CP8873 C/ AE8803-SCW /ARCH7360/ARCH8803 PY/ARCH4803 PY Syllabus

# **Urban Systems Design Workshop** – Urban Design and Systems Engineering for Digital Twins

Fall 2026 – 3 Credits

## Instructor Information

**Instructors: Prof. Perry Yang & Prof. Dimitri N. Mavris & Dr. Michael Balchanos**

**Email: perry.yang@design.gatech.edu; dimitri.mavris@aerospace.gatech.edu; michael.balchanos@asdl.gatech.edu**

**Affiliations:**
School of City and Regional Planning, School of Aerospace Engineering and School of Architecture, Georgia Institute of Technology

**Class Time:** Fridays, 8:00 AM – 10:45 AM

**Class Location:**

Primary: Weber SST III Building, 3rd Floor, Collaborative Visualization Environment (CoVE)

Selected sessions: Clough Undergraduate Learning Commons, Rm 423

**Studio Space:** Eco Urban Lab, Architecture East 304, College of Design

## General Course Information

### Description

**The Urban Systems Design Workshop (USDW)** explores design and modeling methods toward urban digital twins. The workshop addresses complex urban problems by incorporating **systems thinking and design thinking** that are grounded in methods of: 1) urban design; 2) system engineering, with a focus on digital engineering and systems architecting; and 3) urban data analytics, focusing on smart mobility, energy and emerging technologies for shaping future urban systems. It is an approach to designing smart urban systems for resilience and sustainability facing climate challenges.

Georgia Tech's 2026 Urban Systems Design Workshop takes Hartsfield-Jackson Atlanta International Airport, the largest hub of the U.S. with an annual traffic of more than 110 million passengers, and its urban surroundings Aerotropolis as a living laboratory for research. The airport city, or *aerotropolis*, is emerging as a global urban landscape. Many global cities are turning their "city airport" into "airport city", in which city centers are built around globally significant airports (Kasarda, 2013). The 2026 USDW workshop will collaborate with **Hartsfield Jackson International Airport of Atlanta**, **Aerotropolis Atlanta Alliance**, and stakeholders connecting to the ATL airport city areas. Students will have the opportunity to engage in real-world problems related to the future of Atlanta's Airport and Aerotropolis, in which guidance and feedback are provided, reflecting stakeholders and community needs.

Students are expected to attend lecture series and participate in the workshop, in which each student will work in a semester-long project design through cross-disciplinary teamwork. The four themes form a portfolio: Themes 1–2 are airport-centric and Themes 3–4 aerotropolis-centric; Themes 1 and 3 emphasize operations, Themes 2 and 4 planning and development. Every team develops a digital twin or digital model of its system, applying methods from both systems engineering and urban design. Students can choose their own focus in design or research from one of the four themes:

**1. Resilient, Safe and Secure Smart Airport Operations:** Modern airports must be capable of absorbing shocks — severe weather, power and technology outages, and surges from large city-wide events — while remaining safe and secure in daily operations. The student team will select one disruption or security scenario and formulate an operations digital twin to stress-test it through simulated experiments, using public and synthetic data, drawing on smart-airport technologies such as biometric scanning, crowd movement analytics, and sensor fusion. A featured use case is a post-event analysis of the airport traffic during the 2026 FIFA World Cup, extracting lessons for the large events Atlanta will host in the future.

**2. Airport Energy Futures and Master Planning for Carbon Neutrality:** In collaboration with the ATL Airport Sustainability Office, the student team will develop data-driven models for analyzing and tracking carbon neutrality, energy efficiency and resilience, and reduced noise under continued traffic growth — approached from an energy-generation perspective. Using design space exploration methods and tradeoff analysis techniques, teams trade candidate assets for the airport's future energy architecture and strategic energy assets: microgrids, storage, on-site generation, small modular and micro-reactors, and electrified fleet and eVTOL charging loads.

**3. Evolution of Air Mobility Networks: Integrating Aerial (UAM/AAM) and Ground Transportation Systems:** With the first commercial eVTOL services launching in 2026 and airport shuttles emerging as their first application, teams ask how an air mobility network should evolve for the ATL aerotropolis: vertiport placement, corridor phasing, demand ramp-up, and integration with MARTA, ground transit, delivery drones (UAS), and freight.

With guidance provided by stakeholders, the student team will choose one corridor, mode pairing, or network stage, and calibrate transportation models with ATL airport and GDOT data, in order to deliver a mobility digital twin of that slice of the network. By exercising the mobility model, the team will be able to answer questions on impact of route selection, varying people and payload movement demand, position of transit hubs and vertiports, etc.

