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CONTEMPORARY THREATS FACING AIR TRANSPORT

Summary. Transport and logistics are a global enterprise, which means transportation must be provided to and from every continent around the world. This article presents the main threats facing international air transport in the course of necessary flying over dangerous and unstable countries, which represent almost a half of world's land surface.

Keywords: air transportation, aviation security, global logistics

1. INTRODUCTION

Today, aviation is one of the main kinds of transport, with modern logistics conducted on a global scale. This means that that transportation must be provided to and from every continent. Every year, thousands of tons of cargo and millions of passengers are carried on intercontinental routes, whether by land transport, maritime transport (mainly cargo) or air transport [16].

At the same time, about half of the countries in the world are currently unstable, due to major risks in terms of the outbreak of social unrest or even civil war and the collapse of a state. Many of these countries are already considered to be fallen, with crime, corruption and, often, terrorism and piracy prevalent in their territory [1]. A list of the fragile states in the world can be found on Fund for Peace website (http://fsi.fundforpeace.org/).

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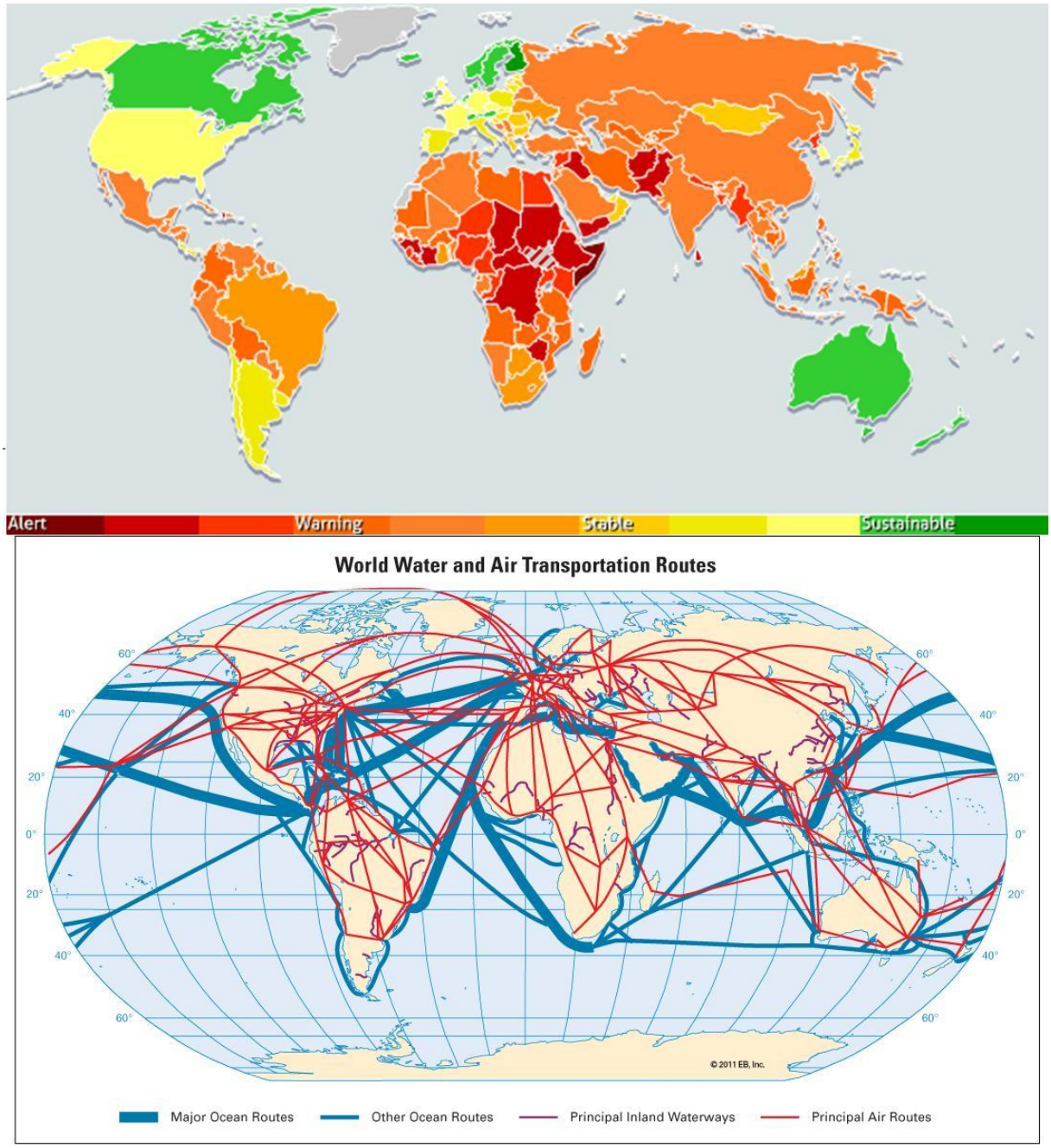

