NASA 2025 SBIR Ignite Phase I Technical Proposal

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Proposal: AI-Driven Multidisciplinary Hardware Design Automation

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Part 1: Identification and Significance of the Innovation

Momentum is a human-in-the-loop, AI-driven framework that converts a plain-language mission brief into a continuously verified and manufacturable hardware design thread. The system targets NASA SBIR Ignite Subtopic I02.01, which calls for multidisciplinary design automation, embedded physics, open interfaces, and human-centric AI agents.

Momentum adopts familiar hardware development maturity milestones, Concept or CoDR (Conceptual Design Review), PDR (Preliminary Design Review), CDR (Critical Design Review), and tracks every design item's progress through these gates. The hardware development is led through a human-centric agentic workflow, connected to multidisciplinary tools using a Model Context Protocol (MCP), an open framework for how applications provide context to Large Language Models (LLMs). MCP is the USB-C of LLM peripherals and accessories.

Momentum is delivered as three cohesive products that align exactly with NASA's "data–process–tool" viewpoint:

Product	What it is	Most important functions	Subtopic I02.01 Relevance
Core (Design-State Framework)	A version-controlled database plus validation logic.	• Requirement and BOM authoring • Maturity gating (CoDR → PDR → CDR) • Continuous Verification Chain commits	Single source of truth. Engineers and agents cannot bypass validation. Reviewers time-travel through Git-like commits.
Loop (Agentic Workflow)	Agentic process that mirrors an engineering org (System Engineer agent + engineering specialist agents). Leverages LangGraph as the framework.	• Generates tasks • Calls tools • Posts knowledge / actions / artifacts for review	Humans remain in control. Loop accelerates trades by a factor of five while preserving engineering signs-off. Scales for future disciplines after Phase II.
Chain (Tool & Knowledge Catalog)	Fleet of MCP servers: high-level Synera workflows (Phase I), micro-services, and a Knowledge-MCP that indexes all analysis artifacts for retrieval.	• CAD, FEA, thermal, DFM, quote actions • Central knowledge repository with source-linked data	Open, vendor-agnostic integration. Add a tool by starting a new server, not by rewriting agent prompts. Phase II can replace or extend servers without touching agents.

Model Context Protocol in Momentum

Model Context Protocol (MCP) is a lightweight JSON-over-HTTP standard that advertises **tools** with typed input and output. A client asks a server for its tool list, then calls any tool by posting one JSON packet. The server runs real code (for example launching a solver, querying a database, uploading a file) and returns a structured JSON result.

MCP constructs

- **Server**: a program that exposes tools, resources, and prompt templates.
- **Client**: software that discovers servers and invokes their tools.
- **Tool**: a named function an agent can call with JSON arguments.
- **Resource:** data served read only to the client (files, database rows, API responses).
- **Prompt**: a text template the client can request to stay aligned with domain style.

Where MCP lives in Momentum

Momentum layer	Named MCP endpoints	Typical tools	Why it helps
Core	**core_mcp** (server)	`get_requirement`, `put_analysis`, `commit_snapshot`, `query_bom`	Agents use a safe, validated API that hides internal schema.
Loop	**loop_mcp_client** (client inside LangGraph)	Discovers every server listed in a config file at startup	Prompts stay clean. Adding or swapping tools needs only a config edit.
Chain	**synera_mcp**, **pynastran_mcp**, **cad_edit_mcp**, **dfm_mcp**, **quote_mcp**, **knowledge_mcp** (servers)	High level CAD/FEA workflows, fine grain microservices for FEA updates/metrics, CAD edits, DFM checks, vendor quotes, document search	Open and vendor agnostic. Knowledge MCP lets agents cite source data so humans see trustworthy context.

MCP and simple REST-like uploads handle all program to program traffic, while humans work through a web UI or open native programs such as NX CAD.

Momentum Datastores and Outputs

- **Design graph**: requirement hierarchy and hardware breakdown, each node tagged CoDR/PDR/CDR.
- **Analytic artifacts**: JSON results from CAD, FEA, thermal, DFM; each linked to its parent node.
- **Verification Chain**: every commit is a delta; milestone tags (CoDR, PDR, CDR) freeze full bundles for audit. Provenance via commit metadata: who changed what, when, and why.
- **User Interfaces**: (a) **UI** for engineers; (b) **Open in native tool** helper for detailed CAD/FEM/program-heavy edits

Significance to NASA

Subtopic I02.01 demands multidisciplinary, API-exposed design automation that collapses requirement ingestion, physics checks and manufacturability into one flow. This proposal is aligned to deliver:

- End-to-end loop from mission brief to verification bundle validated by the demo.
- Embedded physics (CAD, FEA, thermal first-cut) plus live DFM analytics.
- Open schema and agent architecture so new disciplines slot in during Phase II.

- Five-fold faster trade cycles than today's manual CAD-and-email process.

NASA's Digital Transformation gap list (IDs 1492, 1493, 1494, 1542, 1544) notes exactly these missing capabilities. Momentum hits them head-on.

Significance to Industry

Software engineers enjoy significant benefits over hardware teams. In short, hardware teams face a significant infrastructure gap.

Capability	Software	Hardware
Version control	✅Git / PRs	❌SharePoint versions of trades
Continuous integration	✅CI pipelines	❌Disconnected manual CAD/FEA Late manufacturing feedback
Observability	✅Grafana	❌Folder spelunking
Auto-testing	✅Unit & integration tests	❌Human checklist
Collaboration	✅Live code review	❌Slack, Email, Powerpoints

Competing tools (nTopology, HyperSizer, Onshape) tackle only single slices and lack a unifying schema or human-centric agent workflow. Momentum's advantage:

- **Unified design-state:** zero manual required re-entry, but flexible enough to enable it.
- **Steerable agent workflow:** engineers remain decision makers, not spectators.
- **Synera-powered Chain in Phase I:** high TRL today, advanced Momentum Chain tomorrow.
- **Verification Chain:** JSON and STEP bundles at every milestone for instant audit.
- **Open and extensible protocol:** MCP and LangGraph enable extensibility and swappability.

