
# A New Asymmetric Correlation Kernel for GNSS Multipath Mitigation

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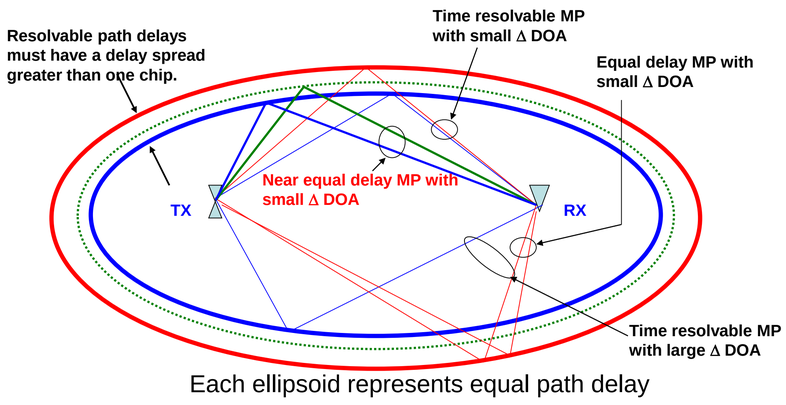
## Autonomous vehicles require *cm* level positioning control

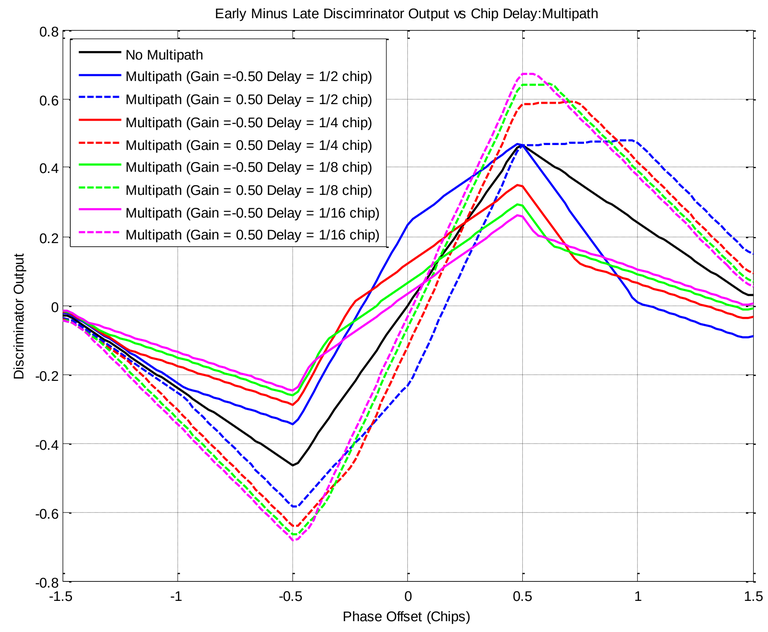
## A GNSS phase estimation problem




Each ellipsoid represents equal path delay

## Unresolved Multipath Dominates Error Budget

## Multipath introduces phase bias in early minus late (EML) correlation kernel




## Novel Solution: Asymmetric Mass Balance Correlation Kernel

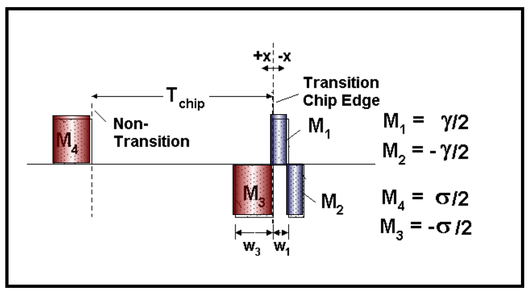
### Advantages

- Better multipath performance given same ROS
- Programmable and increased linear region and gain for ε > 0
- Same noise variance as EML kernel (w/ same ROS)
- Discovered and compensated for GPS L1CA unbalanced transitions and non-transitions.

### Disadvantages

- Requires wider bandwidth
- Has smaller track range for ε < 0, but this can be overcome
- Requires an additional correlator to compute Non-Transition correlation`

