BSAE Program Overview

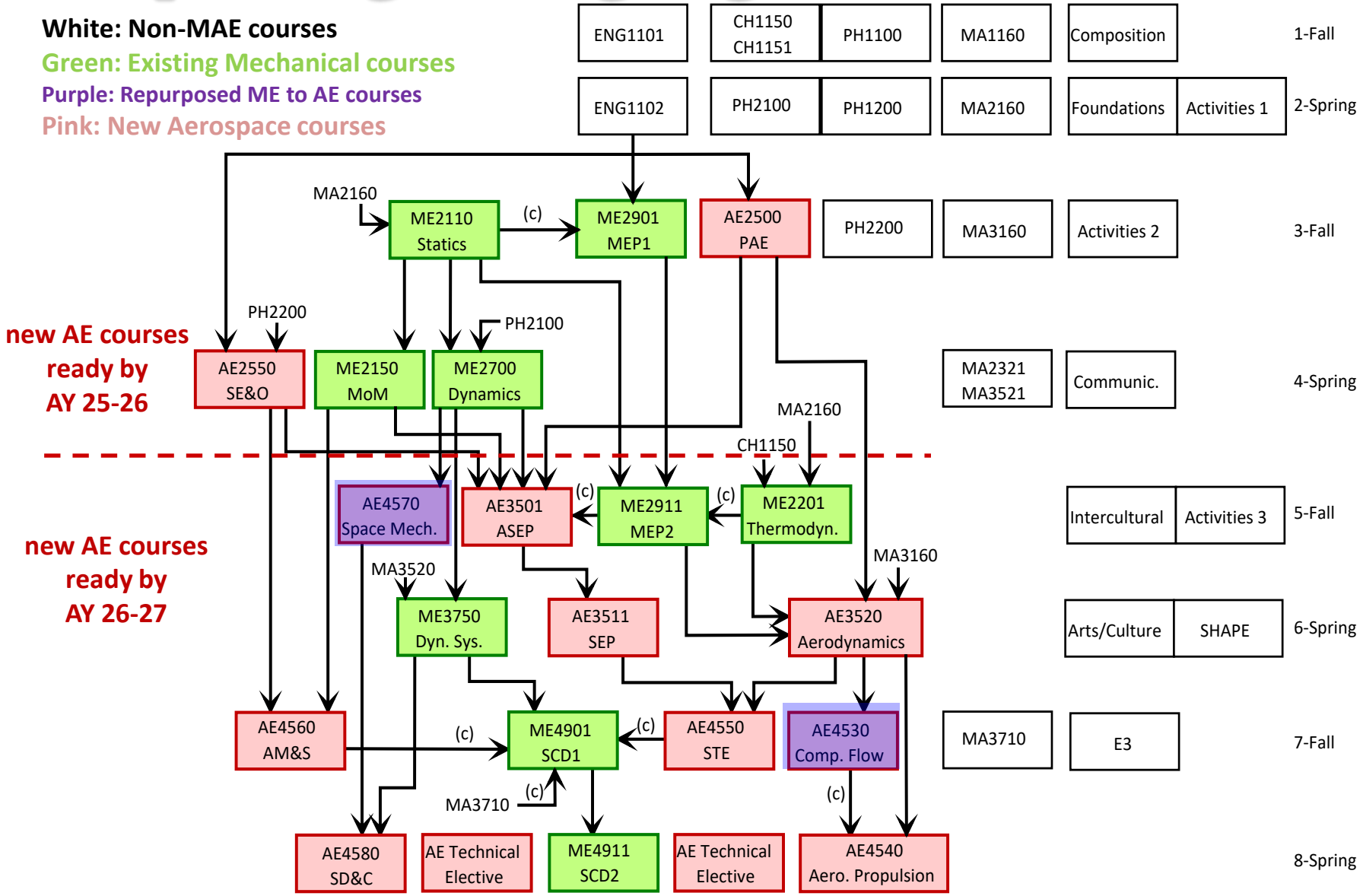
The Aerospace Engineering program (BSAE) requires 128 credits with 11 Aerospace Engineering courses, 9 Mechanical Engineering courses, and 2 Technical Electives.

The 11 Aerospace Engineering courses are:

Fall Semester
AE2500 Principles of Aerospace Engineering (PAE) – 3 cr
AE3501 Aerospace Systems Eng. Practice (ASEP) – 3 cr
AE4570 (AE3570) Space Mechanics – 3 cr
AE4530 Compressible Flow – 3 cr
AE4550 Spacecraft Thermal Engineering (STE) – 3 cr
AE4560 Aerospace Materials & Structures (AM&S) – 3 cr

Spring Semester
AE2550 Space Environment & Operations (SE&O) – 3 cr
AE3511 Spacecraft Engineering Practice (SEP) – 3 cr
AE3520 Aerodynamics – 3 cr
AE4540 Aerospace Propulsion – 4 cr
AE4580 Spacecraft Dynamics & Controls (SD&C) – 3 cr

Aerospace Engineering Degree (BSAE)



Double Major (BSME + BSAE)

An ME + AE double-major **can only require 17 credits above the 128 required for either the ME or AE degree.**