Bottom Line

Momentum gives NASA a concrete pathfinder for Text-to-Spaceship: a TRL-4 payload-adapter demo in six months, a launchpad for broader Phase II expansion and a credible route to commercial SaaS scale-up. The innovation is not another point solution – it is the missing connective tissue that flips every "red" box in hardware development to green.

Part 2: Technical Objectives

Phase I Goal

Reach TRL-4 by proving that Momentum can ingest a mission narrative, orchestrate CAD/FEA/DFM toolchains through Synera, and publish a verification bundle for an ESPA-class payload-adapter demo, all inside a six-month SBIR Ignite schedule.

Specific Phase I Objectives

The objectives below map one-for-one to the innovations NASA requests in Subtopic I02.01 (end-to-end automated loop, embedded physics, manufacturability feedback, open APIs, human-in-the-loop, 5x speed-up, agentic extensibility).

This Phase I effort targets TRL 4 and includes seven primary objectives, each validated through the ESPA-class payload adapter and separation system demo project.

ID	Objective	Phase I Demonstration	Success Metric
1	**Momentum Core operational**	Continuous commits capture requirement edits, BOM updates, maturity changes, and analysis artifacts. Mission → CoDR → PDR design thread for system and subsystem.	100 percent changes validated and versioned; Verification Chain viewable.
2	**Human-Centric Loop Workflow Functional**	User chats with SE agent; discipline agents coordinate; knowledge/action/artifact tags raised to user. Multi-agent trades for structures, mechanisms, thermal, M&P, manufacturing.	≥ 5× faster trade cycle vs baseline set by independent SME; user override accepted without error.
3	**Chain via MCP**	Synera bridge plus at least three micro-services invoked only through MCP.	All tool calls logged by MCP client; swap one micro-service without altering prompts.
4	**CoDR/PDR toolkits**	PDR level definition for system and subsystem.	Compliant design for one PDR level system and all subsystems.
5	**Central Knowledge Repository Available**	Agent-sourced knowledge dynamically presented to the user and captured within the design-state database.	Seamless real-time access to knowledge insights with zero manual re-entry.
6	**Live Verification Chain**	Automatic delta commits; milestone tags for CoDr and PDR snapshots.	Snapshots reproduce margins and masses; hash-verified.
7	**Real-Time Manufacturability Feedback**	Integration of rule-based manufacturability checks and at least one advanced DFM tool (CAM, additive, or similar).	Immediate escalation of manufacturability issues for user intervention, modifying at least one design decision.
8	**Open Interface Docs**	Deliver OpenAPI JSON for Core-MCP and each tool server.	Reviewers can call and run example curl for every tool.

Planned Phase I Deliverables

- **TRL-4 Payload Adapter Design Package**: STEP/CAD models, BOM, cost and lead-time estimates, manufacturability report, and risk assessment.
- **Core Schema & API Documentation**:JSON schema, MCP protocols, agent interface, Synera templates.
- **Live Verification Chain**: Real-time JSON/STEP-linked design-state artifacts for CoDR and PDR.
- **Performance Report**: Benchmarking of design iteration efficiency, real-time manufacturability impacts, and lessons learned in agent workflow.
- **Phase II Development Plan**: Detailed architecture for Momentum Chain and joint development plan demonstrating Synera's Phase II role.

These deliverables directly align with subtopic requirements for multidisciplinary design automation, embedded analysis, real-time manufacturability feedback, and open APIs.

Key Technical Risks and Mitigation

Risk statement	Likelihood	Impact	Phase I mitigation (concise)
MCP server integration slips	Med	Demo scope reduced	Stub **core_mcp** and **synera_mcp** in KICK sprint; nightly tests
MCP contract drift	Med	Loop failures	Freeze tool schemas mid-project; auto-test for breaking diffs
Agent / LLM reasoning errors	Med	Bad analyses, rework	JSON schema validation plus human approval at CoDR / PDR
Verification-Chain bloat	Low-Med	Storage cost, audit pain	Store deltas only; freeze snapshot manifest once
Synera licensing / latency	Low	Slow loops, cost creep	Use Synera only for high-level workflows; fine work via micro-services
Vendor API downtime	Low	Manufacturability feedback gap	Local DFM rules kick in when API unavailable
Manual CAD edits corrupt history	Low	Orphan geometry	File lock during edit; hash check on upload
Security / IP leakage via MCP	Low	Data loss	Servers stay in VPC with token auth
Solver compute spikes	Low	AWS cost shock, chat delays	Budget alerts on usage

NASA TAV / IP usage

No NASA Technology/Asset/Valuation (TAV) or IP is required for Phase I, but may be integrated key technology of interest which has been licensed to Dan Mueller Consulting LLC is below. Any subsequent Phase II integration with NASA IP will follow the Evaluation License Application process defined by NASA.

Tech	Type / Access	Why / Notes
Smallsat Standardized Architecture (GSC-TOPS-286)	Patent	Expanding capability of system design to fit within a NASA backed framework.
Additive Manufacturing Model-based Process Metrics (LAR-TOPS-368)	Patent	Evaluating DFM of additively manufactured hardware.
NASA Instrument Cost Model (NICM v10)	Software / General Public Release	Grounding cost estimates against NASA instrument baselines.
Object-Oriented Optimization Tool 2.0	Software / General Public Release	To be explored as a tool connectivity framework for Momentum Chain.

