Derek Kilfedder,

CC: Joel Daniels, Volkan Aktas, Phillip Carter

Morgan Stanley

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New York, NY 10019

19th February 2025

Dear Derek,

***Proposal for LibAMG performance, testing and porting improvements***

ISG has successfully built a new business with ~10x faster intra-day risk performance, accompanied by commensurate cost increases. You want your equity derivatives architecture to scale to similar performance, such that you can:

1. Lead new markets, from listed zero-day options to structured products, with faster, accurate pricing.
2. Reduce costs by optimizing computations, minimizing release rollbacks, utilizing less machines, and adopting lower-cost hardware.

You wish to meet these objectives by:

1. Upgrading your testing framework and build system to reduce execution time with shorter cycles, expand coverage, and ensure valuation consistency across platform / code variations.
2. Improving LibAMG performance on your existing x86 architecture with SIMD optimization.
3. Porting LibAMG code to more cost-efficient hardware, such as ARM.

This is our updated proposal with accompanying Task Order. We look forward to formalizing both with you and to helping deliver your strategic performance and cost-saving objectives.

# Team and plan

Meeting these objectives requires a combination of skills (derivatives quantitative, data structures, C++, scripting, DevOps, compiler configurations, network topology, hardware architecture, non/model risk and business management). We will deploy these hybrid skills in a small, hands-on team that appreciates your quantitative strats’ team modelling preferences, your technology team’s architecture and budget constraints.

Our team will largely be comprised of Quantitative and Full-stack engineers that you and your IED QS team have met, with a single point person (Martin Kristensen / Daniel Varrichione). Our deliverables will remain your intellectual property, and we will work alongside your teams in New York and London at your offices on a hybrid basis to ensure iterative knowledge transfer. Based on our discussions, our ISG experience and broader work, this is our high-level plan:

**Stream 1** (Month 1-2): Formalize scope; review codebase; identify key algorithms; review profiling tools, evaluate test coverage, identify build system and external library gaps; and agree acceptance criteria and tolerances.

**Stream 2** (Month 2-6): Enhance the testing framework, upgrade the build system, implement SIMD optimizations, and migrate some workforce to ARM.

**Stream 3** (Month 6-12): Expand SIMD optimization, refine the build system, optimize test pipelines, and fully port LibAMG to ARM.

**Ongoing:** Continuous monitoring of performance improvements and cost reductions.

The above plan translates into the following workstreams. We plan to start the first two in parallel, such that we have a scalable build system and testing tools, while providing SIMD optimization quick wins. If you wish to prioritize the ARM platform porting, the build system upgrade will require additional resourcing.

1. Testing platform and build system upgrade:
   1. Transition from single-server batch testing framework to cloud-based for scalability.
   2. Create a regression testing harness. Implement pre-commit, sample-driven regression tests to reduce unnecessary full regressions and improve release quality.
   3. Improve test coverage with more event-driven and functional unit tests.
   4. Develop benchmark profiling and instrumentation tools for migration and optimization.
   5. Enhance build and deploy system to include the new regression test harness and Bazel.
2. LibAMG refactoring:
   1. Restructure code for SIMD optimization, such as utilizing contiguous memory usage.
   2. Vectorize computation using SIMD (e.g. AVX2, SVE/SME), and specify vector lengths.
   3. Create regression and benchmark tests to assure output reproducibility and performance increment after refactoring.
3. ARM platform porting:
   1. This is dependent on build system support, including Bazel and cloud-based testing.
   2. Compile and deploy LibAMG for ARM environment, ideally integrated with the CI/CD pipeline.
   3. Analyze and refactor external libraries to resolve any compatibility issues, such as NAG.
   4. Validate output consistency and reconcile disparities with x86 to achieve dual compatibility between x86 and ARM.

This broad plan is based on our discussion from previous meetings. A more detailed approach is as follows:

# Approach

## Initiation

Once onboarded, we will recap our scope and success criteria in a lightweight Project Initiation Document. This will form the basis for managing our commitments to you and will include high-level deliverables, stakeholders, milestones, and delivery plan. During this first week, our team will also gain access to LibAMG, relevant build, testing, broader systems and external libraries. We will also start to review related documentation, illustrations and source code. We will then start to perform the following activities in parallel:

## Stream 1 - Analysis and Recommendations (Month 1-2)

Based on the agreed scope, we will then perform the following tasks:

