PROMETHEUS ENERGETICS

From Raw Materials to Rocket Motors:

Inside Energetics Manufacturing & Why Prometheus Is Building in Indiana

March 3, 2026

Alex Flanagan

Business Development Director

Alex.Flanagan@Prometheusenergetics.com

Solid Rocket Motor Basics

SRM History

Fire Arrow launcher from 13-14th century Huǒ Lóng Jīng

1941 demonstration of Jet Assisted Takeoff (JATO)

- SRMs live in the family of rocket engines, meaning thrust achieved by mass ejection
- Black powder is the precursor of modern solid propellants (composed of natural ingredients: sulfur, charcoal, and salpetre) – Has been used since the 13th century in Asia
  - That evolved into gun propellants up to WWII -> transitioned to aeronautical applications in WWII, which evolved into missile propulsion and space applications starting in 1945.
- Most modern strategic and tactical missiles use solid propellant propulsion
- Space launchers typically based on assembly of liquid and solid propulsion stages

What are Energetics

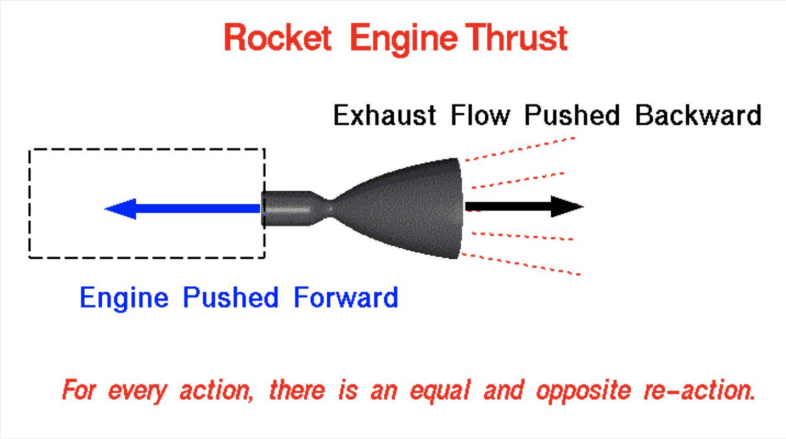
Energetics are engineered materials that release stored chemical energy very quickly and in a controlled way. They are not random explosives. They are precisely formulated materials used for propulsion and controlled effects.

Categories include:

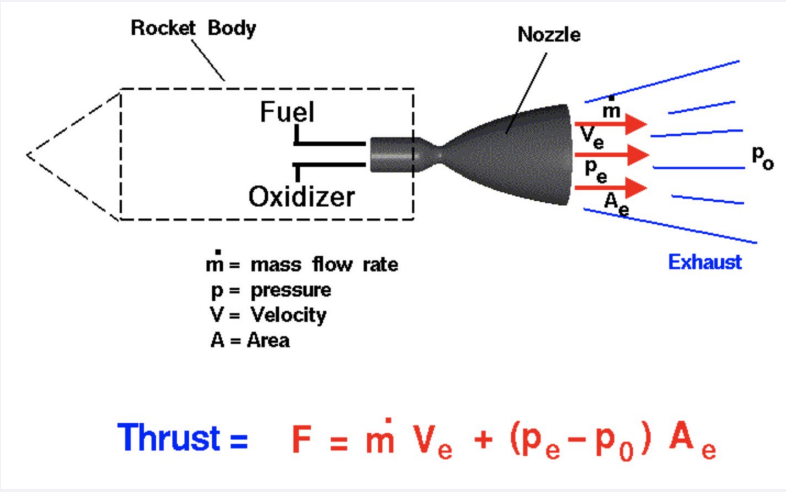
- **Propellants** (for propulsion)
- **Explosives** (for warheads)
- **Pyrotechnics** (for ignition and separation systems)

What is a Rocket

- Simply put: Vehicle used to launch a payload
  - Rockets propel themselves by expelling exhaust at a high velocity

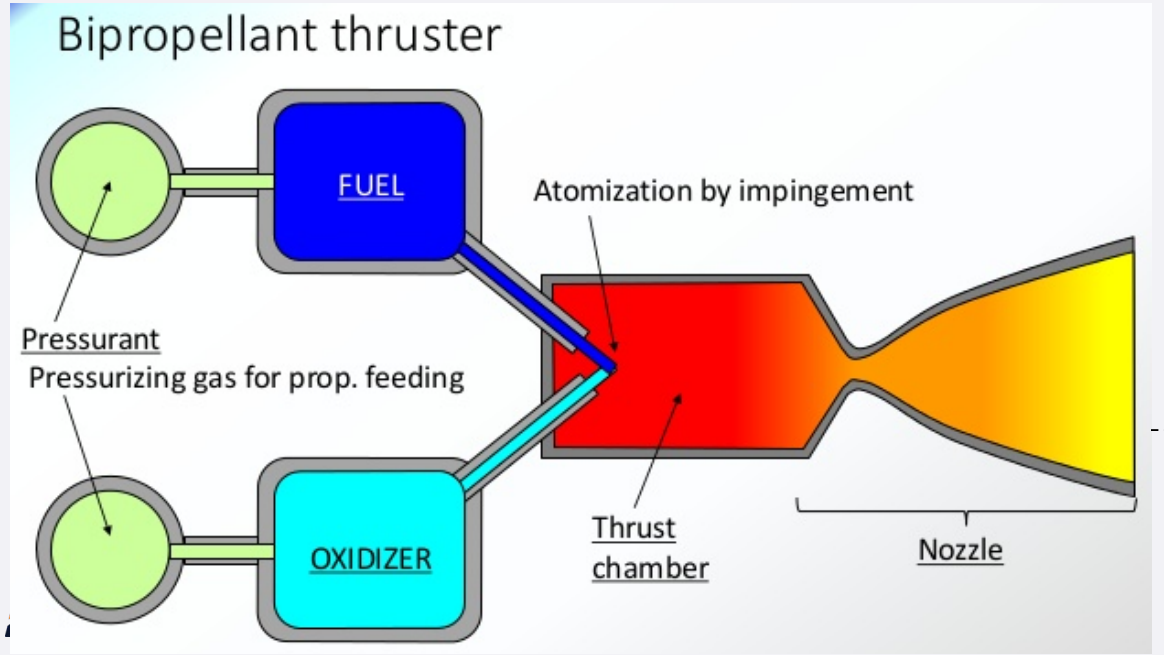


- Inside the rocket, a chemical reaction creates extremely hot, high-pressure gas. That gas has to escape, so it rushes out of a small opening called a nozzle. As the gas shoots out the back at high speed, the rocket is pushed forward in the opposite direction.
- This is Newton's Third Law of Motion:
  For every action, there is an equal and opposite reaction.
- The rocket doesn't push against the air.
  It pushes against its own exhaust.
- That's why rockets work in space. They carry everything they need, both the fuel and the oxygen, to create that hot gas internally. They don't need the atmosphere to move.