Best Case

- **ME Senior Design Primary with AE 2500 as 3 cr ME free elective and AE 4530/4540/4550/4560/4580 as ME technical electives (16 cr for 15 cr requirement).**
- **AE technical electives are ME3400 and ME3911 (6 for 6 cr).**
- **Extra credits then are**
  - **AE2550-3**
  - **AE3501-3**
  - **AE3511-3**
  - **AE3520-4**
  - **AE4570 (3570)-3**

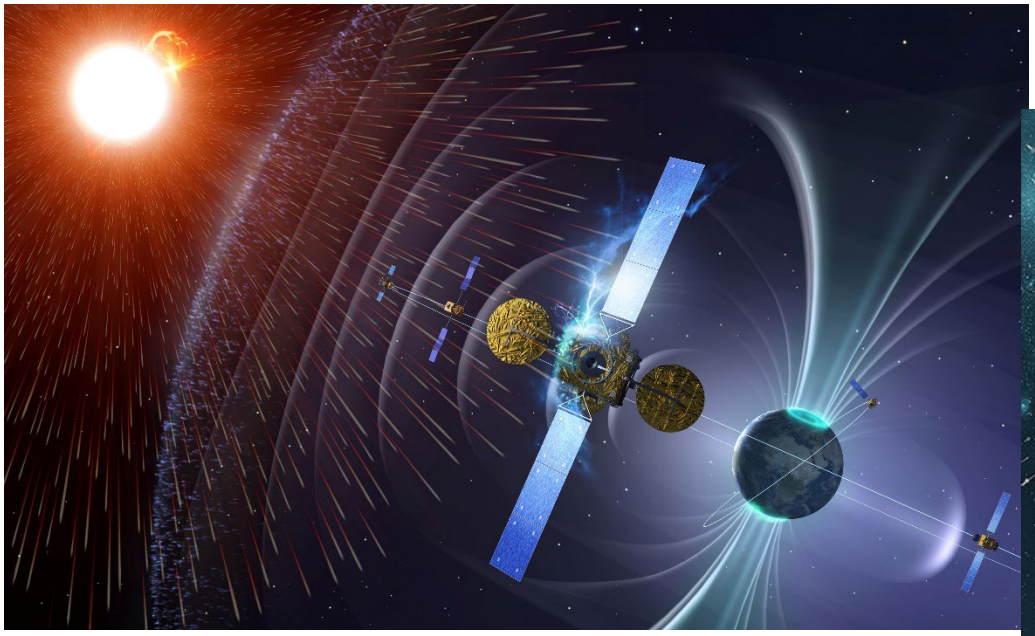
16 cr of AE courses that are only for the BSAE degree plus an extra tech elective credit for 17 total.

AE2500 *Principles of Aerospace Engineering*

- **Introductory course covering the *Principals of Aerospace Engineering***
- **Topics include:**
  - ✓ *Principles of Flight*
  - ✓ *Rocketry and Propulsion*
  - ✓ *Space Mechanics*
  - ✓ *Aerospace Materials*
  - ✓ *Introduction to Jet Engines*
  - ✓ *Basics of Space Environment*
  - ✓ *Thermal Management in Space*

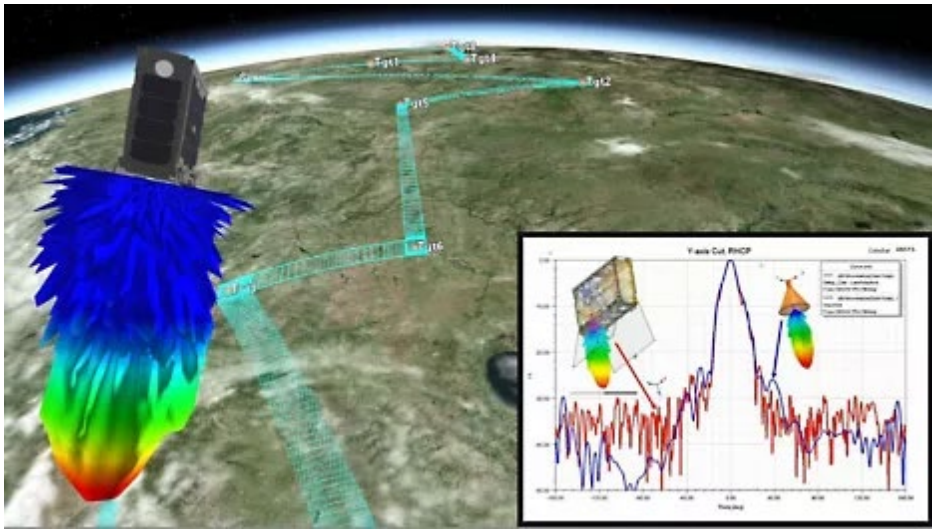
AE2550 Space Environment and Operations

- ✓ *Planetary and Space Environments*
  - ✓ *Electromagnetic fields, radiation, extreme temperatures*
- ✓ *Operational Aspects of Space Missions*
  - ✓ *Basic design*
  - ✓ *Mission phases and total lifecycle*



