Regional Capacity and Talent Development
Aerospace & Defense | Advanced Manufacturing

Ahsan Choudhuri, PhD
Associate Vice President for Strategic Initiatives
Aerospace and Defense Capabilities

Office of the Executive Vice President
Office of Strategic Initiatives

Aerospace and Defense
- NASA MIRO Center For Space Exploration and Technology Research
- Space Technologies
- Aeronautics and Aviation
- Energy Technologies
- Storefront

Advanced Manufacturing
- W. M. Keck Center for 3D Innovation
- Aerospace and Defense Manufacturing
- Energy Manufacturing
- Contracted Services
- Advanced Manufacturing Business Development

Applied Education
- Aerospace and Defense Technology Education
- Aviation Education
- UAS Pilot Certification
- Associate
- Pilot Training Program
- 2+2
- Additive Manufacturing Education
- Advanced Training Certification
- Associate Degrees
- Outreach & K-12 Programs

Special Programs
- Hypersonics and Artificial Intelligence
- Small Business Development Initiatives
- Contracted Services
- Advanced Manufacturing Business Development

Additive Manufacturing
- Advanced Manufacturing Business Development
- Outreach & K-12 Programs
NASA MIRO University Research Center

Center for Space Exploration & Technology Research
The University of Texas at El Paso
MIRO cSETR External Partners
cSETR Facilities
MIRO cSETR On-Campus Facilities

- Secured Facility
- Aerospace Education Lab
- Computational Lab
- cSETR Office Complex
- Spacecraft Design and Engineering Facility
- Goddard Facility
- Unmanned Aerial Vehicle Systems Laboratory
- Challenger-Columbia Facility
MIRO cSETR On-Campus Facilities

Research Capabilities

Goddard Research Facility

Combustion and Propulsion
- Bunker and Control Room
- Projectile Proof
  - 600ft2 Test Area
  - Camera Accessible
  - Remote Control Operation
  - Sea Level Operation
- High Speed Imaging
- Flame Studies Capability
- Emissions Analyzers
- Adaptable Exhaust System
- Planetary/Shaker/Roller Ball Mill

Challenger- Columbia Research Facility

Materials Processing and Characterization
- Multiple High Temperature Furnaces
- Nano-Indentation System
- Vacuum Ovens
- Composite fabrication
- Material Testing Systems
  - For tension, compression and flexural testing
    - Instron Corporation, Model 5866, with 10kN and 0.5kN load cells
  - For static and dynamic testing including durability, fatigue crack growth, high and low cycle fatigue, fracture toughness, tension, compression
    - MTS Systems Corporation, Model 370 servohydraulic system, with 100kN load cell
  - For static and dynamic testing including durability, fatigue crack growth, high and low cycle fatigue, fracture toughness, tension, compression
    - MTS Corporation, Model 370.02 Axial-torsional servohydraulic system, with 25kN load cell, 200N-m torque rating
MIRO cSETR On-Campus Facilities

Research Capabilities

Spacecraft Design and Engineering Facility

Environmental Testing Equipment
- Vibration testing up to Max. 11G, 40 lb. load testing Random, Sine force, & Shock
- Vacuum chamber at 1.4 10^-6 torr & 5 thermocouples (K-type)

Electronics
- Cadence OrCAD Allegro Schematic/PCB Layout Software Suite
- SMTMax QM1500 Pick and Place Machine
- SMTMax AE-F600C ReFlow Oven
- NI USRP Software Defined Radio Device packages: ethernet enabled, real-time software controlled
- Schematic Capture, SPICE, and PCB Design Software
- Laser microwelder (Miyachi LW5AG)

Student Collaborative Area

Unmanned Aerial Vehicle Systems Laboratory

- Unmanned Traffic Management (UTM) systems
- (28) Autonomous Long Range/Long Endurance aircrafts, both fixed and rotary wing
- Autonomous SLAM aircraft able to navigate in confined GPS-denied environments
- Advanced Sensors and applications, to include: EO, Multispectral, IR, UV
- Advanced post-processing capability to produce a range of research-grade data products
- UAV Ground and flight academics
### MIRO cSETR On-Campus Facilities