Phase I plans to use open sources (MMPDS, CMH-17) processed into light databases to support the M&P agent role. Dan Mueller Consulting LLC has requested NASA MAPTIS access to expand M&P agent capability if time allows in Phase I. If MAPTIS is not approved in time, all objectives can be completed with publicly available data.

Part 3: Work Plan

Execution Approach and Schedule

We will execute Phase I over a series of sequential sprints structured as follows: KICK, MVP, Sprint 1, Sprint 2, Sprint 3, Sprint 4, and Sprint 5. Each sprint matures Momentum's core capabilities, clearly tied to the technical objectives outlined in Part 2. Core, Loop/Chain, and the UI are matured in blocks during the sprints, so each major layer builds on the next.

Each sprint duration (in weeks) will be set by the finalized hourly budget estimates from the proposal budget form, constrained to an approximate 78 combined team-hours per week capacity. The final schedule will ensure total duration fits comfortably within the 6-month Phase I performance period.

Methods that cut risk:

- **Schema-first development**: every agent call is generated from the MCP specification, eliminating mismatched parameters.
- **Nightly contract tests**: compare current tool schemas to frozen snapshots; fail build on drift.
- **Dual-LLM fallback**: Primary and secondary LLM options; retry policy prevents a single vendor stall.
- **Continuous Verification Chain**: each commit triggers a delta bundle, preserving provenance.

Sprint	Duration (End Week)	Core Tasks	Loop & Chain Tasks	UI & UX Tasks	Primary Tools & Methods	Milestones Achieved
KICK	1.5 (1.5)	Define open JSON schema; Bootstrap LangGraph framework- Initial CI/repo setup	Stub System-Engineer agent; Prepare Synera workspace	Initial wireframes & UX flow definition	Used throughout: Python, React, GitHub Projects, AWS (data+LLM), LangGraph	*(No milestones complete yet; setup activities only)*
MVP	1.5 (3.0)	Schema validation implemented- Initial database (SQLite)-; Basic knowledge repository setup	Initial CoDR-level agent workflow stubs	UI prototype, basic agent status panels	Pinecone, SQLite/Postgres, LangGraph, Synera workspace	**Objective 1:** Functional Momentum Core *(Framework established; milestone achieved)*
Sprint 1	5 (8.0)	Core maturity progression logic; Dynamic Verification Chain (JSON/STEP exporter) initiated	Fully implement CoDR-level Synera workflows (CAD, FEA, thermal, basic DFM); structures/mfg agents added	Agent-driven UI dashboard with basic maturity & verification status	Used throughout: Synera, NX CAD+Simcenter, Nastran	**Objective 2:** Momentum Loop Agent Workflow *(Initial multi-agent workflows demonstrated; milestone achieved)*
Sprint 2	5 (13.0)	Schema expanded to support full PDR fidelity; Dynamic Verification Chain further developed	PDR-level analyses implemented (CAD, FEA, thermal, DFM, real-time manufacturability checks); Rule-based manufacturability checks, CAM/additive RFQ begun; thermal/mechanisms/m&p agents added	Real-time manufacturability insights	Advanced DFM integration (Synera), Xometry RFQ API	*(Milestones 3-5 initiated, actively in progress)*

Sprint	Duration (End Week)	Core Tasks	Loop & Chain Tasks	UI & UX Tasks	Primary Tools & Methods	Milestones Achieved
Sprint 3	5 (18)	Finalize PDR-level tools; Real-time dynamic Verification Chain fully operational	PDR-level analyses finalized; Topology optimization integrated; Custom tools fully implemented	Advanced verification UI (dynamic audit trails, agent-sourced knowledge insights)	NX Simcenter topology optimization	**Objective 3:** Integrated Tool Orchestration Layer *(Callable APIs validated; milestone achieved)* **Objective 4:** PDR Toolkits *(PDR-level design definition fully validated; milestone achieved)* **Objective 5:** Dynamic Verification Chain *(Fully operational and validated; milestone achieved)*
Sprint 4	4 (22)	Central knowledge repository actively populated by agent interactions	Trade-matrix automation implemented for comparative design studies; Robustness checks and agent interaction refinement; refine manufacturing feedback approach	User experience polished (usability, accessibility); enhanced knowledge exploration capabilities in UI	Pinecone, Accessibility Audits, GitHub CI	**Objective 6:** Real-time Manufacturability Feedback *(Manufacturability checks demonstrated, active escalation & user intervention validated; milestone achieved)* **Objective 7:** Central Knowledge Repository *(Fully populated, operational, and validated; milestone achieved)*

Sprint	Duration (End Week)	Core Tasks	Loop & Chain Tasks	UI & UX Tasks	Primary Tools & Methods	Milestones Achieved
Sprint 5	2 (24)	Final Core schema & API documentation delivered; Dynamic Verification Chain artifacts finalized	Demo preparation and final deliverable bundling (Synera tool calls, trade studies)	UI demo preparation, styling and recording final demonstration video; Final documentation compiled and delivered	Documentation tools	*(All milestones previously achieved; demonstration and documentation finalized)*

Core Tool Stack

A single GitHub repo holds all code, schemas, and CI pipelines. PI will track use swim-lanes to track Core, Loop, Chain, and UI tasks so that each layer matures in lock-step.

