

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

**APS1024H1F2020 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 that we use to mitigate inherent risk. It has also caused a concentration of value in which the value of operations now far exceeds the value of the infrastructure that houses and enables it. Market expectation of corporation behavior 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 that are amplified by the sheer amount that is exposed to loss. Insurance losses in Canada over the last 8 years 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. The current pandemic has exposed the fragilities in our socioeconomic fabric and resilience has become the new value.

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 your operations, in context, and managing the inherent systems risk. The Infrastructure Resilience Planning course will explore the underlying principles of resilience planning and how it is efficiently applied today. We will discuss the concepts of all-hazards, safe-to-fail, intelligent resourcing, 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.

In this course we will build upon your own experience 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 will investigate a real 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, 12 September 2020. The course will be full days, from 09:00 to 17:00 with 30mins for lunch. It will 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 BB Collab, which can be accessed from Quercus.

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

## Calendar:

- 12 Sep 20 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 business. 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.
- 19 Sep 20 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 effects 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.
- 26 Sep 20 Review Assignment 2. Discuss Project progress.  
We will continue looking into the capability requirements of various security and recovery systems, before exploring the concept, technology and practice of control 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.
- 3 Oct 20 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 project is a remote resilience assessment of an international organisation facility in an austere environment. Ordinarily, students would be assigned in groups to real clients to conduct real resilience assessments in real time, with those clients assessing the quality of product. Due to the current constraints, this is not possible this year. 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)