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Definition of clock and bias messages for GPS PPP-AR

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Summary

To permit Precise Point Positioning with Ambiguity Resolution (PPP-AR), a user must obtain more information than is required for traditional PPP. Methods such as the Decoupled Clock Model permit PPP-AR by ensuring that all equipment delays are fully estimated and represented in a combination of clock and bias parameters. Correct application of these parameters enables the estimation of integer ambiguities for independent receivers. The full set of corrections must be available at any one epoch.

The necessary bias parameters are a combination of code and phase equipment delays and integer ambiguities. These biases cannot be uniquely separated from either each other, or the underlying clock. This means that message content must be explicitly defined in terms of the fundamental parameters and underlying signals and frequencies. Hence, alternate formulations are in some senses arbitrary, unless perhaps they produce biases that are closer to the fundamental parameters.

We show here a re-parameterisation of the estimated biases that are a function of the native pseudorange delay plus combinations of phase delays. These permit a more intuitive correction procedure, and more direct application to single-frequency PPP (not shown here). Question: Because they are an inherent set, should the clocks & biases be broadcast in self-contained messages?

Decoupled Clock Model

Based on iono-free and WL/NL combinations:

$$P_3 = \alpha P_1 + \beta P_2$$

$$L_3 = \alpha L_1 + \beta L_2$$

$$A_4 = L_4 - P_6 = gL_1 + hL_2 - [eP_1 + fP_2]$$

Essential message content (1 clock, 2 biases):

$$\overline{dt}_{L3} = dt + [\alpha \bar{b}_{L1} + \beta \bar{b}_{L2}]$$

$$dt_{P3} - \overline{dt}_{L3} = \bar{b}_{A3} = \alpha b_{P1} + \beta b_{P2} - [\alpha \bar{b}_{L1} + \beta \bar{b}_{L2}]$$

$$\overline{dt}_{L4} - dt_{P6} = -\bar{b}_{A4} = g\bar{b}_{L1} + h\bar{b}_{L2} - [eb_{P1} + fb_{P1}]$$

Note: overbar indicates integer-biased parameter.

Equivalent bias parameterisation

$$\bar{b}_{P1} = b_{P1} - [(\alpha - \beta)\bar{b}_{L1} + 2\beta \bar{b}_{L2}]$$

$$\bar{b}_{P2} = b_{P2} - [2\alpha \bar{b}_{L1} + (\beta - \alpha)\bar{b}_{L2}]$$

where: $\bar{b}_{L1} = b_{L1} + \lambda_1 N_1^{datum}$ $\quad \bar{b}_{L2} = b_{L2} + \lambda_2 N_2^{datum}$

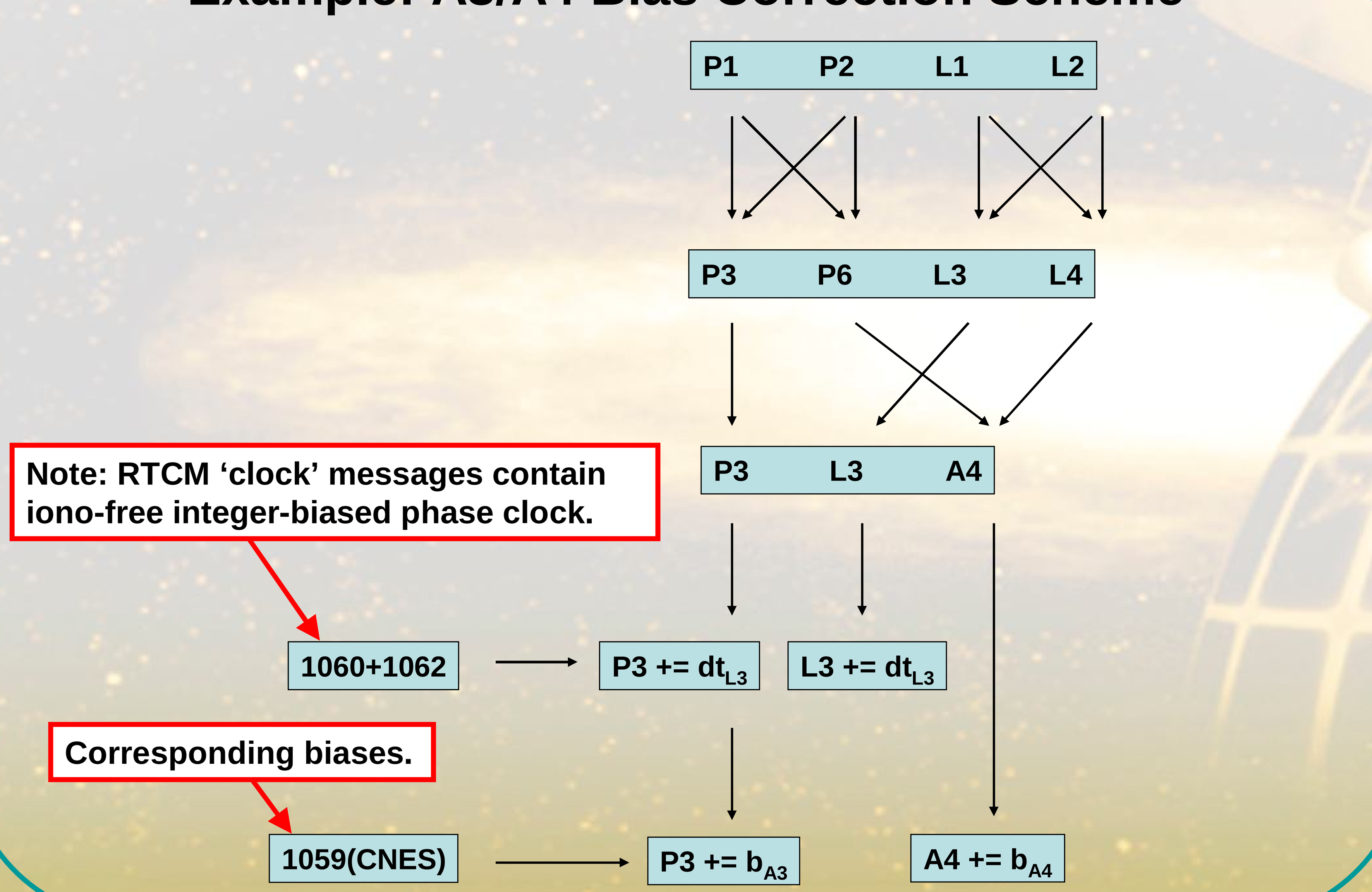
NOTE: 1) Coefficients are multipath combinations.
2) Alternate 'phase biases' dominated by code terms:

$$\bar{\bar{b}}_{L1} = \bar{b}_{L1} - [(\alpha - \beta) b_{P1} + 2\beta b_{P2}]$$

$$\bar{\bar{b}}_{L2} = \bar{b}_{L2} - [2\alpha b_{P1} + (\beta - \alpha) b_{P2}]$$

$$\sigma(\bar{\bar{b}}_{L1}) \approx 5.1\sigma(\bar{b}_{P1}), \quad \sigma(\bar{\bar{b}}_{L2}) \approx 6.5\sigma(\bar{b}_{P2})$$

Example: A3/A4 Bias Correction Scheme



Example: P1/P2 Bias Correction Scheme