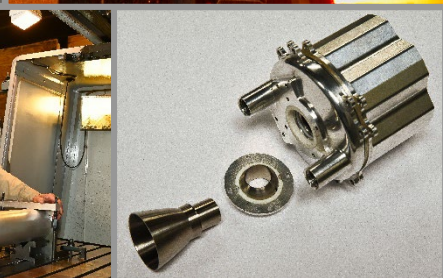


# 2024 Interplanetary Small Satellite Conference

University of Arizona  
Tucson, AZ  
30 April – 2 May 2024



*Session B: Propulsion Technologies,  
Solar Sail Technologies, and  
Launching Capabilities*

*B.6 Exquadrum's FORGE  
Development & Test Site: Current &  
Future Propulsion Testing  
Capabilities*

*Eric Schmidt, President  
David Morrison, Director T&E*



# Innovation is Essential to Exquadrum

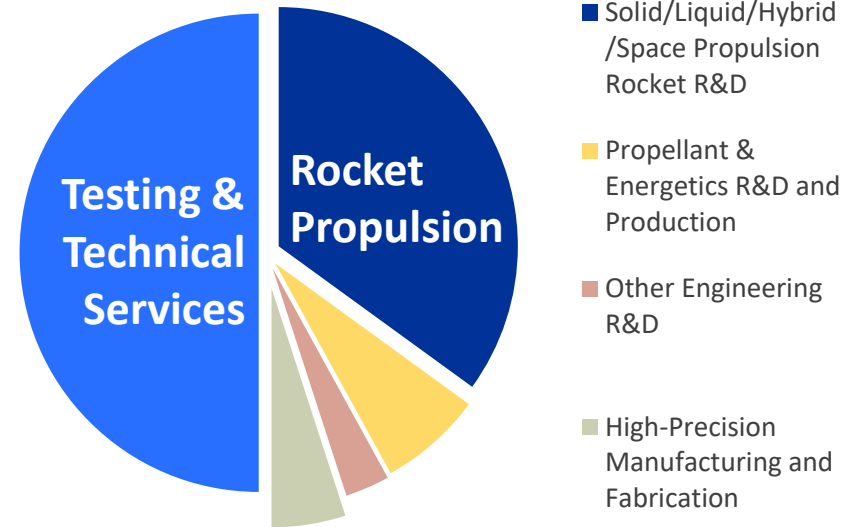
**EXQUADRUM**

In pseudo-Latin, “Exquadrum” means “outside the box” – as in “thinking outside the box”



Founded in 2002 on the principles of **technology innovation and intellectual property through Research & Development**  
Specializing in **rocket propulsion and energetics innovation**

## Business Sectors



**Eric Schmidt**  
President & Co-Founder



**Kevin E. Mahaffy**  
CEO & Co-Founder



**AS9100D**  
CERTIFIED  
**ISO 9001**



U.S. Small Business Administration  
**8(a) Certified**  
Graduation: 2030

NAICS: 541715, 541330, 561210



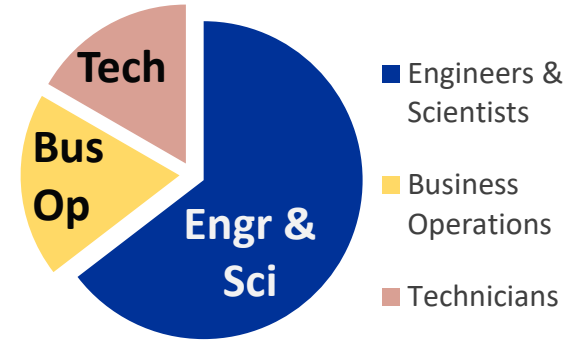
# Exquadrum Continues to Grow in both the R&D and Technical Services Divisions



70,000 sqft Headquarters & 10 Acre Energetics Test Site



## Personnel Composition



## Facility Clearance Level

- TOP SECRET
- Safeguarding: SECRET



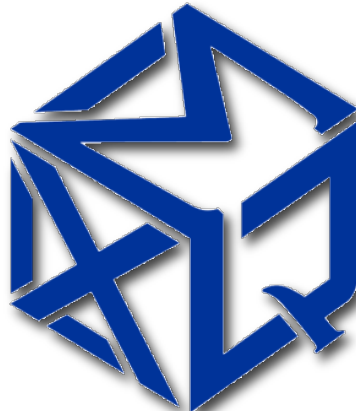
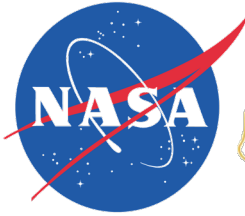
**ITAR**  
Registered

