTECTION USING TOWED DECOYS

An analysis of open source references is given regarding the contemporary systems for the aircraft self-protection that employ the towed decoys. Actual information on such system is scarce, even though the general advertisement materials are well represented. This analysis is an attempt to gather scattered pieces of information on the performance of such systems in order to gain understanding of the fact that towed decoys have become the key element of contemporary aircraft self-protection suits. Yet this fact is not widely admitted by the military experts and the entire issue is not discussed openly among the military aircraft operators, tactics experts, and designers. The purpose of the paper is to draw attention of military aviation specialists as well as other Air Force personnel to the existence of new technologies on the market.

Keywords: *aircraft electronic protection, towed decoy.*

Introduction

Analysis of open sources demonstrates the scarcity of data available on the contemporary onboard electronic systems of the USAF and NATO aircraft protection. One can find openly only advertisements on such means without any references that could reveal the usage scale of electronic self-protection systems employing the towed decoys. Nevertheless, the use of such protection systems has long history both in the US and NATO countries. Lately, some information appeared in the Internet that supports the hypothesis of very successful use of towed decoys particularly by the USAF. Despite the evident official restriction being in place concerning this issue, some official publications can still be found in the public domain that indicate a very high effectiveness level of such systems, especially when protecting contemporary and perspective aircraft against the "air-to-air" and "ground-to-air" missiles guided with the employment of conventional radar means. Towed decoys are becoming a serious challenge to the air defense systems that are to counter very sophisticated air threats today and in near future. However, the information regarding towed decoys is ignored in the media and the public basically regards such systems as toys, which they are not. **Purpose of the work** is to gather and analyze the information that can be found in the open sources regarding the aircraft self-protection systems that employ the towed decoys and to draw attention of aviation and air defense specialists to emerging challenges.

Main part

Some information that clues the effectiveness and the employment scale of towed decoys can be found in official report [1] of General Accounting Office to congressional committees on the state of procurement of electronic means for protection of the US Navy and Air Force aircraft against radar guided surface-to-air and air-to-air missiles. This document stipulates mandatory requirement of installing such means practically at every US Navy aircraft. The document states the following: ”Classified test results show that the ALE-50 towed decoy offers improved effectiveness against radar-controlled threats, including some threat systems against which self-protection jammers have shown little to no effectiveness. Moreover, the future RFCM decoy system is expected to further improve survivability due to its more sophisticated jamming techniques. Recognizing the potential offered by these towed decoy systems to overcome the limitations of using just on-board jammers, such as the ASPJ, the Air Force is actively pursuing the use of towed decoys for its current aircraft.”

Another hint can be found in the book [2] by the well-known military expert and professor at Boston University Andrew Bacewich. In his book, professor Bacewich presented some hints regarding the effectiveness of towed decoys during military campaign in former Yugoslavia.

According to [2], Yugoslavian air defense (AD) fired 845 surface-to-air missiles (SA-2/3, or Soviet made S-300 P AD system, and SA-6, or Soviet made BUK AD system), and downed only two (!) NATO aircraft and 25 UAVs. A total of 1,200 Navy and Marine Corps EA-6B sorties were flown in support of air defense suppression, and US and NATO aircraft fired 743 HARM missiles and expended 1,479 towed decoys (!).

1. Historical reference

First attempts to design a mean for protecting the aircraft against radar guided surface-to-air and air-to-air missiles date back to 1967 when the idea of employing towed decoys first appeared in one of the US patents.

The reasoning was very simple, to lure a missile away from aircraft one has to give it a more preferable target that is to be separated from the aircraft by some distance. This distance is needed to prevent the aircraft damage by the blast wave and killing fragments of the missile warhead.

The idea of placing the electronic countermeasures transmitting antenna outside of the aircraft is not exactly new. This idea had been presented in one of the US patents as long back as 1967. The idea of moving the transmitting antenna away from the aircraft appeared due to necessity to counter the surface-to-air missiles, which at that time obtained a capability to passively home at a source of electronic countermeasures by angular coordinates only. Such missiles endangered the aircraft employing electronic countermeasures in the self-protection mode.

The first operational device was described in the US patent [3] filed in 1989. The patent preamble states that: “An RF decoy for use with RF repeater devices, transponders, noise jammers and other jamming devices. The decoy is adapted to be towed behind an aircraft using a tow line which incorporates a fiber optic link through which signals are transmitted. The device is excited through RF energy which is modulated on a laser carrier and transmitted through the fiber optic link. While the principal application is to repeaters which are towed behind an aircraft, the invention has utility in free-falling and forward fired transmitters as well as land and sea based vehicles.”