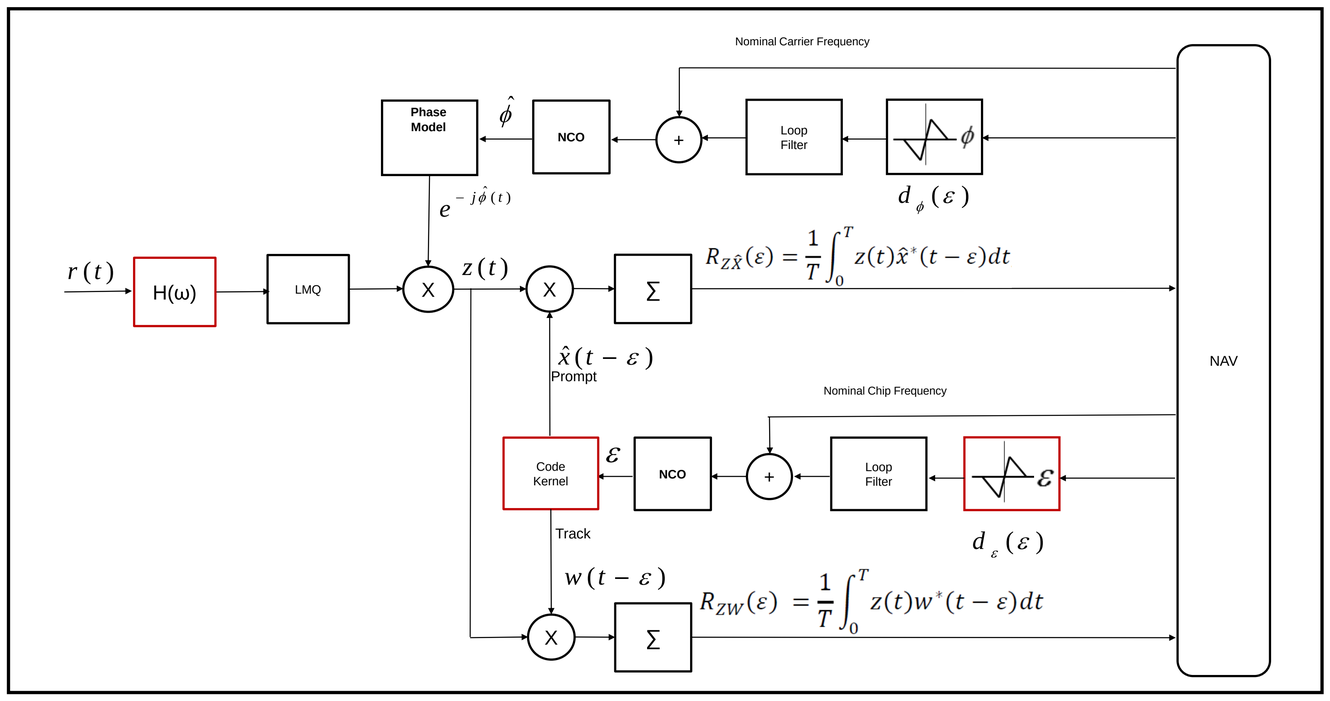
### Asymmetric Correlation Kernels



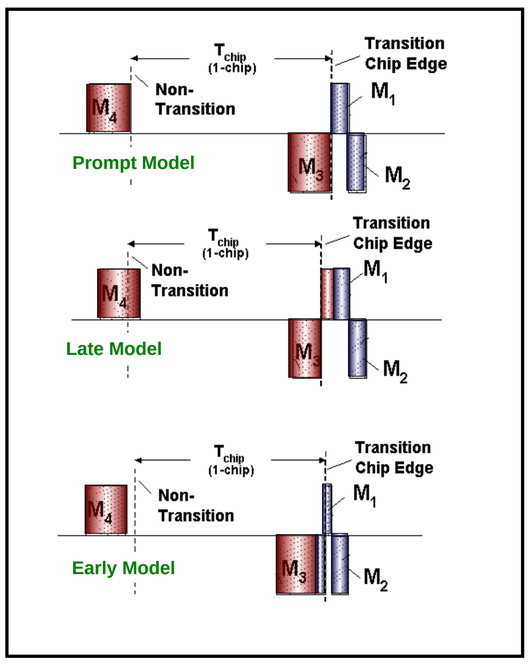

### Design Equations

$$N_T M_1 + N_T M_2 = 0$$
$$N_T M_3 + \alpha N_N M_4 = 0$$
$$\alpha = \left(N_T |M_3|\right) / \left(N_N |M_4|\right)$$
$$\phi_{err} = \kappa \left(N_T S_N + N_N S_T\right)$$

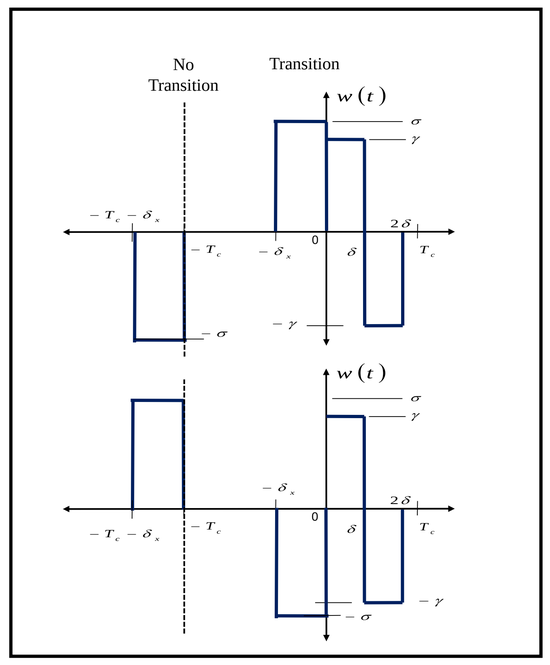
$N_T$ = # of Transitions
$N_N$ = # of Non-Transitions
$S_k$ = Kernel ● Sample
$\kappa$ = Scalar




