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RTCA SC-186 WG-3 and Eurocae WG-51, SG-1

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# T=0 Timing Requirement and Test Procedures

in discussion of the conclusions in WP-27-08

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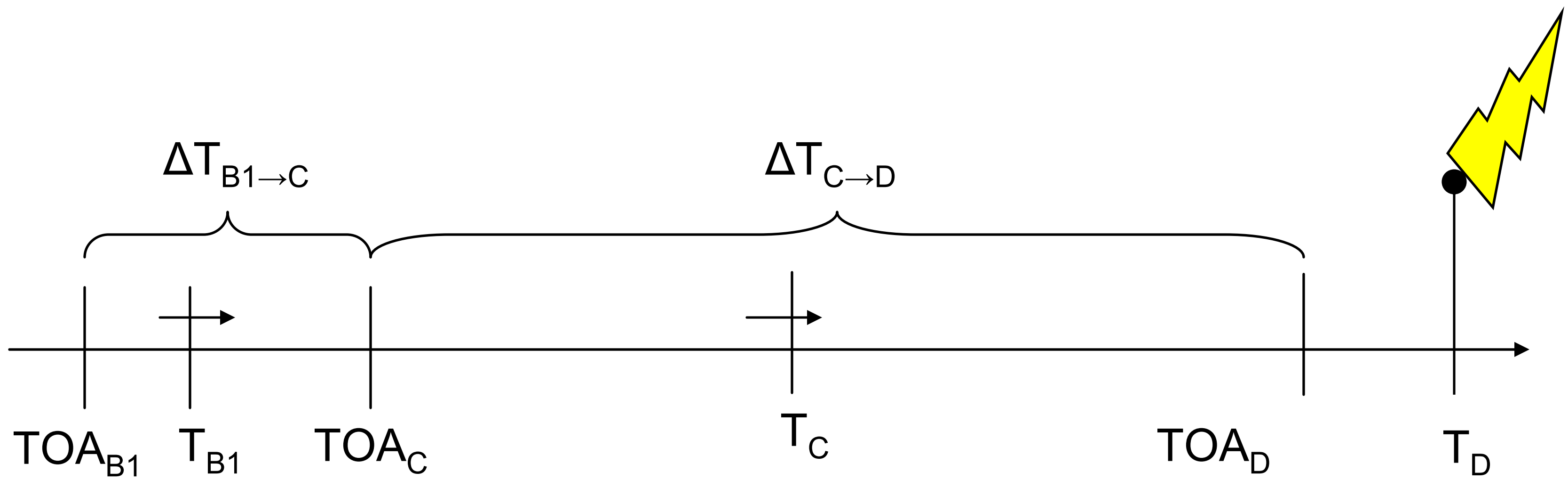
# T=0 timing requirement

- The time of applicability of the position loaded into the register shall never be more than 100 milliseconds different from any time at which the register contains the position data to which the time of applicability applies

