406 Homing solution – Beacon battery considerations (RTCM)

Introduction

This paper sets out the battery requirements for a basic 406 MHz PLB without any special functions that would require additional battery capacity such as a Return Link Service. The annex to this paper provides details on the current allocation of battery capacity which can be summarized as follows:

- 406 MHz 5W Transmitter 37%
- 121.5 MHz Homing Transmitter 33%
- Control Functions and GNSS 30%
- Total Available Battery Energy 21400 Watt Seconds

It should be noted that a Second Generation Beacon could potentially draw more than 37% of the total battery capacity given the longer pulse duration envisaged for SGB depending upon the transmit schedule adopted.

The paper calculates the battery capacity required to power a 406 MHz homing signal and provides some examples of how this could be attributed to the homing signal.

Battery energy formula

To help progress towards a viable solution RTCM offer the formula below as a means for anyone to calculate the beacon energy requirements....

Battery energy = 24 *3600 *t *P / (0.12 *T) (in Watt-Seconds)

P= Power into 50R in Watts (0.12 efficiency)
t=TX pulse length in seconds
T= TX repetition in seconds

This assumes evenly spaced transmissions and the main 406 power amplifier being used at lower signal level. We are unsure what t / T / P values are applicable, several options have been pre-calculated for illustration.

TABLE 1 - RTCM battery limitation (1440 Watt-seconds)

Power (Watts) / dBm	Pulse length (sec)	Repetition (Sec)
0.2W = 23dBm	0.1	10
	0.2	20
	0.5	50
0.4W = 26dBm	0.1	20
	0.2	40
	0.3	70

TABLE 2 - NASA battery limitation (7000 Watt-seconds)

Power (Watts) / dBm	Pulse length (sec)	Repetition (Sec)
0.2W = 23dBm	0.1	2
	0.2	4
	0.4	8
0.4W = 26dBm	0.2	8
	0.5	20
	1.0	40

RTCM vs NASA battery limitation

The tables show two different limitations on available battery energy assigned to 406 homing.

RTCM Assumes 18% of existing satellite 406 energy is redirected towards 406 homing and that this saving is achieved by implementing an Intelligent Transmit schedule for the main 406 MHz satellite bursts.

Leaves 121 homing operating in parallel to meet international homing requirements.

NASA Assumes all existing 121 homing energy is directed at 406 homing.

The RTCM viewpoint is: "adding 406 homing shall not be at the expense of 121 homing". So the 33% of battery that is presently allocated to 121 homing cannot be touched. Until IMO/ICAO concede to 406 homing, beacons must continue to provide 121 homing. Energy for 406 homing needs to come from the 37% of battery which is currently allocated to 406 satellite transmissions. This viewpoint is based both on a "real world" view of IMO/ICAO timescales, plus the RTCM interpretation of G.008 text shown below…

G008 para 3.14.1 : *"Beacon design shall provide for homing and on scene locating. Compliance with other Cospas-Sarsat requirements* ***shall not prevent compliance of the beacon with international*** *and/or national* ***requirements for on-scene locating****, homing, or signal transmission(s) for direction finding (i.e., 406/121.5/243.0 MHz, AIS, etc.)"*

Technical Annex - Battery energy summary

The calculations below are offered to support the "Watt-Second" energy values presented above. RTCM believe the breakdown below is representative of typical best-in-class beacons in service today.

406 energy usage today (37% of battery)
T.001 calls for 1728 transmissions (24h * 60 * 60/50 = 1728)
Each 5W TX is 0.52s long. At typically 56% efficiency this draws 8.9W from the battery
This computes to (8.9 * 0.52 * 24 * 60 * 1728 =) 8000 Watt Seconds

121 energy usage today (33% of battery)
Continuous 121 uses OOK (On-Off Keying) with 37% modulation duty cycle = 24h *3600 *0.37 = 32000 seconds
Typical TX power (into the antenna) is 0.12W, at typically 55% efficiency this draws 0.22W from the battery.
This computes to (32000 * 0.22 =) 7040 Watt Seconds

Control functions (uC, GNSS, indicators etc) account for another 30% of the battery.

Battery energy available (at -20C worst case)
A best-in-class PLB uses 3x type CR123A cells. When cold these can provide a capacity of 1Ah.
Battery voltage lowers when cold and decays over operating life. An average value of 7V is assumed.
The PLB battery thus provides 7 Watt Hours of energy, or 25200 Watt Seconds
To cater for 12 years shelf life and self tests it is common to set aside 15% of available capacity.
Total available capacity (for 24h operation) is thus (25200 * 0.85 =) 21400 Watts Seconds.