

UNIVERSITY OF TORONTO  
FACULTY OF APPLIED SCIENCE AND ENGINEERING  
ELITE Master's Program

**APS1024H1F2022 Infrastructure Resilience Planning**

**Course Outline**

**Introduction**

Our world is changing. The trends in technology have fundamentally changed the way we live, work and play. This has affected societal models and challenged familiar codes of practice and routines to mitigate inherent risk. It also concentrates value, such that the value of operations now far exceeds the value of the infrastructure that houses and enables it. Market expectation of corporation behaviour has changed, with a greatly reduced tolerance of service interruption. Climate Change is a catalyst that, through an increased frequency of extreme weather events, has caused more frequent catastrophic losses amplified by the sheer amount exposed to loss. Over the last ten years, insurance losses in Canada have exceeded \$1Bn each year, save 2015, and the trend is climbing. The cost of loss now exceeds the capacity of governments to cover. We simply cannot afford catastrophic losses; we need to adapt to the new reality. The current pandemic has exposed the fragilities in our socio-economic fabric, and resilience has become the new value, reflected in the UN's Sustainable Development Goals (SDGs) and Principles of Responsible Investment (PRI).

Everything that we create and do is for a purpose. We organize corporations, retain employees and contractors, build infrastructure, develop laws and codes of practice and conduct operations for a purpose. Protecting that purpose is much more than simply business continuity or infrastructure hardening, or even building redundant systems. It is about ensuring that the purpose continues to be delivered irrespective of whether a system component fails or some external event interrupts the supply chain. It comes down to understanding the operation, in context, and managing its inherent systems-risk, including its impact on the health of communities and individuals.

The Infrastructure Resilience Planning course explores the underlying principles of resilience planning and how it is efficiently applied today. We discuss the concepts of all-hazards, safe-to-fail, intelligent resourcing, the synergy between natural built and virtual infrastructure systems, equilibrium theory and current research into carrying capacity, rehabilitation, and protection and recovery investment balancing. We will also look at how it is being incorporated into codes of practice, engineering specifications and legislation, and how it supports the SDGs.

In this course, we will build upon your own experiences and perspectives to develop a core understanding of what resilience is, what it looks like and how to incorporate it into planning. You will investigate approaches to resilience planning in different jurisdictions, exploring how context and culture influence its practice. You will also conduct a project in small groups, in which you investigate a real client requirement and propose a resilience strategy from first-principles. When you complete this course, you will be able to direct resilience planning in engineering projects, conduct the analysis and develop and present strategy proposals.

## Course Designation

**APS1024 Infrastructure Resilience Planning**, starting Saturday, 10 September 2022. The course will be full days, from 09:00 to 17:00 with 30mins for lunch, and run over four Saturdays, either in class or on-line (depending on the current pandemic restrictions). The schedule will be advertised on Quercus. If the course does move to on-line teaching, we will be using Zoom, which you can access through Quercus.

A CRCI foundation course, it is recognized by the international Register of Security Engineers and Specialists; <http://www.crci.utoronto.ca/education/academic/infrastructure-courses>.

## Calendar:

- 10 Sep 22 Course introduction and administration. Issue Assignment and Project.  
We explore the purpose of infrastructure and the context in which it is used; how this context changes both operationally and in terms of wider hazard risk. We investigate the nature of resilience, how it differs from protection, and what it means for communities and businesses. We discuss the drivers of resilience, exploring sustainable economic development, ‘equilibrium’ and ‘carrying capacity.’ We then focus on the primary tools, working from first principles, starting with location risk analysis, calculation plans, and mission analysis, before moving to more complex tools including IPOE, Incident Sequencing, Demand & Dependency Management, and Resilience-Protection Investment Balance. We look at how some of these tools are brought together to deliver specific frameworks for community or utility infrastructure resilience. We then deep dive into the theory and practice of Operational Resilience, All-Hazards and Recovery planning parameters.
- 17 Sep 22 Review of Assignment 1. Issue Assignment 2.  
We explore the concept of Security Integration at the Strategic, Operational and Technical levels, the application of All-Hazards and the  $\Phi_\alpha$  &  $\Phi_\beta$  trade-off and investment balance with resilience and recovery. We will look at security systems in capability terms and how technological change affects their value and efficacy specific to an operation.  
Site Survey – assessing the operational resilience for a major international event – walk-through / talk-through with syndicate and open forum discussions of concept solutions. Ordinarily, this would be at a specific site on campus and in-person. However, this may be a worked example if pandemic restrictions dictate.
- 24 Sep 22 Review Assignment 2. Discuss Project progress.  
Before exploring the concept, technology, and practice of control systems, we will continue looking into the capability requirements of various security and recovery systems. We now put all of the components together to build an operational resilience concept and plan, through a combination of lecture, syndicate work and open forum discussion. We review the process of producing a Resilience Plan and what it means for operational and site assurance, how this affects value and even debt/equity ratios for capital investment.
- 1 Oct 22 Present Project.  
Examination

## Evaluation

There are two essay-type assignments that will require open-source research and critical analysis. Each assignment carries 20% of the total course marks. The assignments are designed specifically critical issues that will allow you to understand how to apply what you learn, wherever and for whomever you may be working in the future.

The project is assigned by group, each with real clients, conducting real resilience assessments in real time. The clients will assess the quality of product. The project carries 30% of the total course marks.

**The Final Exam** represents 30% of the total course marks. The two-hour written examination comprises 3 essays selected from 5 possible titles. The examination is open book.

Throughout, credit will be given for demonstrating a clear understanding of the concepts, principles and application over specific processes or formulae.

## Materials

You are expected to read “After the Flood: Exploring Operational Resilience” by Hay. This book was written specifically for this course, consolidating multiple references and concepts. This will provide you with useful references after the course. You should also read “The Edge of Disaster” by Flynn. You will likely wish to buy these two books. You will find Lewis and MacAulay very useful references throughout, and you may wish to rent these two books. New and second-hand copies of the books are available from the University Bookstore on the corner of St George St and College St.

Address course questions and course work submissions to me at [alec.hay@utoronto.ca](mailto:alec.hay@utoronto.ca)