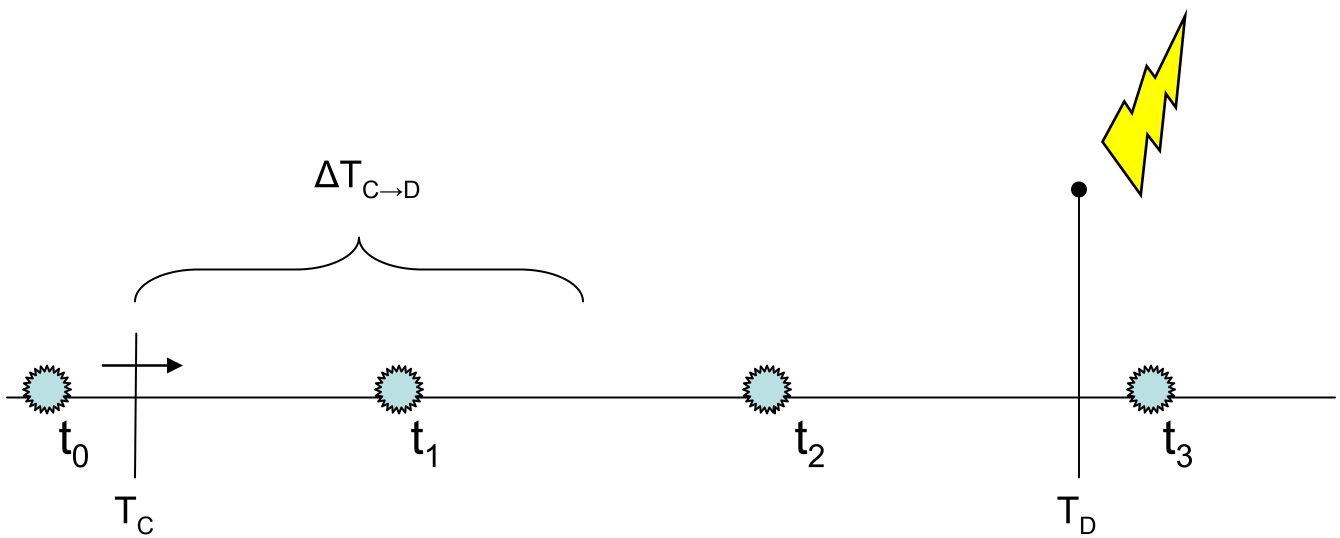
# Recall timing definitions

- For a piece of data and an interface X, let $T_X$ be the time that the data crosses interface X, and let $TOA_X$ be the time of applicability of that data
- For interfaces X and Y, let $\Delta T_{X \rightarrow Y}$ be the total amount of time compensated for by the architecture between interfaces X and Y.

# Timing Diagram



# For a given extrapolated/estimated position loaded (i.e. $\Delta T_{C \rightarrow D}$)




$t_0$, $t_1$, $t_2$, … - Register load times

Assume that the ADS-B equipment does not attempt to compensate for timing prior to interface C. The proposed requirement reads that, for position loaded at time $t_1$, for every $t_{REG}$ between $t_1$ and $t_2$,

$$\left| t_{REG} - (T_C + \Delta T_{C \rightarrow D}) \right| < 100 \text{ milliseconds}$$

# If $TOA_C=T_C$ is not assumed by ADS-B Transmit sub-function

- If ADS-B Transmit sub-function attempts to compensate for timing effects outside of the box this needs to be considered
  - e.g., advancing the position by the expected amount of delay coming out of the GPS box
- If $\Delta T_{EXT}$ is the amount of compensation so performed, then the requirement should be
  - $\left| t_{REG}-(T_C+\Delta T_{C\rightarrow D} - \Delta T_{EXT}) \right| < 100$ milliseconds

# Relationship to uncompensated latency

- At transmission, substitute $T_D$ in for $t_{REG}$
  - $|T_D - (T_C + \Delta T_{C \to D})| < 100$ milliseconds
- TTOA = $T_D$ for the uncoupled case

$$UL = TTOA - TOA_D$$
$$= T_D - (TOA_C + \Delta T_{C \to D})$$
$$= [T_D - (T_C + \Delta T_{C \to D})] + (T_C - TOA_C).$$

So,

$$-100\text{ ms} + (T_C - TOA_C) < UL < 100\text{ ms} + (T_C - TOA_C)$$

  - i.e., UL is comprised of the 100ms allowed plus the error in assuming $T_C = TOA_C$
- Note: if ADS-B transmit sub-function chooses to compensate for external timing effects, subtract $\Delta T_{EXT}$ from both sides of this inequality:

$$-100\text{ ms} + [(T_C - \Delta T_{EXT}) - TOA_C] < UL < 100\text{ ms} + [(T_C - \Delta T_{EXT}) - TOA_C]$$

# T=0 timing test requirements

- Provide a straight-line, high-velocity travel stimulus to interface C.
- Let **x**(t) be the precise stimulus position at time t, and let **v** be the precise stimulus constant velocity.
- Let $t_{REC}$ be the time of reception of an ADS-B position message, and let **X** be the position contained within the message.
- Verify that $|\mathbf{x}(t_{REC}) - \mathbf{X}| < (\mathbf{v} \cdot 100 \text{ ms}) + 6.375 \text{ m}$
- Note: if a compensation factor $\Delta T_{EXT}$ is implemented, this must be accounted for in the setup of the test