Fig. 1. Comparison of maps highlighting the world's most unstable countries and the main transport routes, including flight paths [1]

This article takes 178 countries of the world into account. South Sudan is recognized as the most unstable state (114.5 instability points, in the "Very High Alert" category), with the most stable state is Finland (17.8 points, the only country in the world in "Very Sustainable" category). Poland was in 153rd place (39.8 points, in the "More Stable" category). In the same category was the USA in 158th place with 35.3 points. These are the findings of the *Fragile States Index 2015* [1]. If we compare the map of global instability with the map of the world's major transport routes, you can easily see how many of the latter are located in dangerous areas.

2. THREATS TO CIVIL AVIATION WHEN FLYING OVER DANGEROUS AREAS

One of the main modes of transport in the world today is aviation, which is considered as the safest mean of transport. Its safety depends on many factors, however. One of the risks to aviation is the possible destruction of aircraft by weapons in the air or on the ground. This is a very specific situation, which largely depends on the political situation in the area where the flight is taking place. In fact, while airlines ought to immediately suspend flights over politically dangerous regions, economic and political factors mean that, sometimes civil air connections remain in place in these regions. There have also been cases of friendly fire or the shooting down of communication aircraft in areas where there is no armed conflict. Since the beginning of aviation, there have been many incidents of opening fire on civil aircraft. In this article, we present selected examples from recent history [2].

On 1 September 1983, the most tragic event in aviation history associated with the shooting down of a communication aircraft by a fighter took place. On that day, a Korean Air Lines (KAL) Boeing 747-230B was performing a scheduled flight from New York to Seoul with a stopover in Alaska (flight KAL007). The planned flight route was via the Bethel beacon and the R-20 airway (marked on the maps in red), which was only 28 km away from the Kamchatka Peninsula in Soviet airspace. However, for unknown reasons, shortly after take-off, the KAL Boeing airplane began to veer off course, missing Bethel by more than 20 km and entering an area comprising Soviet military bases between Kamchatka and Sakhalin. At the same time, to the east of Kamchatka, an American RC-135 airplane belonging to the US Air Force was performing a reconnaissance mission to monitor Soviet missile tests.

Although the RC-135 was about 1,500 km from the KAL Boeing airplane, the Soviets assumed that both were on a military mission. When flight KAL007 first flew into the airspace over Kamchatka and left the Sea of Okhotsk, Soviet fighters failed to catch it. Sometime later, the Korean airplane again crossed the border into the Soviet Union and travelled in the direction of Sakhalin. This time, flight KAL007 was intercepted by a pair of Soviet Su-15 fighters, commanded by Major Gennady Osipovich, whose fighter number was 805. The Russians argued that a warning had been given in the form of gunfire, but the Korean crew did not see it. In addition, Osipovich's Su-15 remained behind the KAL Boeing, rather than next to it, so it was inevitable that the crew would not see it. This confluence of events proved to be tragic for flight KAL007.

