AE 6393 Syllabus

Introduction to System of Systems A/Q01 – 3 Credits

Fall 2026

Instructor Information

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General Course Information

Description

This document provides basic information regarding the Introduction to System of Systems class for the Fall 2026 academic term. The course is listed as AE 6393 for 3 credit hours in the course catalog of the Georgia Institute of Technology. Section A is for students on the US main campus; and Section Q is for distance-learning students.

The focus of AE 6393 is the study of complex System-of-Systems (SoS) through systems engineering and computer-based modeling, with particular attention to how these methods are used to frame and develop Grand Challenge projects. The course is less about mastering a single tool and more about learning how to think across interconnected systems, define architectures, and plan analyses that can support real decision-making. The lectures will cover systems engineering methods, model-based systems engineering, systems-of-systems architecting, the DoD Architecture Framework, executable architectures, the Unified Architecture Framework, systems-of-systems modeling fundamentals, mathematical graphs, system dynamics, discrete-event simulation, agent-based simulation, and systems-of-systems modeling execution.

The official AE 6393 class website is on Canvas at https://canvas.gatech.edu/ . This website is intended to provide all official lecture material, handouts, presentations, notices, and relevant information. Note that the website will be updated regularly and must be checked frequently. All announcements are automatically emailed to your GT student account. It is the student's responsibility to maintain access to this account and address email filtering issues. To log in, use your GT account username (usually your first name initial followed by your last name and a number, e.g., *gburdell3* and your GT account user password. Once on Canvas, select the AE 6393 course.

To facilitate project coordination and reviews, a Microsoft Teams site named *Grand Challenges* will be used. Within this site, there will be a **2026-2027 System of Systems Grand Challenge** channel. Unless discussions are restricted, all project review meetings will be held through this channel and recorded when possible. Students are encouraged to revisit the recordings and review the feedback they receive.

The Teams site will also serve as a repository for project presentations, reports, and other project-related files. Each team will be assigned a folder in which to store its work. Students are encouraged to view other teams' work, but they may not interfere with or modify another team's files. Students will be added to the Teams site after registration closes on Friday of the first week of classes.

Teams are free to create separate Teams sites for their own internal coordination. However, by the time of each review, all presentations and any other materials to be shown to the instructors must be available in the class Teams site. This arrangement allows for efficient switching between team presentations during the review sessions.

Pre- & Co-Requisites

Students enrolled in this course must register for AE 6394 in the following Spring semester, which provides credit hours for the second semester of the research project. Students who do not plan to enroll in AE 6394 in the Spring semester should notify the instructor and teaching assistants as soon as possible.

Required Course Materials

All required course material will be provided through lectures and course handouts; no additional readings or supplemental references are required.

Course Goals & Instructional Approach

Course Learning Outcomes

Upon successful completion of this course, you should be able to:

1. Explain key concepts underlying the study of complex systems and system of systems.
2. Identify and discuss the unique challenges involved in systems-of-systems development and engineering.

3. Apply relevant systems engineering, modeling, and analysis methods to systems-of-systems problems.
4. Use concepts such as complexity, mathematical modeling, computer simulation, and emergent behavior in the analysis of complex systems.
5. Evaluate and compare methods for studying and designing system of systems.
6. Apply course concepts to both individual assignments and team-based projects.
7. Extend your understanding of course topics through independent research and self-directed learning.
8. Present technical findings and project work clearly and professionally.

Rationale for Teaching Techniques

These are graduate-level courses designed with the expectation that learning will take place both inside and outside the classroom. Lectures are intended to organize the material, highlight key ideas, model ways of thinking, and create opportunities for discussion, but they are not meant to deliver every detail needed for mastery. Students are therefore expected to prepare before class, engage actively during lecture, and revisit the material afterward through review, practice, and reflection. This approach is consistent with learning science findings showing that durable learning is strengthened by effortful engagement, retrieval practice, spacing, and working through ideas rather than only rereading or listening passively [1, 2, 3].