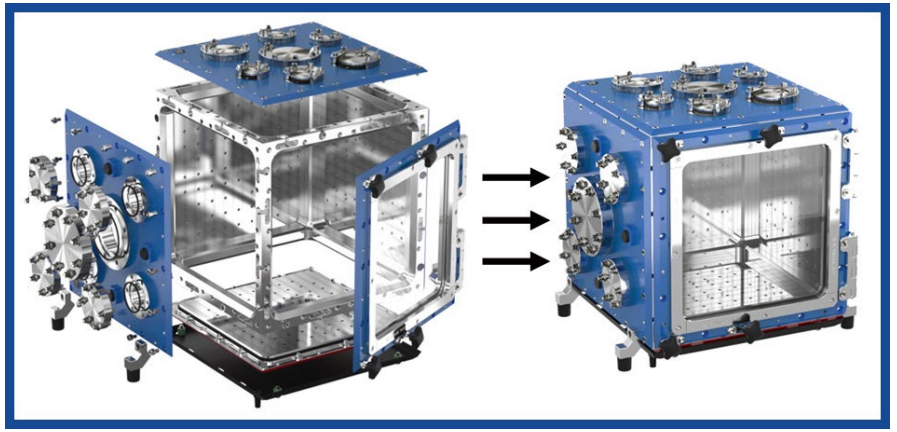
AE3501 Aerospace Systems Engineering Practice (ASEP)

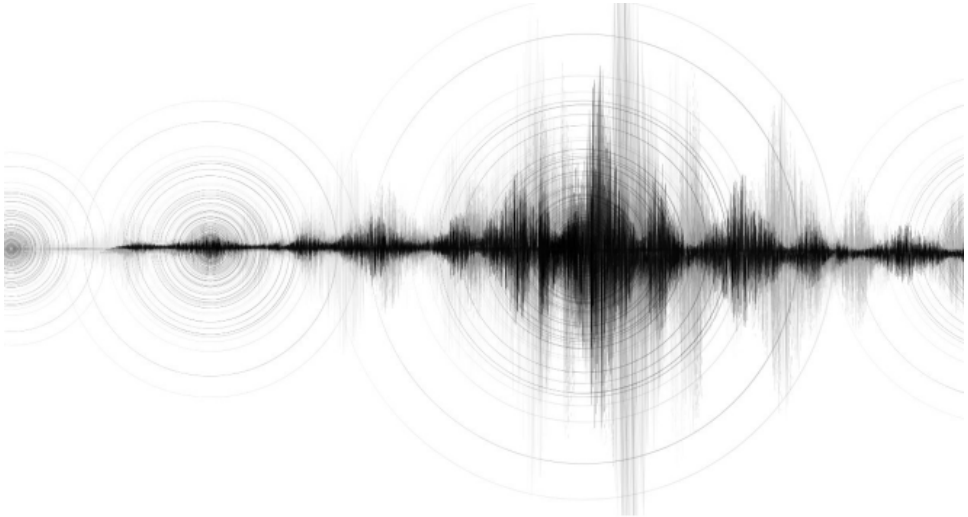
- **Topics include**:
  - ✓ Definition of Scope and Requirements
  - ✓ Requirement Flow-Down
  - ✓ Validation and Verification Methods
  - ✓ Concept of Operations
  - ✓ Failure Mode and Effects Analysis
  - ✓ Risk Mapping
  - ✓ Interface Control Definitions
  - ✓ Design Reviews, Project Phases and Life Cycle
  - ✓ Documentation, Traceability and Application of Standards



AE3511 *Spacecraft Engineering Practice (SEP)*

- **Second half of the Systems Engineering sequence**
- **Students will be guided through the standard testing practice for flight qualifying space hardware**
- **Topics include**:
  - ✓ Interface Control Specifications
  - ✓ Component-level mechanical, thermal, and electrical requirements for system/mission specifications
  - ✓ Test-Like-You-Fly processes (space industry standards)
  - ✓ Vibration testing verification
  - ✓ Shock testing verification
  - ✓ Thermal testing verification



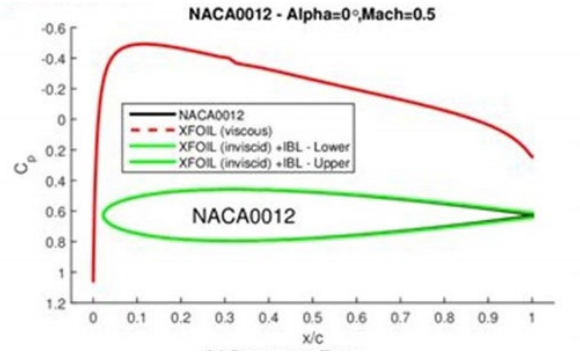


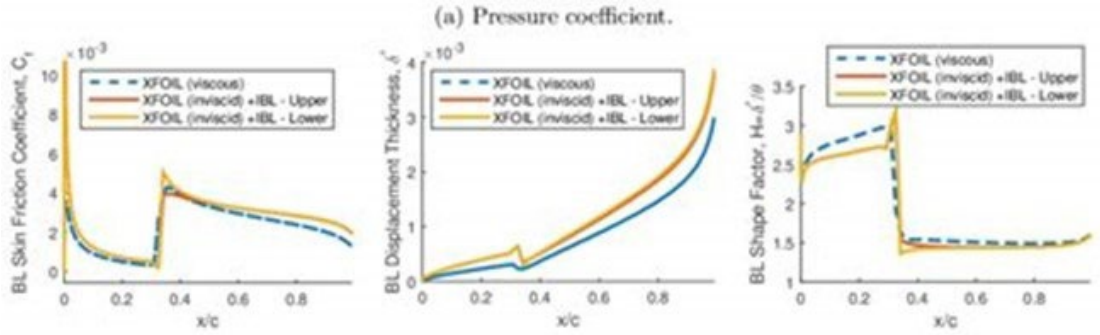
AE3520 Aerodynamics

- **4-credit course that includes a wind tunnel testing lab**
- **Topics include**:
  - ✓ Fluid dynamics of gases
  - ✓ Convective heat transfer from external flow
  - ✓ Potential flow
  - ✓ Boundary layers
  - ✓ Aircraft dynamics, stability, and control
  - ✓ Testing and simulation of airfoils
  - ✓ Instrumentation, sensors, and DAQ
  - ✓ Flow visualization techniques