1. Evaluate and enhance your existing performance KPIs/metrics and instrumentation to identify bottlenecks through profiling and benchmarking tests. We will focus on critical modules within the LibAMG library and related frameworks as follows:
   * 1. Review the codebase, and identify algorithms and data structures for potential linearization and acceleration.
     2. Identify the initial set of modules and instruments for optimization.
     3. Agree on the required refactoring, test plan and reconciliation tolerances.
     4. Confirm and set up KPIs, which we will monitor throughout the project. This may include improved execution times for key computational workloads, and measurable testing execution time reduction from cloud infrastructure optimization.
     5. Communicate refactoring needs and constraints to ensure we are on the right track. For promising optimizations, we will capture test impacts, modelling differences and tolerances.
     6. Confirm the target platform and environments for development work.
2. We will review your current build system, testing frameworks and coverage to identify gaps:
   1. Analyze the build system implementation, including leveraging existing Bazel configuration templates for other libraries, and work with QS to resolve non-standard legacy build issues.
   2. Evaluate the testing process, coverage, benchmarks, testing scenarios, regression and back testing methodologies, application design, hosting systems, AWS accessing and task scheduling schemes, and broader multi-cloud and hardware considerations, including GPU.
   3. Collect user requirements on execution duration, benchmarks, user interface, report of results, cost limits, events and functions to be covered in testing.
   4. Evaluate and propose project scope on the implementation and scaling of overnight bulk tests and sample-based pre-screening regression tests.
   5. Propose a testing strategy to better mimic production and highlight pre-release issues to minimize rollbacks.
3. Describe expected model documentation implications.

We will produce recommendations for the above, and agree the approach and priorities.

## Stream 2 – Focused Implementation (Month 2-6)

In parallel to Stream One, we will:

1. Implement SIMD and other relevant optimizations in priority order.
2. Implement an enhanced cloud-based testing framework for bulk regression tests, sampled quick tests according to agreed priority and scope.
3. Implement tools to detect output disparity, measure gains in runtime, latency and data transfer.
4. Enable the build system to compile and deploy LibAMG on ARM platforms, while migrating to Bazel.
5. Analyze ARM compatibility with LibAMG libraries, and refactor or suggest alternative solutions.
6. Update model and application documentation.

## Stream 3 – Full Implementation and Optimization (Month 6-12)

We will then scale our implementation and refine the system:

1. Expand SIMD optimization across LibAMG.
2. Optimize the test harness and enhance regression testing to include new scenarios.
3. Improve cloud integration for scalable performance and cost optimization.
4. Implement quick tests for real-time model updates; time permitting.
5. Fully port LibAMG to ARM with all SIMD optimizations and reconcile differences with x86.
6. Refactor build systems and refine the CI/CD pipeline.

We will use the results from this implementation to validate the goals from the previous analysis and adjust in close cooperation with you.

## Continuous monitoring (Ongoing)

Following the above streams, we will continuously monitor performance improvements and cost reductions.

# Deliverables

In appointing us to undertake this project you are acquiring:

| **Deliverable** | **Description** | **Format** |
| --- | --- | --- |
| Project Initiation Document | Scope, success criteria and governance outline. | Document |
| Testing System Improvements | Cloud-based bulk tests, unit tests across builds, sampled regression tests. | Code |
| SIMD refactoring | Computation vectorization, memory allocation optimization, instruction set optimization. | Code |
| ARM target building process | Creates compile and deploy process of LibAMG on ARM platform, output reconciled with x86 results. | Code |
| Build System Upgrade | Migrate build system to Bazel and implement cloud-based scripts. | Code |
| Model Documentation Updates | Updates to existing model documentation to reflect new features and algorithms. | Document |

# Timescales, fees and governance

The above plan assumes that 12 months is a reasonable period to agree deliverables and milestones for. We will perform the work with a team size of 5-6+ Senior Quantitative Developers and Full-Stack Technologists in New York and London, as scope and budget permits. We can work on a Time & Materials full-time basis at daily rates between $1,250-$1,500+ / £1,100-£1,300+ depending on seniority.

Based on this term and a team size of six evenly split between New York and London, we estimate the following budget based on starting 10th March 2025:

* 12-month term to be $2,166,000. The accompanying Task Order assumes we finish 31st March 2026.
* 2025 budget to be $1,714,750. This is based on finishing year-end on 31st December 2025.

We assume we will mainly work from your 1585 Broadway, 750 7th Avenue and/or 20 Bank Street offices.

We will ensure our expectations remain aligned throughout the engagement by sending you and your stakeholders a weekly status report and meeting with you periodically to review it. If required, a Partner can be onboarded on a part-time basis at the rate of $2,000-$2,600/day.

# Next steps

We look forward to finalizing this proposal and Task Order with you and your colleagues. Hopefully, it aligns to your objectives for more proactive testing, alongside faster, cheaper releases; optimized LibAMG performance; and reduced hardware and cloud costs. Once the Task Order is executed, we can start the work.

A close-up of a signature

Description automatically generatedYours sincerely,

Kevin Wells

Director

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AI-generated content may be incorrect.

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