For that reason, students are expected to be active and proactive in their own learning. Office hours, Piazza, and other course support structures are provided not as substitutes for independent effort, but as places to ask questions, test your understanding, and get help when you are stuck. Students are strongly encouraged to form study groups, compare approaches, and discuss concepts with one another, since structured cooperative learning has been shown to support achievement and engagement. At the same time, each student must still do their own intellectual work: struggling with a problem, attempting a solution, identifying what is missing, and repairing errors are essential parts of the learning process. In that sense, failing to do the work yourself not only violates course expectations; it also deprives you of the very practice that helps learning stick [3, 4, 5].

This is also why complete worked solutions are not routinely released. Research in learning and memory shows that students learn more when they must retrieve information, generate a response, and diagnose their own mistakes than when they passively read an answer key. Accordingly, students are encouraged to return to lecture notes, the assigned materials, and provided guidance to identify what is missing in their work and correct it themselves. Teaching assistants remain available during office hours and on Piazza to help clarify concepts, confirm corrected reasoning, or assist when students cannot resolve an issue on their own. The goal is not to withhold help but to support the productive effort that leads to stronger retention, transfer, and later performance [1, 3, 5].

Course Policies & Expectations

Attendance & Participation

For students in section A, the class meets on Tuesdays & Thursdays from 5:00 PM to 6:15 PM EST. Distance learning students in section Q are encouraged to attend lectures during class time to ask questions in real time. However, the instructors understand that this may not always be possible because of time zone differences and work schedules. Class recordings will be made available to students in the Q section of the class website shortly after each lecture. Distance learning students are expected to keep up with the class material within the same week that it is presented. This is important because some group deliverables may depend on lecture content. Assignment due dates are the same for both on-campus and distance learning students.

Students are expected to attend lectures, participate actively in class discussions, and ask questions whenever they are uncertain about the material. Lectures are conducted in a discussion-based format, in which regular questioning of concepts is encouraged, and student engagement is essential. Students should notify the instructors in a timely manner if they are unable to attend a lecture or meet a deadline so that alternative arrangements may be considered.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe it is important to foster an atmosphere of mutual respect, acknowledgment, and responsibility between faculty and students. The Student-Faculty Expectations outline the basic expectations you may have of me, as well as those I have of you. Ultimately, respect for learning, dedication to hard work, and courteous interactions help create the kind of environment we value. We encourage you to remain committed to Georgia Tech's ideals throughout this course.

Collaboration, Group Work & Use of Generative AI

a) Collaboration:

Collaboration is encouraged when it supports learning, professional growth, and thoughtful engagement with course material. Students are welcome to discuss concepts, compare approaches at a high level, and help one another think through difficult ideas. However, collaboration must never cross the line into submitting work that is not genuinely your own. Unless explicitly stated otherwise, each student is expected to produce their own individual assignments, write their own solutions, and be able to explain and defend their work independently. Productive collaboration should clarify understanding, not replace the intellectual effort required of each student. When in doubt, students should ask the instructional team for clarification before proceeding.

b) Group Work:

Group work is a central part of these courses and is intended to reflect the realities of professional engineering practice. Teams are expected to function in a coordinated, responsible, and equitable manner. No team member should carry a disproportionate share of the workload, and no student should disengage and rely on others to complete the work on their behalf. Responsibilities should be clearly divided, progress should be communicated regularly, and each member should remain accountable for both their own contributions and the project's overall direction. Effective teams do not wait for problems to escalate, they raise concerns early, adjust workloads when necessary, and seek guidance from the instructional team when issues cannot be resolved internally. Peer and self-assessments may be used to reflect the quality and consistency of each student's contribution.

c) Use of Past Student Work:

For individual assignments, students may not use materials created by students who took the course in previous years or by their current classmates. Doing so undermines the purpose of an individual assignment and will be treated as a violation of the Honor Code.

d) Use of Generative AI:

Students may not use generative machine learning models or services (i.e., AI tools) to create text, technical figures, or code for any assignment submitted for a grade. The use of such tools is permitted for research purposes; however, students are reminded that these models are trained on imperfect data and may produce inaccurate or misleading results. Tools such as ChatGPT are not acceptable scholarly sources. If students use such tools during their research, any resulting statements must be supported by published sources that can be properly cited.