International Traffic  
in Arms Regulations



# Exquadrum Has Significant Customers and Teammates

**Tibbetts Award Winner for Excellence in DoD Small Business Technology**





EXQUADRUM

# Location of FORGE

## Facility for Operations and Research in Game-changing Experiments (FORGE)

- 33 Acres with 3 test pads, support laboratories & propellant storage
- DCMA approved site plan for explosive operations
- DoD 4145.26-M compliant
- BATF approved
- 24/7 security & enclosed by FAA fence & RFI badge access

Facility for Operations and Research for Game-Changing Experimentation (FORGE)



**EXQUADRUM**  
Innovation's Prime Contractor™

13409 Forge Street

Normal Operating Hours: 760.246.0279  
Facility Security: 760.530.7960 (After Hours)  
Facility Safety: 760.530.7959 (After Hours)  
In Case of Emergency CALL 911

**33± Acres**

**Wastewater Reclamation Facility**

**Primary Runway**

**Airplane Storage & Boneyard**



Google

Imagery ©2019 Google, Map data ©2019 Google, United States, Terms, Send feedback, 500 ft L



EXQUADRUM

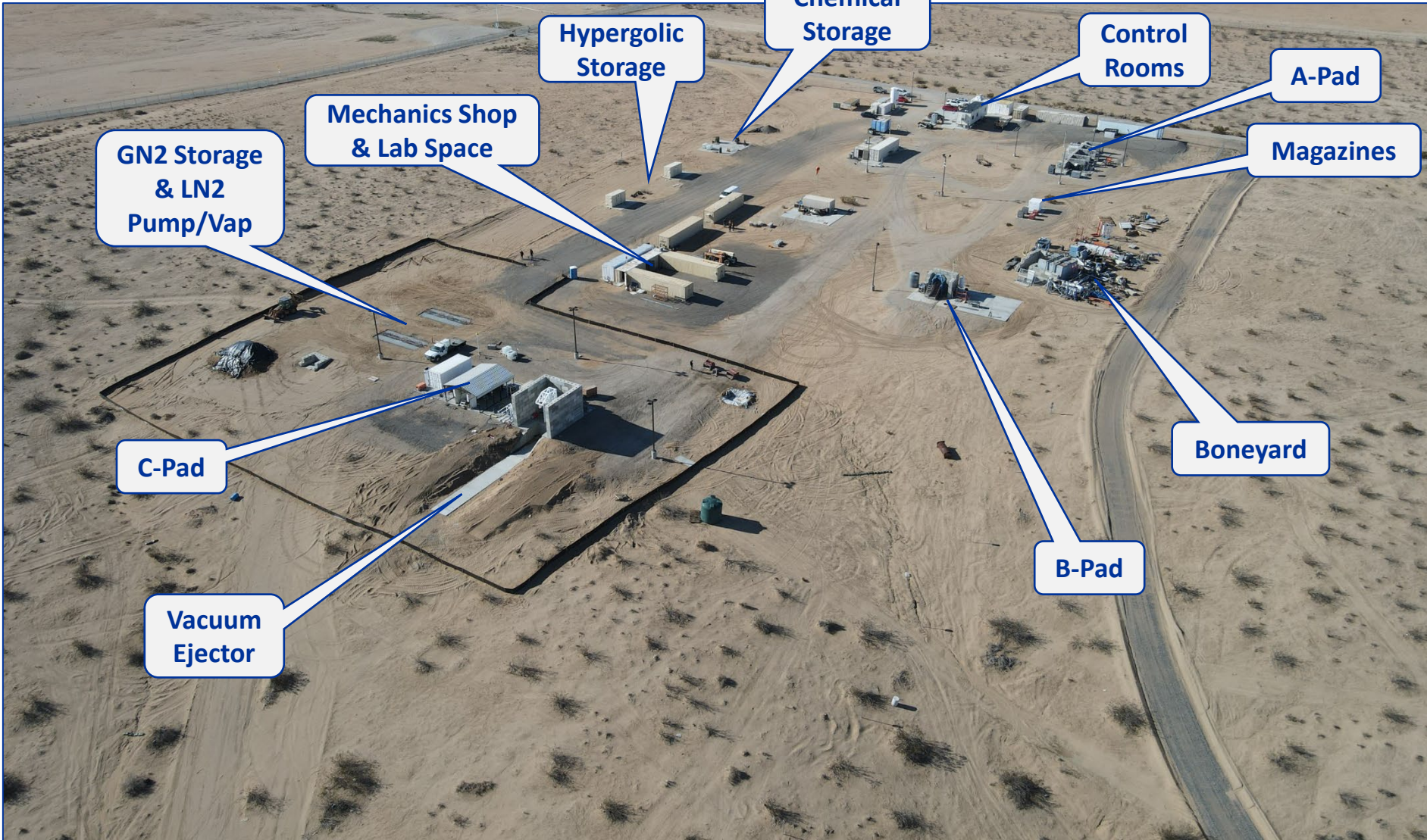
# FORGE Aerial (Facing Northeast)