#### Research Capabilities

**Computational Laboratory**

**Computational Work**
- (12) Desktops
- Securely controlled servers and storage array
- Software available:
  - Abacus
  - ANSYS Workbench
  - Fluent
  - Matlab
  - Mathematica
  - HyperWorks
  - ASPEN One
  - CAD (NX 10, Solidworks, CREO)

**cSETR Office Complex**

**Student Office Space**
- Seats 30 students
- (4) White boards
- (2) Mobile white boards
- (2) Conference Rooms
- Seats 6 people each
- General office supplies
  - Rulers, staplers, dry-erase markers, etc.
- Kitchen area with appliances
  - Refrigerator
  - Coffee machine
  - Oven
  - Microwave
MIRO cSETR On-Campus Facilities
Research Capabilities

Secure Research Facility | Under Construction

- High Security Area (ICD 705) | ~4,000 sf
  - 5 separate program spaces* | ~430 sf each
  - Data Center/Server Room* | ~170 sf
  - Admin Room* | ~170 sf
  - Training/Conference Room* | ~450 sf
  - Vestibule/security desk
    - In addition to the security perimeter (pink), each space is built to accommodate a separate program IAW ICD 705 standards. Each space is linked to the data center by secure conduit.
- 8 Collateral work spaces | 200 sf each
- FSO & security admin spaces | ~800 sf
Facilities Available to NASA MIRO cSETR

Design Studio I: 3-D Printing

- 3-D Printing machines
  - MakerBot Replicators, uPrint
- Assembly area

Design Studio II: Machine Shop

- **Studio Area**
  - Design Stations with 38” displays
    - NX 7.5, Solidworks, Pro-E and CATIA
  - Project Presentation Facility
  - Team Meeting Room
  - FMD 3D Printer
  - HP DesignJet Plotter
  - Bench-top Workstations

- **Machine Shop Area**
  - CNC: Mill & Lathe
  - Conventional: Mill & Lathe
  - Tig & Mig Welder
  - Vertical / Horizontal saw
  - Grinding Stations
**MIRO cSETR Off-Campus Facilities**

**tRIAc - Alpha Site**
- Research & Development
- Control Center
- Test Cells
- Vertical Test Stand

**Fabens, TX**

**Tornillo Unmanned Aerial System Flight Test Range**
- 20-25 acres facility + Flight Test Range (600 acres)
- 400-ft Runway
- Test Support Facility (planned)

**Fabens, TX**

**tRIAc - HQ Site**
- Design studio & Manufacturing Workshop
- Fabrication and Integration Shop
- Collaboration Common: Graduate, Undergraduate, & K-12

**Fabens, TX**

**Fabens General Aviation Airport**
- Partner Facility
- Managed by El Paso County
- 4,200 ft. & 2,300 ft. Runways
- 400 acres

**Fabens, TX**

**Tornillo Unmanned Aerial System Flight Test Range**
- 20-25 acres facility + Flight Test Range (600 acres)
- 400-ft Runway
- Test Support Facility (planned)

**Fabens, TX**

**tRIAc - Aeronautics Research and Learning Facility (Planned)**
- Flight Wind-Tunnel Research and Education Complex
- Subsonic Wind Tunnel
- Water Tunnel Supersonic Tunnel

**Fabens, TX**

**Francis Facility**
- Instructional & Training Facility
- Satellite Ground Station (underdevelopment)
- 2.4 m S-band antenna | 436 MHz UHF antenna

**El Paso, TX**

**Horizon City Aerospace and Defense Accelerator**
- Partner Facility
- Horizon City Economic Development Corporation
- Small Business Incubator

**Horizon, TX**

**TMD Defense and Space**
- Partner Facility
- Administrative Area & 21,000 sf warehouse, Hazardous Material Assembly Area with (10) Missile Assembly Cells & (7) Storage Magazines & Firefighting Support Building

**Horizon, TX**
MIRO cSETR
Off-Campus Facilities
Technology Research & Innovation Acceleration Park
(tRIAc Park)

Fabens, Texas
tRIAc Park
Alpha Site

- Phase A - Complete
  - Access Road
  - Electrical Services
  - 3 Test Cells
- Phase B
  - Access Road
  - Electrical Services
  - 2 Test Cells
  - Vertical Test Stand
- Phase C
  - Access Road
  - 2 Test Cells
  - Vertical Test Stand
- Phase D
  - Aeronautics Research and Learning Facility
tRIAc Park
Alpha Site