AI tools may be helpful when beginning a literature review in an unfamiliar area, as they can sometimes provide a broad overview of a field. However, students are expected to continue their literature review by reading survey papers as well as papers directly related to the methods and processes relevant to their specific research needs.

Students may use AI tools to help overcome writer's block or to explore possible starting points for coding assignments. However, all work submitted for grading must be the student's own. Model-generated text must not be copied into any submitted document, even if it is later edited. Likewise, AI-generated code may not appear in any submitted assignment. Students may use such tools to support learning, but not to complete the work on their behalf. Any AI-generated code used during the learning process must be discarded and independently recreated by the student so that the instructors can properly assess the student's understanding.

If AI-generated text, figures, or code are detected, the student-or the entire team, if applicable-will receive a zero for that portion of the assignment. Repeated use of auto-generated text or code may result in additional penalties in accordance with Institute policies established by the Office of Student Integrity.

Students with questions about the appropriate use of AI tools should contact the instructors for clarification and obtain permission if they believe a particular use is justified. Office hours and post-lecture discussions are the best opportunities to resolve such questions. Students should also keep in mind that AI use policies may differ across courses; permission granted in one course does not automatically apply in another.

Experience has shown that work produced by generative models is often unsatisfactory and of poor quality, frequently resulting in grade penalties and weak academic performance. Students are here to develop new skills and methods, and they are expected to focus on building those abilities rather than relying on shortcuts that are easily recognized and reflect poorly on their work ethic.

Assessment & Grading

Assignments

Please note that the assignment description handout, available on the class website, will include detailed assignment descriptions, team information (if applicable), instructions, deliverables, and helpful resources. Students should direct any questions to the teaching assistants through Piazza under the appropriate assignment tab.

a) Homework:

There will be three individual homework assignments designed to assess learning in Model-Based Systems Engineering and two modeling paradigms. The lectures will provide the theoretical background for each homework and will be followed by demonstrations or hands-on exercises before the assignments are due. Students are encouraged to take advantage of the recorded lectures and review the relevant material as they complete the assignments.

(1) MBSE Homework

Creating requirements, decomposing a system, and performing analysis to check against requirements for a commercial aircraft. The homework follows the same general exercise presented by the teaching assistants during the lecture. By working through similar steps, students will become more familiar with MagicDraw, which they may also use in their Grand Challenge projects. A few modifications to the lecture example are included so that students can apply their new skills to a new problem that is still familiar in structure.

(2) Graph Theory Homework

Creating a graph for a classic use case and its variations. In the Towers of Hanoi game, there are three poles and a varying number of disks. Each disk has a unique size, and the game typically begins with all disks stacked on one pole. The objective is to move the full stack from the starting pole to the destination pole by unstacking the original tower and rebuilding it on the final pole. The game has two rules: only one disk may be moved at a time, and a larger disk may not be placed on top of a smaller disk; that is, at any time, the disks on each pole must remain ordered from largest at the bottom to smallest at the top.

(3) System Dynamics Homework

Modifying a baseline model to study a disease outbreak. Students will use the Susceptible-Infected-Removed (SIR) system dynamics model developed during the lecture sessions and modify it to incorporate additional logic and analyze the resulting differences in system behavior. In particular, students must add at least two additional stocks, each with its corresponding flows, and three to five variables that affect the outcome of the simulated scenario. The model must also be updated with additional plots showing the time histories of all stock levels and relevant parameters.

b) Class Survey:

To help place students on projects that align with their interests, a class survey will be released at the start of the semester. On-campus students must complete the survey by noon on Friday of the first week, while distance-learning students must submit their preferences by midnight that same day. Students will rank project options in order of preference, and they must be logged in when completing the form so that responses can be matched to their accounts. The instructors and teaching assistants will finalize project placements before the following lecture, once registration has closed.

