Course Title:

Next Generation Airport Terminals
Design Non-conventional Architectural Structures

Spring 2019
ARCH 704-209
Mondays, Wednesdays (Fridays) 2:00 – 6:00 pm

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PSL

Polyhedral Structures Laboratory
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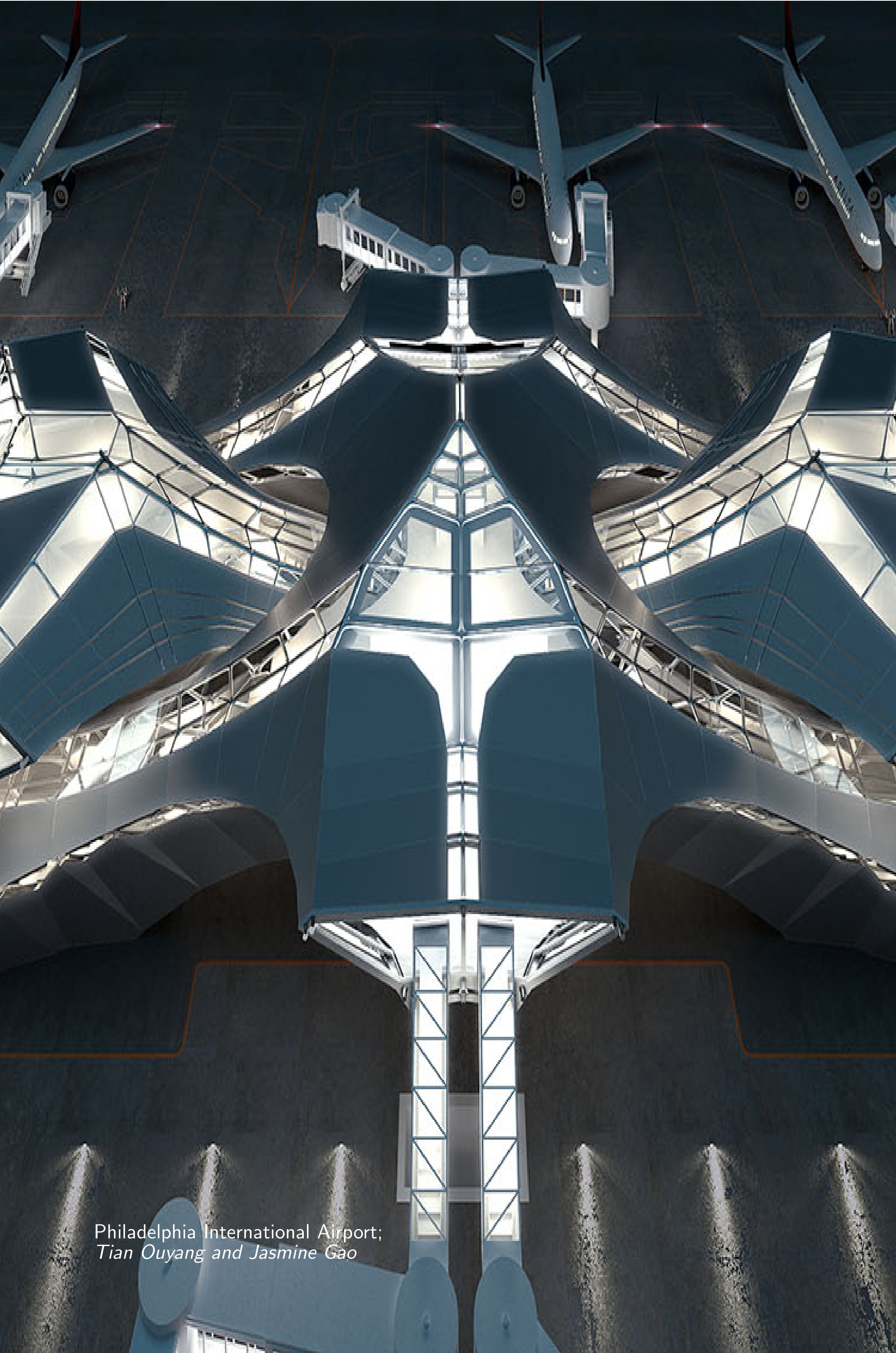

