Benchmarking WIPL-D Simulation Methods for Monostatic RCS of an Aircraft at X-Band (10 GHz)

Introduction

Monostatic RCS of an electrically large target like an aircraft is among the hardest problems in computational electromagnetics. Full-wave solvers provide the highest fidelity but can take days to converge, while fast approximate methods return results in seconds but lose the details that matter most.

This application note benchmarks five simulation approaches available in WIPL-D: **full-wave Method of Moments (MoM), the Domain Decomposition Solver (DDS), Physical Optics (PO), Extrapolation, and a hybrid Extrapolation + PO method** against the same aircraft model at 10 GHz, so engineers can choose the right tool for their accuracy and turnaround requirements.

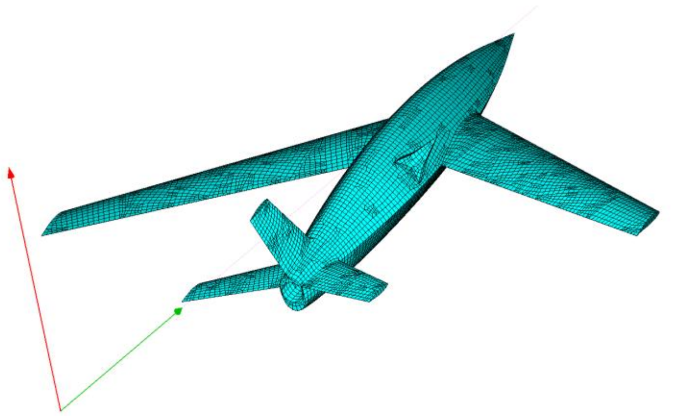

Figure 1. Aircraft (evaluation) model.

All simulations were performed on a workstation with the specifications in Table 1.

Table 1. Workstation used for simulation.

Hardware	Description
Processor	Intel® Xeon® Gold 6248R (3.00GHz)
RAM	768 GB
GPU	NVIDIA GeForce RTX 3080

** The simulations were performed using **two GPU cards**.*

Full-wave MoM Reference

The full-wave Method of Moments (MoM) simulation was performed as the reference solution, providing the highest level of accuracy for this model. The simulation required approximately **1.4 million unknowns** and **nine days** of computation to complete. MoM results are given in Figure 2.

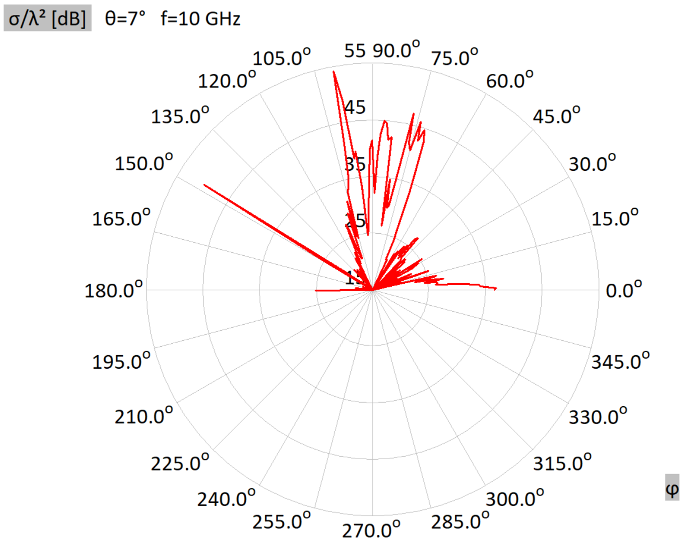

Figure 2. Full-wave MoM results at 10GHz.

Domain Decomposition Solver (DDS) Simulation

The Domain Decomposition Solver (DDS) is built to make electrically large problems tractable without abandoning a full-wave formulation. We used DDS to simulate the model at **10 GHz**. The simulation completed in approximately **50 hours**, with the **0th iteration** lasting **8 hours** and **each subsequent iteration lasting 6 hours**.

The DDS approach significantly reduces the computational time and memory requirements of electrically large problems.

