Syllabus MOOC DelftX NGI101
Next Generation Infrastructures, part 1

Understanding the socio-technical complexity of infrastructure systems in the 21st century
A. Basic information

1. Introduction
Welcome to the MOOC Next Generation Infrastructures, part 1! This syllabus will describe the learning objectives for the course, the content and explain the course grading system.

Part 1 focusses on the theoretical framework and lasts 7 weeks including a final test. We will explore the future challenges of infrastructure design, management and governance. You will learn why infrastructural systems are becoming more and more complex and why they are so difficult to design and manage. Building on your understanding we will then introduce a number of tools/approaches to cope with this complexity. We will also discuss a number of case studies from all over the world.

During part 2, starting in September or October 2014, you will have the opportunity to study a specific infrastructure of your choice in more detail and explore ways to improve its resilience, security, affordability and flexibility.

2. Learning Objectives Part 1
After this course you will:
A. Understand why infrastructures are becoming more and more complex from different perspectives (historical, globalization, new actors, emergence, new technologies, new producers) and why the traditional technology, policy and management interventions can be counterproductive.
B. Understand the main driving forces behind these developments.
C. Understand the implications for the design and governance of tomorrow’s infra-systems.
D. Be acquainted with tools and instruments to analyse problems of infrastructures.
E. Consider infrastructures as complex systems (‘the complex systems approach’).

During the course we will make reference to a number of case studies around the globe. We will also invite you to ‘upload’ your own cases studies and experiences for further discussions during the course.

We know that some of you will simply audit the course because of time or other constraints. Our weblectures and readings will indeed give you the basic understandings. However, we still hope that you will join the discussions at any time. By collaboration with other students, by sharing your own reflections and by completing the assignments, you - and your fellow students! - will gain the most from this course. And eventually this will help to shape better infrastructures for a better society.

3. Prerequisites
The prerequisites for this course are analytical skills, curiosity about new developments and an interest in the design and governance of infrastructures for a better future.

4. Course materials & workload
We will have a number of web lectures each week (10-15 minutes average) and corresponding course materials (further readings, case studies, references to additional resources) as well as quizzes, moderated group discussions and an invitation to submit your own case study. We will return to your cases during the course.

The expected workload throughout the course will be approximately 8 hours per week but this will depend a lot on your ambitions and prior knowledge.
Every week quizzes and assignments will be used to test whether you understand the concepts introduced to you. The quizzes and assignments also function to self-monitor your progress which is indicated at the dashboard of the course. For grading and certificates, see part C.

Communication will occur via the announcements, e-mail, and the discussion forum. Announcements will mainly be used to address practical matters throughout the course and the discussion forum should be used to discuss the content of the course. We invite you to use the discussion forum actively! Experience has shown us that the discussion forum can play a vital learning role in MOOCs. Students can pose their questions or topics of discussion and other students can freely respond to these topics. In this way you will also be able to help and learn from each other. The discussion forum will also be monitored by the instructors and on a weekly basis they will try to address the main questions raised via weekly feedback videos.

5. Set-up and logistics
- This is a multidisciplinary course. For this reason you will see a lot of different teachers.
- Each week we will start with a description of the learning objectives.
- Each week (apart from week 1) we will end with 'connecting the dots': we will apply the new insights to a specific case study or discuss your questions with practitioners.
- We will also highlight 2 upcoming events ('Electrifying Africa and the NG Infra conference in May 2014). During the NGG Infra conference, we will record a keynote lecture for the MOOC.
- The assignments at the end of each week will focus on understanding, analysing and assessing an infrastructure which you have selected. As part of these assignments we will pay attention to some essential analytical skills such as problem demarcation (week 1) and actor analysis (week 2 and 3).
- This course is not a linear course. You may go into depth in some part of the course depending on your interests and available time. Because of the multidisciplinary character, some parts may already be familiar; other parts may involve a steep learning curve. Our focus is on discussions and sharing knowledge, not on closed questions.

6. Networking and sharing knowledge
In this course we also count on your generosity. Become part of the network! Share your thoughts and ideas. We have a few mechanisms in place:
- News page (wiki). Here you can upload any news on infrastructures you think is worthwhile to share. Think about articles and photos in newspapers or any other media coverage.
- A Twitter account: #DelftxNGI
- Discussion forum. Here you can raise any questions on the content of the course and/or seek collaboration with other students.
- Last but not least a world map. We will use the world map for uploading the assignments and to share them with other students. Other students can react. Obviously, you can also make anonymous contributions.
- In many other MOOCs, students have set-up Facebook pages, Google hang-outs or similar facilities. Please do feel encouraged to do the same.
B. Content of the course per week

This course aims to teach you what makes designing and operating infrastructures complex from a social perspective (economic, values, security, actors, human behaviour, and policies) and from a technical perspective. While progressing through the course you will also learn how to cope with complexity and what the implications of complexity are for designing infrastructural systems. Below you will find a brief description of the content for each week.

Week 0: Welcome
This week consists of a general introduction to the course, an invitation to introduce yourself on our world map, a first reading and the opportunity to update your information skills if necessary.

Week 1: Introduction to NGI

![Image](image_url)

Figure 1: Electricity network, railway network and ICT network (operating the signs for the railway).