### Kernels ● Receiver Samples

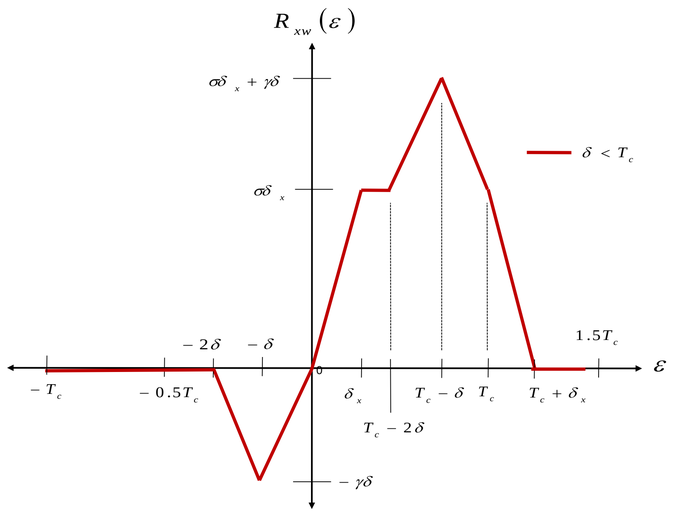


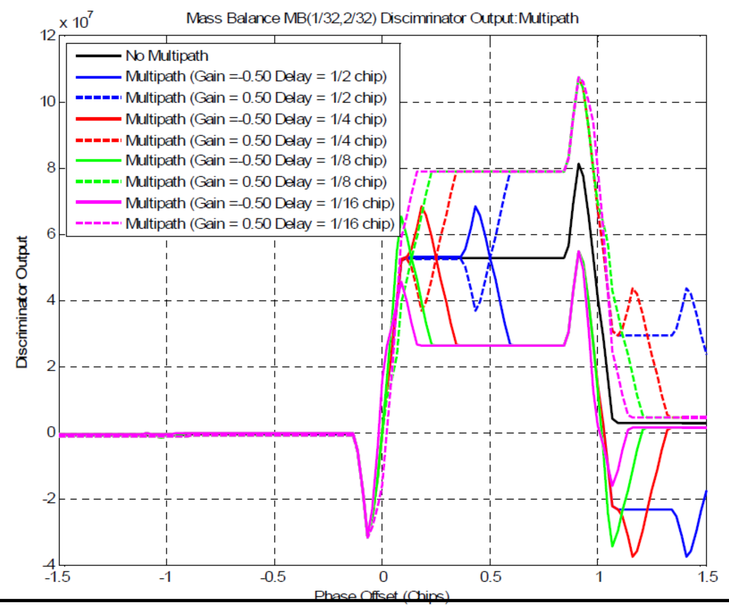

### Kernel Functions



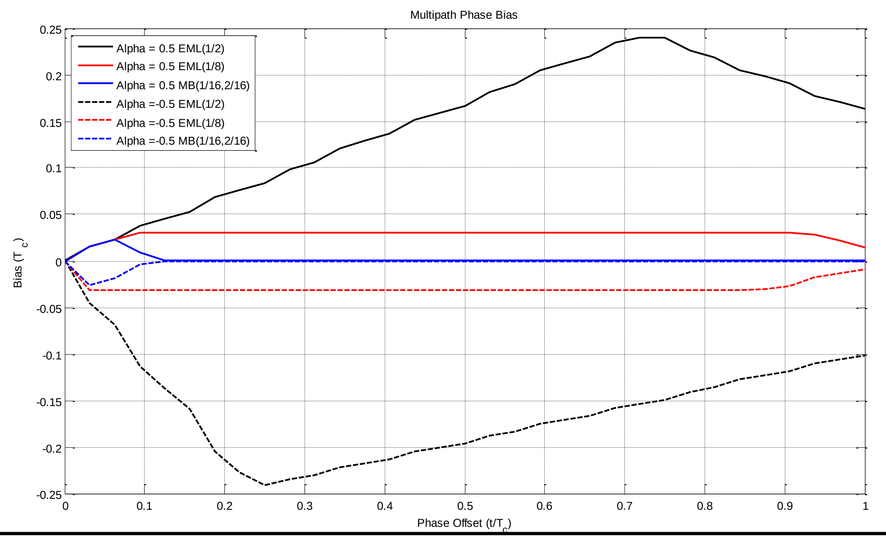

## Performance

### Discriminator




### Multipath Error Envelope




## References

[1] S. Miller, X. Zhang and A. Spanias, "Multipath Effects in GPS Receivers," Morgan & Claypool Publishers, September 2015, to be submitted.
[2] S. Miller, “Multipath mitigating correlation kernels,” Ph.D. Dissertation, Arizona State University, 2013.
[3] S. Miller, X. Zhang, and A. Spanias, “A new asymmetric correlation kernel for GNSS multipath mitigation,” in *Sensor Signal Processing for Defense*, 2015