We aim to form balanced teams across projects, including integrating distance-learning and on-campus students where appropriate, to support a comparable learning experience across the class.

c) *System of Systems Grand Challenge:*

While the ultimate goal of the Grand Challenge projects extends through the end of the Spring semester, teams will make steady progress throughout the Fall semester, with that progress reviewed approximately each month.

The class projects are integrated into the natural flow of AE 6393. They are intended to give students an opportunity to apply the methods, approaches, and tools introduced in lecture to realistic engineering problems. Project topics will be released during the first week of the semester, and students will select their preferred systems-of-systems project topics from the options provided. Teams will be formed by the second week of the semester, once registration has closed and the class roster has stabilized. After teams are finalized, they may recruit undergraduate student researchers as additional project members.

Students will work together across both the Fall (AE 6393) and Spring (AE 6394) semesters. These projects provide academic, yet realistic, engineering problems through which students can apply newly acquired knowledge. In the Fall semester, AE6393 focuses on problem formulation, system architecting, and analysis planning. In the Spring semester, teams will execute their models, collect simulation data, analyze quantitative results, build decision-making environments to answer research questions, and report their findings and recommendations to stakeholders.

Each project is supported by technical advisors drawn from selected ASDL research faculty or senior Ph.D. students with relevant subject-matter expertise. One of the technical advisors will introduce each project during the first week of classes. Teams are expected to meet with their technical advisors weekly to track progress and plan short-term activities. Technical advisors will also provide participation assessments for each student based on their contributions to the project. In addition to meetings with technical advisors, team members are encouraged to meet several times each week to coordinate their work effectively.

Comprehensive project reviews will take place twice to three times during the semester and serve as the primary mechanism through which instructors provide feedback to the teams. Teams are expected to build their slide decks progressively throughout the semester, and some repetition of earlier material will therefore be necessary during later reviews. After each review, teams should prepare a **succinct story** of the previous review so that the next presentation can focus on new developments without losing the context established by earlier work.

The reviews will begin relatively short and grow in length as the projects develop and expectations increase. In addition to technical feedback, the instructors will comment on whether the work is being assembled into a coherent **story** that a general technical audience can follow. Because the final Spring deliverable is a presentation to external technical experts, teams are expected to improve both their presentation skills and their technical explanations over time. The Fall semester will focus on establishing research goals, architecting a solution, and planning for experimentation.

The Fall semester includes three major project phases, centered on the following topics.

(1) Problem Formulation:

Literature Review, Problem Statement & Objective Definition:

During this phase, teams will establish their project objectives. The process begins with guidance from the technical advisors and quickly moves into a literature review. At this stage, teams are expected to learn as much as possible about the problem they are addressing. The phase concludes with a synthesis of the state of the art, an identification of the major challenges facing the field (technical, societal, economic, and otherwise), and the formulation of a clear research objective. Teams will also prepare a management plan agreed upon by all team members and technical advisors, including meeting times, member roles, and a conflict-resolution process.

(2) Architecting

System of Systems Architecting & Engineering:

During this phase, teams will define a candidate solution approach. This includes identifying desirable systems-of-systems architectures within the design space permitted by the project requirements. Teams will document their requirements as informed by the project sponsor, the literature review, and relevant industry rules, regulations, and standards. The resulting systems-of-systems architecture will be defined using appropriate artifacts, such as diagrams and tables, and documented in a report.

(3) Modeling Plan

Computer Modeling & Simulation Planning:

In the final phase of the Fall semester, teams will formulate a plan for their simulation approach. Computer simulation will be used to quantify the consequences of design decisions and ultimately identify better-performing solutions within the design space. These simulations may follow a variety of paradigms, including graphs, system dynamics, discrete-event simulation, and agent-based modeling. Using the knowledge developed in the lecture, students will formulate a modeling plan based on the systems-of-systems architecture defined earlier. Very preliminary results may also be discussed to confirm that the team is on a productive path.

Because the instructors and technical advisors work with industry and government agencies to offer a wide range of project topics, the number of projects to be reviewed is substantial. As a result, reviews may not fit within regular lecture hours. Review schedules will be published in advance, and students will be asked to sign up for times that work for them. Each review cycle may require 15-20 total hours. While instructors will make time for all teams, students are expected to attend only their own review and a limited number of additional reviews to compare progress across teams and provide peer feedback.