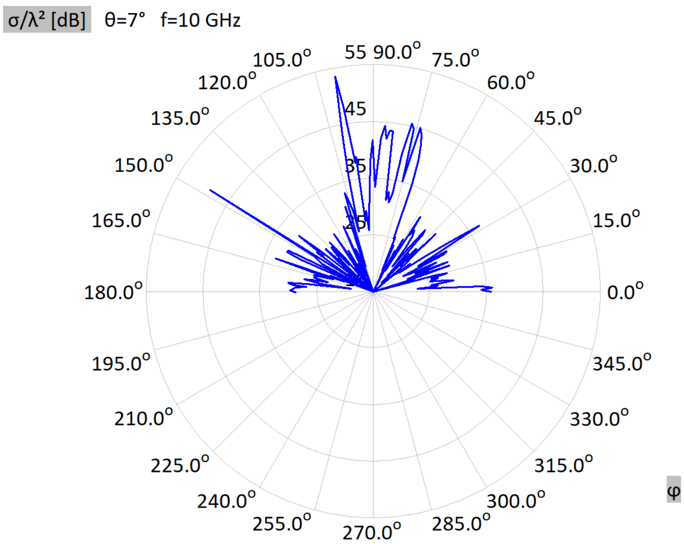

Figure 3. DDS 7th (final) iteration results at 10GHz.

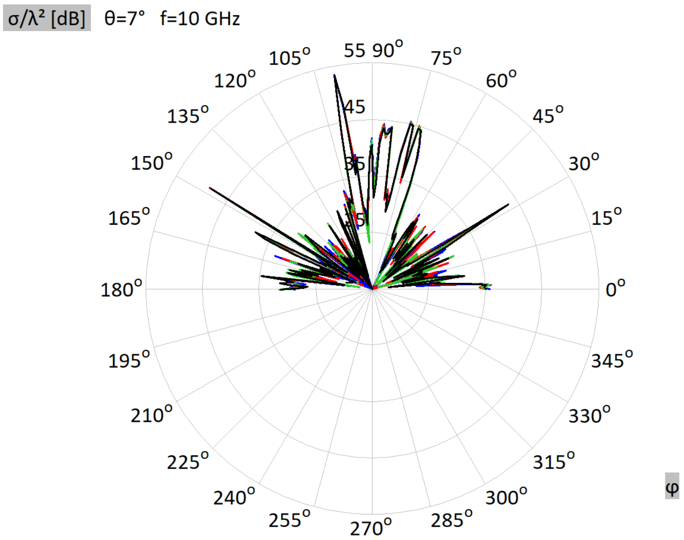

Figure 4. DDS 4th-7th iteration results at 10GHz.

The solution converges quickly. The **4th-7th iterations** (Figure 4) are nearly indistinguishable, and the **7th iteration** (Figure 3) matches the MoM reference closely across the full pattern (Figure 8). At the dominant lobe at ϕ = 148°, DDS predicts 48.8 dB against the reference 50.1 dB, within 1.3 dB. If your application needs even tighter agreement, additional iterations can refine the solution further.

Fast Approximate Methods: PO, Extrapolation, and Hybrid

In addition to the full-wave approaches, for applications where turnaround time is the priority, WIPL-D offers three lighter-weight approaches:

- **Physical Optics (PO)** - an answer in 73 seconds. It reproduces the dominant scattering structure and predicts 50.4 dB at the 148° peak against 50.1 dB for MoM (Figure 9).
- **Extrapolation** - reuses a lower-frequency full-wave solution and projects it to the target frequency, completing in **2416 s (about 40 minutes / ~0.67 h)**.
- **Hybrid (Extrapolation + PO)** - combines both techniques and delivers a full 10 GHz pattern in **2489 s (under 42 minutes / ~0.7 h)**. It captures the overall lobe structure of the reference and lands at 48.1 dB at the 148° peak, within 2 dB of the MoM result (Figure 10).

Extrapolation methods rely on a lower-frequency full-wave MoM run, which should be included in the total time budget.

Physical Optics is an asymptotic, high-frequency method whose accuracy improves with the target's electrical size relative to the wavelength, well suited to SHF/EHF targets like this one, but less reliable for electrically small targets at lower frequencies.

Results for PO, Extrapolation, and Hybrid are shown in Figures 5–7, with timing comparisons in Table 2.

