Information for Reproducibility for "Exact Amplitude–Delay Information Crossover for an Idealized Helical DAS Array"

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TABLE I
PRINCIPAL NUMERICAL SETTINGS

Item	Frozen value
Nominal helix	60 point channels; $R = 0.25$ m; $p = 0.02$ m
Sampling	0.1 m arc spacing; 5.9 m fiber span
Information scan	40 frequencies; 3 elevations; 181 azimuths
Information SNR	$\rho_E = 100$ for scan; $\rho_E = 1$ for baselines
Winding scan	20 winding angles; 9 directional anchors
Mismatch bridge	50 realizations $\times$ 3 bearings
Archived comparator	2 kHz; 200 Hz; 20 Hann segments; 721-point grid
Record classes	$N = 2000$: 100-point segments/DFT, 200 Hz bin; $N = 100$: 5-point segments, 64-point DFT, 187.5 Hz bin
Sandwich grid	$K = 20, 50, 100, 500, 2000$; SNR $= 0, 10, 20$ dB
Sandwich study	15 scenarios; 225 conditions; 118,500 estimates
Fair baselines	5 designs; 4 frequencies; 161 azimuths
Numerics	float64; deterministic seeds; locked tolerances

I. Frozen Configuration

The observation model is a coherent point-channel helix with unknown shared complex amplitude and circular white Gaussian noise. The array-domain pseudo-true parameter is computed by continuous maximization of normalized manifold coherence. The pipeline-domain comparator uses the locked Hann–DFT–MUSIC protocol: 2 kHz sampling, a 200 Hz target, 20 segments, a 721-point $[-90°, 90°]$ grid, and quadratic peak refinement. Long and short records are evaluated separately; the short zero-padded record is a negative control. The sandwich scenarios comprise matched, fixed D1-G, and q10/q50/q90 D1-G geometries at three bearings. The reported A and B are per-snapshot quantities, so the predicted covariance is $K^{-1}A^{-1}BA^{-1}$. Each condition starts with 500 Monte Carlo replicates. It expands to 2000 if the variance relative standard error exceeds 7% or any estimate jumps by more than $5°$, and then to 5000 if the relative standard error still exceeds 5% or the jump rate exceeds 1%.

The 150 paired-output records and the 30 bridge controls are distinct audits. For paired outputs, the archived Hann–DFT–MUSIC estimates and continuous array-domain optima use the same prespecified geometry metadata, seed, direction, and frequency; their separate implementations are compared by record identifier. The bridge audit instead evaluates five scenarios at three bearings for each record class, using replicated curves and compatibility gates. It tests the effect of record construction rather than adding independent geometry realizations.

II. One-Command Execution

From the workspace root on Windows:

```
& pa2/04_code/run_full_pipeline_local.ps1
  -WorkspaceRoot <root> -Python <python>
  -Policy resume
```

On Linux:

```
bash pa2/04_code/run_full_pipeline_cloud.sh
  <root> resume auto python
```

The controller executes tests, T0–T8, the closed-form theory gate, source-data extraction, all paper figures, and compilation of the main paper and both accompanying pages. 'resume' validates and skips passed results; 'force' recomputes them.

III. Data, Code, and Integrity Checks

The public Zenodo archive contains the code, frozen configurations, derived numerical data, and figure-source tables (https://doi.org/10.5281/zenodo.21603787). Machine-readable evidence is stored under:

- `pa2/05_data/derived/`: frozen JSON/NPZ results;
- `pa2/06_figures/source_data/`: ten figure-source CSV files;
- `pa2/06_figures/paper/`: SVG, PDF, TIFF, and PNG figures;
- `pa2/06_figures/paper/figure_manifest.json` and `Fig3_manifest.json`: the main-figure and crossover manifests;
- `pa2/00_manifest/result_registry.json`: paths, status, scope, and SHA-256 hashes;
- `pa2/00_manifest/environment_lock.json`: the recorded software environment.

The verification suite contains 37 focused tests. Before the manuscript revision, all registered evidence artifacts were present and hash-consistent; the revised PDFs are added to the same registry after compilation. The legacy `Fig2_mismatch`/`Fig3_crossover` filenames do not define display order: the manuscript displays crossover as Fig. 2 and mismatch as Fig. 3. Independent local–cloud comparisons traverse numerical fields rather than comparing file bytes. The maximum absolute differences for T6, T7, and T8 are 2.25×10^{-13}, 4.13×10^{-11}, and zero. T2 uses mixed absolute/relative tolerances to avoid unstable relative errors near zero.