CAPABILITIES:

- 12” x 12” test section
- 100 m/s air velocity
- Temperature controlled

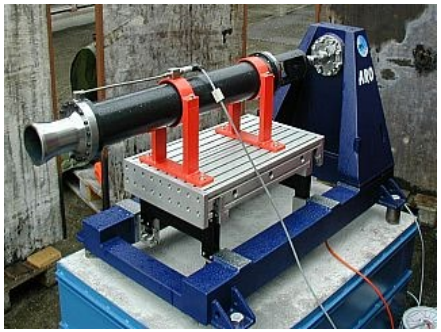




AE4540 Aerospace Propulsion (Jet Engine & Rocket Labs)

- **4-credit course that includes three propulsion facilities**:
  - ✓ Jet Engine Testing Lab
  - ✓ Rocket Testing Lab
  - ✓ Electrified Aircraft Lab

- **Topics include:**
  - ✓ Principles of jet engine propulsion
  - ✓ Principles of rocket propulsion
  - ✓ Brayton & rocket cycle analysis
  - ✓ Propellants
  - ✓ Turbomachinery
  - ✓ Compressor performance mapping
  - ✓ Nozzle design and performance
  - ✓ Electric propulsion (aircraft & drones)
  - ✓ Battery performance in aircraft
  - ✓ Propeller performance
  - ✓ Propulsion simulation

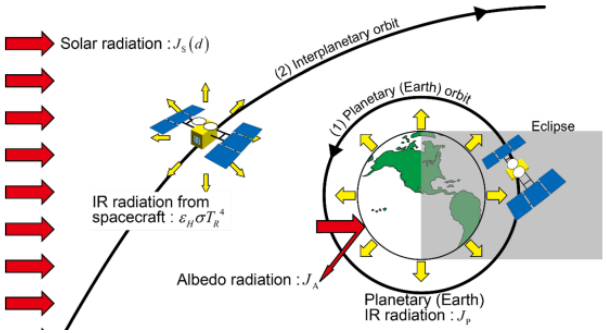


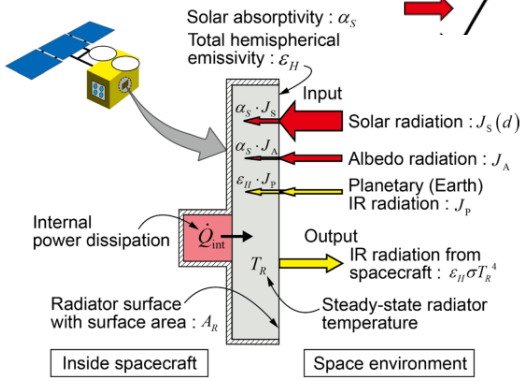
Capabilities:

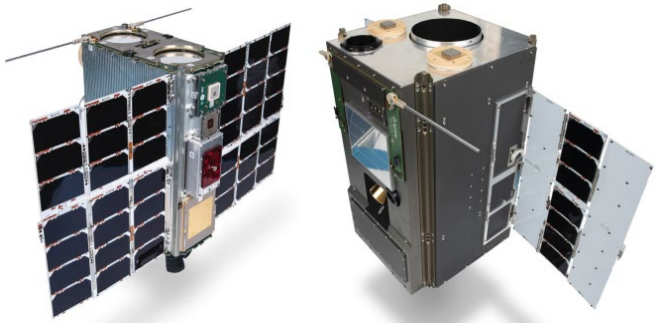
- 40 lbf thrust jet engine test stand (2 units)
- Rocket test stands – Size TBD
- Electric-driven propeller testing

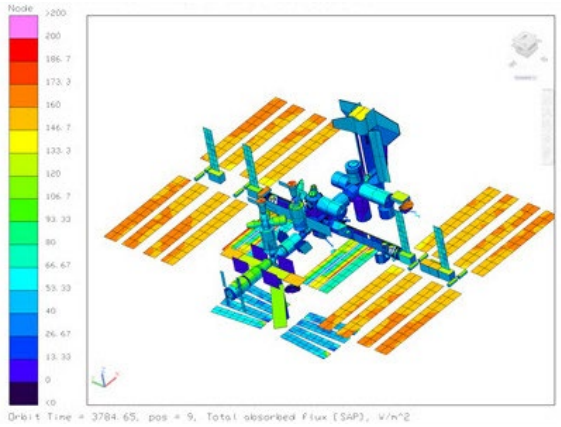
AE4550 Spacecraft Thermal Engineering (STE)