**4. Smart and Equitable Aerotropolis Development: Airport-Oriented Development (AOD) in the Age of Digital Infrastructure:** Communities around the airport carry chronic burdens — pollution, noise, water quality, safety, cost of living, and limited access to basic needs — that shape well-being and economic opportunity. Building on the AOD framework developed from previous cohorts of the course and presented in the USDW 2023-2025 Final Reports that focus on chronic community burdens (pollution, noise, water quality, cost of living, access to food, healthcare, and housing), the student team will explore current smart-city enabling paradigms (urban digital twins, open data, sensing, AI-assisted planning) and apply them to the south metro's rapid data center growth, whose water, energy, land-use, and equity implications are under intense local debate. The team's work may include water/energy/land trade-off models built for alternative siting scenarios. In order to answer questions on community level impact, the team will work on interactive parametric decision-support dashboards for the Aerotropolis Atlanta Alliance, AACIDs, and surrounding municipalities for stakeholder supported use cases.

## Course Structure

The course is organized into four phases:

1. **Introduction to Design (3 weeks)**
2. **Problem Formulation as a System-of-Systems (4 weeks)**
3. **Infrastructure and Digital Twin Applications (5 weeks)**
4. **Project Reviews and Final Reporting (4 weeks)**

## Project Milestones

- **Proposal Presentation (Sep 4):** Students present individual ideas by 3 slides
- **On-site Stakeholder Workshop (Sep 18):** Problem formulation with stakeholders at Aerotropolis HQ
- **Midterm Review (Oct 9):** Conceptual Urban Systems Design

- **Project Preview (Nov 20):** Integration of design and modeling
- **Final Review (Dec 4):** Presentation to external reviewers
- **Final Report (Dec 11):** Submission of finalized work

## Weekly Schedule Overview

### Part I – Introduction to Design (August-September)

Aug 28 Introduction

- 8:00-8:10am Welcome
- 8:10-10:30am Introduction

  1. **Engineering Systems Design** for complex problems – Dr. Dimitri Mavris
  2. **Urban Design** for Airport City - Dr. Perry Yang
  3. **Project Context and Course Outline -** Dr. Michael Balchanos

- 10:30-10:45 – Discussion

September 4 Urban Systems Design + Proposals of Student Ideas

- 8:00-9:20 – Urban Systems Design toward Digital Twins – Dr. Perry Yang
- **9:30-10:45 – 1st Round Idea Presentation: Students to present individual ideas by 3 slides each; Forming the Groups**

  1 Page Proposal submission – by Individuals/Students

September 11 Concept Design + Tutorial on Urban Building Energy Modeling

- 8:00-9:30 – Concept Design + Tutorial on Urban Building Energy Modeling – Dr. Perry Yang, Jingyuan Shen, Hina Ahmed, Tran Duong Nguyen and Kamyar Fatemifar

- 9:30-10:45 — Workshop session

### Part II – Problem Formulation as a System-of-Systems (September-October)

**September 18** Problem Formulation – **On-site Workshop** at **Aerotropolis HQ**

- **7:30 -8:00 – Welcome and Introduction**

- **8:00-9:20 - Problem formulations with stakeholders around ATL Aerotropolis**

  Aerotropolis Atlanta Alliance

**Mr. Shannon James/CEO and Mr. Brian Dorelus/VP of Aerotropolis ATL**

Other presentations (TBA)

- 9:30-10:45 – Idea presentation from Georgia Tech groups and discussions
- **10:45 am** – Discussion
- Short field trip to ATL to follow (note: 7:30 AM start; session may run past 10:45 AM; details on Canvas)

**September 25** Systems Engineering and Design

- 8:00-9:20 – Systems Engineering & Design Introduction – Dr. Dimitri Mavris
- 9:30-10:45 – System-of-Systems Engineering Methods – Dr. Dimitri Mavris

**October 2** Advanced Design Methods + Tutorial on Agent-based Modeling

- 8:00-9:30 – Design Space Exploration Method + Tutorial on Agent-based Modeling and SoS Discrete events modeling – Dr. Michael Balchanos and Devesh Murugesan

- 9:30-10:45 –– Workshop session: **Midterm working session**

**October 9** **Midterm Review**

Midterm submission – Conceptual Urban Systems Design (by student groups)

**Part III – Infrastructure and Digital Twin Applications (October-November)**

October 16 Infrastructure Digital Twins

- 8:00-9:00 – Digital Twins Mobility Infrastructure, Dr. Michael Balchanos
- 9:00-10:00 - Digital Twins Lunar-based systems, Dr. Michael Balchanos
- 10:00-10:45 – Workshop Session

October 23 Digital Twins Systems

- 8:00-10:00 – Digital Engineering Systems and Digital Twins, Dr. Olivia Fischer
- 10:00-10:45 – Workshop Session

October 30 Energy & Environment

- 8:00-9:20 - Energy Infrastructure, Dr. Scott Duncan
- 9:30-10:45 - Airport Noise and Emissions, Dr. Holger Pfaender

November 6 Visual Analytics

- 8:00-10:45 – Visualization for modeling and digital twin, Dr. Michael Balchanos

November 13 Digital twins Applications and Use Cases

- 8:00-10:45 - Digital Twins use cases presentation, presented by the workshop alumni

**Part IV – Project Reviews and Final Reporting (November-December)**

November 20 Project Preview

November 27 (No class, Thanksgiving break)

**December 4 Final Review: Symposium of Future Airport City**

December 11 Final Report due (no class session)

## Course Logistics & Platforms

Course materials, announcements, and communications will be managed through Canvas. Students are responsible for regularly checking the course website and their Georgia Tech email.