EXQUADRUM

# FORGE Aerial (Facing Southwest)





# Control Room Data Acquisition & Capabilities

- National Instruments hardware
- LabVIEW-based test operations
- Remote control of hazardous ops
- IRIG-B (GPS Sync)
- Fire control (Red crew lock-out)
- E-Stop fail-safe control
- UPS to ensure safe shutdown

- Video & Photo
  - PTZ facility cameras (5)
  - Hi-speed (100k frames/sec)
  - FLIR
  - 4k/8k video & photo

Highly Reconfigurable & Rapidly Deployable





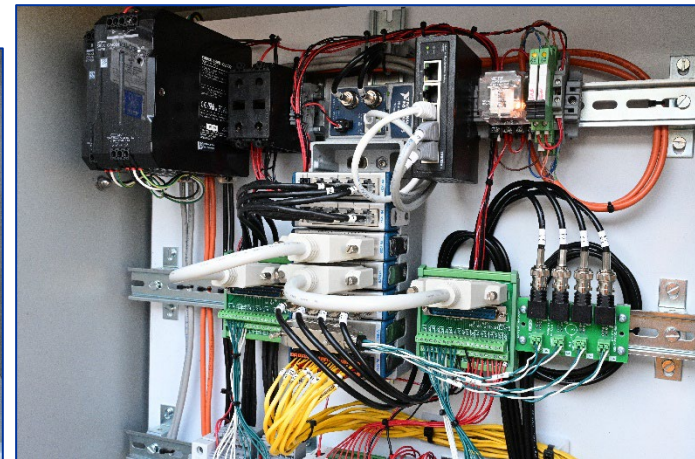
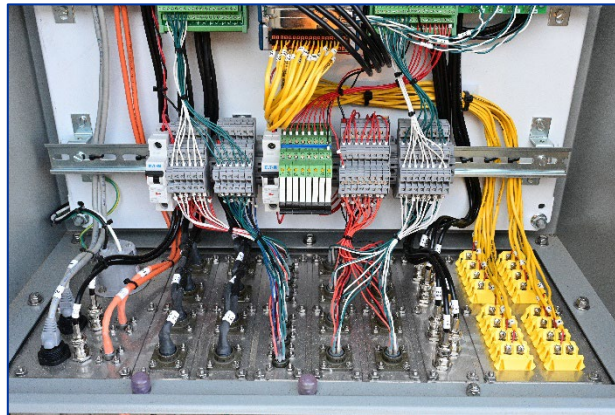
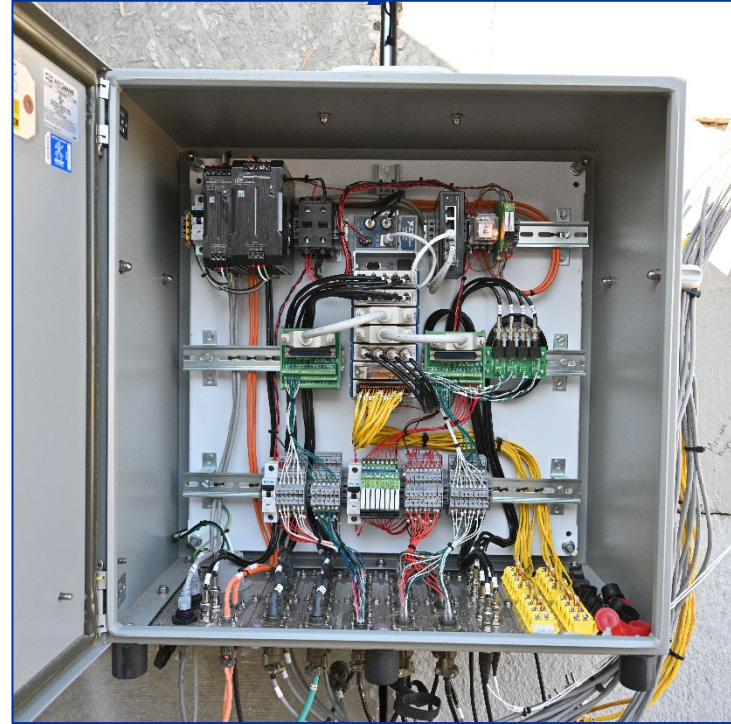