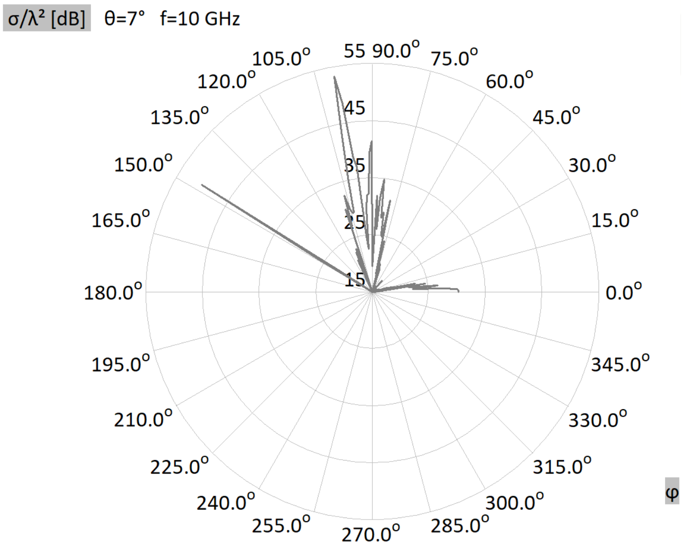

Figure 5. PO results at 10GHz.

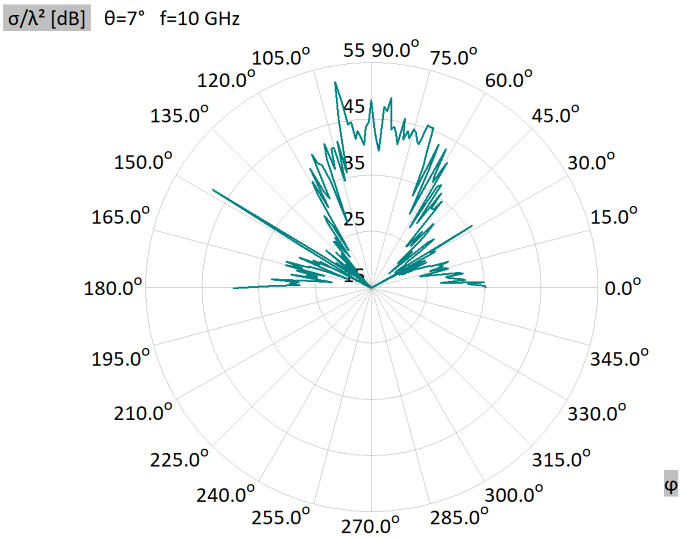

Figure 6. Extrapolation method results at 10GHz.

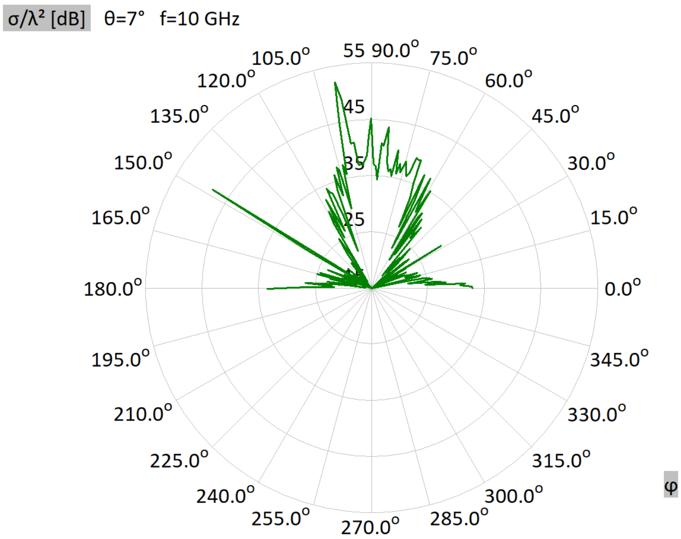

Figure 7. The hybrid (Extrapolation + PO) method results in 10GHz.

Table 2. Simulation Times for Different Methods.

Method	Time
MoM	9 days
DDS	50 h
PO	73 s [0.02 h]
Extrapolation	2416 s [0.67 h]
Hybrid	2489 s [0.7 h]

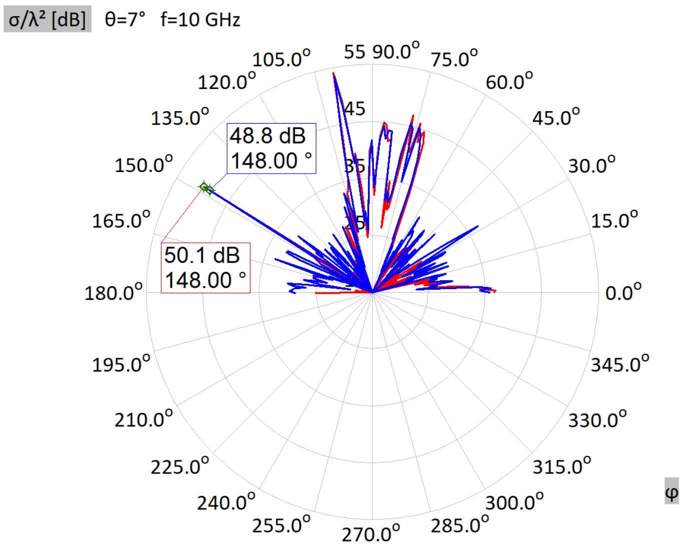

Figure 8. Overlay of MoM (red) and DDS (blue) simulation results at 10GHz.

