Zeitschrift: Revue Militaire Suisse
Herausgeber: Association de la Revue Militaire Suisse
Band: 145 (2000)
Heft: 12

Artikel: Combat SAR : electronic search beyond the radio horizon
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DOI: https://doi.org/10.5169/seals-346091

Combat SAR[1]

Electronic search beyond the radio horizon

La recherche de pilotes abattus n'est pas une tâche facile. Outre l'engagement de spécialistes, elle requiert des moyens de localisation et de transmission performants. Des moyens qui soient suffisamment compacts pour pouvoir être facilement emportés par le pilote, suffisamment puissants pour que celui-ci puisse entrer en contact avec ses sauveteurs, mais suffisamment discrets pour que l'adversaire ne puisse repérer celui qui s'en sert. La réponse à ces questions est essentiellement, pour l'instant, affaire de techniciens. L'auteur présente ici les différentes données du problème, assorties de possibles solutions. Nous inaugurons une rubrique en anglais destinée à améliorer l'interopérabilité des cadres de notre armée.

By Olivier Desjeux

Scope

Combat SAR is a very specific discipline within armed forces. Only specifically trained squadrons operate this discipline because of the multiple issues to be considered:

– The downed pilot is often in a hostile environment behind the enemy's lines. The enemy knows that a plane crashed and is actively seeking, for many important reasons, for the survivor(s).

– The downed pilot is often way beyond the radio horizon, rendering any radio-communication very difficult. Moreover, the pilot is in surviving conditions, which is characterised by a shortage of supplies, including electrical supplies.

– Due to the combat situation, the rescue must comply with very strict flight plans: very low altitude flight level, usually in bad weather conditions or at night, no radio transmission.

History

Many combat SAR operations happened in different wars during the last decade. The most publicised is definitely Captain Scott O'Grady's, operation relayed by the mass media. The 2nd of June 1995, his *F-16* was shot down over Bosnia, and it appears that his only mean to give his position was a Vietnam era Emergency Locator Transmitter (ELT) and a *GPS*. Hopefully, he managed to escape foes during 6 days, and to give some signs of life when friendly aircraft flew nearby the crash's position. The statement «hopefully» is not quite correct: he had a very clear understanding of the situation, of the limitations of his equipment, and he really managed intelligently to get the best out of it. But, just like the very few downed pilots able to share his experience, he had a very hard time finding out when to transmit his distress message. May he have transmitted a bit longer would he have been spotted, may he have transmitted a bit shorter would he have not been found. Of course, the

[1]No information in this short paper is given about the name of products or manufacturing companies. No mention is made either on any armed force using such and such type of equipment. Of course, the sharp eyed reader will recognize both the material described and the armed force involved. But, no classified information is given away. Anyway, these new solutions are more on the experimentation side than an equipment given to each soldier.

[2]L'auteur a notamment travaillé au développement de la montre Breitling Emergency. Il a créé sa propre entreprise, INGECOM, spécialisée dans la miniaturisation des équipements de transmission et des appareils de localisation par ondes radio (desjeux@ingecom.ch).

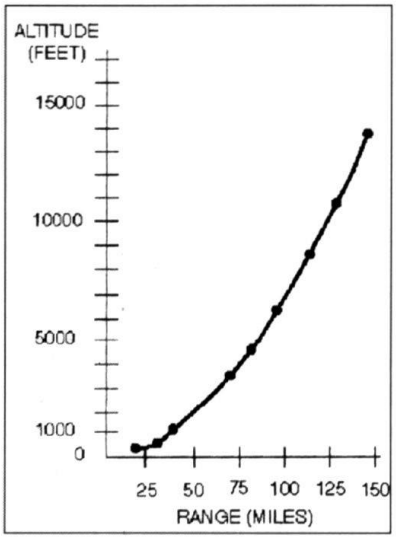
distress messages must be transmitted in a radio horizon range, i.e. a bit less than the line of sight. Any receiver beyond this range is deaf to his distress messages.

Tactical communications over radio Horizon range

In order for a portable transmitter to communicate to a receiving station located outside the radio horizon range, the frequency must be relayed by a repeater. In combat situation, in enemy's zone, no terrestrial infrastructure is available to relay the frequency. So the repeater should be airborne in either a fixed wing or rotor aircraft, an Unmanned Aerial Vehicle (UAV), or a satellite.

Type and use of repeaters

Satellite repeater: Due to the volume and weight limitation of the ELT, the satellite needs to be on a rather low orbit. The power budget limits so far the possibility to reach geostationary satellites. The advantage of this situation is that the velocity of the satellite enables to compute a position using the Doppler effect. The civilian Cospas-Sarsat network uses this feature to pinpoint 406 MHz ELTs. In order to improve the localisation, the ELT can also transmit its *GPS* position.



Radio horizon range.

Fixed wing or rotor wing aircraft repeater: A repeater airborne on such platform only relays the information received to a ground station. So, in order to get a position fix, the message sent by the ELT shall include its *GPS* position. Another solution is to use a Direction Finder (DF) onboard the aircraft. The pilot shall make a few DF measurements in order to compute precisely the localisation of the ELT.

UAV repeater: For the same reason as for aircraft repeaters, several long range UAV payloads are equipped with DFs. Each UAV (Unmanned Aerial Vehicle) has its own identification number and its position is permanently transmitted by telemetry to the ground station. DF QDM bearings are sent over telemetry to the ground station, enabling to plot on a map the localisation of the downed pilot. As many UAVs can fly simultaneously a battlefield, the localisation is updated as soon as the pilot activates his ELT.