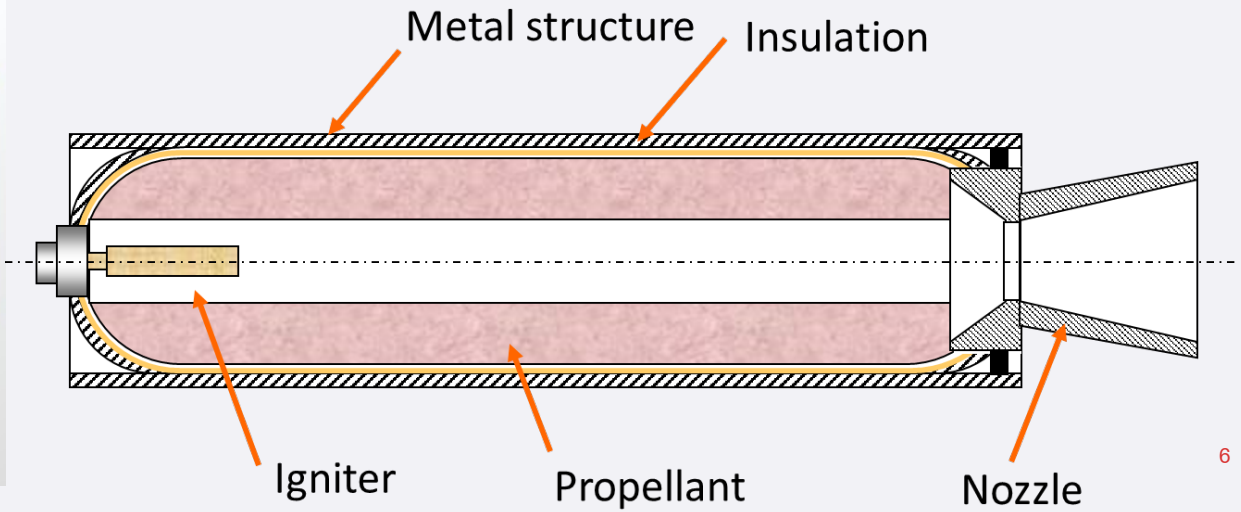


Solid Rocket Motors vs Liquid Rocket Engines

- A liquid rocket engine works by pumping liquid fuel and liquid oxidizer into a combustion chamber where they burn to create high-pressure gas that expands through a nozzle to produce thrust.
- Solid rocket motors pack all their propellant into the combustion chamber, eliminating the need for separate fuel and oxidizer tanks, plumbing, and heat exchangers. This is a large part of why solid rockets are much less costly than liquids.



- **SRM Advantages**
  - Simple (less system components)
  - Reliable (few moving parts)
  - Reduced storage volume
  - Storable (especially compared to cryogenics)
  - Easier to start (vs pump fed LRE)
  - Generally less expensive
- **SRM Disadvantages**
  - Lower ISP
  - Harder to test – no subcomponent tests
  - Hard to actively throttle
  - Manufacturing defects (e.g cracks) and degradations at extreme storage conditions
  - Emissions (HCl and chlorinated compounds) and signature (smoke) for most propellants



HOW SOLID ROCKET MOTORS WORK

The propellant contains both fuel and oxidizer, so these motors can operate in the vacuum of space.

Igniter

An electrical signal is sent to the igniter, creating a flame that ignites the main propellant grain.

Propellant Grain

BAKED TO A PENCIL-ERASER CONSISTENCY

A mixture of fuel and oxidizer that is poured into a case and cured.

Motor Case

The body of the missile acts as a pressure vessel for the combustion chamber.

Combustion Chamber

As the propellant grain burns, it produces high temperature combustion gases.

Nozzle

The combustion gases are accelerated through a nozzle, generating thrust to power a missile or rocket through the air or into space.

How Does an SRM Produce Thrust

- Chemical reaction produces high-temperature gas
- Gas expands through converging-diverging nozzle
- Newton's Third Law → thrust
- Geometry controls burn rate

Technical Explanation:

- The composite propellant contains:
  - Fuel (typically polymer binder + metal powder)
  - Oxidizer (usually ammonium perchlorate)
- When ignited:
  - The oxidizer decomposes.
  - The fuel reacts.
  - Reaction generates high-temperature gas (~2,500–3,500 K).
  - Chamber pressure builds (often 500–2,000 psi depending on design).
  - Gas expands through a de Laval nozzle.
  - Accelerated exhaust produces thrust.
  - The **internal grain geometry** (star, finocyl, etc.) controls surface area → which controls thrust profile.

Thrust equation:

$$F = \dot{m}V_e + (P_e - P_a)A_e$$

Where:

$\dot{m}$ = mass flow rate
V_e = exhaust velocity
P_e = exit pressure
P_a = ambient pressure