In this week we will underline the essential services infrastructures provide and how dependent societies have become on these services. We will introduce not only the technical but also social complexity. Furthermore, we will describe key developments like internationalization of physical infrastructure networks and markets, convergence, inverse infrastructures and increasing interactions between different infrastructure systems to name a few. Furthermore, we will pay attention to the analytical skill ‘problem demarcation’.

Week 2: Infra-systems

Infrastructure systems are traditionally understood as engineered systems (composed of physical links and nodes), the behaviour of which can be fully understood and predicted. In this course week, the traditional engineering perspective is challenged with two new perspectives: the perspective of complex systems and the perspective of socio-technical systems. We will illustrate that these new perspectives are essential to understand the structure and behaviour of today’s infrastructure systems.

We will first pay attention to the general characteristics of complex systems. We will introduce the term infra-systems to mark the difference with the traditional engineering perspective, and we introduce the challenges of governing infra-systems: how do we ensure reliable and affordable infrastructure bound services in complex socio-technical infra-systems, which defy traditional steering approaches?
We will also make you familiar with the analytical skill ‘actor analysis’.

**Week 3: Fuzzy Borders**

This week we will focus on the often ill-defined system boundaries of infrastructures. The reason is that infrastructures continually evolve (because of new technologies, new policies, interdependencies, internationalization, changing public values, etc.) and consist of interconnected networks (which can cross sectors and national borders).

We start with the physical network dimension and the operational challenges, then add the actor network dimension (changing responsibilities, new institutes, privatization, changing rules, changing demands) and conclude with the governance challenges of interconnected networks.
Figure 2: Change sides of the road while crossing borders. The concept design is called ‘The Flipper’ from NL Architects. This bridge does not only allow you to physically change sides of the road, but also aims to make the road users aware of the fact that they are entering a zone where the normal driving lane is opposite by using curves in the road (Quick, 2013).

Week 4: Modelling Complexity

This week is all about introducing you to a selection of modelling techniques that can help us deal with the complexity encountered and say something meaningful about infrastructural systems.

First of all we will give you an insight into the different kind of modelling techniques that exist, how they function and when they can be used. Modelling techniques discussed are:

- Network theory
- Discrete Modelling
- Agent Based Modelling
- System Dynamics
- Serious Games

Partly connected mesh
Example: Road network

Interconnected star
Example: Wireless telecom network

Central ring with trees
Example: Electricity grid; Transmission network (Ring) plus distribution grids (Trees)

Figure 3: Graphical representation of different network topologies. These networks have been generated in an agent-based-model for further simulation purposes (Dankers, Kerckhoffs, & Oei, 2013).
Week 5: Assessing Infra-systems
Given the importance of the function that infrastructures fulfil, this week will give you an insight on how to assess the performance of infrastructural systems. We will discuss:

- The concepts of robustness and resilience. How can an infrastructure resist random failures? How will it deal with target attacks or virus spreads?
- Typical performance indicators of infrastructures and which are used by network regulators? How are tariff systems designed?
- Public values (accessibility, availability, affordability, acceptability) and the trade-offs between these values (choices being made).

![Northeast blackout of 2003 seen from outer space.](http://www.physics.sfasu.edu/astro/social/social086.htm)

*‘The blackout affected an estimated 10 million people in Ontario and 45 million people in eight U.S. states. The blackout’s primary cause was a software bug in the alarm system at a control room of the FirstEnergy Corporation in Ohio. Operators were unaware of the need to re-distribute power after overloaded transmission lines hit unpruned foliage. What would have been a manageable local blackout cascaded into widespread distress on the electric grid.’* (Wikipedia, 2013)

Week 6: Governance
Due to the social and technological complexity of infrastructural systems their behaviour is very difficult to predict and therefore also to govern and to manage. We will explore a number of options that policy makers and managers can employ to shape the behaviour of infra-systems. Concepts that will be used are:

- Variety and selection versus analysis and instruction.
- ‘The invisible hand’ as a price and quality driving force seen in markets
- Risk sharing models
- Trial and error intervention policies
- Introduction to monitoring systems
- Reversible interventions
- The use of redundancy in networks
- Value sensitive design.

C. Quizzes, assignments and grading

- After each (series of) weblecture(s) there will be a number of questions, discussions or polls. They are meant to reflect on your new knowledge. These do not count for the final certificate.
- At the end of each week there will be one or two assignments for upload on a world map. The assignments are meant to learn in a systematic way the complexity of infrastructures: problems, actors, developments, challenges for the future and ways to approach these problems and challenges. You can select your own infrastructure to work on. All the assignments can be discussed with your fellow students.
• The final assignment (week 7) is a synthesis of the assignments during the weeks before. We will ask you to write a short issue paper (around 2 pages).

If you want to obtain a certificate, you will have to finalize at least 3 out of the 6 the assignments during week 1-6 and submit an issue paper (week 7). Details on the assessment of the issue paper will follow.

We will also make an analysis of all your contributions and the similarities and differences in countries and publish this in August 2014. Learning is sharing!

The authors of the two best papers will be invited to participate in the Next Generation Infrastructures Conference in Vienna in September 2014. In order to qualify for the contest you also have to pass the course which means you have to finalize at least 3 out of 6 assignments during week 1-6. Selection of the top best issue papers occurs based on their peer reviews. Out of this list we’ll select the two best issue papers based on a re-assessment from our side, based on the same criteria the peer assessment and self-assessment are based on.

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References


GOOD LUCK AND ENJOY THE COURSE!
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