Philadelphia International Airport;
Tian Ouyang and Jasmine Gao

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1 Studio brief

In the most recent assessment examining current infrastructure conditions of the US, needs, capacity, and safety, American Society of Civil Engineers (ASCE) graded the overall quality of the US infrastructures as D+, rated from A to D where A is exceptional and fit for future and D is poor and at risk. Most of the infrastructural projects in the US were built in the 50s and 60s and were aimed to serve almost 50 years. Those projects need to be replaced immediately including half of the existing bridges in the country (The Economist, June 17th, 2014 Economist).

The ASCE grade for the aviation infrastructure is D. Although aviation industry uses technologically advanced aircrafts, their receiving airport infrastructures heavily suffer from the lack of the equivalent facilities and organization systems to handle large passenger traffics. The most recent major airport in the US was built almost 20 years ago in Denver and stays in the 28th place in the annual ranking of the top 100 airports in the world together with Boston Logan airport in 89th place according to Skytrax. Crumbling infrastructures will limit the US ability to contribute to the ever-growing global economy of the future. Thus, reconstructing/replacing the deteriorating infrastructures is unavoidable.

1.1 Problem statement and Objectives

Indeed, architects should play a significant role in designing and rethinking the future of infrastructures. In response, this studio aims to research the formal and organizational configuration of the next generation of infrastructures specifically airports.

The architecture of the future will be positively affected by technology: the technological advances in the transportation industries such as drone taxis and Hyperloop will change our perception of commuting, transitional space, and the so-called terminals. The terminals will be the interstitial spaces occur at the intersection of multiple transportation modes, and therefore pose an interesting architectural question for us: what is the terminal of the future?

Designing such architectural spaces requires utilizing specific structures. In fact, the studio will concentrate on the development of non-conventional architectural structures that can respond to the needs of such spaces and programs more succinct than the conventional solutions.

Therefore, the main research objectives of the studio can be summarized as follows:

- formal structural explorations of the efficient structural typologies suitable for infrastructural design;
- material computing research including tectonic studies on the design of structural forms using various construction materials and prefabrication techniques including as wood, stone, brick, concrete, steel, carbon fiber, etc;
- programmatic studies of the future airport terminals including the integration of high-speed ground transportation station with drone port; and,
- and finally the architectural design of the space to manifest the research.

2 Design research approach

The studio will be divided into multiple modules to design a structure for a terminal in Philadelphia airport. The following sections will expand on the approach of the studio.

Workshop on parametric 3D Graphic statics The studio will include an intense 3D graphic statics workshop introducing constrained 2D graphic statics to lay the foundation for describing geometrically constrained structural forms and their force diagrams in 3D. The workshop will present the equivalent methods in 3D and students will develop constrained spatial structures with compression and tension combined systems. Relevant readings will be suggested from Akbarzadeh et al. (2014, 2015a,b); Akbarzadeh (2016); Schumacher (2016); Harris and Li (2012).

Structural module development The students will develop parametric structural modules as building components and explore variety of equilibrium states by manipulating the force diagram. The parametric studies will be translated into physical scale models to test the space-making potential of the studies. Relevant readings will be suggested from Engel and Rapson (2007); da Sousa Cruz (2016); Moussavi (2018).

Material computation The structural forms developed in the previous step will be translated into construction materials. Algorithms will be developed to populate the structural forms with discrete/continuous elements. Innovative construction systems such as prefabrication and smart assembly of the parts will be developed and tested in smaller scales to manifest the research. Following references will be introduced to students including Block et al. (2017); Gramazio et al. (2014); da Sousa Cruz (2016); Meijs and Knaack (2009); Hauschild and Karzel (2011); Tichelmann and Pfau (2008).