Grain Geometry

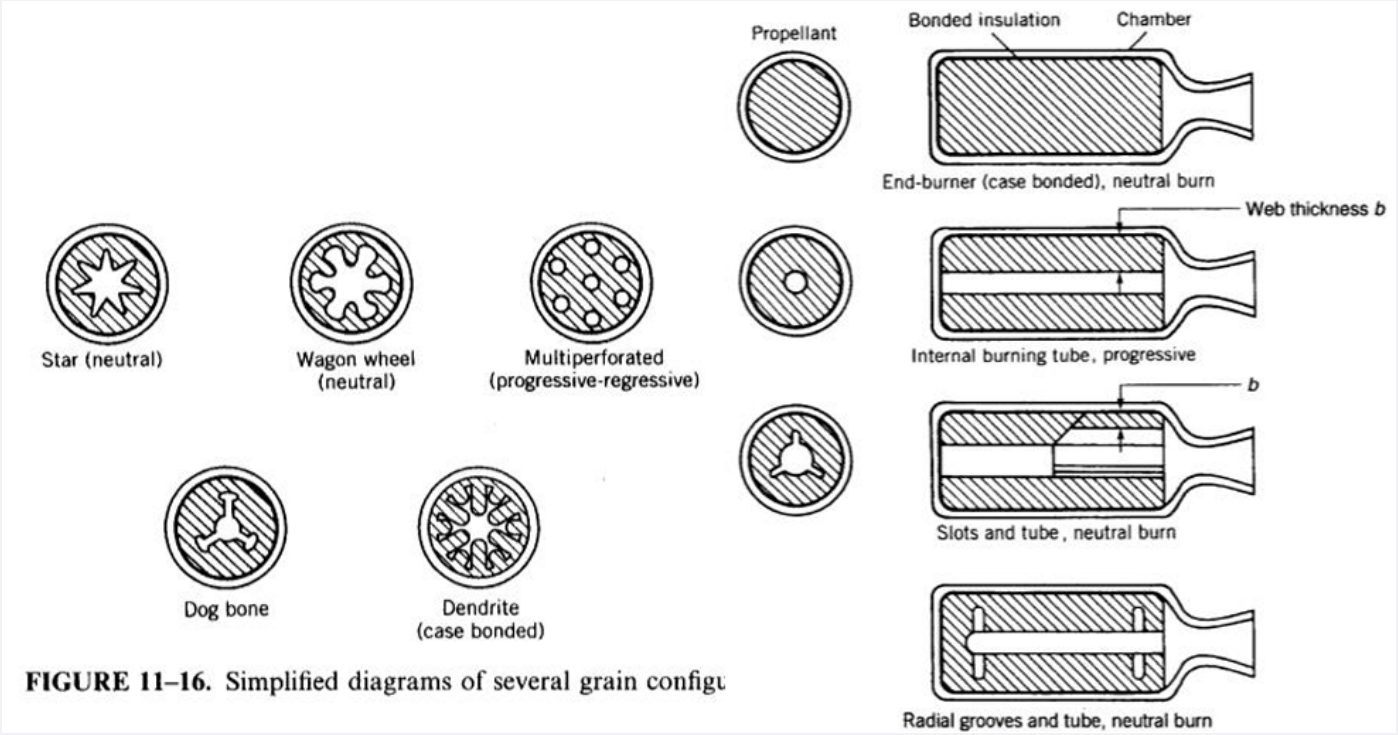
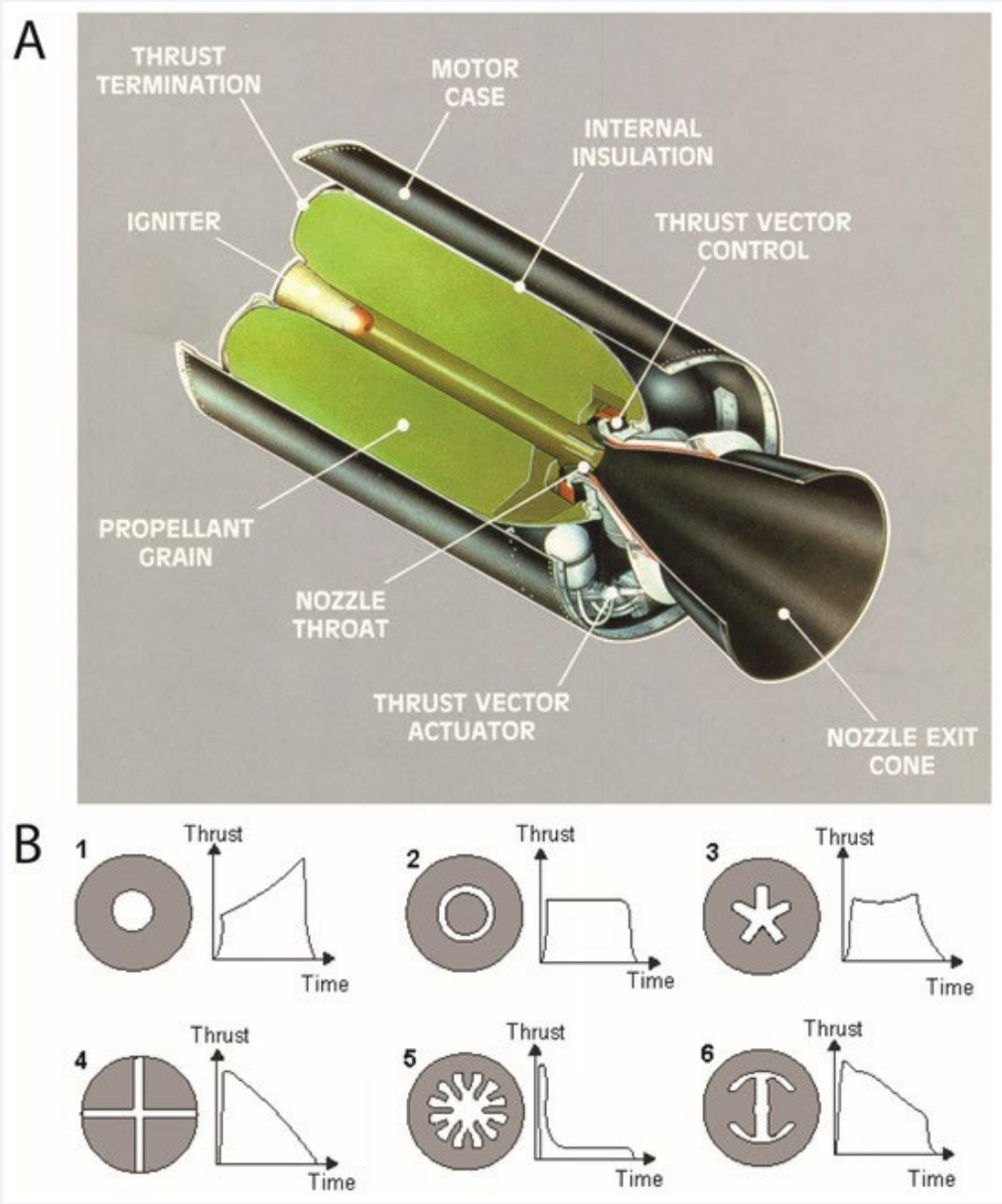


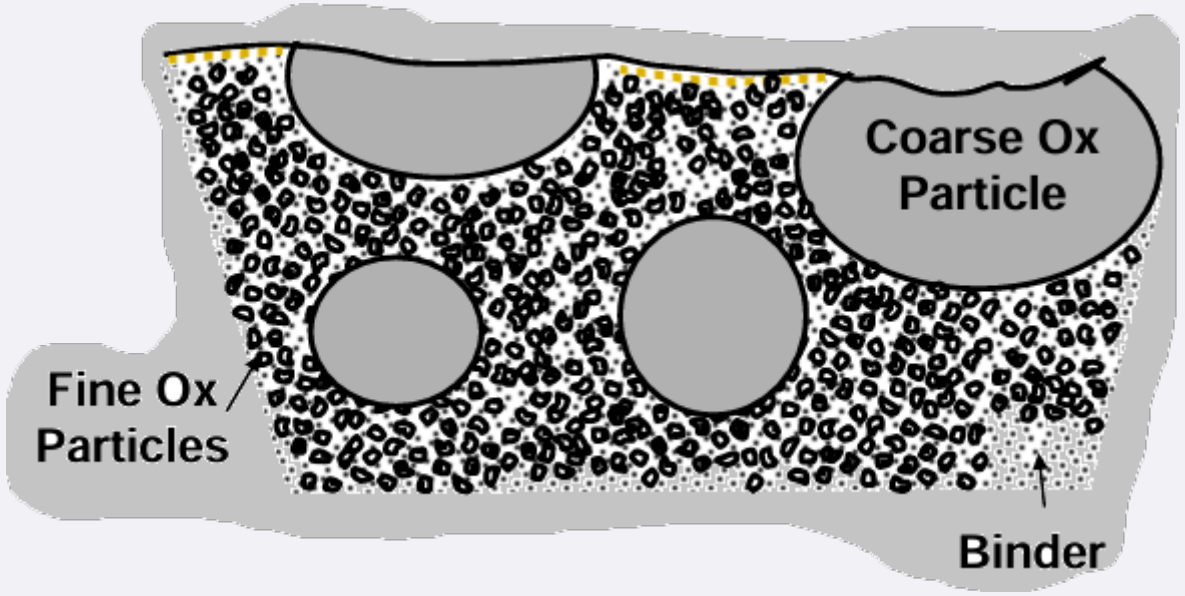
FIGURE 11–16. Simplified diagrams of several grain configu

*The **internal grain geometry** (star, finocyl, etc.) controls surface area → which controls thrust profile.*



What is the Propellant Made of

- 65–75% Oxidizer (Ammonium Perchlorate, AP)
- 15–20% Aluminum powder (metal fuel)
- 10–15% Polymer binder (HTPB)
- <1% curing agents, plasticizers, additive



Oxidizer - Ammonium Perchlorate (AP)

Function:

- Provides oxygen for combustion.