Layer	Essential technologies (all Python server-side unless noted)	Role in Momentum
Core	• Python • FastAPI implementing **core_mcp** • PostgreSQL (JSONB)	Stores requirements, BOM, maturity level, analysis artifacts, and Verification-Chain commits with Git-like version control.
Loop	• LangGraph for agentic workflow • Single **mcp_client** library • Pydantic validation	Runs the System-Engineer and discipline agents, makes uniform MCP calls to Core and Chain, and guarantees valid JSON.
Chain	FastAPI servers: • **synera_mcp** (high-level CAD / analysis) • micro-services (**pynastran_mcp**, **cad_edit_mcp**, **dfm_mcp,** etc.) and **knowledge_mcp**	Delivers CAD/FEA/DFM/quote tools and a searchable knowledge repository, each exposed as an MCP tool list so agents can cite source data.
UI	Lightweight React front-end (requirements & BOM grid, chat with knowledge / action / artifact cards, “Open in Native Tool” button)	Human interaction only—no heavy 3-D viewer in Phase I.
DevOps	• GitHub Actions CI / CD • Docker Compose (local) • AWS VPC + IAM, one managed Postgres (RDS)	Reproducible builds, secure single-cloud deployment, and spend guardrails, nothing exotic.

A complete list of tools and methods can be found in NASA TAV / IP usage and Part 7: Facilities and Equipment.

Resource Allocation

Sprint	PI (hrs)	Software Eng. (hrs)	UI/UX (hrs)	SME (hrs, in-kind)	Total Sprint Hrs
KICK	30	30	30	2	**92**
MVP	30	70	10	8	**118**
Sprint 1	190	160	40	8	**398**
Sprint 2	210	130	40	8	**388**
Sprint 3	220	130	40	8	**398**
Sprint 4	190	80	30	8	**308**
Sprint 5	90	40	10	8	**148**

Sprint	PI (hrs)	Software Eng. (hrs)	UI/UX (hrs)	SME (hrs, in-kind)	Total Sprint Hrs
Totals	**960**	**640**	**200**	**50**	**1850**

Workload Distribution Statement

Not a joint venture or limited partnership. All tasks executed by Dan Mueller Consulting LLC with limited contract support (<33% of total budget). SME provided by Astris Design in-kind via signed commitment letters (50 hrs total).

Proposal Budget

Labor Cost (Personnel Hours & Rates)

Personnel Role	Skill Level	Total Hours	Hourly Base Rate ($/hr)	Total Cost ($)[1]	Fraction of Total Labor Cost
Principal Investigator (PI)	Principal	960	40[2]	[Total PI cost]	%
Software Engineer (SWE)	Senior	640	72	[Total SWE cost]	%
UI/UX Engineer	I	200	48	[Total UI/UX cost]	%
Contracted: Subject Matter Expert (SME, in-kind)	Staff	50	0	[SME cost (in-kind)]	%
Total Labor Cost	N/A	1850	N/A	$137,770	%

Totals estimated based on labor rates below from market research and PI hiring experience.

Level	Experience	Description (additive from previous level)	Expected Annual Salary	Weekly Base	Hourly Base
I	Entry level	Learning on the job	$100,000	$1,923	$48
II	2-5 years	Developed core skills	$125,000	$2,404	$60
Senior	5-8 years	Mastered core skills, develops some new ideas	$150,000	$2,885	$72

[1] Total cost includes 33% fringe + 10% overhead.
[2] PI rate includes "sweat equity rate" to balance project resources.

Level	Experience	Description (additive from previous level)	Expected Annual Salary	Weekly Base	Hourly Base
Staff	8-15 years	Developing core product and concepts	$175,000	$3,365	$84
Principal	15+ years	Leading overall project strategy and vision	$200,000	$3,846	$96

Tools, Software, and Licenses

See Part 7: Facilities and Equipment. Sum total $26,352.

Technical and Business Assistance (TABA)

Sum total $6,500. Quote attached for Valid Eval application.

Cost Sharing / In-Kind Contributions

Contribution Type	Source	Value ($)	Notes
SME Consulting for Mechanical Design, Analysis, and Manufacturing	Astris Design	$0	50 hours at SME hourly rate
Total In-Kind Contributions		**$0**	

Signed letters in valid eval

Total Cost Summary

Budget Category	Total Amount ($)	% of Total
Personnel Labor	$137,770	80.7%
Tools, Software & Licenses	$26,352	15.4%
Technical and Business Assistance (TABA)	$6,500	3.8%
Grand Total (Phase I)	**$170,622**	**100%**

Financial Responsibility Statement

Dan Mueller Consulting LLC is a newly formed business with no prior federal audits, which is typical for early-stage SBIR applicants. While I haven't directly managed corporate accounting systems, I do have substantial experience managing technical project budgets within complex aerospace programs. Prior to award, Dan Mueller Consulting will consult a federal accounting expert to ensure the company's financial systems fully comply with NASA SBIR requirements and federal contracting standards.

Part 4: Related R/R&D

Previous Relevant Research and Development

Dan Mueller Consulting LLC has developed significant prior R&D directly supporting this proposal through the creation of the “Aerospace Chatbot.” This project was independently developed by the PI, Dan Mueller, from November 2024 to February 2025, while simultaneously employed full-time as a Senior Manager of Structures and Mechanisms at Relativity Space, dedicating approximately 10 hours per week or less to the effort (≤170 hours total). This tool, tailored specifically for aerospace hardware engineers, leverages Retrieval-Augmented Generation (RAG) technology combined with an agentic backbone, setting a robust foundation for Momentum.

Aerospace Chatbot Demos

The publicly available Aerospace Chatbot indexes NASA’s Aerospace Mechanisms Symposia and the European Space Mechanisms & Tribology Symposium papers. Demonstrations showcase essential RAG features including:

- User-uploaded document ingestion and parsing.
- Interactive Q&A with dynamic source highlighting for verification.
- Advanced embedding techniques enabling enhanced document retrieval and ranked searches.
- Agentic backend workflows for tailored interactions and information retrieval.