ΣXQUADRUM

# Test Cell Data Acquisition Systems

- National Instruments based hardware
- FPGA test cell DACs
  - CompactDAQ & CompactRIO Based
  - Real-time OS
- Fiberoptic network back to Control Rooms
- Multi-Chassis time synchronization
- Maximum Channel Capability
  - High-Speed: 128
  - Bridge Completion Analog: 40
  - Temp: 128
  - RTD: 32
  - Digital I/O: 192
  - Analog I/O: 192
- Sample Rates
  - Up to 500k hz

**Highly Reconfigurable &  
Scalable**

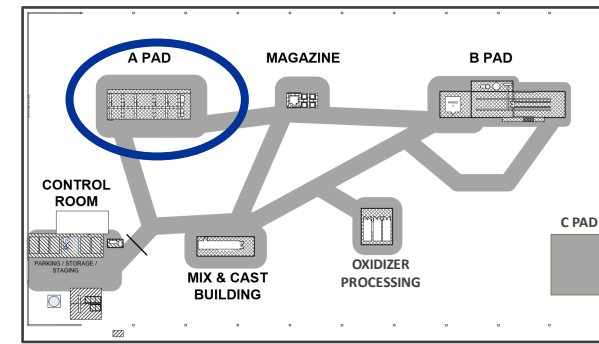




# A Pad – Prototype & Component Testing

## Component Level/Prototype Testing

- Five Modular Component Level Test Cells
- 1,500 lbf thrust
- 1,500 lbm 1.3C



Modular “LEGO” style eco-blocks are reconfigured to customize test cells on a per program basis



Test Cell View

Each test cell is supported by feed & pressure systems routed through the modular eco-blocks



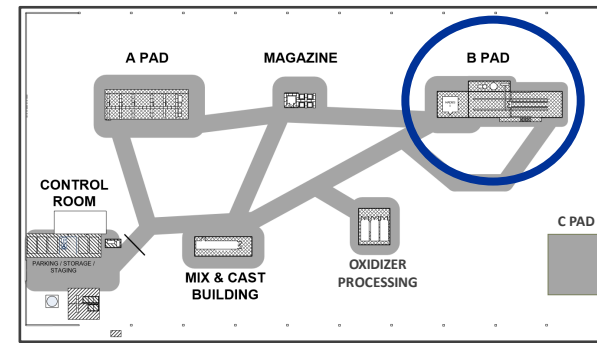
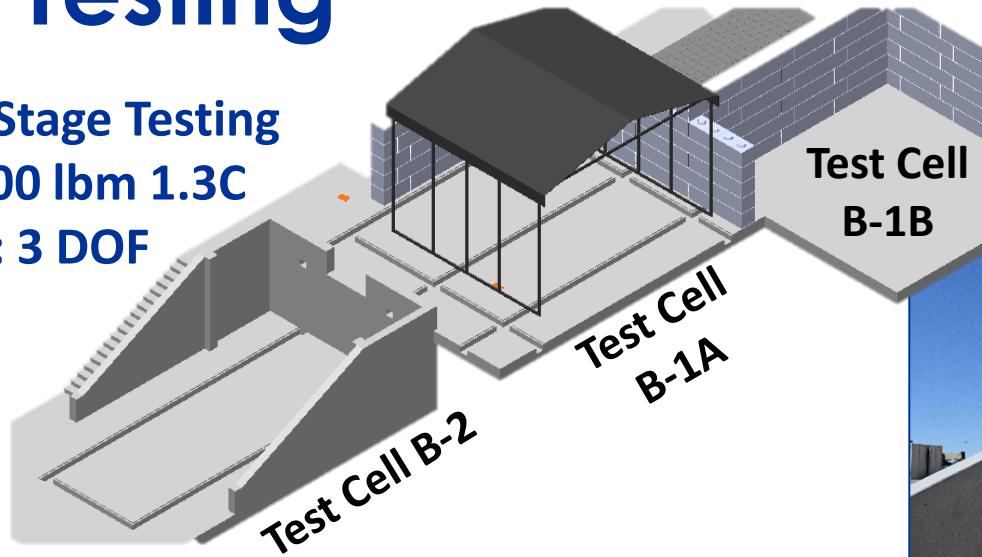
Back of Test Cell View