A sophisticated design for employing multiple towed decoys was patented in [4]. The use of multiple decoys at the same time is illustrated in fig. 1.

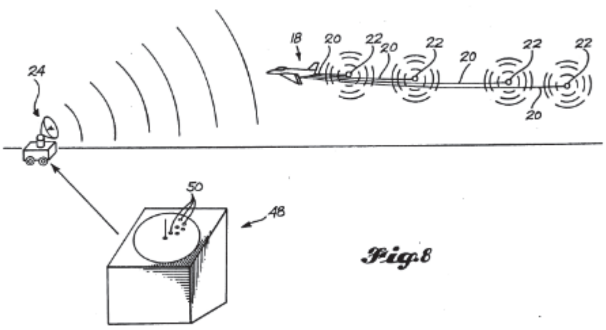


Fig. 1. Schematic diagram of an aircraft towing several radio frequency decoys [4]

The patent [4] preamble states the following: “One or more decoys (22) are towed by an aircraft (18) to confuse hostile radar. The tow lines (20) to the decoys (22) include fiber optic components which optically transmit to the decoys (22) both radio frequency signals for retransmission to hostile radar (24), and direct current power. The fiber optic components absorb strain forces imposed by towing the decoys (22). Multiple decoys (22) are deployed at varying distances from the aircraft (18) to increase the overall range of frequencies covered by the system, simulate a plurality of false targets, or accomplish angle gate deception.”

2. Operational designs of towed decoys

2.1. Towed decoys by Ratheon

General characteristics and appearance of towed decoys by Raytheon and BAE Systems can be found in [5–6]. However, this information is for advertisement purpose only, so it doesn’t include any tactical or technical specification.

Actual appearance of one of the prototypes of the ALE-50 towed decoy suspended at a pylon of F-16 aircraft can still be found in network, for example in [7]. Appearance of decoy, which is not deployed yet, is shown in fig. 2. In fig. 2 the decoy hangs from a container suspended to the left wing pylon. The container includes hardware of electronic protection suite.

Fig. 2. Photo of an F-16 aircraft bearing one of the prototypes of ALE-50 towed decoy [7]

Fig. 3 shows the deployed decoy, which is being towed by the aircraft. A part of towing line is also visible.

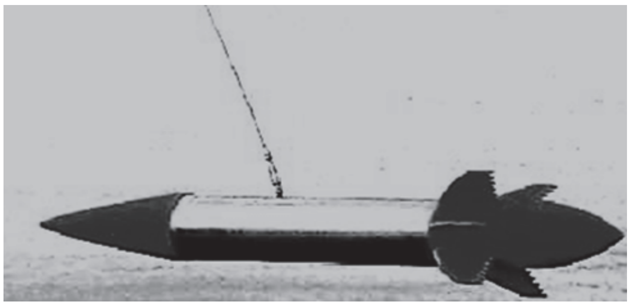


Fig. 3. Photo of one of the prototypes of ALE-50 towed decoy being towed by an aircraft [7]

The ALE-50 Towed Decoy system, also known as “little Buddy,” is a state-of-the-art defense system designed by Raytheon. The main objective of the system is to create an effective countermeasure to defend American aircraft against radar-directed missiles. This anti-missile countermeasure decoy system is currently used for different U.S. Air Force, Navy, and Marine Corps aircraft, in addition to some other air forces [5].

The first deployment of the system dates back to 1995. Nonetheless, the system is currently used on multiple aircraft that include the F/A-18E/F Super Hornet and the B-1B Lancer. Further, The system has also been incorporated into the innovative ALQ-184(V)9 ECM pod. This integration has helped the system become more vigilant towards threats, and it has also enabled it to be ready to be used on numerous platforms.

The system has been used in various combats, where the ALE-50 Towed Decoy System successfully demonstrated its effectiveness in thwarting enemy missile attacks. When employed, the system shields the aircraft and crew against guided missiles (surface-to-air and air-to-air missiles). The system lures the missile toward a more attractive target and away from the intended one. The decoy that the system utilizes is used when required and cut free before landing. The “Little Buddy” offers the possibility of being operated manually as an independent device. However, it can also be incorporated and controlled by the ALE-47 Airborne Countermeasures Dispenser System (made by BAE Systems) [5].

Next generation of towed decoys is much more compact. The serial produced ALE-50 aircraft protection system by Raytheon can be integrated into a weapon bearing pylon 2/8 of F-16 aircraft as shown in fig. 4 (grey box mounted immediately under the wing, to which the weapon bearing pylon is attached).