These capabilities significantly streamline aerospace engineering workflows by improving rapid technical literature access.

Open-Source Development on GitHub

The foundational technology is actively maintained as open-source under the AGPL-3.0 license in the "aerospace_chatbot" GitHub repository, featuring:

- Over 770 code commits and 18 releases, most recently v0.0.10.1 (February 2025).
- Detailed technical stack (LangChain, Voyage/OpenAI embeddings, colbert-ir RAG framework, Pinecone, ChromaDB, Docker-based deployment).

This transparent, accessible documentation ensures robust and extendable methodologies.

Relationship to Proposed Effort

Momentum directly expands upon the Aerospace Chatbot’s established infrastructure, enhancing capabilities for handling complex aerospace literature, precise retrieval, and scalable agentic backend interactions. This prior development significantly mitigates project risks by providing proven methodologies for document parsing, UI design, and backend coordination.

Future Coordination

The agentic framework was specifically designed for further expansion into multidisciplinary tool orchestration, underpinning Momentum Loop development. Continued community and industry collaboration, through beta testing and ongoing GitHub contributions, will ensure relevance and continuous improvement.

Part 5: Key Personnel/Team

Principal Investigator (PI): Dan Mueller

Dan Mueller, founder of Dan Mueller Consulting LLC, will serve as the Principal Investigator (PI), dedicating full-time effort to lead, manage, and execute the Momentum Phase I project. He will oversee overall technical direction, detailed project planning, execution oversight, and maintain direct communication and compliance with NASA throughout the project's duration.

Dan Mueller brings a unique and compelling blend of individual contributor expertise, leadership, analytical depth, design proficiency, tactical project management, and direct manufacturing experience. With over a decade of aerospace industry experience focused on structures, mechanisms design, development, and certification, his extensive background distinctly supports his role as PI. He currently serves as Senior Manager of Structures and Mechanisms at Relativity Space, where he leads and rapidly grows technical teams responsible for critical vehicle systems, including electromechanical actuators, interstage structures, and payload sections for the Terran R vehicle. Notably, Dan successfully doubled his team size, demonstrating his proficiency in recruiting, hiring, onboarding, and integrating talented engineering teams.

His comprehensive industry experience includes:

- Leadership and execution of aerospace hardware design, analysis, certification, and qualification programs.
- Direct engagement with NASA, FAA, EASA, and USAF for certification and qualification processes.
- Running the structural analysis methods and tools team at SpaceX, demonstrating strategic oversight of critical analytical capabilities.
- Specialized expertise in composite overwrapped pressure vessels (COPVs), actuator systems, and aerospace structural design standards.
- In-depth knowledge and proficiency with industry-standard aerospace tools including NX, Teamcenter, Simcenter, Hyperworks, Nastran, and Optistruct.
- First-hand experience with significant manufacturing pain points including difficulty finding time to develop prototypes for flight actuators, inefficiencies from redundant effort and tool switching, extensive and inefficient cycles from design iterations to part quoting, and unnecessary complexity in supply chain interactions.

Motivated by these lived experiences, Dan independently developed the Aerospace Chatbot, an advanced agentic, retrieval-augmented generation (RAG) tool specifically tailored to efficiently access and analyze complex aerospace mechanisms literature. This tool is explicitly designed as the foundational agentic capability that will be expanded and leveraged within the Momentum Loop product. This significant achievement, completed between November 2024 and February 2025, showcases his capability to manage and execute complex technical projects efficiently, even concurrently with full-time leadership responsibilities.

Dan holds an M.S. in Aerospace Engineering (Aerospace Structures) from the University of Southern California and a B.S. in Engineering Mechanics and Physics from the University of Wisconsin Madison.

Mechanical and Manufacturing SME Support: Astris Design

Clayton Button from Astris Design will provide 50 hours of SME consulting as an in-kind contribution, supporting detailed technical analysis and independent validation of Momentum’s technology. Astris Design specializes in:

- Aerospace structural, thermal, mechanisms, and manufacturing design and analysis.

- Development of custom analytical tools and performance benchmarking against industry standards.
- Independent validation of advanced aerospace hardware solutions.

Additional Phase I Personnel (Planned Upon Award)

Dan Mueller Consulting LLC will strategically expand the team upon successful award to include dedicated software engineering and UI/UX professionals. Dan will leverage his well-established aerospace industry network and extensive experience in all aspects of recruiting, hiring, onboarding, and integration of technical talent to quickly and effectively build a highly capable and cohesive team. New team members will be hired directly into Dan Mueller Consulting LLC, ensuring seamless project execution and readiness for commercialization.