Technical Details:

- Chemical formula: NH_4ClO_4
- Particle size distribution critical (fine and coarse blends)
- Milled and classified for performance tuning
- Accounts for majority of propellant mass

Supply chain reality:

- Limited domestic AP production capacity
- Historically consolidated suppliers
- Long lead times

Metal Fuel: Aluminum Powder

Function:

- Increases energy density and chamber temperature.

Technical Details:

- Spherical atomized aluminum
- Particle size ~5–50 microns
- Improves specific impulse
- Raises combustion temperature and plume signature

Supply considerations:

- High purity required
- Consistency critical to burn rate stability

Binder System: HTPB

Hydroxyl-Terminated Polybutadiene (HTPB)

Function:

- Acts as both fuel and structural matrix
- Holds oxidizer and aluminum together
- Provides mechanical integrity

Details:

- Liquid prepolymer cured with isocyanates
- Cross-link density determines elasticity
- Must withstand temperature cycling and vibration
- This is what makes the propellant look like “rubber.”

Other Critical Materials

- **Curing agents** (IPDI or similar isocyanates)
- **Plasticizers** (improve flexibility)
- **Bonding agents** (adhesion to case liner)
- **Insulation materials**
- **Nozzle materials** (carbon phenolic, silica phenolic, graphite inserts)
- Nozzles must withstand:
  - 2,500–3,000°C (Over 5,000°F)
  - Extreme erosive flow
  - High mechanical load

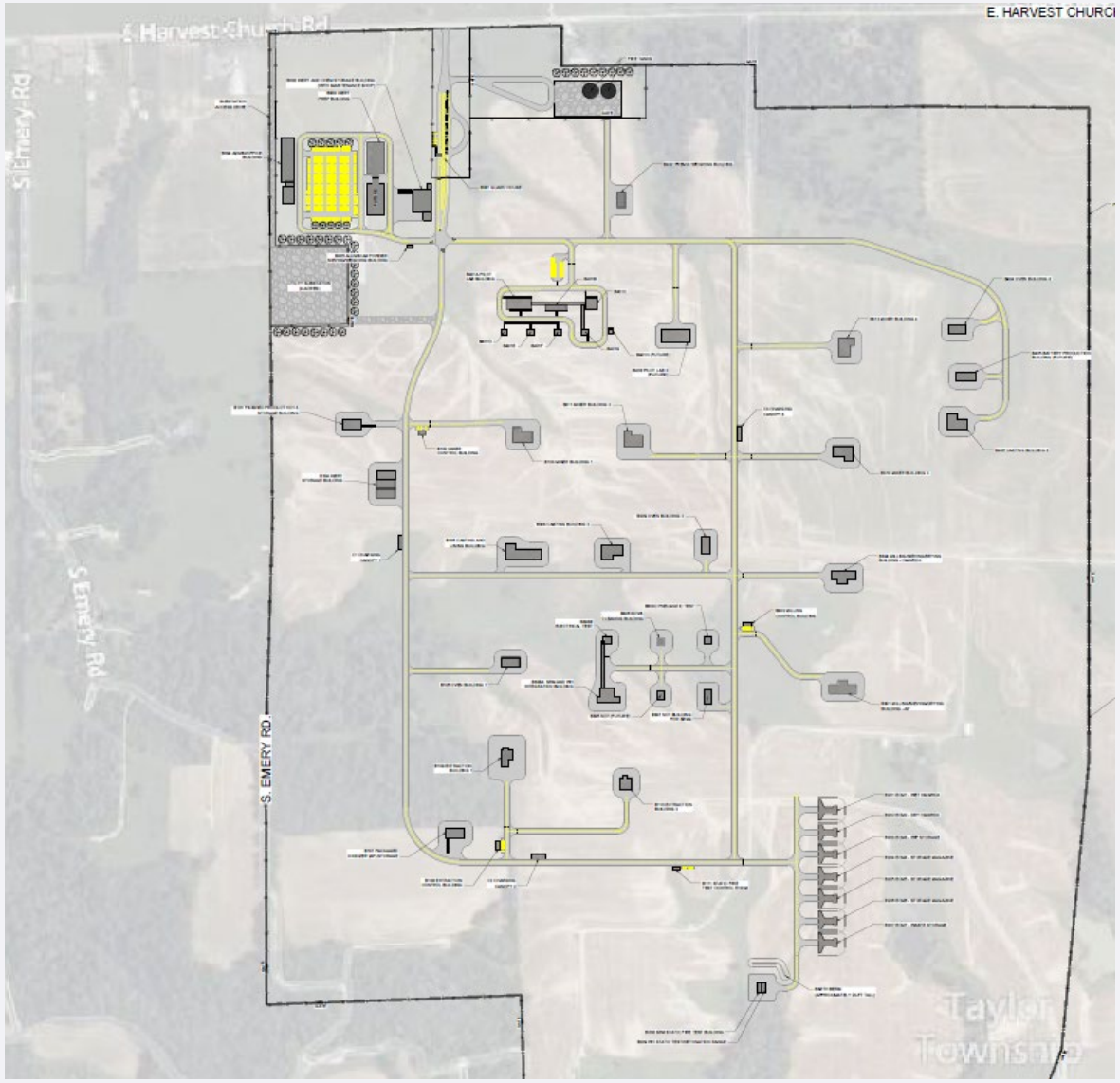
What an Energetics Campus Actually Looks Like