Programmatic studies of future terminals In the next exercise, students will research the programmatic relationships among various transportation systems intersecting at an airport terminal involving Hyperloop, drones, and airplanes and derive their needs and necessities to efficiently lead passengers within the space.

Developing massing strategies based on structural module The programmatic studies from previous exercise will be used to develop a massing strategy for the terminal incorporating the programmatic studies. This massing strategy will also follow the geometry of the structural modules that were developed earlier.

Developing sectional strategies Student should specifically address the sectional design of the terminal to receive and circulate passengers in multiple levels from Hyperloop, drones, and airplanes. Necessary geometric and construction details should be developed to reflect various structural and architectural properties of the project. The relevant readings will be introduced including (Kerez et al., 2009; Morgan and Sobek, 2004; Conzett and Mostafavi, 2006)

3 Studio schedule

Table 1 represents the schedule including the titles of the lectures and their related exercises.

Course Sessions		Date	Titles
Part I: Developing a structural module			
	w1	Jan 16	Intense workshop on 2D/3D Graphic Statics and relevant assignments
	w2	Jan 21	workshop on and relevant assignments
	w3	Jan 28	Form finding exercises
	w4	Feb 4	Form finding exercises
	w5	Feb 11	Structural module development
	w6	Feb 18	Structural module development
Part II: Designing an airport terminal			
	w7	Feb 25	Programmatic research
	w8	Mar 4	~~No class~~ (Spring break)
	w9	Mar 11	Massing studies/figure
	w10	Mar 18	Massing studies/figure ground
	w11	Mar 25	Sectional development
	w12	Apr 1	Structural module manipulation
	w13	Apr 8	Concept development
	w14	Apr 15	Sectional development
	w15	Apr 22	Model/detail production
	w16	Apr 29	Documentation

Table 1: Studio schedule highlighting its parts and exercises.

References

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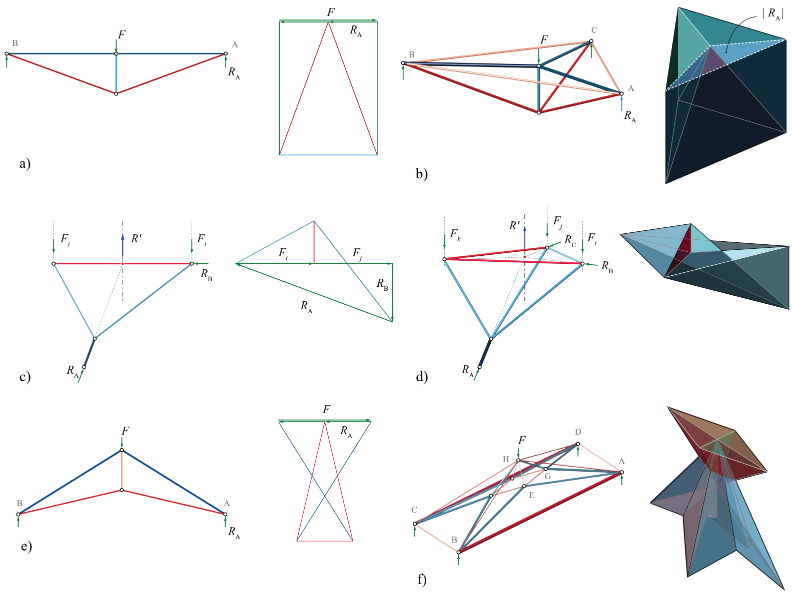

Figure 1: a) 2D form and force diagram generated using 2DGS; b) similar structural system and its polyhedral force diagram in 3D; c) 2D branching system and its force equilibrium; d) similar branching system in 3D and its force equilibrium; e) a 2D truss system and its force diagram; and f) a similar 3D truss and its polyhedral force diagram.

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