Frequency Saturation

When "time-coupled", ADS-B can be synchronized to the GNSS pulse per second (PPS). The result is a cacophony of broadcast messages all occurring in lock step every 200 milliseconds. It takes only a handful of "time-coupled" emitters to cause frequency saturation. Worse, the closer two emitters are to one another, the greater the likelihood of mutual interference. Color My Data proposes an alternative.

Time Division Multiple Access (TDMA)

Our solution divides the time between PPS into 1024 distinct broadcast periods and then lets emitters self-organize by selecting a broadcast period for all of their five or six messages. Zero latency is achieved by sampling data on the synch pulse and then adjusting message receipt time backwards in time to the preceding synch pulse. Up to 1024 emitters can share data with no mutual interference.

Other Sources of Interference

ADS-B isn't the only use case for 1090 MHz. That frequency is also used by surveillance radars and transponder replies to Identification Friend or Foe (IFF). Surely, these sources will interfere with ADS-B broadcasts. Color My Data proposes a number of strategies to mitigate this type of interference.

Low Cost / Size / Weight / Power / Altitude / Velocity (Lo CSWPAV)

ADS-B organizes emitters by category set. Category Set A includes conventional aircraft and rotorcraft with ample power. With the exception of commercial spacecraft, Category Set B includes emitters likely to be battery powered on vehicles or persons operating at low horizontal velocities at mostly low altitudes. Examples include unmanned aerial systems (UAS), gliders, balloons, hang-gliders, parachutists, etc. Category Set C is for surface based emitters like service and emergency vehicles, point, cluster or line obstacles etc. Category Set D is presently reserved. Color My Data proposes Category Set D be assigned to trans-atmospheric vehicles such as spacecraft and high-altitude balloons, UAS or manned aircraft operating at or above FL 450. With this realignment new requirements can be defined for interactive ADS-B on all Category Set B emitters.

Power

The effective radiated power (ERP) requirement for "realigned" Category Set B emitters is reduced from 70 watts to 1 watt. This limits the radius of detection and by consequence, interference to a few miles.

No Transponder / No IFF

Realigned Category Set B emitters have NO transponder and use Downlink Format (DF18). With no transponder there is no reason to have IFF. This means no new False Replies Unsynchronized in Time (FRUIT). It also means radar surveillance of realigned category set B targets will get only skin paints.

Size

Antenna diversity gives ADS-B the option to transmit or receive from two widely separated antennas. For small UAS the vehicle may be smaller than the minimum required separation. This means a vehicle must use a single antenna and cannot receive while it is transmitting, a clear reason for using TDMA instead of the "time-coupled" case of a standards compliant ADS-B system.

Pulse on Pulse Logic

The probability of a surveillance radar pulse interfering with one of the five or six broadcast messages is relatively high. Legacy ADS-B broadcasts and FRUIT may also cause interference. However, using techniques developed for electronic warfare, up to three overlapping pulse trains may be deinterleaved thus separating the broadcast being processed from FRUIT, radar pulses and other broadcasts. This is in addition to the cyclic redundancy check (CRC) performed on the input message.

New Message Formats

Compact Position Reporting (CPR) yields locations that are ambiguous. The ambiguity is resolved either by assuming a position close to the fix or by using two messages with two different scales. In the absence of high-g maneuvers there is no rationale for twice per second reporting other than CPR. The unintended consequence of CPR on frequency saturation is dramatic. It cuts the number of emitters that can be accommodated in half. For TDMA this means a maximum capacity of 512 emitters in lieu of 1024 emitters. By eliminating CPR we not only mitigate frequency saturation, we eliminate the complexity and processing time needed to resolve the ambiguity. Message types 25 and 26 which have been reserved for latency data are instead allocated for both airborne and surface position reporting in conjunction with TDMA. The following tables show the amended formats.

MSB	Bits	Parameter	Remarks
1	5	type = 25	TDMA Horizontal Position Message
6	2	surveillance status	same semantics as in Airborne Position Message
8	1	is airborne	yes: airborne aircraft; no: aircraft on ground or category C emitter
9	1	is valid data	yes: data are valid; no: do not use latitude or longitude
10	23	latitude	twos-complement; msb weight = -90 degrees (2.4 meters res)
33	24	longitude	twos-complement; msb weight = -180 degrees (< 2.4 meters)

MSB	Bits	Parameter	Remarks
1	5	type = 26	TDMA Vertical Position Message
6	3	category subtype	includes Category Set B and D "realignment"
9	2	category set	enumerated {0: Set A; 1: Set B; 2: Set C; 3: Set D}
11	4	radius of containment	lookup table[0..13] used in lieu of NIC + NIC supp A,B,C
15	1	surface status	0: N/A; 1: height is top of Category Set C surface obstruction
16	2	baro exponent	barometric pressure altitude exponent[see altitude equation]
18	10	baro significand	barometric pressure altitude significand; 12.5 ft resolution
28	3	hae exponent	height above ellipsoid exponent[see altitude equation]
31	10	hae significand	height above ellipsoid significand; 12.5 ft resolution
41	8	wind direction	unsigned; MSB weight = 180 deg
49	8	wind velocity	unsigned; lsb = 1 knot; range -1 to 254 knots; -1=N/A

$$altitude_{feet} = \begin{matrix} Not\ Available & when\ f = 0 \\ f \times 12.5_{feet} - 1000_{feet} & when\ f > 0 \end{matrix}$$

Where $$f = \begin{matrix} significand & when\ exponent = 0 \\ (significand + 1024) \ll (exponent - 1) & when\ exponent > 0 \end{matrix}$$