Not One Factory, But a Campus

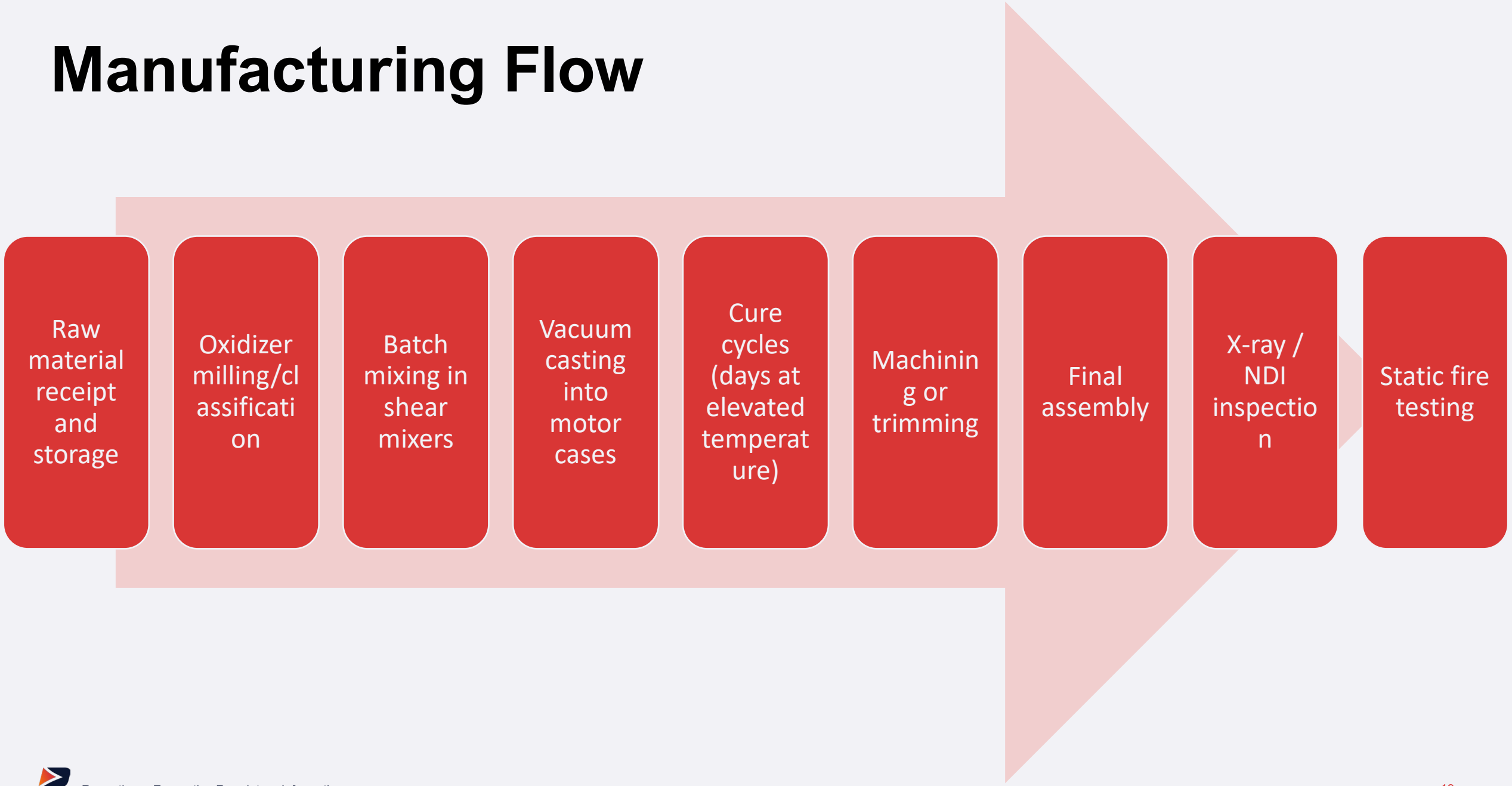
- Segregated buildings
- Blast arcs and safety distances
- Controlled personnel flow
- Environmental and safety systems

Energetics manufacturing requires:

- Distance separation between operations
- Reinforced structures
- Explosion relief panels
- Earth-covered magazines



Manufacturing Flow



The Supply Gap

Demand is Growing

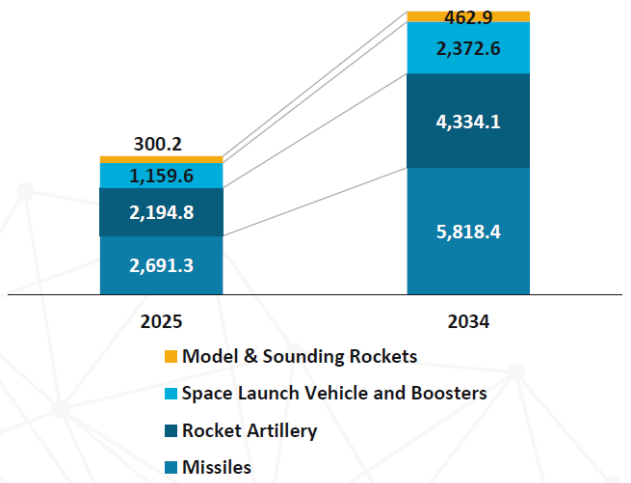
Key Drivers:

- 30+ years of industrial base consolidation
- Post–Cold War demand collapse
- Fewer qualified producers
- Surging demand from:
  - Missile defense
  - Ukraine replenishment
  - Indo-Pacific deterrence
  - Space launch

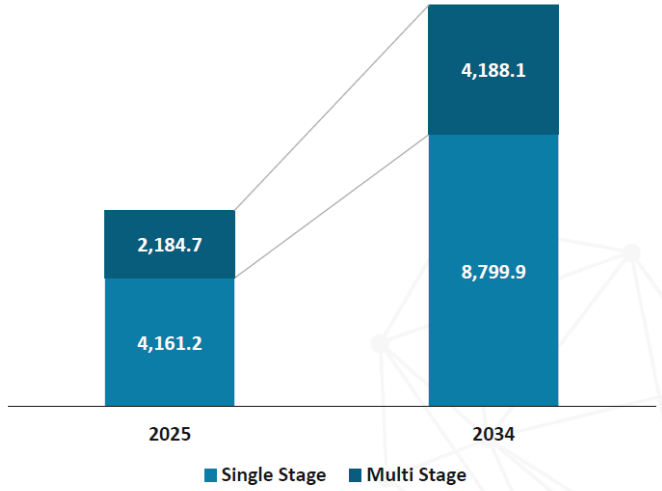
FORTUNE BUSINESS INSIGHTS

Executive Summary

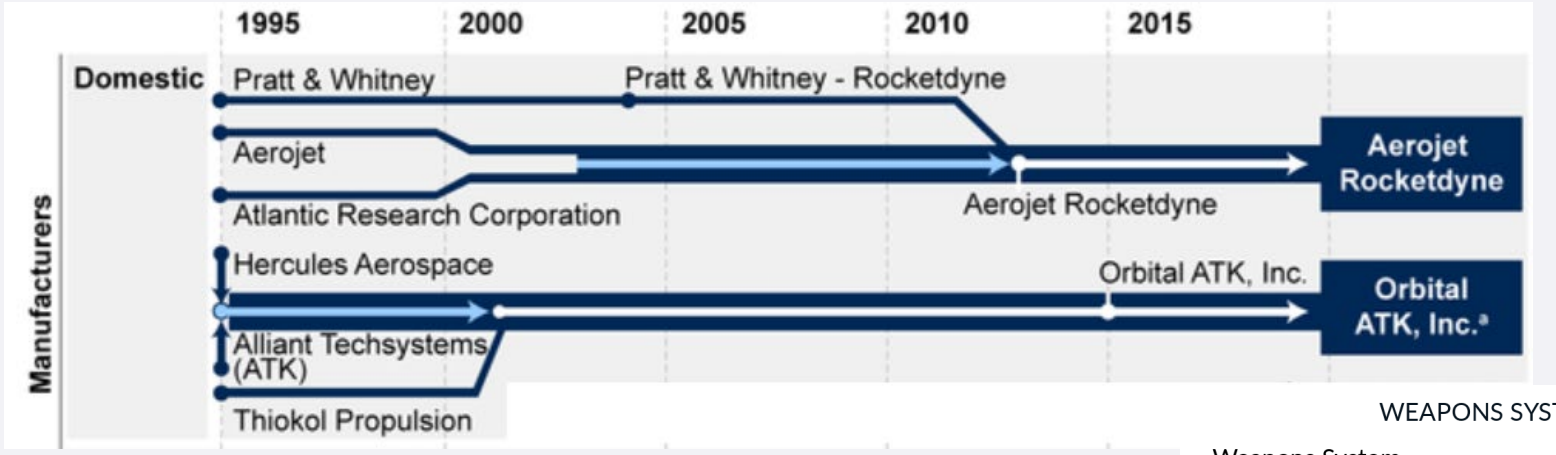
Global Solid Rocket Motor Market By Platform, 2025 and 2034 (in USD Million)



Global Solid Rocket Motor Market By Stage, 2025 and 2034 (in USD Million)