Collaboration tools (e.g., GitHub) will be used for project coordination, data management, and version control during workshop sessions.

### Pre- & Co-Requisites

There are no required prerequisites for enrollment.

Students from Aerospace Engineering are recommended to have prior experience with programming (e.g., MATLAB or Python), data analytics, and visualization tools.

### Required Course Materials

All required materials will be provided through lectures and instructor-distributed resources.

### Required References

Aerotropolis Atlanta Alliance & Atlanta Regional Commission. (2016). *The Aerotropolis Atlanta blueprint*.

Hartsfield-Jackson Atlanta International Airport. (2023). *ATL Future Forward: Environmental, social, and governance (ESG) report*. https://next.atl.com/

Kasarda, J. D. (2013, April–May). Airport cities: The evolution. *Airport World*, 24–27.

Mavris, D. N., Balchanos, M. G., Pinon-Fischer, O. J., & Sung, W. J. (2018). Towards a digital thread-enabled framework for the analysis and design of intelligent systems (AIAA 2018-1367). *AIAA Information Systems–AIAA Infotech@Aerospace, AIAA SciTech Forum*. https://doi.org/10.2514/6.2018-1367

Pinon Fischer, O. J., Matlik, J. F., Schindel, W. D., French, M. O., Kabir, M. H., Ganguli, J. S., Hardwick, M., Arnold, S. M., Byar, A. D., Lewe, J.-H., Mahadevan, S., Duncan, S., Dong, J. J., Kinard, D. A., & Maiaru, M. (2022). Digital twin: Reference model, realizations, and recommendations. *INSIGHT, 25*(1), 50–55. https://doi.org/10.1002/inst.12373

Rogers, M. M., Ota, W. M., Burola, N., & Piquado, T. (2026, February 11). *The infrastructure equation: Water, energy, and community policy for Georgia's data center boom* (arXiv:2602.10526). arXiv. https://arxiv.org/abs/2602.10526

Urban Systems Design Workshop. (2023, 2024, 2025). *USDW final reports* [Course report]. Georgia Institute of Technology. Available on the course Canvas site.

Wang, X., Yang, P. P. J., Balchanos, M., & Mavris, D. (2023). Urban airspace route planning for advanced air mobility operations. In R. Goodspeed, R. Sengupta, M. Kyttä, & C. Pettit (Eds.), *Intelligence for future cities: The Urban Book Series (CUPUM 2023)*. Springer. https://doi.org/10.1007/978-3-031-31746-0_11

Yamagata, Y., & Yang, P. P. J. (Eds.). (2020). *Urban systems design: Creating sustainable smart cities in the Internet of Things era*. Elsevier. - https://www.sciencedirect.com/science/chapter/edited-volume/abs/pii/B9780128160558000014?via%3Dihub

## Course Goals & Instructional Approach

### Course Learning Outcomes

Upon successful completion of this course, students will be able to:

- Understand contemporary methods in smart city systems design
- Develop research and design frameworks for urban systems projects
- Apply interdisciplinary approaches integrating urban design and systems engineering, as well as System-of-Systems (SoS) Engineering
- Collaborate effectively in cross-disciplinary teams
- Develop and present complex urban system solutions

### Discipline-Specific Expectations

**Students from College of Design:**

- Apply skills in GIS, architecture, or urban design
- Engage in physical planning and stakeholder coordination

**Students from Engineering:**

- Apply systems engineering and modeling techniques
- Develop simulations for mobility, energy, and digital twin systems

## Course Policies & Expectations

**Attendance & Participation**

Students are expected to attend all lectures and actively participate in workshop sessions. The course is highly interactive and relies on consistent engagement in both discussions and hands-on activities.

Because the course involves collaborative project work, attendance is critical to team progress. Students should notify instructors in advance of any anticipated absences.

**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 us, as well as those we 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 this course 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

### Grading Breakdown

| Component | Percentage |
|---|---|
| Attendance & Participation | 30% |
| Midterm Review | 15% |
| Project Preview | 15% |
| Final Presentation & Report | 40% |

### 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-point 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.

Students must submit the required extension or leave-of-absence request form, available on the course website, to make alternative arrangements.

**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 in 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.

**Additional Notes**

- Key sessions marked with (*) will be held in the CoVE facility at the Aerospace Engineering building.
- Students are expected to engage with real-world stakeholders and produce professional-quality deliverables throughout the semester.