PROSECUTING 406/121.5 MHZ DISTRESS BEACONS

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1. **Purpose and intended recipients of this document:**
   a. This document discusses the technical issues associated with 406 MHz Distress Beacons, limitations of our existing capabilities and the procedures required to mitigate those limitations.
   b. This document is recommended reading for certain Incident Command Staff (specifically ICs, OSCs, PSCs, AOBDs, and GOBDs), Mission Pilots, Mission Observers and Ground Team Leaders.
2. **Synopsis:**
   a. Newer 406 MHz Distress Beacons are now being sold that transmit on 406 MHz channels that are not detectable by CAP's current airborne direction finder, the Becker SAR-DF 517. That device is only capable of detecting and processing 2 of the eighteen 406 MHz Distress Beacon Channels (excluding the 406.022 MHz Reference Channel).
   b. All 406 MHz Distress Beacons used in the United States transmit 121.5 MHz Homing Signal at a power level that is significantly reduced from the old analog-only beacons.
   c. CAP is modernizing its SAR-DF 517 equipped aircraft to a more capable RHOTHETA model RT-600.
   d. In the interim, an awareness of today's limitations and the implementation of additional procedures to mitigate those limitations must be in place to effectively prosecute newer 406 MHz Distress Beacons.
3. **406 MHz Distress Beacon Channels and Radio Frequency Spectrum:**
   a. The radio frequency spectrum band for 406 MHz Distress Beacons comprises 19 channels between 406.022 MHz and 406.076 MHz. A 406 Distress Beacon Channel Listing is included below:

Ch-1	406.022 MHz (Reference)	Ch-11	406.052 MHz
Ch-2	**406.025 MHz (SAR Mode)**	Ch-12:	406.055 MHz
Ch-3	**406.028 MHz (SAR Mode)**	Ch-13:	406.058 MHz
Ch-4:	*406.031 MHz (In Use Today)*	Ch-14:	406.061 MHz
Ch-5:	*406.034 MHz (In Use Today)*	Ch-15:	406.064 MHz
Ch-6:	*406.037 MHz (In Use Today)*	Ch-16:	406.067 MHz
Ch-7:	406.040 MHz	Ch-17:	406.070 MHz
Ch-8:	406.043 MHz	Ch-18	406.073 MHz
Ch-9	406.046 MHz	Ch-19	406.076 MHz
Ch-10	406.049 MHz		

b. The COSPAS-SARSAT System's planned sequential release of the additional channels has been directly tied to the number of *Emergency Position Indicating Radio Beacon* (EPIRB), *Emergency Location Transmitter* (ELT) and *Personal Locator Beacon* (PLB) devices sold and registered internationally.

c. Ch-1 (406.022 MHz) is designated as the Reference Channel. The first operational channel (Ch-2: 406.025 MHz) was released for use when the system was initially established. Ch-3 (406.028 MHz) was released in the 2002 timeframe.

d. Although the first 406 MHz Distress Beacon rescue occurred as early as 1984[1], it was not until more recently that Distress Beacons using the additional channels began to be fielded. Since then, the popularity of these devices has mushroomed and the release of additional channels has been exponential.

4. Limitations of the Becker SAR-DF 517:

a. The Becker SAR-DF 517 airborne Direction Finder (DF) in use on newer Civil Air Patrol aircraft was manufactured by RHOTHETA and is similar to their model RT-500 airborne DF.

b. While operating in the SAR Mode, the SAR-DF 517 monitors 121.5 MHz (Aviation Emergency & Distress Beacon Homing Signal), 156.8 MHz (VHF Maritime Distress Channel 16), 243.0 MHz (Military Aviation Emergency and former Military Beacon Distress Signal), as well as 406 Ch-2 (406.025 MHz) and 406 Ch-3 (406.028 MHz).

c. The SAR-DF 517 does not scan the additional 406 Distress Beacon channels currently in use today. It is tuned near 406.025 MHz with a ± 0.005 MHz detection range (406.020 – 406.030 MHz), allowing it to also receive and process 406 Ch-3 (406.028 MHz).

1) When initially obtained by CAP, the SAR-DF 517 was limited to 406 Ch-2 (406.025 MHz) only (as well as 121.5 MHz, 156.8 MHz, & 243.0 MHz). For that reason, early user manuals and training materials only referred to 406.025 MHz.

2) We recently learned that, while the SAR-DF 517 is capable of being programmed by the operator to additional frequencies while in Training Mode, it is limited to increments of 0.025 MHz. This design limitation restricts the SAR-DF 517 to the

[1] COSPAS-SARSAT Information Bulletin 22; Issue Enclosure - February 2010 (http://www.cospas-sarsat.org/images/stories/SystemDocs/Current/bul22_final_enclosure.pdf)

following programmable frequencies: **406.025**, **406.050** and **406.075** MHz. Given the ± 0.005 MHz bandwidth, even with operator programmability, the SAR-DF 517 is not capable of detecting or processing most of 406 Channels.