• Testing Facility
  • Size:
    • Phase 1: 3 Acres
    • Total: 18 acres
  • Test Cell Maximum Static Load
    • 13,000 lbs.
• Electrical
  • Site: 480V/3phase
  • Test Cell: 220V/3phase
tRIAc Park
HQ Site

- Manufacturing and Integration Facility
- Size
  - Indoor: 10,800 ft\(^2\)
  - Total: 3.92 acres
- Electrical Service
  - 200 AMP/240V

Courtesy of JR Hernandez

Courtesy of JR Hernandez

Courtesy of JR Hernandez
Tornillo Unmanned Aerial System Flight Test Range

- Facility Designated for Unmanned Aerial System Flight Testing
- Location: Tornillo, TX | 38 Miles from UTEP main campus
- Size:
  - 20-25 acres facility
  - Flight Test Range (600 acres)

Phase A - Dirt work and Signage
- Rock in access road
- Level Site Bravo area
- Establish entry sign at current gate entrance
- 300’ x 20’ Runway
- Storage facility
- Gravel parking lot

Phase B - Facilities & Paved Access
- Pave 500’ x 20’ Runway
- Facility Offices
- Paved Roads

Site Bravo: Top View
Francis Facility

- Instructional & Training Facility
  - Size: 9,000 sf
  - 20 parking spaces
- Satellite Ground Station (underdevelopment)
  - 2.4 m S-band antenna | 436 MHz UHF antenna
Partner Facilities

**Fabens General Aviation Airport**
- Managed by the County of El Paso
- 4,200 ft. & 2,300 ft. Runways
- 400 acres

**Horizon City Economic Development Accelerator**
- Capabilities
  - 2400 ft² of Space
  - 3 Cubicles for small businesses
  - Soon to be expanded to 6 Cubicles
  - Conference Area
- Subsidized office space for small business growth.
Partner Facility

**TMD - Horizon Facility**

- **Capability**
  - Administrative Areas
    - Conference Room
    - Kitchen / Break Room
  - Warehouse
    - 21,000 sf
    - 20ft clear ceiling height
  - Hazardous Material Assembly
    - (10) Missile Assembly Cells
    - (2) Loading bays with Drive-in Doors
  - Munitions Storage Magazine
    - (7) Storage magazines (1,650 sf each)
  - Firefighting Support Building
    - 250,000 gall water storage
    - 2,000 gal/minute pump capacity
  - Change Building
    - Dressing area, Lockers, & Showers
cSETR  Aerospace Technical Goals

A Giant Leap Forward
volt.utep.edu/cSETR
...a bold research agenda

- CSpLV, Centennial Small Payload Launch Vehicle
- HypTest, Hypersonic Test Vehicle
- Janus, Robotic Lunar Lander
- Orbital Factory, SmallSat On-Orbit Manufacturing
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<tr>
<th>LO$_2$/Methane</th>
<th>Torch Igniter</th>
<th>CROME 500 lb</th>
<th>CROME-X 2000-4000 lb</th>
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<td>Green Propellant</td>
<td>Propellant Fundamental Study</td>
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<td>NASA WSTF Cold Gas Module</td>
<td>Orbital Factory III</td>
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<td>Unmanned Traffic Management</td>
<td>UAS Research and Training</td>
<td>Beyond Visual Line of Sight Operation</td>
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W.M. Keck Center for 3D Innovation

Research Capabilities

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W.M. Keck Center for 3D Innovation

- Founded in 2000 - 13,000 sq ft facility with 50+ additive manufacturing (AM) machines
- Expanding to 17,000 sq ft facility in downtown El Paso (large area AM, training, economic)
- R&D projects with more than 100 industrial clients and 10 federal agencies
- Broad and expanding patent portfolio
- Students becoming leaders in AM industry – workforce development pipeline
- Economic development initiative – creation of regional AM-based businesses
- Selected as America Makes Satellite Center in 2015
Equipment/Capabilities Snapshot

- **30,000 sq ft on and off campus facilities** (AM and hybrid AM – polymers, metals, ceramics, electronics, composites; materials synthesis and characterization; metrology, microscopy and mechanical testing; cell culture; training; economic development)