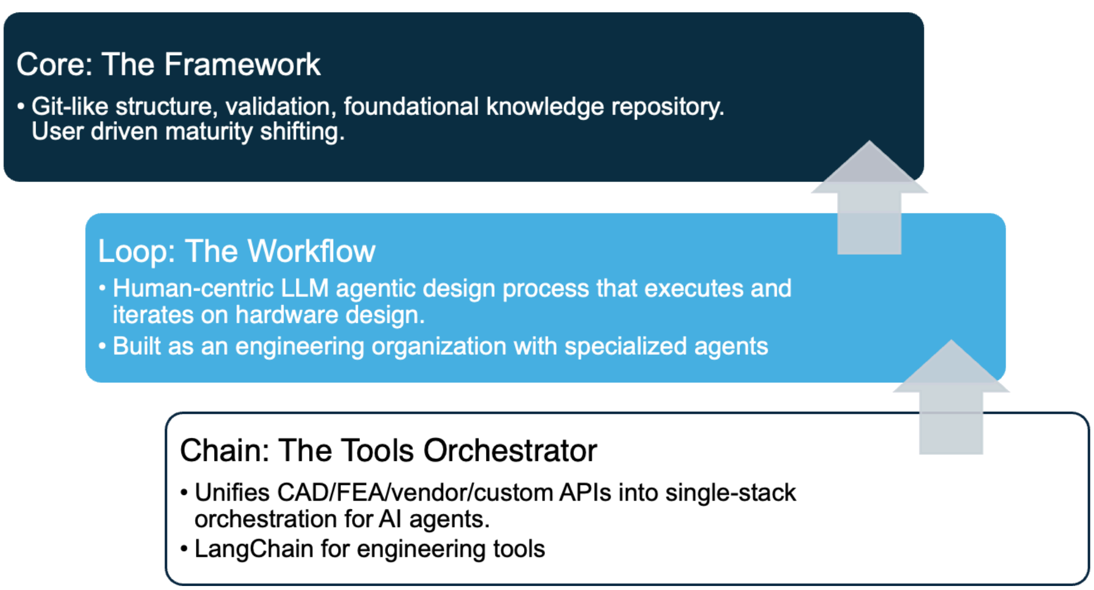
Eligibility and Commitment

Dan Mueller Consulting LLC confirms that Dan Mueller meets the PI employment criteria outlined by the NASA SBIR Ignite Solicitation. Dan commits full-time effort and dedicated leadership, providing comprehensive technical oversight and project management critical to achieving successful Phase I outcomes and ensuring strong future commercialization potential. Signed commitment letters by the PI and SME supporters have been attached to the Valid Eval application.

Part 6: Commercialization and Business Plan

Introduction

Momentum is an advanced, human-centric, AI-driven workflow designed to significantly accelerate aerospace hardware development from mission concept to fully manufacturable and validated designs. Directly addressing NASA's "Text-to-Spaceship" initiative, Momentum seamlessly blends intelligent automation with human-driven oversight, reflecting a realistic engineering organization's workflow structure. For tool orchestration, Phase I strategically employs Synera's established infrastructure to achieve immediate, risk-mitigated capabilities, transitioning in Phase II to a robust, code-native Momentum platform designed for sustainable scalability and commercial growth.



Product and Solution

Momentum bridges the critical "infrastructure gap" in aerospace hardware development, providing engineers with essential tools to rapidly advance multidisciplinary designs:

- **Core Framework:** Structured, auditable data schema and comprehensive knowledge repository.
- **Agent-Based Workflow (Loop):** AI-driven design iterations managed collaboratively by human engineers.
- **Tools Orchestration (Chain):** Unified integration of CAD, FEA, DFM, and vendor tools initially via Synera, transitioning to a code-native Momentum platform in Phase II.
- **Real-Time Manufacturing Insights:** Immediate manufacturability feedback, including integrated cost and lead-time visibility.
- **Verification Chain:** Instantaneous and dynamic traceability ensuring complete validation at every design milestone.

Development Scope Comparison

Development Area	Phase I (6 Months)	Phase II (24 Months)
Product Focus	Core, Loop, Chain via headless Synera, basic UI/UX	Full production-grade platform, robust UI, expanded API/tool integrations, expand Momentum Chain capability
Design Maturity	CoDR → PDR for system/subsystem	Comprehensive CoDR → CDR maturity for multi-component systems
Disciplines Supported	Structures, Mechanisms, Thermal, Manufacturing, Materials & Processes	Adds Power Systems, Avionics-Mechanical, Fluids, Propulsion, GNC, Loads & Dynamics
Tooling Infrastructure	Synera for orchestration; NX CAD/CAM, rule-based DFM	Momentum-native orchestration; full-stack NX Simcenter, Femap, advanced DFM tools
Demonstrated Capability	Payload adapter & deployment structures	Integrated spacecraft & launch vehicle subsystems

Product Specialties

- **Actuator Design Toolkits:** Integrated thermal, mechanical, and rapid prototyping capabilities.
- **Trade Study Agents:** Efficient, domain-specific early-phase architectural evaluations.
- **Prototype Generator:** Rapid vendor-ready procurement packages including STEP, BOM, and metadata.
- **Secondary Structure Design:** Automated designs for brackets, avionics mounts, subsystem interfaces.
- **Disparate Catalog Integrator:** Efficient consolidation and management of diverse standard engineering catalogs.

Market Opportunity and Industry Attractiveness

Momentum directly supports:

- **Launch Vehicle Integrators:** Needing structured yet flexible subsystem development tools
- **Spacecraft OEMs and Suppliers:** Benefiting from scalable manufacturing trade studies and prototyping feedback

Adjacent sectors include:

- Dual-use aerospace and defense R&D (e.g., ISR, hypersonics, robotics)
- Complex mechanical system integrators (e.g., EV platforms, energy systems)

Moats and Differentiation

- **Human-Led Agentic Workflow:** Maximizing engineer creativity through AI-driven efficiency.
- **Curated Domain Data & Adapters:** Specialized resources tailored specifically for flight hardware.
- **Agile Framework:** Embedded maturity metrics and milestone gates familiar to engineers.
- **Open & Traceable:** Comprehensive, auditable design and verification processes.
- **Veteran Founder Insight:** Direct industry experience shaping high-value solutions.

Landmines Avoided

To maximize a successful product delivery for Phase I, Momentum intentionally avoids:

- Low-TRL manufacturing methods and speculative workflows.
- Advanced solvers or nonlinear analysis during early phases.
- Complex UIs in Phase I.
- Edge-case hardware use cases.