2.2. Towed decoys by BAE systems

The AN/ALE-55 towed decoys by BAE also have compact design. The advertising materials by BAE systems can be found in [8].

Appearance of the decoy is presented in fig. 5, a, b. The system includes the decoy, container, and hardware module (fig. 5, a). Fig. 5, b shows decoy sticking out of container.

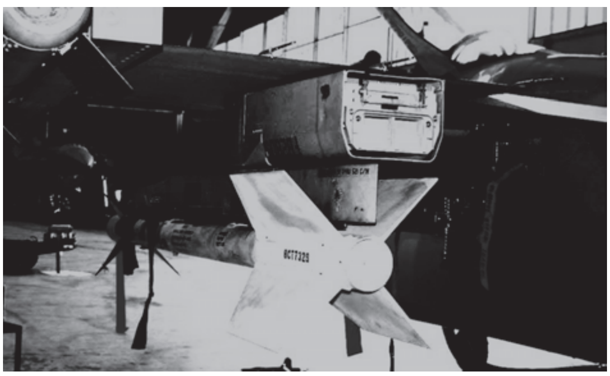
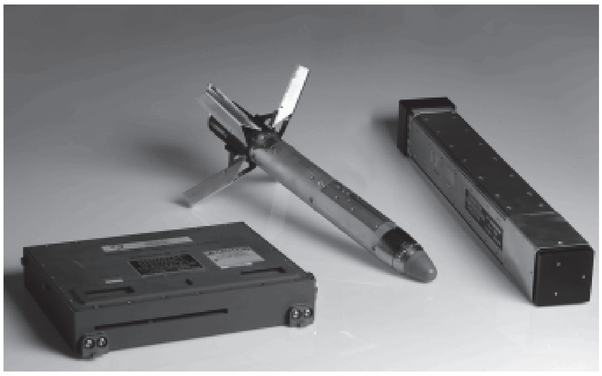
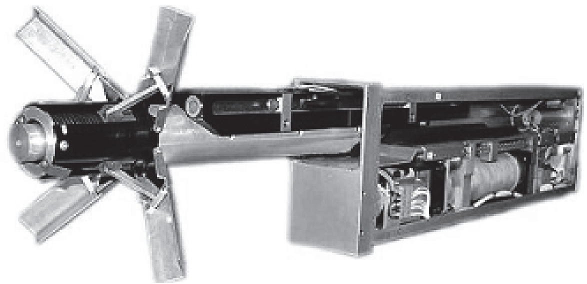


Fig. 4. A photo of container housing the serial produced ALE-50 aircraft protection system by Raytheon

According to [8], the AN/ALE-55 Fiber Optic Towed Decoy (FOTD), manufactured by BAE SYSTEMS Information & Electronic Warfare Systems (IEWS), Nashua, N.H., is an integral component of the joint U.S. Navy - U.S. Air Force Integrated Defensive Electronic Countermeasures (IDECM) Radio Frequency Countermeasures (RFCM) system.



a



b

Fig. 5. General appearance of the AN/ALE-55 towed decoy by BAE (a), and view of a decoy partially sticking out of its container (b)

IDECM incorporates onboard receivers and off-board countermeasures that include the high-powered FOTD and deployment canister. IDECM provides a highly effective electronic warfare defense for U.S. military aircraft against current and future RF missile threats. Currently, the IDECM is slated for deployment on the F/A-18E/F, the B-1B, and the F-15 aircraft.

The AN/ALE-55 fiber-optic towed decoy and the AN/ALQ-214 radio frequency countermeasures (RFCM), designed by BAE Systems and ITT Avionics, were designed to improve aircraft survivability by providing an enhanced, coordinated onboard/off-board countermeasure response to enemy threats. The onboard portion of the RFCM system is designed to receive radar signals from potential threat emitters via antennas on the forward and aft sections of the aircraft and to generate an electronic countermeasures response to the threat. Jamming may use either onboard transmitting capabilities or the off-board transmitting capabilities of a towed decoy.

For the off-board response, an effective jamming signal is generated by onboard RFCM equipment and provided to a decoy towed behind the aircraft for amplification and transmission. To reach the decoy, the signal is converted to light and transmitted down a fiber-optic link to the decoy. In the decoy, the light signal is converted back to RF, amplified, and transmitted using antennas integral to the decoy.

The ALE-55 FOTD system is different from the operational ALE-50 towed decoy system, in that the ALE-50 has no fiber-optics and generates its own electronic response to enemy threats. Being able to use the processing capabilities of onboard RFCM, equipment allows a much more robust threat response for the ALE-55 FOTD system.