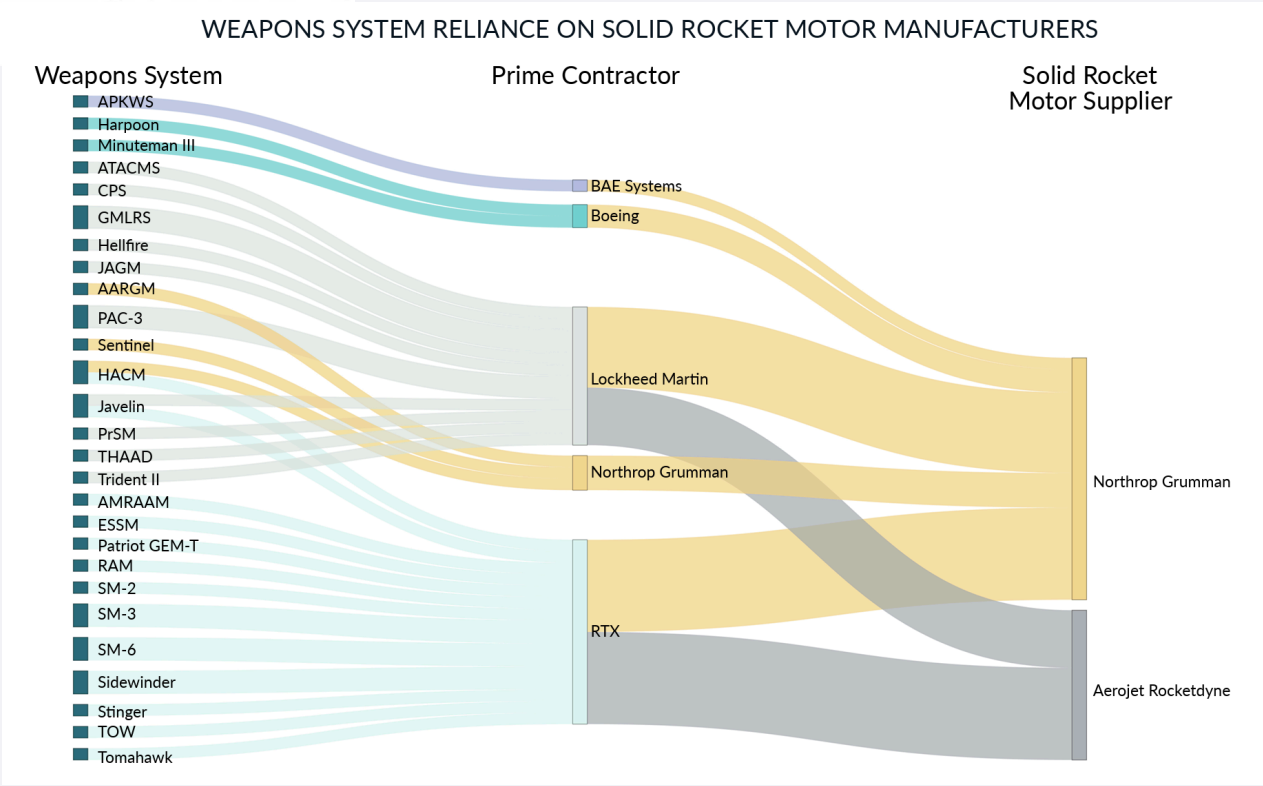
Two Suppliers. National Consequences.



AEROJET ROCKETDYNE
An L3Harris Technologies Company

NORTHROP GRUMMAN

- Over three decades, the U.S. solid rocket motor industry consolidated from multiple independent manufacturers to two primary suppliers.
- Today, most major missile systems rely on a single qualified motor provider — creating capacity constraints and supply chain concentration risk.



What are the Challenges with Scaling?

- From the outside, it may look like you could just build another factory and increase output.

- In reality, energetics manufacturing requires:
  - Specialized buildings with large separation distances
  - Heavy-duty mixing equipment & other specialized equipment
  - Extensive safety systems
  - Highly trained personnel
- Standing up new capacity takes years, not months.

- The industrial base for solid rocket motors has consolidated significantly over the past few decades. At the same time, demand for missile systems and propulsion systems has increased.

- That gap between demand and available production capacity is part of why expanding domestic manufacturing capability is strategically important.

Insert: Prometheus Energetics

Company Summary

Joint Venture

- Prometheus Energetics is an independent U.S.-based joint venture between Kratos and Rafael Advanced Defense Systems, established to develop and manufacture next-generation solid rocket propulsion and energetics systems as a true merchant supplier.
- Combines proven technology from Rafael with the speed and affordability model of Kratos, delivering rapid, cost-effective systems built entirely in the U.S.
- Onshores key proven SRM and warhead production technology from a trusted ally in the independent U.S.-based joint venture

Our Mission

- Rooted in innovation and a legacy of performance, Prometheus aims to meet urgent defense and deterrence needs across domains.

High-performance

- From missile interceptors to tactical strike systems, Prometheus has been established to deliver high-performance, cost-effective, warheads and solid rocket motors that help maintain the U.S. readiness and capability and that of our allies.

KRATOS®

Decades of experience in the design, development, qualification, production management, sustainment, and retrofits of multiple rocket motors as well as material design, analysis, and testing for rocket motor and warhead products for the DoD and DIB

RAFAEL

Develops, manufactures, and sustains combat-proven technologies, products, and systems-of-systems for air, land, naval, space and digital applications at scale. Current, SRM and WH delivery is enabled by vertically integrated facilities

PROMETHEUS ENERGETICS

U.S.-Based Joint Venture delivering advanced propulsion and energetics systems to meet the evolving demands of U.S. national security, powered by the expertise of Kratos and Rafael

Why Prometheus?

Market Forces:

1. Legacy propulsion companies, owned and operated by large primes, are driving up prices and lead times without regard to customer requirements or desire to continue supporting the whole market
2. New start propulsion companies are primarily not merchant suppliers, and they are bringing low TRL technologies at a higher cost without credible development plans

Mandate to Prometheus

Be **independent US propulsion merchant supplier** starting with combat-proven build-to-print products, serving US and Foreign Allies with high quality affordable production at scale.

- Prometheus financial model based on **70% US products** and **30% IL products**