External technical experts from leading aerospace companies and agencies also support many projects. Students will have opportunities to meet with these experts to understand project goals better, learn from their experience, and receive guidance on project direction. Although such external meetings are ungraded, teams are strongly encouraged to prepare carefully and make full use of the opportunity to engage with experts in the field.

As noted earlier, one of the major project deliverables is a final presentation to a panel of industry experts. These presentations will take place during the student conference component of the ASDL's External Advisory Board (EAB) review at the end of the Spring semester. As part of the conference proceedings, each project will be represented by an abstract and a team badge, and team members will be featured through a short professional biography. The EAB meeting provides students with a valuable opportunity to meet experts in the field and present their work to potential future employers or research sponsors.

(a) Publication Policy

Students are strongly discouraged from publishing directly from Grand Challenge work. Instead, any publication efforts should be pursued as spin-off work through 8900-series projects or thesis research.

(4) Actions Items Identified in Reviews

Following each presentation review, teams will prepare an action list. This list must be submitted by the first day of the week following the review period and will be revisited during the next review. Teams are expected to consult their technical advisors before submitting the action list.

(5) Feedback to Other Teams

Each student is required to attend **three** reviews given by other teams and provide constructive feedback on their classmates' work. Students may choose which teams to observe, although they are encouraged to attend reviews related to their own topics to identify potential overlaps, opportunities for collaboration, and useful points of comparison. The instructors will not use feedback from these peer reviews to influence the receiving team's grades. Students should therefore feel comfortable identifying weaknesses, gaps, or concerns, provided that their comments are constructive and aimed at improving the work rather than criticizing it for its own sake. Because the feedback is not anonymous, teams will know who submitted it, and students are expected to communicate professionally and respectfully.

In addition to helping classmates strengthen their future work, this assignment gives students visibility into the approaches, standards, and progress of other teams. Observing other reviews can help students identify practices that may improve their own team's work and better judge the quality and direction of their own progress.

(6) Self, Peer & Advisor Assessments

There will be a small number of logistical assignments related to the operation of the class and its projects. Students should pay attention to these assignments, as they typically require little effort but may provide the final points needed to earn a higher letter grade.

Peer and self-assessments will be used throughout the course. Team members will evaluate both their own contributions and those of their teammates relative to the level of effort and engagement expected by the group. Each assessment will include a self-reflection on areas for individual improvement, as well as an opportunity to identify team practices or behaviors that could be improved to support more effective collaboration. These assessments are private between the students and the instructors and will not be shared with other students or technical advisors. A standardized form will be provided for collecting feedback.

Technical advisors may also provide feedback on the team as a whole and on individual contributions. Students will likewise have an opportunity to comment on any challenges they encounter when working with their advisors, such as difficulties with communication, coordination, or meeting scheduling. If serious disagreements arise within a team, students should contact the instructors promptly rather than waiting until the next review cycle. Office hours may also serve as a neutral setting to discuss concerns and resolve issues before they become larger problems.

Grading Policy

Grades will be based on the Grand Challenge project, homework assignments, and participation. The distribution of these elements is shown in Table 1.

An additional 2% bonus may be earned through the CIOS survey if at least 80% of students complete the CIOS survey.

Table 1 Grade Breakdown

Course Component	Item	Percentage of Final Grade
Class Logistics & Participation	Class Survey Participation	10%
	Presentation Participation	
	Self, Peer & Advisor Assessment	
Problem Formulation	Presentation	15%
	Individual Contribution	
	Actions Items List	
Architecting	Presentation	20%
	Report	
	Feedback to Other Teams	
	Individual Contribution	
	Actions Items List	
Modeling Plan	Presentation	25%
	Report	
	Feedback to Other Teams	
	Individual Contribution	
	Actions Items List	
Homework	MBSE Homework	30%
	Mathematical Graphs Homework	
	System Dynamics Homework	
Bonus	CIOS Survey	+2%

Most graded components of this course are group-based and are associated with the development and progress of the project. The main exceptions are Homework, Class Logistics assignments, Feedback to Other Teams assignments, and the Individual Contribution grade.