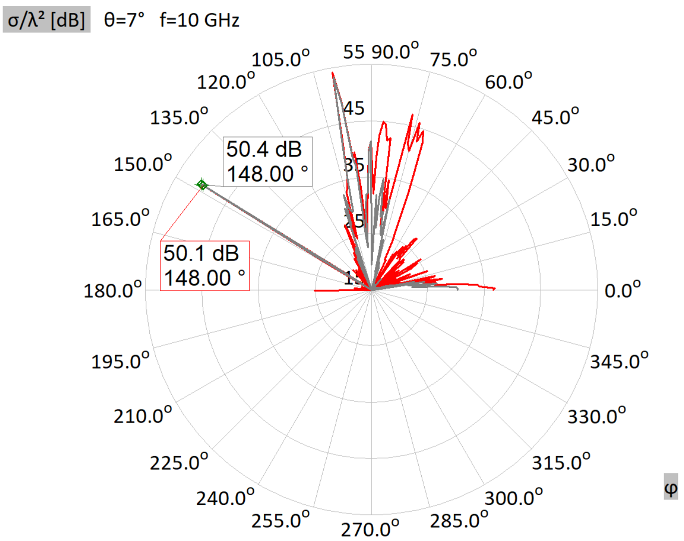

Figure 9. Overlay of MoM (red) and PO (gray) simulation results at 10GHz.

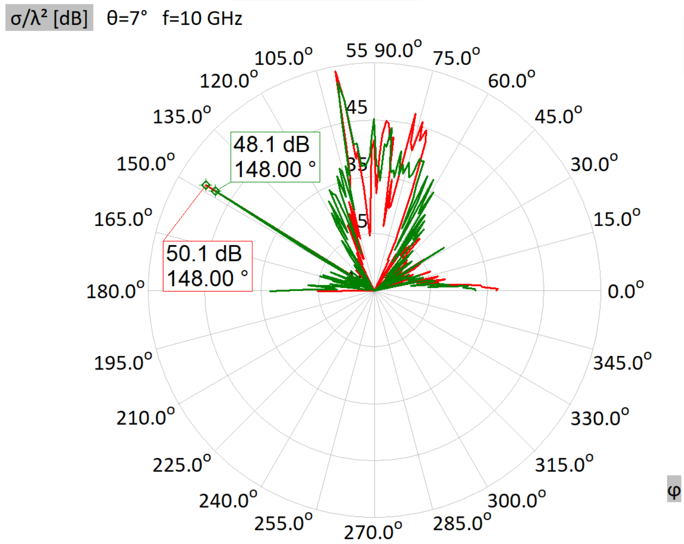

Figure 10. Overlay of MoM (red) and hybrid method (green) simulation results at 10GHz.

Conclusion: The Right Solver for the Job

The analysis demonstrates the trade-off between computational cost and solution accuracy among the simulation methods available from WIPL-D.

There is no single "best" method for monostatic RCS simulation, only the best method for a given accuracy requirement and time budget. DDS stands out for engineers who need full-wave-level confidence without a multi-day wait, while the Hybrid method offers a compelling fast-turnaround option when approximate results are acceptable. WIPL-D's suite of solvers lets engineers move fluidly between these approaches within the same modeling environment, adapting the method to the problem rather than the other way around.

Need full-wave confidence on an electrically large target?

DDS delivers it in about two days instead of nine.

Need to iterate design changes quickly?

PO and the Hybrid method turn a 10 GHz aircraft around in about a minute to under 42 minutes, with the main scattering behavior intact.

Want to move between the two?

All five methods run in the same modeling environment, so you adapt the method to the problem instead of the problem to the tool.

*For a more detailed description of the **PO** and **Extrapolation** methods and their implementation in WIPL-D, please refer to the WIPL-D Pro User Manual or the latest **Release Notes** available at the following links:*

- WIPL-D Pro CAD 2025 release notes
- WIPL-D Pro v21 release notes