In October 2002 the U.S. Navy and BAE SYSTEMS successfully completed a series of flight tests of the BAE SYSTEMS AN/ALE-55 Fiber Optic Towed Decoy on the Navy's new F/A-18 E/F Super Hornet. The success of these tests followed similarly successful test flights on a U.S. Air Force B-1B bomber in June and July 2002. The flight tests, conducted at Naval Air Station Patuxent River, Maryland, were designed to test the endurance and in-flight stability of the FOTD under extremely stressful flight conditions.

During these tests, the ALE-55 was subjected to combat representative flight maneuvers. Its fiber optic towline, which connects the decoy to the aircraft, endured multiple exposures to the fighter's afterburner plume. The ALE-55 maintained fiber optic and electrical continuity throughout the entire flight profile.

In September 2002 the U.S. Air Force and BAE SYSTEMS successfully completed a series of flight tests of BAE SYSTEMS AN/ALE-55 Fiber Optic Towed Decoy aboard the Air Force's B-1B bomber at Edwards Air Force Base, California. The tests included the first performance of the decoy while the B-1B was operating at supersonic speeds. During the flight tests, decoys were successfully deployed from the aircraft on four different occasions and were subjected to the most aggressive combat maneuvers attempted to date.

The tests demonstrated decoy deployment, safe separation, and in-tow performance while pushing the outer regions of the decoy's flight envelope. All decoys maintained towline integrity until commanded sever during the most aggressive B-1 maneuvers to date. Signal line continuity results varied with the maximum sustained signal continuity for approximately 45 minutes.

Preliminary results indicate decoy stability in the supersonic region appears to be exceptional. Supersonic test points included towing the decoys at supersonic speeds while performing multiple wing and airspeed tests.

Operational effectiveness of towed decoys was hinted also in analytical review of contemporary electronic countermeasures [9], where a photo of decoy directly hit by an air-to-air missile in live fire tests was presented (fig. 6).

Fig. 6. A decoy directly hit by a surface-to-air missile in live fires conducted by USAF

The manufacturer claims that such self-protection system including several towed decoys can be installed practically at any aircraft. Functional diagram of the aircraft self-protection system with the AN/ALE-55 towed decoy is sketched in fig. 7 (according to data from [8]). According to the same source, the system creates three echelons of defense for the air platform (fig. 8).

The first echelon involves electronic suppression, where the decoy transmits jamming signals in the frequency range of a missile guidance radar of enemy air defense systems. During this stage, the jamming signals reduce the aircraft detection range by enemy air defense radars and reducing the probability of target acquisition by missile guidance radars.

The second echelon involves generation of deceptive interferences if the aircraft was acquired as target. Such deceptive interferences are designed to introduce errors into the target tracking and missile guidance loops by means of range gate, Doppler gate, and angle gate pulling interferences. Generation of such interferences involves a sophisticated techniques for re-transmitting the radar illuminations while changing their characteristics (time lag, Doppler frequency, and direction of arrival) at the receiving side.

The third echelon lures the missile away from the protected aircraft and towards the decoy. This is achieved by re-transmission of the homing radar signals while retaining their exact parameters and amplifying them.

Employment of autonomous expendable jammers can solve this problem of protecting the aircraft only partly. Firstly, this is due to very limited time (dozens of seconds) of their operation using autonomous power supplies.

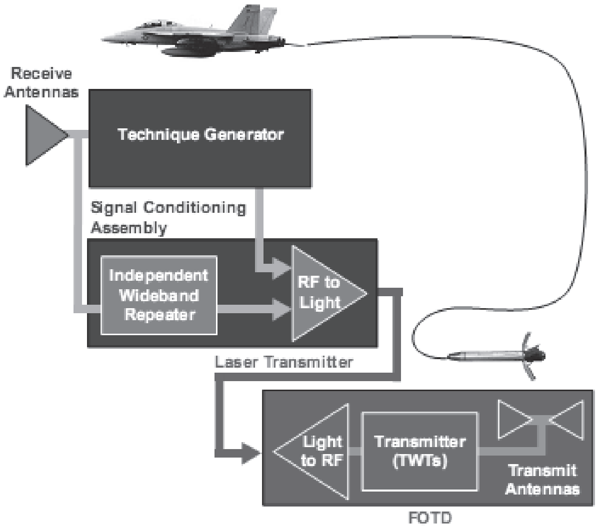


Fig. 7. General diagram of electronic aircraft self-protection system that employs a towed decoy