- **Will teach fundamentals of conduction and radiation heat transfer through thermal management of a satellite**
- **Topics include:**
  - ✓ Heat transfer fundamentals
    - 1D and 2D steady and transient heat conduction
    - Single and multiple surface radiation
    - Internal heat generation
  - ✓ Earth IR and albedo heat loads
  - ✓ Space radiation
  - ✓ Passive thermal control
    - Thermal straps,
    - Fasteners
    - Coatings, tapes, and gaskets
    - MLI
    - Thermal switches
    - Phase change materials
    - Heat pipes
    - radiators
  - ✓ Active thermal control
    - Heaters and thermoelectric elements
    - Louvers
    - Fluid loops
  - ✓ Simulation using Thermal Desktop (industry standard)
  - ✓ Thermal FEA



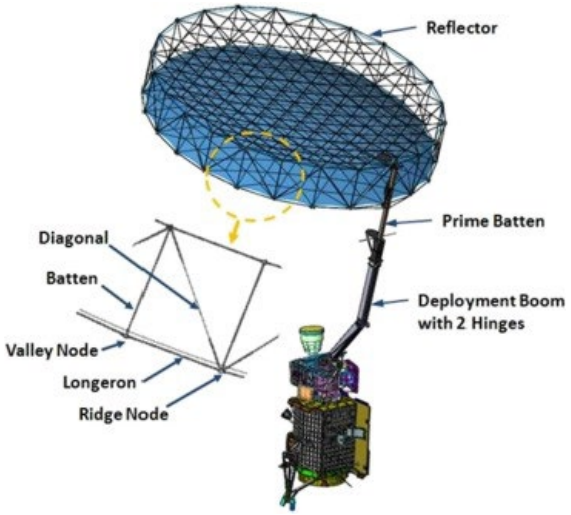


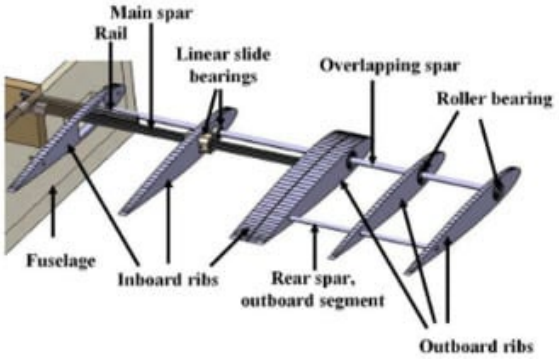


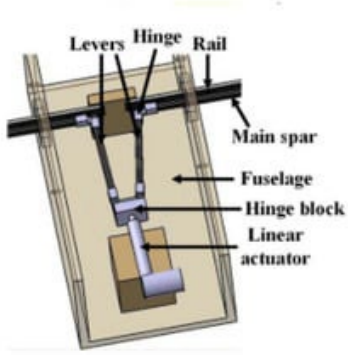


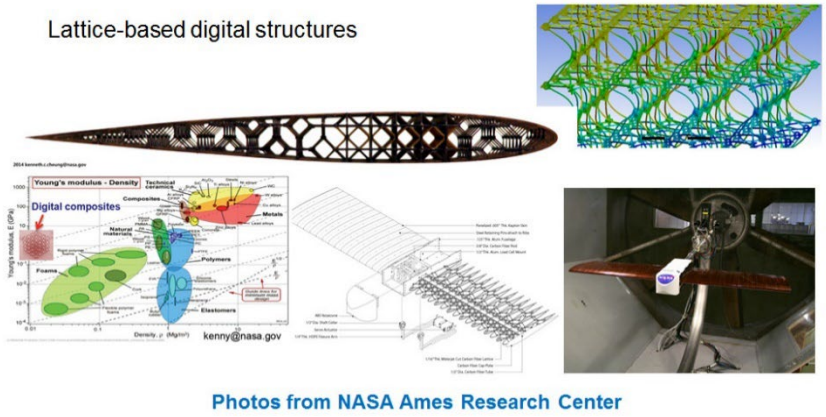
AE4560 Aerospace Materials & Structures (AM&S)

- **Aeronautical and Space Platforms**
- **Topics include:**
  - ✓ The Fundamentals of Lightweight Alloys
  - ✓ High-Performance Super Alloys
  - ✓ High and Low Temperature Materials
  - ✓ Ablative Materials
  - ✓ Fiber-Reinforced Composites
    - Including structure-property relationships
  - ✓ Structural Behavior of Thin-Walled Aerospace Structures
    - Including torsion, warping, bending, and buckling
  - ✓ Adaptive Structures





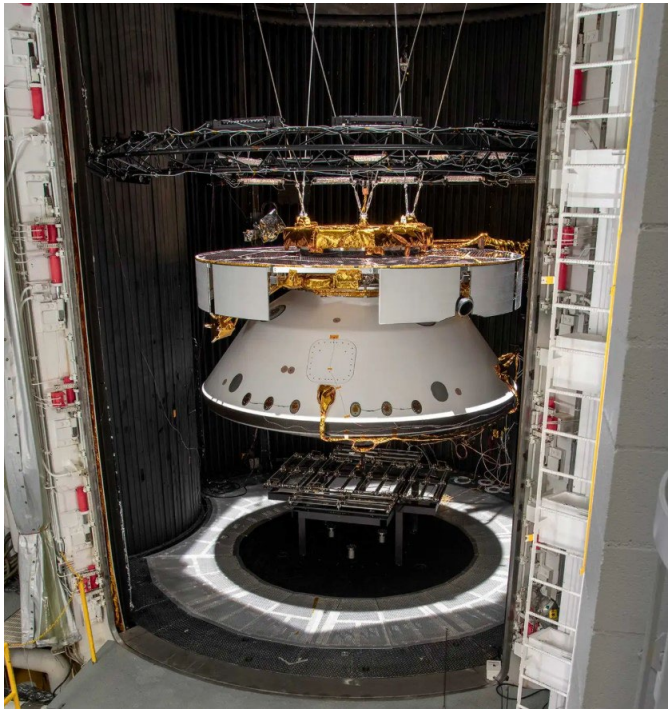




Photos from NASA Ames Research Center

AE4580 Spacecraft Dynamics & Control (SD&C)