Kratos Support

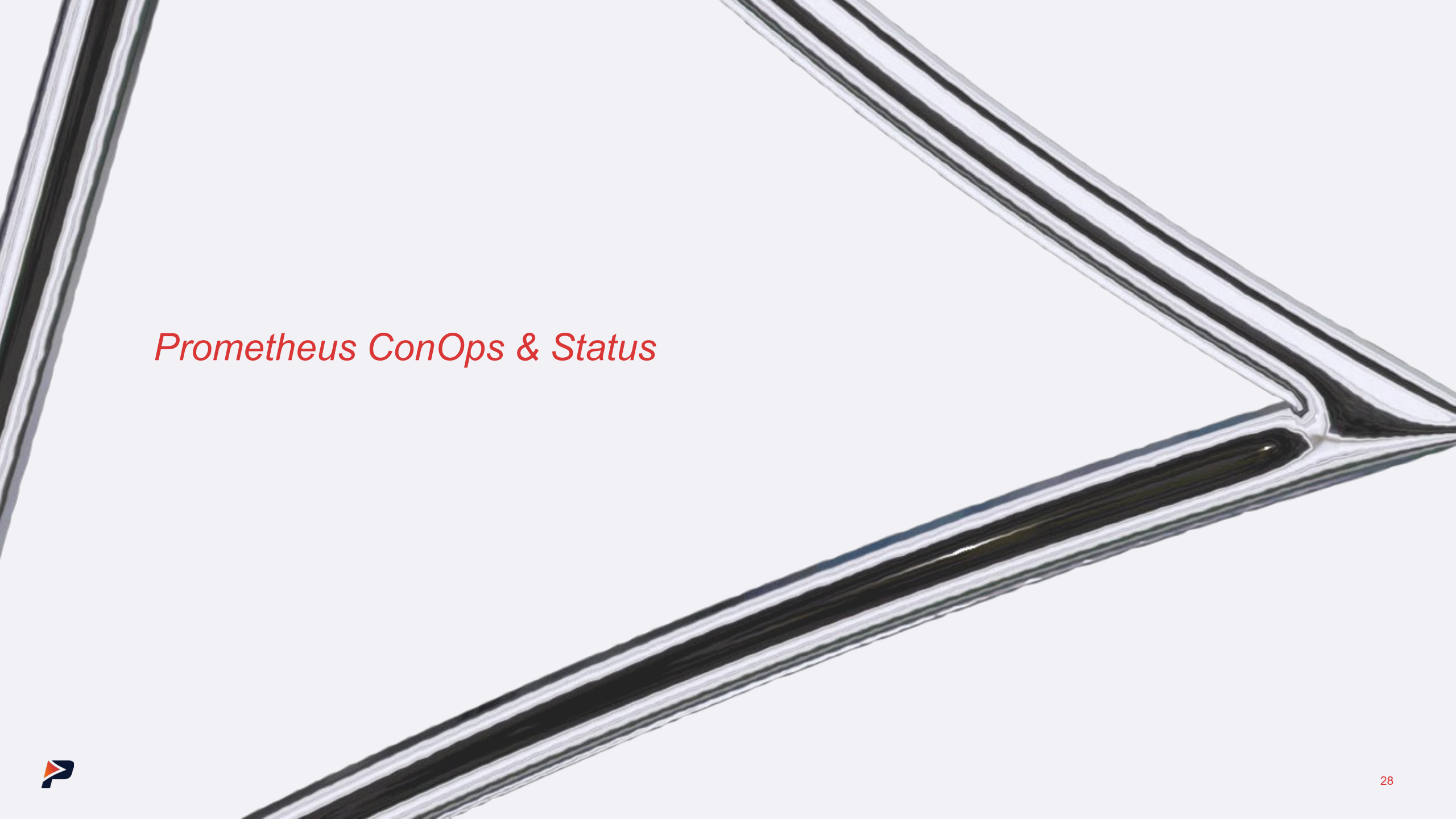
Brings market leaders and propulsion experts to setup Prometheus and hand-off to new leadership to execute.

- Company start-up, site selection, site development planning, long-lead equipment and materials planning, leadership hiring and training, regulatory agency support, product requirements, initial funding, federal partnerships

Rafael Support

Provides decades of combat-proven rocket-motor and warhead design, manufacturing IP, and technical transfer to ensure Prometheus delivers mature, field-ready products from day one.

- Transfer of proven designs and processes, technical instruction and training, production line design and establishment, materials handling and safety protocols, initial funding



Prometheus ConOps & Status

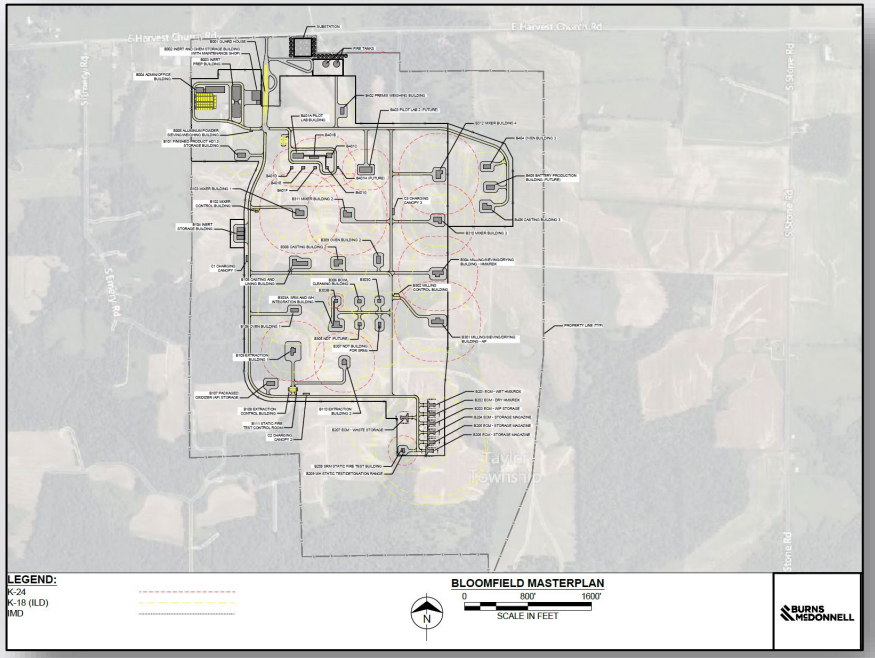
Location Established

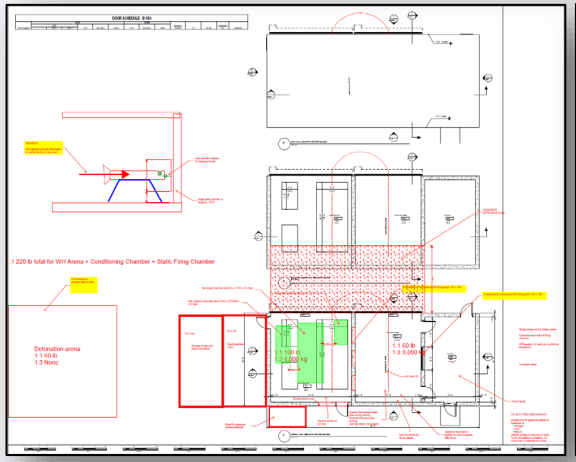
Headquartered in Bloomington, IN

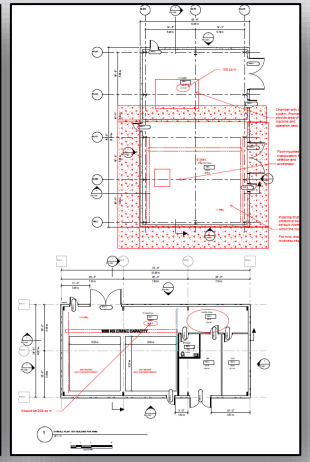
Anchor tenant on the MCEIP funded Munitions Campus as part of the ACMI National Security Industrial Hub near Crane Army Ammunition Activity and Naval Surface Warfare Center Crane

New, state-of-the-art energetics manufacturing campus will cover more than 600 acres