# B Pad – Large Rocket Testing

## Engine/Stage Testing

- 10,000 lbm 1.3C
- TMS: 3 DOF



## Recent & Future Programs

- Flight system tubing water/hypergolic hammer effects
- Lunar lander hypergolic propulsion module check-out
- Hypergolic main engine combustion verification
- Tactical SRM V&V

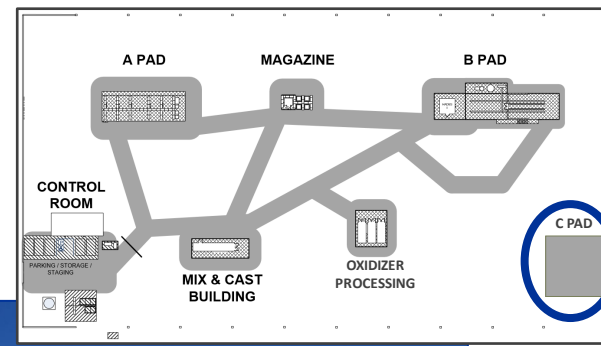
**Test Cell B-2 Capability**

- 50k lbf thrust (horizontal)
- 25k lbf thrust (vertical)



# C Pad – Hypergolic Testing

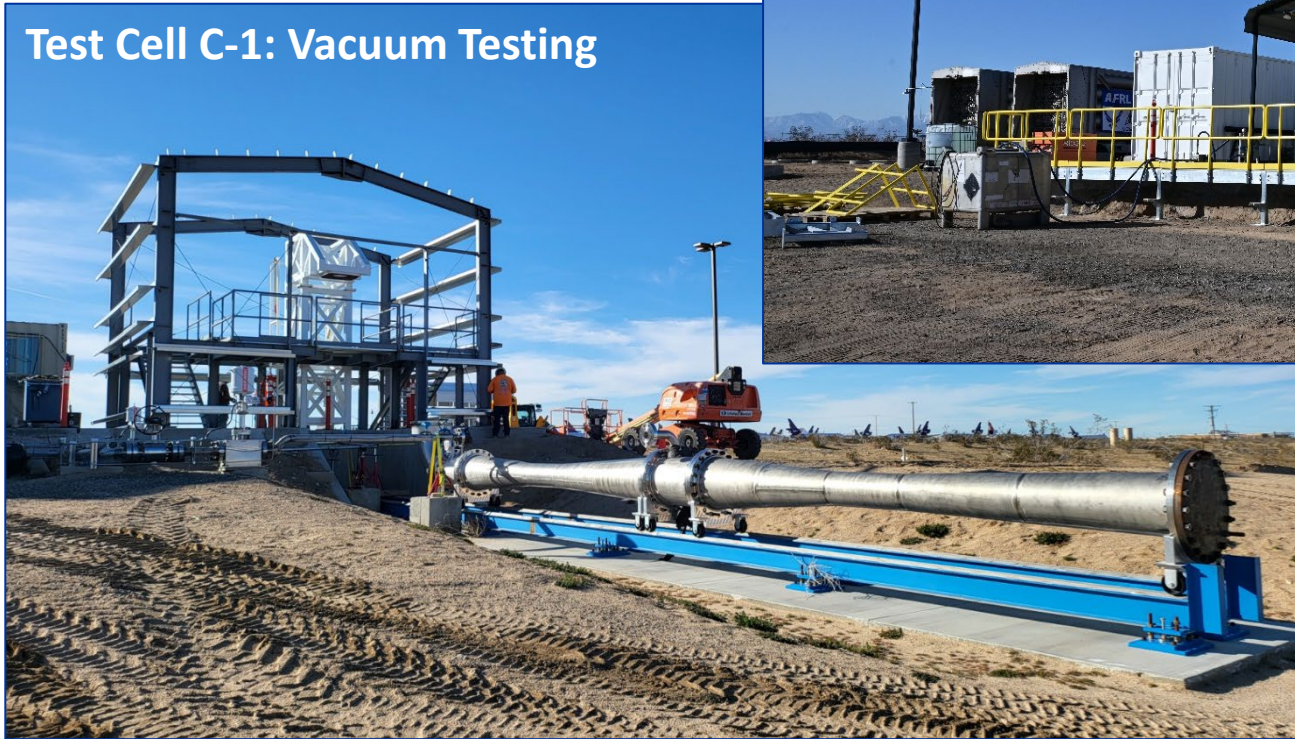
- Experienced personnel
- Fully permitted & approved
- SCAPE capable
- Storage for fuels & oxidizers
- 1000's of test firings