Firstly, the KAL Boeing was barely in Soviet airspace. Secondly, Osipovich, whose fighter was starting to run out of fuel, do not inform the Soviet ground station that he was aiming fire at civilian aircraft (he did not do so because nobody asked about it). After receiving the command from the ground, Osipovich fired two R-98 (NATO code AA-3 Anab) rockets into the Boeing. The first missile, guided by infrared, missed the target, but the second, guided by radar, hit the Boeing, causing decompression and destroying three of its four hydraulic systems. After 12 minutes, the burning Boeing crashed into the sea about 37 km west of Sakhalin, killing all 269 people on board. At the time of being hit, the Boeing was already a few kilometres outside of Soviet airspace [3].

The reason why flight KAL007 veered off its planned flight path is still unknown to this day. The official investigation ruled out the participation of the aircraft in an espionage mission, declaring it to have been a mistake caused by the autopilot settings. That said, both the Russian side and some Western experts continue to dispute this official version. The tragedy of flight KAL007 had other consequences: in 1986, the USA, Japan and the Soviet Union established a joint air traffic control agreement over the North Pacific Ocean, which gave Soviet inspectors full access to all civil flight plans. The most important change,

however, was the decision by President Reagan to open up a GNSS for full civilian use; this is now known as GPS [3].

Many transport aircraft have also been shot down by a ground-based anti-aircraft artillery. For example, in 1978 and 1979, the terrorist organization, the Zimbabwe People's Revolutionary Army, downed two Vickers Viscount aircraft belonging to Air Rhodesia (flights 825 and 827) using Strieła shoulder missiles fired from a man-portable air-defence (MANPAD) system. In the first case, some passengers survived the crash, but were murdered by terrorists on the ground. This took place within the territory of Rhodesia, which is now Zimbabwe.

On 27 June 1980, a Douglas DC-9 being to the Aerolinee Itavia airline (flight 870) crashed into the Tyrrhenian Sea about 40 minutes after take-off from Bologna, Italy. Apparently, an object was seen approaching the plane just before the crash. All 81 people on board were killed. This case of this incident is still not clear, but there are indications that it could have been mistakenly shot down by NATO forces.

On 24 February 1985, the Dornier 228 Polar 3 survey-and-research airplane, belonging to the Alfred Wegener Institute, was shot down by guerrillas from the Polisario Front over Western Sahara. All three crew members were killed. The Polar 3 was on its way back from Antarctica and took off from Dakar in Senegal in order to reach Arrecife on the Canary Islands.

On 6 November1987, the Air Malawi's Shorts Skyvan, with the registration 7Q-YNB, was shot down during a domestic flight from Blantyre to Lilongwe near the city of Ulongwe in Mozambique. Eight passengers and two crew members were killed.

However, the most well-known case of shooting down a communication aircraft with a ground (or water) armament is that of Iran Air flight IR655, involving an Airbus A300B2-203, with the registration EP-IBU, on 3 July 1988 [3, 6]. The flight took off at 10:17 from Bandar Abbas in Southern Iran, before heading for Dubai. On board were 16 crew members and 274 passengers. The flight left after a 27-minute delay, reaching an altitude of 4,300 m above the Strait of Hormuz in the Amber 59 (A 59) international airway, with a width of 35 km, in an almost straight line from the take-off point to the destination airport. The entire flight was to last about 30 minutes.

At that time, the Strait of Hormuz was patrolled by the American cruiser USS Vincennes (Ticonderoga type cruiser), which was equipped with the AEGIS air defines system. The ship was commanded by Captain William C. Rogers III. This unit patrol was part of Operation Earnest Will, which was designed to protect Kuwaiti oil tankers from attacks from Iraqi or Iranian forces. As we know, these two countries had, for years, been in state of absolute war. On the morning on 3 July, the USS Vincennes entered Iranian territorial waters in order to pursue a number of Iranian boats, which was carried out in accordance with international maritime law. These units had earlier fired on an American helicopter in Iranian airspace.

At about 10:47, the radar of the USS Vincennes detected an approaching object that was mistakenly identified as an Iranian F-14 Tomcat fighter. The mistake was in part explained by the fact that the airport, from where the Airbus had departed, was also used as a base for the F-14, and, as mentioned, the Airbus took off after a delay of almost half an hour (so it was not in accordance with the filed flight plan). The Americans maintain that, before opening fire for as much as 11 rounds, they tried to establish communication with the approaching plane. The ICAO report states that the Americans tried to contact its crew on seven occasions using the military frequency and three times on the civilian frequency before declaring it to be an unidentified aircraft flying at a speed of 350 knots.