Instead, the platform focuses on the 80% of common workflows that dominate engineering practice, ensuring Phase I and II deliver usable capability and generate trust from both customers and investors.

Phase I Infrastructure and Intellectual Property

Momentum leverages Synera's proven infrastructure to ensure rapid, reliable capability demonstration, while Momentum retains full control of essential intellectual property (IP):

Layer	Managed By	Details
LangGraph Agent Logic	Momentum	Custom logic, agent roles, and process flows
Verification Chain & Maturity	Momentum	Auditable, dynamic JSON verification and rollback capabilities
Engineering Tools	Synera-wrapped	Integrated third-party tools (NX, Simcenter), facilitating rapid initial capability

Orchestration Substrate	Synera (initial)	Executed via Synera, transitioning to Momentum-native orchestration in Phase II
UI & User Interaction	Momentum	Lightweight and scalable, evolving into fully integrated platform interfaces in Phase II

This architecture allows Momentum to rapidly scale capabilities while retaining full control over intellectual property, extensibility, and agent design logic.

Phase II Transition

Momentum pricing aligns with comparable engineering software platforms such as HyperSizer, nTopology, and Onshape Enterprise, which range from $30k–$120k per seat. Our early pricing tiers reflect clear value: affordable entry for startups, scalable licensing for OEMs and primes, and targeted consulting for integration. High gross margins (~85%) and strong customer ROI potential (time and cost savings) support pricing integrity and investor interest.

Offer	Core Benefit	Buyer Persona	Early Price Target
Momentum SaaS Starter	Cloud workspace, 3 agents, CoDR-to-PDR	Seed-stage aerospace startups	$35k/year
Momentum SaaS Pro	Unlimited agents, full CDR toolkit, vendor plugins	Growth-stage OEMs, Tier-1 suppliers	$60–90k/year
Enterprise Subscription	VPC/on-prem, extended SLA, audit capabilities	Prime contractors, NASA centers	$80–120k/year
Professional Services	Workflow setup, Synera integration, DFM consulting	Teams upgrading workflows	$225/hr (average)

Phase I to Phase II Team Expansion

Team Role	Phase I	Phase II	Justification
Principal Investigator (PI)	1 FTE	1 FTE	Continued technical and strategic oversight
Software Engineers	0.75 FTE	2 FTE	Increased development complexity and integration tasks
UI/UX Engineer	0.25 FTE	1.5 FTE	Expanded platform UI complexity and user experience demands
SMEs	1 part-time	3–4 part-time (Avionics, Mfg,	Broader discipline coverage required for comprehensive design

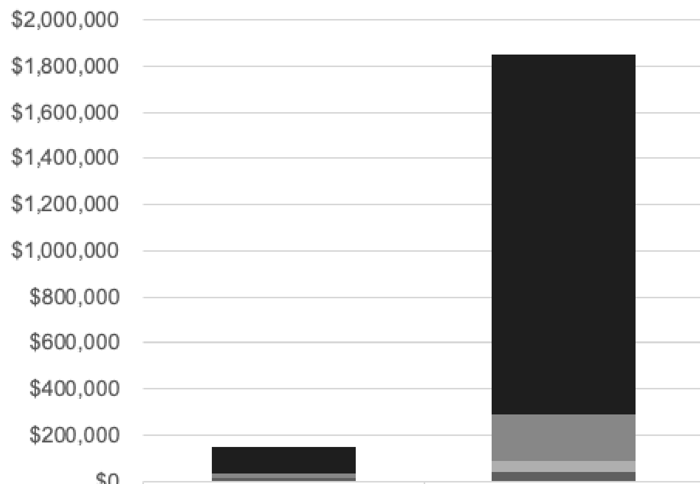
Team Role	Phase I	Phase II	Justification
		Test, Flight Sciences)	

Tool Scope Expansion

Tool Category	Phase I Scope	Phase II Scope
CAD/FEA	NX CAD/CAM, basic structural analysis	NX Simcenter, Femap, comprehensive structural and thermal analysis
DFM Tools	Rule-based DFM	Advanced DFM integration (e.g., CAM, additive manufacturing)
Orchestration	Synera for initial integrations	Code-native implementation of tool orchestration for Momentum Chain
APIs	Limited vendor integrations (McMaster, Protolabs, Xometry, etc.)	Comprehensive API integrations and catalog support (robust quote support)

Phase II Funding Gap and Use of Funds

Cost Category	Estimated Cost	Justification
Personnel	$1,560,000	Ensure robust development pace and capability
Software & Tools	$200,000	Expanded access to advanced engineering tools
Hardware Demo	$50,000	Validate platform in realistic operational conditions
Direct/Indirect Costs	$40,000	Increased travel, compliance, infrastructure expenses
Total Required	**$1,850,000**	
NASA SBIR Grant	$850,000	
External Investment	**$1,000,000**	**Required for risk mitigation and rapid market launch**