Test Cell C-2: Atmospheric Testing



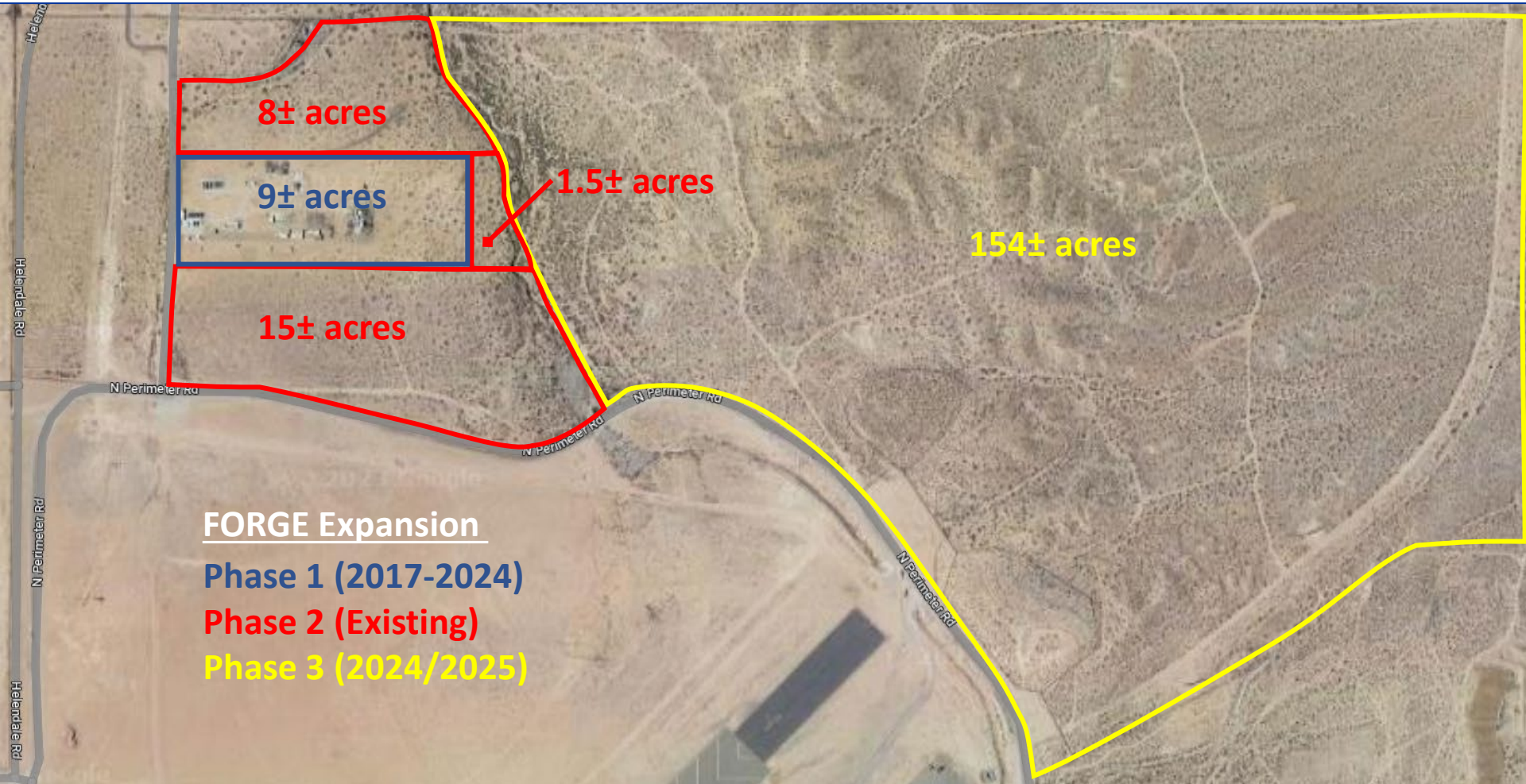
Test Cell C-1: Vacuum Testing