The black box recorder of the A300 confirmed that the Iranian crew took the last three messages, but admitted that they were directed to the Iranian P-3 Orion maritime reconnaissance aircraft, which previously operated in the area. A few seconds before opening fire, the A300 crew conducted an exchange in English with traffic control in Bandar Abbas. The Americans do not hear this exchange because they did not have the necessary frequency set on their receivers. The American cruiser had also great difficulties in contacting Iranian air traffic control, not only due to the tense situation between Iran and the US, but also due to a lack of adequate training in this regard. The Americans had in mind the attack involving a Iraqi Mirage F1 fighter, which, a year earlier, fired an Exocet missile at the American frigate USS Stark, killing 37 sailors and injuring a further 21. The Airbus' ascent was interpreted by the Americans as preparation for firing a sea-to-air missile. At about 10.54, the commander of USS Vincennes ordered two SM-2MR missiles to be fired, both of which hit the Airbus, while flying at an altitude of 4,100 m at a distance of 14 km from the cruiser, killing everyone on board.

The incident further worsened US-Iran tensions, with the Soviet Union requesting a UN resolution condemning US actions in the Persian Gulf. Meanwhile, on 24 October 1988, the USS Vincennes returned to the USA, where the crew of the cruiser were greeted as heroes and received two Armed Forces Expeditionary Medals (including one for the officer responsible for the coordination of fire). In 1996, the US government decided to pay compensation to the Government of Iran to the sum of 61.8 million US dollars for the 248 Iranian citizens who lost their lives on Iran Air flight IR655.

That said, the Americans refused to pay compensation for the destroyed aircraft (30 million US dollars). The US government also announced that the payment of compensation for the victims of the incident was an act of goodwill, not an admission of guilt. This payment was made following an investigation by the International Court of Justice, during which Iran accused the US of a deliberate attack. To this day, this issue remains controversial. For example, in 2003, the International Association of Strategic Studies, an NGO, decided that placing a ship with an AEGIS system in the area of an operating communication aircraft was irresponsible, while the behaviour of the American captain was aggressive.

Ninety of the cases of the intentional downing of civilian communication aircraft have occurred against the backdrop of local conflicts. For example, on 21 September 1993, a Tu-134A airplane, which belonged to the Transair Georgia airline and was flying from Sochi in Russia to Sukhumi in Georgia, was shot down on landing by pro-Russian Abkhazian separatists. A shoulder missile was fired from a MANPAD system from a boat, resulting in the deaths of five crew members and 22 passengers. A day later, Abkhaz separatists downed a Tu-154B airplane, belonging to Orbi Georgian Airways, on its landing approach. The aircraft burned on the runway, causing the deaths of 8 out of 12 crew members and 100 of the 120 passengers.

Another example of this kind took place on 10 October 1998, when a Boeing 727 belonging to the Lignes Aeriennes Congolaises was flying from Kindu to Kinshasa in Congo. Shortly after take-off, the Boeing was hit by a Strieła MANPAD. All passengers and crew were killed.

A highly dramatic case occurred on 22 November 2003 involving an Airbus A300B4-203F (OO-DLL), which belonged to European Air Transport, a company managed by the famous transportation business DHL. The A300 was flying from Baghdad to Bahrain, with only three crew members and cargo on board. A few minutes after take-off, at about 09:03 local time, the Airbus was hit at a height of 2,450 m by a 9K34 Strieła 3 MANPAD missile. The rocket hit the trailing edge of the left wing. The attack had been carried out by a small group of

fedayeens, who were accompanied by a French journalist; indeed, it is speculated, that her presence (and, consequently, the likelihood of appearing in the media) provoked the attack. The explosion of the rocket damaged one of the fuel tanks and caused a fire. That said, it did not explode because, paradoxically, it was almost full (vapours are the main cause of the firing and exploding of fuel; but, in this case, there was not enough space to produce sufficient vapours in an almost full tank). However, the airplane experienced a leak of hydraulic fluid, resulting in the loss of hydraulic power in the steering systems. After about 10 minutes, the crew managed to regain some control over the airplane and mechanically lowered the landing gear. The first landing attempt was unsuccessful because the airplane was too high. The second attempt was successful and the Airbus landed. During taxiing after touchdown, the A300 went off the runway and stopped outside the airport. The evacuation of crew was very difficult due to the fact that the airplane landed on a minefield. However, all were rescued.