Transmitting without being localised by foes

Obviously, if friendly forces can localise the downed pilot, an extreme caution should be applied to the transmission protocol, in order to avoid interception or jamming of the transmission by foes. The protocol may be of different natures:

Spread spectrum: Frequency hopping or direct sequence spread spectrum is certainly the most difficult to intercept. It is also the most difficult to localise by conventional means, so the message sent with this protocol should include a GPS position.

Digital communication: Digital communication is also difficult to intercept, provided that very short sequences are transmitted. But typically, a coded distress message lasts no longer than a few hundreds of milliseconds. So chances of being intercepted is very weak. This protocol is typically adapted for communication through a satellite repeater.

Time management: Analogue communication should be avoided if no time emission frame has been convened previously. A military ELT, such as the ones still in use in most of the armed forces world-wide, must be equipped with a time emission management system. Such a system has the main advantage to be very cost effective, easy to use, and has also often the possibility to voice transmit and receive. Moreover, conventional directional finding systems can localise the ELT with high accuracy. Time emission management only requires a watch in addition to the ELT. The time management is also a code bet-

Versatile par excellence, *the* AS 532 U2 *offers a large cabine. Its extended range and its integrated navigation systems make it a SAR and combat/SAR helicopter perfectly suited for today's requirements (day/night missions).*

ween the downed pilot and his allied forces. If the time management procedure is correctly followed by the downed pilot, it enables also an authentication of the sender. If anybody is able to transmit a distress message, including foes, not anybody knows when and during how long time he is supposed to transmit.

Transmission towards the downed pilot

At this point of the discussion, no mention has been made of the communication towards the downed pilot. If the reason of the communication from the downed pilot towards its allied forces is obvious to understand, the other way may be for two reasons:

Acknowledgement of receipt of the distress transmission: The acknowledgement has one main meaning: stop transmitting, keep your position and hide. The only reason to start another transmission is if the position has changed.

Request to send (RTS): A new kind of Position Locating System (PLS) is born: the downed pilot carries his PLS which doesn't send any information until a RTS information is received from a friendly aircraft. Of course both the RTS and the answer from the PLS are coded, enabling authentication of both the friend and the PLS. Duration of each transmission is within a few hundreds of milli-seconds, with a totally random activation time, rendering the localization of both the aircraft and the PLS very difficult.

Tendencies

The Gulf's downed pilots, and more recently the war in Bosnia has highlighted the fact that a simple Vietnam era ELT is no longer enough to solve the downed pilot problem. Among the different solutions suggested by industrials, three of them seem to retain the attention:

Digital beacon: An ELT which includes a GPS, transmits a digital information to a satellite repeater. The pilot can configure the message to be sent, and an acknowledgement is received when the distress message has been picked. The line of sight, or radio horizon, is broken by the use of dedicated satellites. The duration of the transmission is very short in order not to be intercepted. So this system seems very close the requirement of the combat SAR situation. However, it relies on very expensive infrastructures, and also very expensive terminals. The product currently under evaluation has even three levels of redundancy: a dedicated UHF satcom link, a classified one, and a link via commercial SAR satellites.

PLS: The PLS has been described in the chapter «Transmission towards the downed pilot». In its simplest form, a PLS is an active transponder sending replies upon specific requests. The reply may contain a few information of primary interest such as the GPS position and the status of the downed pilot. It is activated usually by a rotor wing aircraft flying over zone. The aircraft has the possibility to localize the transmission, and also to identify the PLS. The terminal is also an expensive device, like the digital beacon, but the

infrastructure is much more cost effective.

Conventional ELT: Conventional ELTs, the same as used world-wide, still have some good days to live: those easily available transmitters can always be switched on and off very easily, enabling the transmission time management. Nowadays, several UAVs are available with a DF as a standard payload. Theses small aircrafts can offer a good battlefield monitoring, including sometimes even video transmission, back to the ground station, way beyond the terrestrial radio horizon range. Flight conditions is not an issue as important as for manned aircrafts, first because the flight parameters are fully automated, and second because the casualties in case of a crash are far less important.

So this combination of «usual» ELTs used together with a reliable watch enables the authentication of the downed pilot. With a battlefield permanently monitored by UAVs on which a DF payload is installed, the allied forces know for each transmission the position of the downed pilot. This combination has the main advantage over the two previous ones to use existing equipment with an inexpensive upgrade, if the UAVs in service are not already equipped with a DF.

About GPS

Mention of the GPS has been made, to give the position of the downed pilot using PLS or Digital beacon. However, during war time, there is only one country able to decide on the accuracy of the GPS encoding. So, if sending the GPS position seems an interesting feature, it may not be very reliable, depending on the political situation. In such case, the only way to get a reliable positioning is via DF systems.

Summary

The zero casualty war concept kicks off some new ways of recovering downed pilots in hostile territory. The global concepts described here-above include necessarily some time and money consuming investment. In order to make a decision on which type of system to use, the deciders are aware that no panacea exists on earth, i.e. for each system, a weak point will be identified. Being aware of these weak point, it is then a question of prioritisation to chose for the correct system. In our modern world, armed forces have two bottom lines when they report to the government: the money and the casualties. For many governments, the second one is more important than the first.

O. D.