## Vacuum Test Capabilities

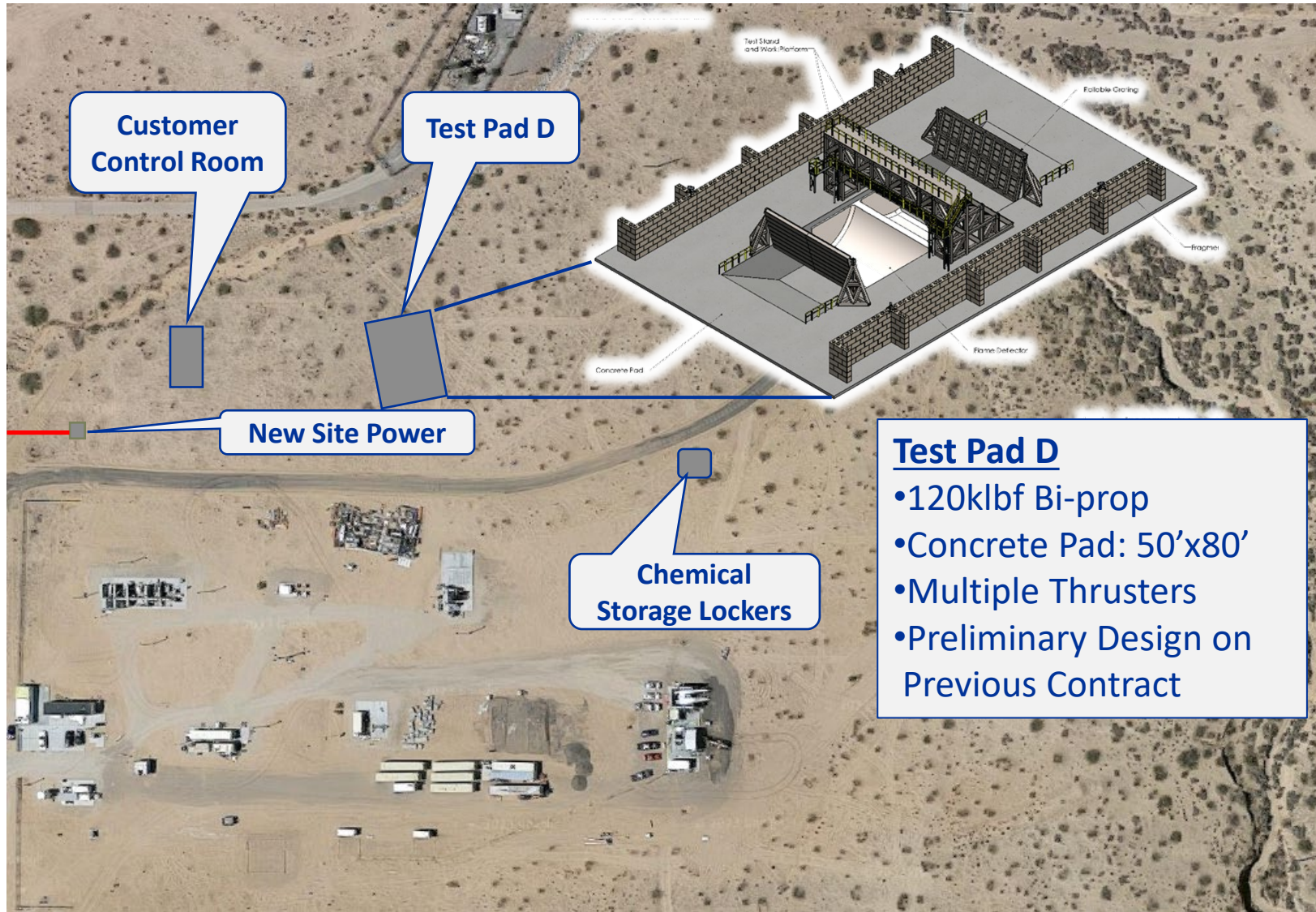
- 10 min test
- 0.1 psi
- 1,000 lbf bi-prop engine
- GN2 motive gas