- **Industrial AM Systems:** Cincinnati BAAM; Fortus 900, 400(s); SLA 500, Viper(s); ExOne M-Flex; Laser PBF (AconityOne, SLM 125, EOS M290); Electron Beam PBF (Arcam A2 and high temp S12)

- **Hybrid AM Systems:** Robotic handling; Tool exchange; BAAM; Desktop(s)

- **Experimental AM Systems:** ExOne X1-Lab; Zprinter 450(s); Multi-material SL; micro-SL; many desktops

- **Suite of Mechanical Testing and Polymers/Metals/Ceramics Characterization Instrumentation and Equipment**
Keck Center - Driving the Additive Manufacturing Revolution

Research and Technology Development
- Polymers, metals, ceramics, composites, electronics AM
- Hybrid AM, large area AM, automation, robotics
- Multi-functional applications

Industry and Government Partnerships
- AM, CAD, and testing service center
- Value added expert AM solution providers

Education, Training and Workforce Development
- Graduate 3D engineering and AM certificate program
- Point-of-need basic, expert, and custom AM training
- Workforce development pipeline program

Economic Development
- Creating technology spin-off companies
- Recruiting AM companies to El Paso
Enhancing Member Benefits through New America Makes Model

New Enhanced Benefits

- Fees/Cost Share for membership
- Certified testing
- OEM equipment and materials partnerships
- AM database
- Advanced workforce
- Economic development
Technical Research Areas

**In-situ monitoring and control**
- IR imaging, pyrometry
- Layerwise fabrication control
- Defect detection and correction
- Microstructure control and tailoring

**AM-enabled materials**
- Multiple material fabrication
- Polymers, metals, ceramics, composites, electronics
- Mechanical testing and materials characterization

**Hybrid manufacturing, stop-n-go manufacturing**
- 3D electronics
- Embedded sensors
- Reinforcement
- Design software
- Artificial intelligence
- Machine development
- Large area AM
- Robotics

**Ceramics and sensors**
- Piezoelectric materials
- High temperature materials
- Sensors
AM Metal Materials Expertise

Copper

Inconel 690

Stainless 316L

Ti48Al2Nb2Cr (γ-Ti)

Ti6Al4V

Inconel 718

Inconel 625

Ni-based Superalloy

CoCrMo

Niobium

1000°C  1330°C  1360°C  1415°C  1460°C  1630°C  2470°C
Multi³D Demonstrations

Robot Multi³D System Capabilities:
• Material extrusion (filament)
• Thermal wire embedding
• Foil embedding
• Direct-write
• Robotic component placement
• Machining
• Robot material handling

Tool Exchange Multi³D Capabilities:
• Filament Extrusion
• Pellet Extrusion
• Machining
• Wire Embedding
• Foil Application
• Pick-and-place
• Machine Vision

Eliminates labor-intensive fabrication

Electronic component integration

Machining and foil application for antenna fabrication

Wire embedding for axial motor stator fabrication

Wire Embedding Tool
Pick-and-Place Tool
Big Area Additive Manufacturing (BAAM)

- Material is typically reinforced with carbon or glass fibers to mitigate warping and distortion
- Single-screw extruder
- Platform is equipped with heating elements
- Build envelope: 3.5 x 1.6 x 1.8 m
  (140” x 65” x 72”)

<table>
<thead>
<tr>
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<th>medium thermoplastic material extrusion</th>
<th>large thermoplastic material extrusion</th>
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<tr>
<td><strong>build volume</strong></td>
<td>0.03 – 0.3 m³</td>
<td>25 m³</td>
</tr>
<tr>
<td><strong>deposition rates</strong></td>
<td>0.015 - 0.082 kg/h</td>
<td>up to 50 kg/h</td>
</tr>
<tr>
<td><strong>build material cost</strong></td>
<td>$100 – 200 per kg</td>
<td>$2 – 10 per kg</td>
</tr>
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UTEP’s Cincinnati BAAM machine
Functional Ceramic Printing

- Binder jetting focused, but also exploring material extrusion and vat photopolymerization
- Piezoelectric (PZT and BaTiO3) and high thermal conductivity (AlN) ceramics – current interest
- Increasing density and functionality using various process optimization and post processing techniques

![Directional Properties](image)

\[
C_{\text{total}} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}}
\]

![Dielectric Constant](image)
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