Participation will be graded on active participation during the review presentations. To earn full points on presentation participation, each student must present for 10 minutes during project reviews.

The individual contribution grade is based on each student's contribution to the advancement of the project and will be determined by the technical advisors.

Project presentations and reports are cumulative. Teams are expected to build on previous versions, maintaining and refining existing sections while adding new material as appropriate.

The points sum to 100%, and final letter grades will be assigned according to the overall course percentage, as shown in Equation 1.

Equation 1 Letter Grade Based on the Overall Course Percentage

$$\text{Final Grade} = \begin{cases} \text{A if } 90\% \leq \text{Course Percentage} \leq 100\% \\ \text{B if } 80\% \leq \text{Course Percentage} < 90\% \\ \text{C if } 70\% \leq \text{Course Percentage} < 80\% \\ \text{D if } 60\% \leq \text{Course Percentage} < 70\% \\ \text{F if Course Percentag} < 60\% \end{cases} \quad (1)$$

Extensions, Late Assignments & Rescheduled/ Missed Exams

a) Extensions:

Because group assignments are based on collective effort, an extension for a group deliverable will not normally be granted solely because one team member has an Institute-approved absence. Teams are expected to adjust responsibilities and coordinate accordingly to maintain progress. If exceptional circumstances arise that substantially affect the group's ability to complete the assignment, the team should notify the instructional staff as early as possible.

b) Late Assignments:

Assignments submitted up to seven days late will incur a flat 20% penalty. Assignments not received within seven days of the deadline will receive zero. For example, an assignment that earns a grade of 95/100 but is submitted late will receive a final grade of 75/100. If an assignment is marked late on Canvas, it will be treated as late.

c) Rescheduled or Missed Exams

This course does not include a midterm or final exam.

Institutional & Administrative Policies

Academic Honesty & Integrity Statement

a) Honesty and Academic Integrity:

Georgia Tech is committed to fostering a community grounded in trust, academic integrity, and honor. Students are expected to uphold the highest ethical standards and to abide by Georgia Tech's Academic Honor Code.

b) Georgia Tech Honor Challenge Statement:

I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community.

Students are responsible for familiarizing themselves with the Honor Code and the expectations governing academic work in this course.

Students are expected to submit original work of their own. Suspected cases of cheating or plagiarism will result in serious penalties, including a deduction from the final course grade and referral to the Office of Student Integrity.

Institute Approved Absences

Students should review Georgia Tech's attendance policy regarding Institute-approved absences. According to the Georgia Tech Catalog, students who are absent due to participation in approved Institute activities, such as field trips, professional conferences, and athletic events, must be permitted to make up any missed work. Students with illness- or emergency-related absences should also consult Georgia Tech's student absence policy for the applicable expectations and documentation requirements.

Students are expected to communicate promptly regarding any planned absences. Failure to provide timely notice may result in the absence being treated as unexcused and in receiving a zero for all missed assignments.

Accommodations for Students with Disabilities

Student experience in this course is important to us. Students who have not yet established services through the Office of Disability Services, but who have a temporary health condition or a permanent disability requiring accommodations, should contact the Office of Disability Services at *(404) 894-2563* or dsinfo@gatech.edu as soon as possible. This may include, but is not limited to, mental health, attention-related, learning, vision, hearing, physical, or other health-related impacts.

Students who have already established accommodations with the Office of Disability Services are expected to notify the instructor of their approved accommodations at their earliest convenience so that course-specific needs can be discussed. Disability Services coordinates reasonable accommodations through an interactive process involving the student, the instructor, and Disability Services. Georgia Tech is committed to creating an inclusive and accessible learning environment consistent with federal and state law.

Because there are exams on this course, it is the responsibility of students to work with the Office of Disability Services to arrange any necessary exam proctoring or testing accommodations. Special accommodations cannot be granted without approval from the Office of Disability Services.