# The Future of FORGE - Three Phase Master Plan





# Proposed Northern Expansion (Phase 2)

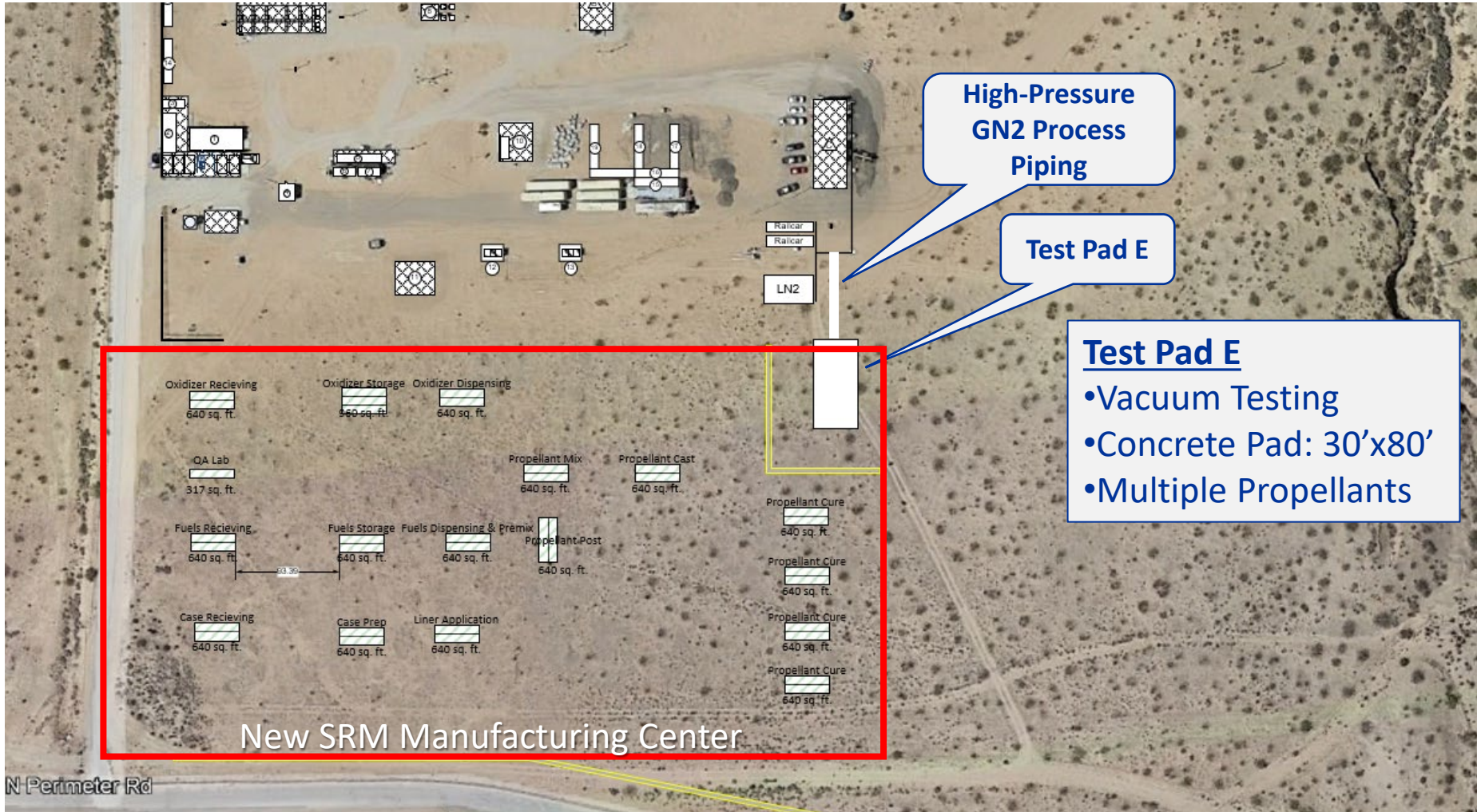


**Test Pad D**

- 120klbf Bi-prop
- Concrete Pad: 50'x80'
- Multiple Thrusters
- Preliminary Design on Previous Contract



# Proposed Southern Expansion (Phase 2)





# Conclusions – Wrap Up

- Exquadrum has been testing rockets and energetic systems for over 20 years.
  - Founders have been designing, building, and testing rockets for cumulative 60+ years.
- Exquadrum is able to test solid rocket motors, cryogenics, and hypergolics.
- Exquadrum's vacuum systems continue to evolve for space-based rocket applications.
- Exquadrum plans to be the **largest independent hypergolic test facility** in the world.





**Eric E. Schmidt**  
**President & Cofounder**  
**Exquadrum, Inc.**

[eric.schmidt@exquadrum.com](mailto:eric.schmidt@exquadrum.com)  
**(760) 530-7922**



**EXQUADRUM**  
Innovation's Prime Contractor

**David Morrison**  
**Director, Test & Evaluation**  
**Exquadrum, Inc.**

**david.morrison@exquadrum.com**  
**(760) 530-7956**