5. **121.5 MHz Homing Signal's Reduced Effective Radiated Power for 406 MHz Distress Beacons:**
   a. 406 MHz Distress Beacons authorized for use within the United States[2] include a 121.5 MHz Homing Signal. This Homing Signal is designed to narrow down the location of the beacon once SAR assets arrive into the local search area.
   b. Since GPS-equipped 406 Distress Beacons have an accuracy of better than 100 yards (1-3 NM when GPS data is not available), the signal strength of the 121.5 MHz Homing Signal is significantly reduced from the dedicated 121.5 MHz-only beacons. The 121.5 MHz component's transmitter is reduced from 0.100 Watts to 0.025 Watts to minimize the impact on the aviation use of this frequency for emergency communications.
   c. A greater impact to the detectability of the signal is that the newer beacon's shorter 7 inch antenna is optimized for its 406 MHz component's 5 Watt transmitter.
   d. The combined result is that the Homing Signal's effective radiated signal strength may be less than 1/10th of the older dedicated 121.5 MHz Beacons with antennas that are over 24 inches long.
   e. The lower radiated power results in situations where air, ground and maritime SAR assets may not detect the 121.5 Homing Signal until within a few hundred yards or less of the beacon.
6. **CAP Airborne Direction Finder Modernization Efforts:**
   a. CAP's National Headquarters is currently modernizing its fleet of Becker SAR-DF 517 equipped aircraft with the RHOTHETA RT-600 airborne DF.
   b. New aircraft are being acquired with the DF-600. Based on available funding, the RT-600 may be used to replace unrepairable SAR-DF 517 units.
   c. The DF-600 uses state of the market technology to simultaneously monitor all 406 MHz Distress Beacon channels.
   d. The upgrade effort for existing aircraft is tied directly to available funding and may become protracted in our current budget climate.
7. **Interim Procedures to Ensure Success When Prosecuting Newer 406 MHz Distress Beacons:**
   a. In the interim, it is critical that personnel involved in Missing Aircraft, Vessel and Person searches where there is a probability of a 406 MHz Distress Beacon, including missions based on 406 MHz Distress Beacon detections, be aware of the procedures necessary to mitigate these technology limitations and challenges.

[2] 406 Distressed Beacons manufactured in certain countries do not include a 121.5 MHz Homing Signal. These devices are not authorized for use in the United States.

1) The Incident Commander must ensure that the *Air Force Rescue Coordination Center* (AFRCC) provides the COSPAS-SARSAT detected 406 MHz frequency. This information is provided to the AFRCC (and other *Rescue Coordination Centers* (RCCs)) by the *U.S. Mission Control Center* (USMCC), operated by NOAA.

2) The Incident Commander must inform the Mission Aircrew of the specific COSPAS-SARSAT detected frequency. If the detected 406 MHz frequency is not Ch-2 or Ch-3, the Aircrew will not be capable of detecting the signal in SAR Mode. The Aircrew must depend solely on their ability to detect and prosecute the significantly reduced power 121.5 MHz Homing Signal. In the case of a COSPAS-SATSAT detected 406 MHz, the Aircrew should initially focus on the reported fix location to reduce their search area.

3) Whenever a 406 MHz Distress Beacon is suspected, Ground Teams must be clearly advised that these devices radiate a significantly reduced 121.5 MHz Homing Signal.

   a) When a 406 MHz Distress Beacon has been reported, their primary tasking should be to proceed immediately to the exact location of the provided COSPAS-SARSAT fix. Typically, this is within 100 yards or better of the 406 MHz Distress Beacon. Since the Homing Signal is so weak, GTLs may find themselves doubting the validity of the COSPAS-SARSAT fix when they don't pick up the 121.5 MHz Homing Signal within a few hundred yards of the reported location. The expectation to begin picking up the signal further out from the anticipated beacon location is something they came to expect from older, higher power 121.5 MHz Distress Beacons. That higher power signal was necessary when the optimal COSPAS-SARSAT fix was no better than 8 miles from the actual beacon location, resulting in an area of more than 200 square miles to be searched.

8. When a COSPAS-SARSAT Fix is not obtained from a 406 MHz Distress Beacon-equipped aircraft:

a. Natural and man-made obstructions (e.g. ravines, crevasses, buildings, or fuselage) may prevent a 406 MHz Distress Beacon from obtaining a GPS signal. While these obstructions may impede the beacon's ability to provide an accurate fix, the 406 MHz encoded data burst, transmitted every 50 seconds at 5 Watts, should punch through any tree canopy, crevasses and other formations. Typically, while the obstructions may prevent the beacon from obtaining a GPS fix, enough of the 5 Watt data burst, including reflections, should be detected and processed by overpassing *Low Earth Orbit Satellite* (LEOS), the *GEO-stationary Satellite* (GEOS) and *Medium Earth Orbit Satellite* (MEOS: fully operational by 2018) constellations.

b. In the case of a Missing Aircraft with a 406 MHz ELT, the lack of any 406 MHz COSPAS-SARSAT detection implies that the ELT may be damaged and unable to transmit its data burst.

c. In these cases, as well as where an older technology 121.5 MHz analog-signal Distress Beacon is suspected, SAR assets should be especially vigilant for the significantly weaker 121.5 MHz Homing Signal.

9. Summary:

a. It is critical for personnel involved in 406 MHz Distress Beacon and Missing Aircraft missions to be cognizant of the 406 MHz technology, its capabilities, our resources' limitations, and effective mitigations.