Fig. 2. The 9K34 Strieła MANPAD rocket launcher (USA/NATO code SA-7 Grail) [7]

The most famous incident of recent times is the tragedy involving a Malaysian Airlines Boeing 777 (9M-MRD, flight MH17) on 17 July 2014 [4, 5], resulting in the deaths of 283 passengers and 15 crew members. An examination of the wreckage revealed that the Boeing had been hit by an anti-aircraft missile. Officially, the guilty party has not been identified, but it was most likely shot down by Russian separatists using a 9K37 Buk M1 (SA-11 Gadfly), after incorrectly identifying the target as a Ukrainian military An-26. A piece of evidence to support this claim was a Twitter post by the separatist leader Igor Strielkov, who praised the alleged shooting down of another Antonov, before it quickly disappeared from the platform. This issue requires some comment. True, most of the blame lies with the separatists, given that there are many indications to suggest that they shot down the Boeing. However, we should also enquire as to who, allowed the Boeing to be in the area in the first place? Based on common sense (and civilized principles), airspace over areas characterized by armed conflicts should be closed immediately after the start of fighting, regardless of the type of armaments at a disposal of the warring factions. This space is controlled by Ukrainian air traffic services. Why was this not done?

The Ukrainian side has explained that there was no need to stop civilian air traffic in the respective area because separatists only possessed light anti-aircraft equipment, which is not capable of hitting high-flying aircraft. This cannot be taken seriously as advanced missile sets with bigger ranges can be delivered from Russia within a few hours every day. The problem is that Ukraine is still very dependent on Russia for gas supplies. Therefore, despite intense fighting, the Ukrainian Government operations in the eastern regions are still not defined as warfare activities, but officially as internal stabilization operations. Closing the airspace over

the eastern regions of Ukraine would be an admission to the world that the government does not have complete control over the situation, and maybe what is carried out there constitutes real war. That said, this airspace was closed to civilian air traffic following the Malaysian B777 incident. Even before, flights in that area had been withdrawn by airlines from the EU and the USA.

3. CIVILIAN AIRCRAFT PROTECTION AGAINST MISSILES

The means to mislead enemy missiles have long been known in military aviation. These mainly include on-board or suspended pods, which emit energy to jamming systems, as well as rocket flares and chaffs (aluminium strips). They are used to jam homing infrared systems (flares) and radar systems (aluminium strips) of flying missiles. The civilian aviation community is also interested in such devices.

Fig.3. Rafael Britening system: 1) detection of attack, 2) rocket jamming [11]

The idea of arming civilian means of transport is not new. Throughout history, transport ships were often armed for defence purposes. Equipping civilian ships with weapons on a larger scale was only abandoned in the 20th century. The current threat of instability in many countries of the world, however, will mean a return to this concept, at least to some extent. Currently, this also applies to aviation.

So far, attempts to protect communication aircraft operating in troubled areas have mainly involved ad hoc methods. In the 1980s, Soviet communication aircraft, when landing in Afghanistan, were escorted by military helicopters, which fired flares throughout the landing phase. This method also establishes a very steep approach path for the landing plane, enabling

it to decrease the flight time into the potential range of fire as much as possible (MANPAD operators could have been located close to the airport). While such methods are still used today, they are not appropriate for civil aviation. Designers around the world are trying to find cheaper and more efficient solutions, while several airlines are already using on-board systems for jamming (or even destroying) missiles. Their disadvantage is their high price tag (one to three million US dollars per single set) [8]. The leader in this field is Israel, which, for years, has equipped aircraft of the El Al airline with such systems. The Rafael company has been working on such systems since 2002.