- **Topics include:**
  - ✓ Spacecraft Kinematics
  - ✓ Dynamics
  - ✓ Stability
  - ✓ Control
    - Including actuation and sensing techniques
  - ✓ Simulation-based analysis
  - ✓ Eventual plan to offer a choice for Aircraft Dynamics & Control



BSAE Program Rollout – 2nd Year Courses

Course Title	Cr	Description
AE2500 Principles of Aerospace Engineering (PAE) – FIRST OFFERING FALL 2025	3	Introductory course covering the principals of aerospace engineering. Topics include principles of flight, rocketry and propulsion, space mechanics, aerospace materials, introduction to jet engines, basics of space environment and thermal management in space.
AE2550 Space Environment & Operation (SE&P) – FIRST OFFERING SPRING 2026	3	Introductory course on space environment and operations. Topics include, planetary and space environments, space mission operational aspects and consideration of space and planetary environment. Basics of spacecraft functionality and design considerations will be discussed in the various operational environments from launch, to cruise, to arrival, to operation and end of life.

BSAE Program Rollout – 3rd Year Courses

Course Title	cr	Description
AE3501 Aerospace Systems Engineering Practice (ASEP) – FIRST OFFERING FALL 2026	4	This course will introduce Aerospace System Engineering. A project will guide students through the practice of applied system engineering. Topics covered include definition of scope, requirements, requirement flow-down, validation and verification methods, concept of operations, failure mode and effects analysis, risk mapping, interface control definitions, design reviews, project phases and life cycle, documentation, traceability and application of standards. Students create simulations and validation procedures to verify that components and assembled system meet desired requirements. Experimental methods, simulation, data processing, comparing experimental and analytical results, and engineering communication methods are emphasized.
AE3511 Spacecraft Engineering Practice (SEP) – FIRST OFFERING SPRING 2027	3	This course will teach students the processes and concepts necessary to design, build, and integrate spacecraft components into a vehicle. As the overarching theme, the course will use an Interface Control Specification to highlight and isolate mechanical, thermal, and electrical requirements that are necessary to integrate components into a functioning spacecraft in the space environment. Fundamental concepts of structural mechanics and heat transfer will be reinforced through experiments designed to quantify component interfaces to determine compatibility. Simulation techniques will support and extend experiments to verify component performance. Space industry standard testing processes, such as Test Like You Fly philosophy and NASA General Environmental Verification Standard, addressing vibration loads, mechanical shock, and thermal balance will be introduced and referenced throughout the course.

BSAE Program Rollout – 3rd Year Courses (cont.)

Course Title	cr	Description
AE3520 Aerodynamics – FIRST OFFERING SPRING 2027 (possibly Spring 2026)	4	This course addresses the fluid dynamics of gases and convection heat transfer around the aircraft and through propulsion systems. Potential flow, boundary layer, characteristics of laminar and turbulent flows, wall friction, Reynolds analogy, and convection heat transfer correlations are discussed. The course covers the introductory discussion of aircraft dynamics, stability, and control. Students develop testing and simulation skills as they validate the airfoils, wings, and model aircraft. The goal of this course is to characterize the model airplane designed and fabricated by students against simulations. To reach the goal, students learn the fundamentals of aerodynamic measurement methods.
AE4570 Space Mechanics (will be renumbered as 3570)	3	This course presents the vector-based solution of the two-body problem and the solution for Kepler's equations. The course will also cover basic orbit determination techniques, impulsive orbit transfer maneuvers, interplanetary trajectories, ground tracks, and rendezvous problems.
AE4530 Compressible Flow	3	Fundamentals of one-dimensional gas dynamics, including flow in nozzles and diffusers, normal shocks, frictional flows, and flows with heat transfer or energy release; introduction to oblique shocks.