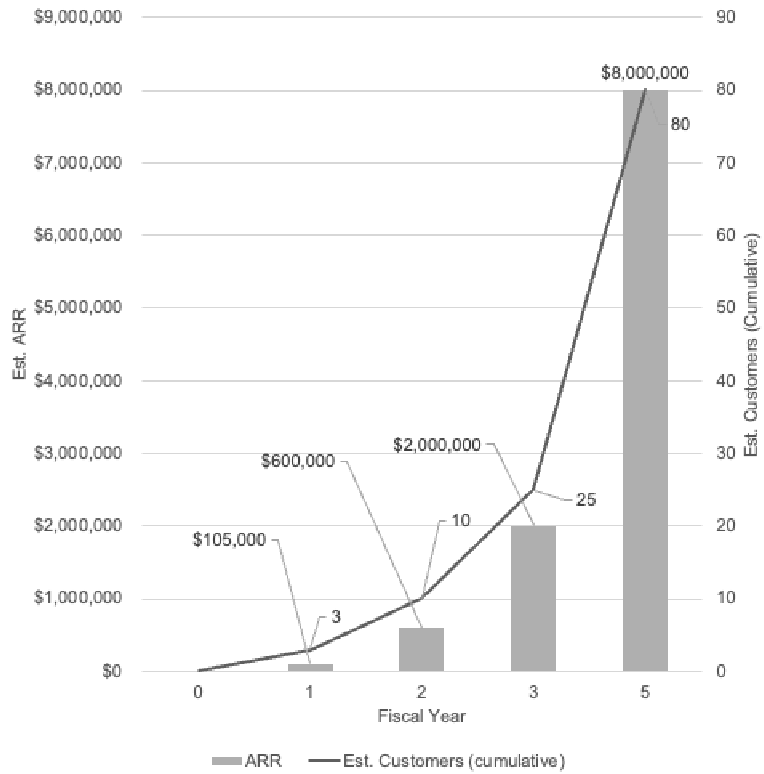
	Phase I	Phase II
Personnel	$117,000	$1,560,000
Software & Tools	$20,000	$200,000
Hardware Demo	$0	$50,000
Other Direct/Indirect Costs	$13,000	$40,000

This delta is the target for investor participation or matching contributions (e.g., Phase II-E) and ensures technical robustness, partner credibility, and demonstration success.

Financial Outlook and Phase III Strategy

Momentum's commercial ramp is modeled for early traction, profitability by FY-3, and long-term scalability:

Fiscal Year	Capability Drop	Est. Customers	Avg. Contract	ARR	Notes
FY-0	TRL-4 demo, sandbox experience	-	-	$0	Phase I R&D only, no revenue
FY-1	PDR Alpha Loop SaaS	3	$35k	$105k	Two startups, one NASA center
FY-2	CDR toolkits, prototype support	10	$60k	$600k	Commercial traction demonstrated
FY-3	Multi-tenant SaaS + on-prem	25	$80k	$2.0M	First cash-flow positive quarter, break-even achieved
FY-5	Adjacent sector expansion	80	$100k	$8.0M	Sustained 50%+ CAGR



Phase III Objectives

- Launch Momentum as a full SaaS subscription product
- Support enterprise customers with robust, secure deployments
- Target broader mechanical design markets: EV, energy, aerospace subsystems
- Use Phase II-E or private capital to support GTM scale-up and enterprise readiness

Support and Commitment Strategy

Letters of support:

- Vinay Goyal (Senior Technical Director, The Aerospace Corporation)
- John Olds (Managing Principal, Tyger River Capital)

Letters of commitment:

- In-work

Part 7: Facilities and Equipment

All work to be performed in the US. The project is to be centrally located in Long Beach, CA at Dan Mueller Consulting LLC. All partner team members and contractors will perform the work hybrid-remote. Any travel cost will not be included in the scope of this NASA SBIR proposal.

No government resources (equipment, facilities, or services) are to be used in this proposal. Licensed NASA software and patents which may be integrated during this proposal in Phase I are covered under TAV tools in NASA TAV / IP usage.

Physical Equipment

All physical equipment furnished at no cost to NASA by Dan Mueller Consulting LLC and supplied in advance of the proposal work being started.

Tools, Software, and Licenses

Tool / Software	Vendor	Type	Category	Cost ($)	Notes
Synera License	Synera	Annual	Chain	[Cost]	Primary orchestration platform
NX CAD/Simcenter License	Siemens	Small Business Annual	Chain	[Cost]	CAD/modeling, Structural/Thermal FEA
Zoo CAD License	Zoo CAD	Team	Chain	[Cost]	Parametric CAD modeling
Prototype Vendor Manufacturer APIs	Xometry, Protolabs, McMaster	Free	Chain	[Cost]	Manufacturing RFQs
Pinecone	Pinecone	Monthly	Core/Chain	[Cost]	Vector Database
LangSmith	LangChain		Loop	[Cost]	LLM prompt tracking
Unstructured.io	Unstructured.io		Chain	[Cost]	Document parsing
GitHub CI & Repository	GitHub		All	[Cost]	Version control & integration
AWS Infrastructure	AWS	Monthly	All	[Cost]	Infrastructure cost (monthly)
AWS LLM	AWS	Token Based	All		LLM access
Storage Resources (Cloud)	AWS, Onedrive		All	[Cost]	General
Research tools (guides, standards, etc.)	IHS, SAE, AIAA		Core/Chain	[Cost]	For knowledge base
Total Tools & Licenses				$26,640	

ITAR, Export Control, and Government Resources

No ITAR or CUI data will be generated, shared, or accessed.

Part 8: Subcontractors/Consultants

Clayton Button at Astris Design will provide in kind support totalling 50 hrs over the duration of the Phase I period of performance. Services to be provided are:

- Custom structural, mechanism, M&P, thermal, and manufacturing tools to be called by agents
- Evaluation of Momentum Objective 2 for: ≥ 5x faster iteration vs baseline manual design loop
- Independent evaluation of Momentum performance against industry standard tools.

Astris Design is contracted and not partnered due to the limited scope required for supporting the Phase I project.

Part 9: Related, Essentially Equivalent, and Duplicate Proposals and Awards

Dan Mueller Consulting LLC has not submitted any related, essentially equivalent, or duplicate proposals and awards for any federal contracts.