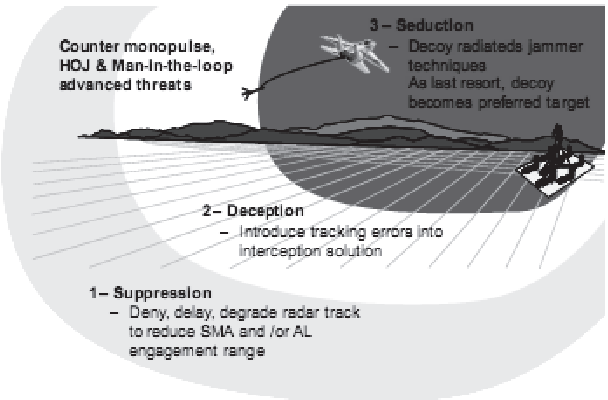


Fig. 8. Artistic representation of the aircraft protection echelons as delivered to an aircraft by the electronic protection suit

Secondly, such jammers are programmed prior to their firing and, once fired, they transmit countermeasure signal with unchanged parameters. However, for the countermeasures to be effective one needs to track the changes in the homing radar signal parameters online. This can be done only when the transmission of countermeasures and reception of enemy signals are conducted simultaneously. Such option cannot be provided by a small device intended for a single use.

In contrast to expendable electronic decoys, the towed decoys are capable of protecting its bearer for a prolonged time intervals. Besides, spatial separation of transmitting and receiving antennas facilitates their simultaneous operation.

Conclusions

Brief analysis shows that new emerging systems for protecting the aircraft are not advertised by their owners. Even though the idea underlying the use of towed decoys has been known for decades, its actual applications have been shrouded in silence. Information that indicates the scale of towed decoys employment is scarce, besides it's been scattered among many sources. However, the hints given in official documents of governmental bodies of the USA give us reasons to assume that such systems have been proved to be very effective, especially when protecting military aircraft against guided missiles of earlier generations.

Unfortunately, the designers of contemporary guided weapons intended for the air defense are reluctant to introduce new technologies that can counter advanced air threats such as sophisticated jamming techniques employing the off-board transmission of countermeasures.

If the existence of towed decoys stays unnoticed further by the national military and industrial complex, this can lead to a drastic decrease in effectiveness of future air defense systems against threats that already exist. Towed decoys have shown high performance in past military operations and, in near future, such systems are going to be even more sophisticated.

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ОГЛЯД СУЧАСНИХ СИСТЕМ САМОЗАХИСТУ ЛІТАКІВ З ВИКОРИСТАННЯМ БУКСИРУВАНИХ ХИБНИХ ЦІЛЕЙ

В.М. Орленко, І.Є. Ряполов

Наводиться огляд відкритих джерел, присвячених сучасним системам самозахисту літаків з використанням буксируваних хибних цілей. Детальна інформація про такі системи практично не публікується, хоча матеріали рекламного характеру досить поширені. Даний аналіз є спробою зібрати розкидані дані, які дозволили б судити про ефективність таких систем з тим, щоб зрозуміти чому буксирувані хибні цілі стали ключовим елементом сучасних електронних систем самозахисту військових літаків. Проте, даний факт замовчується військовими експертами, а самі системи не обговорюються в відкритих джерелах за участю фахівців, які експлуатують подібні системи, розробляють тактичні прийоми, а також вдосконалюють самі пастки. Метою цієї статті є привернення уваги авіаційних фахівців, а також фахівців ППО до факту появи нових технологій.

***Ключові слова**: радіоелектронний захист літака, буксирувана хибна ціль.*

ОБЗОР СОВРЕМЕННЫХ СИСТЕМ САМОЗАЩИТЫ САМОЛЕТОВ С ИСПОЛЬЗОВАНИЕМ БУКСИРУЕМЫХ ЛОЖНЫХ ЦЕЛЕЙ

В.М. Орленко, И.Е. Ряполов

Приводится обзор открытых источников, посвященных современным системам самозащиты самолетов с использованием буксируемых ложных целей. Подробная информация о таких системах практически не публикуется, хотя материалы рекламного характера достаточно распространены. Данный анализ является попыткой собрать разбросанные данные, которые позволили бы судить об эффективности таких систем с тем, чтобы понять, почему буксируемые ложные цели стали ключевым элементом современных электронных систем самозащиты военных самолетов. Тем не менее, данный факт замалчивается военными экспертами, а сами системы не обсуждаются в открытых источниках с участием специалистов, которые эксплуатируют подобные системы, разрабатывают тактические приемы, а также совершенствуют сами ловушки. Целью настоящей статьи является привлечение внимания авиационных специалистов, а также специалистов ПВО к факту появления новых технологий.

***Ключевые слова:** радиоэлектронная защита самолета, буксируемая ложная цель.*