BSAE Program Rollout – 4th Year Courses

Course Title	cr	Description
AE4540 Aerospace Propulsion – FIRST OFFERING PLANNED SPRING 2027	4	Principles of jet propulsion, cycle analysis and component analysis (non-rotating components, compressors, turbines). Principles of rocket propulsion, chemical rockets, propellants, turbomachinery, electrical propulsion. Review of thermodynamics for fluid flow, one-dimensional gas dynamics, and boundary layer theory included. Students will obtain hands-on experience of the operation and performance characterization of aerospace propulsion systems in three modules that are jet propulsion, electric aircraft propulsion, and rocket propulsion. In the jet propulsion module, students test compressors, exhaust nozzles, and an entire jet engine. The electric aircraft propulsion module covers the characterization of propellers, electric motors, and electric aircraft. The rocket propulsion module includes the testing and analysis of small-size solid rocket motor.
AE4550 Spacecraft Thermal Engineering (STE) – FIRST OFFERING FALL 2026	3	This course covers fundamentals of heat transfer with applications to spacecraft thermal control. Heat transfer topics focus on steady and transient heat conduction (1D and 2D) as well as single and multiple surface radiation. Passive thermal control topics include thermal straps, coatings and tapes, MLI, thermal interface materials and gaskets, thermal switches, phase change materials, heat pipes, and radiators. Active thermal control topics include heaters, thermoelectrics, louvers, fluid loops, and flexible/morphing radiators. Computational engineering tools (Thermal Desktop, FEA) is used to demonstrate thermal control strategies that meet spacecraft temperature, temperature stability, temperature gradient, and heat flux requirements for structures, instruments, and telecommunications.
AE4560 Aerospace Materials & Structures (AM&S) – FIRST OFFERING FALL 2026	3	This course will address the most relevant aspects of the materials and structures used in aeronautical and space vehicles. The fundamentals of lightweight alloys, high-performance super alloys, ablative materials, and fiber-reinforced composite materials will be covered, including structure-property relationships. The fundamentals associated with structural behavior of thin-walled aerospace structures will be covered, including torsion, warping, bending, and buckling. Basic concepts of adaptive structures will be introduced.
AE4580 Spacecraft Dynamics & Control (SC&D) – FIRST OFFERING SPRING 2027	3	This course covers spacecraft kinematics, dynamics, stability and control including actuation and sensing techniques. Simulation-based analysis is introduced to illustrate concepts and connect theory to practice.

Aerospace Engineering Minor for BSME Students

There are differences in the minor requirements prior to Fall 2025 and then for Fall 2025 and later:

- **Students that have the pre-requisites to take ME 4810 in Fall 2025 – MEEM 2150 and MEEM 3201 – can complete the minor on the 2024-25 (Fall 2024 catalog year) requirements.**
  - **Minor students that will be in ME 3201 in Fall 2025 and graduating before Spring 2027 should add themselves to the ME 4810 wait list.**
- **Fall 2025 is the last time ME 4810 will be offered.**
- **Students that cannot take ME 4810 in Fall 2025 will need to move onto the newer 2025-26 (Fall 2025 catalog year) minor requirements.**
- **The new minor requirements will have AE 2500 and AE 2550. These courses must be taken for the minor and represent 3-6 extra credits for BSME students earning this minor. AE 2500/2550 cannot be counted as ME technical elective credits.**
- **Anyone that declares the Aerospace Engineering major (BSAE, alone or as an ME/AE double major) cannot also earn the Aerospace Engineering minor. Students can drop the minor to add the major or vice versa.**
- **Aerospace Engineering majors cannot take ME 4810.**
- **See an MAE advisor to discuss your individual situation.**

Michigan Technological University
Minor in Aerospace Engineering
Program Code EMAE, Academic Year 2024-25
College of Engineering
Total Credits Required: 18

Required Courses: 10 Credits

- MEEM 2150 Mechanics of Materials (3) *Prereq: MEEM2110*
  - **or** ENG 2120 Statics-Strengths of Materials* (4) *Prereqs: MA2160 and PH2100 and ENG1102*
- MEEM 3201 Intro Fluid Mechanics & Heat Transfer (4) *Prereqs: MEEM2201 and MEEM2911 and MA3160*
  - **or** CEE 3200 Thermodynamics/Fluid Mechanics* (4) *Prereqs: CH1112 or (CH1150 and CH1151) and PH2100 and ENG1102 and MA2160)*
- MEEM 4810 Intro to Aerospace Engineering (3) *Prereqs: (MEEM 2150 or ENG 2120) and (MEEM 3201 or ENG 3200)*

Elective Courses: 4 credits minimum

- ENT 4950 Enterprise Project Work V** (2) *Prereqs: (BE3350 or BE3700 or BE4900) or (CEE3620 or CEE3810) or (CM4855(c)) or (CS3712 or CS4711 or CS4760) or (ENT3960 and EE3131 and EE3901)*
- ENT 4960 Enterprise Project Work VI** (2) *Prereqs: ENT4950 and (BE4900 or CEE3620 or CEE3810 or CM4855 or CS3712 or CS4711 or CS4760 or EE3171 or EE3173 or GE3880 or GE3890 or MSE4141 or CMG4210 or EET4253 or MET4460 or SAT4541 or SU4100 or ENG3830 or (ENG3505 and ENG4505) or (MEEM3750 and MEEM3201)*
- ENT 4961 Enterprise Project Work VII** (1) *Prereqs:ENT3950 and ENT3960 and (ENT4950 and ENT4960) or (ENT4900 and ENT4960)*
- MEEM 4202 Applied Fluid Mech & Heat Transfer (3) *Prereqs: MEEM3201 and (MA3520(c) or MA3521(c) or MA3530(c) or MA3560(c))*
- MEEM 4210 Computational Fluids Eng. (3) *Prereqs: MEEM3201(c)*
- MEEM 4230 Compressible Flow/Gas Dynamics (3) *Prereqs: MEEM3201*
- MEEM 4701 Analytical & Experimental Modal Analysis (4) *Prereqs: MEEM3750*
- MEEM 4720 Space Mechanics (3) *Prereqs: MEEM2700*
- MEEM 4820 Intro to Aerospace Propulsion (3) *Prereqs: MEEM3201*
- MEEM 5180 Mechanics of Composite Materials (3) *Prereqs: MEEM4901(c) or ENT4950(c)*
- MSE 4430 Composite Materials (3) *Prereqs: MY2100 or MSE2100 or BE2800*