Rafael's Britening system has sensors for the detection of incoming missiles, which are triggered by changes in heat in the environment. If this occurs, the Britening system generates a powerful beam of light, which interferes with the guiding system of the missiles [8, 9, 14, 15]. It can protect against light-guided missiles, especially during take-off and landing, while the system works automatically. The Britening system is based on the Aero-Gem protection system for military helicopters, with costs of around two million US dollars. Another similar system is the Israeli IAI/Elta Flight Guard, which working in a similar way to the Britening system except that it detects missiles using Doppler radar. IAI says that the Flight Guard offers 99% efficiency and is able to operate in any weather conditions. The system weighs 60 kg, with dimensions of 306 x 361 x 207 mm, and consumes 500 W of energy [11].

Fig. 4. C-MUSIC system on a Boeing 737-800 belonging to El Al

Another Israeli system of this type is the C-MUSIC. The Defence24.com portal reports [12]: "The company Elbit Systems announced the installation of anti-missile system C-Music on the first passenger aircraft belonging to the Israeli airline El Al. Music or Multi Spectral Infrared Countermeasures, is a system that protects aircraft from guided infrared missile fired with hand-held launcher. Its action depends on detecting the firing of a missile, and blinding or the destruction of its infrared tracking head by strong laser. Version C-Music is designed to protect large communication aircraft. The entire system is housed in a gondola installed below the fuselage. Due to the growing threat of civil aircraft by hand-held launchers held by the terrorist formations, interest in this type of systems has been growing since the beginning of the century, especially after the incidents in Kenya in 2002. The Israeli airline El Al are among the most threatened by terrorist attacks and therefore introduced a program to protect their machines under the name 'Sky Shield.' Under this program, we installed the first system C-Music on the Boeing 737-800 aircraft belonging to the airline."

Another country that develops on-board anti-missile systems for civil aircraft is the USA. On 21 December 2008, the US Department of Defense signed a contract with BAE Systems for this type of equipment. Under this contract, anti-missile systems were to be installed on aircraft belonging to American Airlines flying between New York and California [8]. The similar Guardian system has been developed by Northrop Grumman, which is civilian variant of the AN/AAQ-24 (V) Nemesis military system. Guardian can be placed almost anywhere on the fuselage and increases fuel consumption by only 3-4% [8].

Fig. 5. Northrop Grumman Guardian on a FedEx MD-11 [13]

4. SUMMARY

As indicated above, the risk of destruction faced by civil communication aircraft by means of combat is still prevalent. In the case of conflicts taking place in less stable countries, where opponents are often unspecified terrorist groups, the main risk involves the widespread use of lightweight MANPAD systems, usually in the form of Strieła type (SA-7) shoulder rocket launchers. Such terrorist groups are the only ones whose intent is to destroy aircraft and maximize the number of victims in in order to increase their media exposure.

Cases from this century, in which civilian aircraft have been shot down by heavier, vehicle-based rockets, can be classified as tragic mistakes or the results of negligence, not as intentional acts. That said, we must remember that there is every possibility that these terrorist groups will gain access to such advanced systems in the future. Heavy missile systems demand experienced crews, but the black market is full of unemployed soldiers and officers from the former armies of Saddam Hussein, Muammar Gaddafi et al.

Given the increasing level of instability around the world, the number of potential attacks on communication aircraft and tragic mistakes similar to those described in this article is likely to rise.

As such, the instability in many countries and the prevalence of terrorist group feeding it could represent the primary threat facing transcontinental air transport (as well as global transportation in general) in the 21st century. Today's modern means of transport (especially aircraft) are already so advanced that the risk of technical failure is minimal (especially in air transport). But we still have no effective solution to protect transport of any kind against acts of unlawful interference. For this to happen, we would need to stabilize the political, social and economic situation in the troubled regions of the world, something which is unfortunately very far away. At present, the only solution is the use of on-board self-defence systems on communication aircraft. Such systems will undoubtedly be developed throughout the rest of this century.

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