The Prometheus Campus







- Kratos and Rafael have jointly committed **$175 million in capital** to build the factory
- First prototype rockets by the end of 2026 and full **production in 2027**
- **270k sqft under roof**
  - 48 buildings on 600 acres (4 production lines)
  - Layout optimizes space and flow around campus
- **Individual building layouts complete for all buildings**
  - Conceptual layout of rooms and major equipment
  - Process flow through each building
- **Expansion options to south & north**
  - Discussions with landowner underway
  - North area part of ACMI Munitions Campus could be an option

Prometheus Startup Focus

- **Onshoring technical process knowledge from Rafael**
  - Starting with Build to Print (B2P) of Rafael Product (both solid rocket motor and warhead)
  - 1-2 yr Rafael residency at Prometheus to transfer knowledge
    - 1st motors built with Prometheus & Rafael “hand in hand”
    - B2P engineering & work instructions transcribed into Prometheus systems
    - Equipment operation and Preventative Maintenance programs
  - Hiring experienced leadership in key positions (engineering, operations, and quality team leads)
  - Robust training program for new employees
- **Building infrastructure of company using cutting edge tools and technology**
  - Design and build facility to classified standards for both physical and IT security
  - Right sized ERP system for Prometheus (independent selection from parent ERPs)
  - Electronic work instructions, QMS, TPM systems (little to no paper)
  - Augment systems with AI where able to do so safely (e.g. “RocketGPT” for ULA)
  - Institutional partnerships for recruiting and work force development (Purdue, Indiana, Ivy Tech, etc.)

Prometheus Phased Build Plan

A strategic & sustainable approach to growth

Establish

Phase 1

- Laboratory and subscale mix & cast
- Production line #1
- Production line #2
- **400 tons** propellant/explosive capacity per year

Scale

Phase 2

- Production line #3
- **600 tons** propellant/explosive capacity per year
- Classified hardware production capability

Sustain

Phase 3

- Production line #4
- **800 tons** propellant/explosive capacity per year
- Flexible, product agnostic manufacturing space

Strategic Partnerships In Place

Company Development

- Kratos – Joint Venture Partner, supply chain access
- Rafael – Joint Venture Partner, TDP owner, OJT support

Site & Process Development

- Burns & McDonnell – Veteran energetics site design firm
- ACMI – Indiana Munitions Campus owner, Federal OSD funds for shared resources
- State of Indiana – Supporting state regulatory compliance and utilities planning
- Greene County – Supporting local regulatory compliance and utilities planning
- Crane Army Ammunition Activity – Can augment facilities during scale-up, hazardous waste disposal, motor storage
- Safety Management Services (SMS) – Supporting BATF and DoW compliance
- AFRL/RXM – Supporting OSD industrial base study, providing feedback on approach
- Sparc Research – Independent SRM design firm, manufacturing operations analysis, automation planning

Workforce Development

- Purdue University – Onsite training programs, intern/coop program
- Ivy Tech Community College – Partnered with Purdue for ordnance technician and safety training
- Indiana University – Onsite training programs, intern/coop program
- Crane Army Ammunition Activity – Onsite training programs

Engaged Utility Providers

- **Monthly Utilities Meetings** being held to ensure project progress and communication for the entire project team

Why Indiana

- **Skilled & Scalable Workforce**
  - Deep talent pool with a strong manufacturing heritage and hands-on technical culture
  - Major engineering pipelines from Purdue, Indiana University, Notre Dame, and Rose-Hulman
  - Robust technician and operator pathways from Ivy Tech and Vincennes University
  - Workforce development programs aligned with defense manufacturing needs
- **Proximity to Critical Defense Infrastructure**
  - Close alignment with NSWC Crane, a major Navy energetics and ordnance hub
  - Immediate access to testing, qualification, and technical collaboration
  - Embedded presence within a growing Indiana defense ecosystem (Army, Navy, Air Force)
- **Strong State Support & Economic Development Incentives**
  - Indiana’s pro-manufacturing business climate and competitive cost of operations
  - Incentives supporting capital investment, workforce training, and long-term job creation
  - Highly engaged state and regional partners accelerating permitting, infrastructure, and site readiness

Building an Energetics Manufacturing Campus Requires Diverse Talent

Engineering & Technical Roles

- Propulsion Engineers
- Chemical Engineers (propellant formulation & processing)
- Materials & Polymer Engineers
- Mechanical & Structural Engineers
- Manufacturing Engineers
- Process & Industrial Engineers
- Quality & Reliability Engineers
- Systems Engineers
- Test & Instrumentation Engineers
- Safety & Explosives Engineers

Manufacturing & Skilled Trades

- Propellant Mixing Technicians
- Casting & Curing Operators
- CNC Machinists
- Composite Technicians
- Welders & Fabricators
- Maintenance Technicians (mechanical & electrical)
- Industrial Electricians
- Tooling Specialists
- Non-Destructive Inspection (NDI) Technicians
- Production Supervisors

Safety, Quality & Compliance

- Explosives Safety Professionals
- Environmental Health & Safety (EHS) Specialists
- Quality Inspectors
- Configuration & Documentation Control
- Regulatory & Compliance Specialists
- Hazard Analysis & Risk Engineers

Operations & Infrastructure

- Supply Chain & Procurement Specialists
- Materials & Logistics Coordinators
- Warehouse & Inventory Management
- Program Managers
- Production Planning & Scheduling
- IT & Cybersecurity Professionals
- Facility & Utilities Engineers

Corporate & Business Functions

- Finance & Cost Analysts
- Contracts & Legal
- Business Development
- HR & Workforce Development
- Security & Physical Protection

The Prometheus Advantage

- ✓ New **U.S.-based SRM manufacturer** built on Rafael's combat-proven production expertise for SRM and warhead design and manufacturing experience
- ✓ Kratos provides U.S. industrial credibility and immediate program-level manufacturing experience
- ✓ Partners committed significant capital to build scalable infrastructure and production lines
- ✓ **Merchant-supplier** model: factory optimized to fulfill prime customer orders quickly and reliably
- ✓ Anchor demand: both partners will initiate purchases of SRMs and warheads, de-risking early production
- ✓ Tamir motor selected for first production campaign, enabling a short turnover and fast fielding
  - ✓ Focused factory leadership and proven processes ensure first-product production
  - ✓ Production capacity can be accelerated as program demand grows
- ✓ DOW priority munitions can be prioritized and accelerated as first products for Prometheus
- ✓ Committed to establishing a **resilient American supply chain**

PROMETHEUS ENERGETICS

Thank You!

Alex Flanagan
Prometheus Director of BD
M: 938.273.7489
Alex.Flanagan@PrometheusEnergetics.com

PROMETHEUS
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Motor Equations

$$I_S = \frac{F}{\dot{m} * g}$$

- Efficiency of a motor defined by Specific Impulse, or ISP
  - The higher the specific impulse, the better the rocket

I_s= Specific Impulse [in*s]
F = Force [kg]
$\dot{m}$=mass flow rate ejected by the rocket [in∗kg/s]
g = gravity constant 9,806 [m/s^2]

$$C^* = \frac{P_o A_c}{\dot{m}} (m.s^{-1})$$

C* = Characteristic Velocity

P_o = Pressure in Combustion Chamber

A_c = Nozzle Throat Area [m^2]

Ideal Rocket Equation:

$$\Delta v = v_e \ln \frac{m_0}{m_f}$$

where:

Δv	Change in velocity
v_e	Exhaust velocity
m_0	Initial (launch) mass
m_f	Final (dry) mass