Remaining Elective Courses: select remaining credits from the following course list

- MEEM 4150 Intermediate Mechanics of Materials (3) *Prereqs: MEEM2150*
- MEEM 4170 Failure of Materials in Mechanics (3) *Prereqs: MEEM3501 or MEEM3400*
- MEEM 4180 Engineering Biomechanics (3) *Prereqs: MEEM2150 and MEEM2700*
- MEEM 4201 Applied Thermodynamics (3) *Prereqs: MEEM3201*
- MEEM 4630 Human Factors (3) *Prereqs: none*
- MEEM 4650 Quality Engineering (3) *Prereqs: MEEM3600(c) and (MA3710 or MA3720 or MA2710 or MA2720)*
- MEEM 4702 Shock and Vibration (3) *Prereqs: (MEEM3911 and MEEM3750) or MEEM4775*
- MEEM 4704 Acoustics and Noise Control (3) *Prereqs: MA2160*
- MEEM 4705 Intro to Robotics and Mechatronics (4) *Prereqs: MEEM3750*
- MEEM 4707 Autonomous Systems (3) *Prereqs: MEEM3750 or MEEM4700 or MEEM4775*
- MEEM 4775 Analysis & Design of Feedback Control Systems (4) *Prereqs: MEEM3750 or EE3160*

**Minor credit cannot be granted for ME majors for these two courses.*
***Requires minor advisor approval of project.*

Michigan Technological University
Minor in Aerospace Engineering
Program Code EMAE, Academic Year 2025-2026
College of Engineering
Minimum Credits Required: 18

Required Courses: 3-6 Credits

- ME/MEEM 4810 Intro to Aerospace Engineering (3) *Prereqs: (MEEM2150 or ENG2120) and (MEEM3201 or ENG3200) c*
  - **or** AE2500 Principles of Aerospace Engineering (3) *Prereqs: ENG1102*
    and AE2550 Space Environment & Operation (3) *Prereqs: ENG1102 and PH2200*

Elective Courses: 12-15 Credits

- AE 3501 Aerospace Systems Engineering Practice *Prereqs: ME2150 and ME2700 and ME2911(C) and AE2500 and AE2550*
- AE 3511 Spacecraft Engineering Practice *Prereqs: AE3501*
- AE 3520 Aerodynamics *Prereqs: AE2500 and MA3160 and (ME2911 or MEEM2911)*
- AE 4540 Aerospace Propulsion *Prereqs: (AE3520 and AE4530) or MEEM3201 or ME3201*
- AE 4550 Spacecraft Thermal Engineering *Prereqs: AE3520 and AE3511*
- AE 4560 Aerospace Materials & Structures *Prereqs: AE2550 and (ME2150 or MEEM2150)*
- AE 4580 Spacecraft Dynamics & Control (SD&C) *Prereqs: AE4570(C) and (MEEM3750 or ME3750)*
- ME/MEEM 4202 Applied Fluid Mech & Heat Transfer (3) *Prereqs: MEEM3201 and (MA3520(c) or MA3521(c) or MA3530(c) or MA3560(c))*
- ME/MEEM 4210 Computational Fluids Eng. (3) *Prereqs: MEEM3201(c)*
- ME/MEEM 4230 Compressible Flow/Gas Dynamics (3) *Prereqs: MEEM3201*
- ME/MEEM 4701 Analytical & Experimental Modal Analysis (4) *Prereqs: MEEM3750*
- ME/MEEM 4720 Space Mechanics (3) *Prereqs: MEEM2700*
  - **or** AE 4570 Space Mechanics *Prereqs: MEEM/ME 2700*
- ME/MEEM 4820 Intro to Aerospace Propulsion (3) *Prereqs: MEEM3201*
- ME/MEEM 5180 Mechanics of Composite Materials (3) *Prereqs: MEEM4901(c) or ENT4950(c)*
- MSE 4430 Composite Materials (3) *Prereqs: MY2100 or MSE2100 or BE2800*
- ME/MEEM 4150 Intermediate Mechanics of Materials (3) *Prereqs: MEEM2150*
- ME/MEEM 4170 Failure of Materials in Mechanics (3) *Prereqs: MEEM3501 or MEEM3400*
- ME/MEEM 4180 Engineering Biomechanics (3) *Prereqs: MEEM2150 and MEEM2700*
- ME/MEEM 4201 Applied Thermodynamics (3) *Prereqs: MEEM3201*
- ME/MEEM 4650 Quality Engineering (3) *Prereqs: MEEM3600(c) and (MA3710 or MA3720 or MA2710 or MA2720)*
- ME/MEEM 4702 Shock and Vibration (3) *Prereqs: (MEEM3911 and MEEM3750) or MEEM4775*
- ME/MEEM 4704 Acoustics and Noise Control (3) *Prereqs: MA2160*
- ME/MEEM 4705 Intro to Robotics and Mechatronics (4) *Prereqs: MEEM3750*
- ME/MEEM 4707 Autonomous Systems (3) *Prereqs: MEEM3750 or MEEM4700 or MEEM4775*
- ME/MEEM 4775 Analysis & Design of Feedback Control Systems (4) *Prereqs: MEEM3750 or EE3160*