Innovative Solutions for Climate Change effects on Transport Networks

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Climate Change
Consequences on Transport Networks (I)

- Shifts in tourism & agricultural production due to increased temperature
- Rise in sea levels & associated increase in storm surges (frequency & intensity)
- Shifts in weather patterns
- Precipitations

- Shifts in Passenger & Freight Transport
- Coastal flooding
- Beach erosion
- Infrastructure disruption
- Delays, detours, cancellations
- Affect road safety
- Increase Congestion
Consequences on Transport Networks (II)

All the above, plus:

Impact on Generalized Costs of various Transport Modes

Climate Change causes Large GDP Losses

STRONG, EARLY ACTION NEEDED TO OUTWEIGHT THE COSTS

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THE TARGET:

Improve the Resilience of Transport Networks to Climate Change & Extreme Weather Conditions & simultaneously:

Reduce Cost of Maintenance

Extend Life Time of Constructions

Increase Capacity
How?

• Innovative & Practical Solutions
• Technological Integration &
• Adaptation of Lessons Learnt
1. Road Networks (I)

- Classical Methods: Increase Resilience

- The example of the oldest Ancient Road preserved until today is in Crete (1700 BC), 50 km long, connecting Knossos with Gortyna and the South.

1. Road Networks (I.a)

- What engineers had found in 4000 BC was that:
  
  Multiple – Layer construction, as well as Adequate Drainage System,

was a prerequisite for the protection of their roads against extreme weather phenomena.
1. Road Networks (II)

• Classical Methods : Increase Resilience

- Babylonians used a naturally occurring asphalt (nanoclays) to reinforce their roads. We can still see patches of the old pavement in the ancient city (installed in ~ 600 BC).

- Michigan Technological University are testing nanoclays in asphalt mixtures, in order to improve viscosity, provide stiffness and resist hot weather and heavy traffic.
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1. Road Networks (III)

The Risk of Flooding – the problem

- Not only for coastal regions
- Can cause damages, travel delays, bridge collapses
- Huge cost consequences
1. Road Networks (III.a)

The Risk of Flooding – Innovative Approach

- **Ex-ante** information on which parts of the network are:
  - Most vulnerable
  - Most critical in terms of mobility/accessibility
  - Crucial facilities (e.g., hospitals)

**Is essential for decision-making on potential adaptation strategies**
1. Road Networks (III.b)

There is a growing body of research in the area:

**US DHS Science & Technology Directorate did it *** after Katrina:*

- New computer software predicts how water will spread!!! (FLOOD SIMULATION TOOL)
- Modeling flood inundation (eg: doom failures, levees, tides, tsunamis), predicts how water will move around buildings, bridges and roads.
- Seamless web application, combining speed + sophisticated technology → to visualize a flood → address consequences, really fast
1. Road Networks (III.c)

- **Other tools:**
  - State-of-the Art Geospatial viewers
  - Real-Time information about weather
  - Monitoring & Information Systems (ICT)

**In order to:**
- Decide strategy
- Provide Information
- Dynamic Rerouting
- Save Life, Time, Cost
2. Railway Networks (I)

- Whilst Rail is relatively safe, failures can have huge consequences.
2. Railway Networks (II) : the problem

Climate Change consequences:
- Scouring of bridge foundations due to flooding
- Heavy rainfall induced landslides

Can Cause:
- Critical elements of the rail network (bridges, tunnels, earthworks) being at risk of failure

Results in:
- Loss of Life
- Replacement cost (in M€)
- Line closures (loss of capacity) – can last for months

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2. Railway Networks (III) : SmartRail

The **SMARTRAIL** research project, performed by EURNEX, 3 Research Institutes & 5 universities, proposes a framework for infrastructure operators to ensure:

- Safe
- Reliable
- Cost Efficient
- Sustainable

operation of railway networks, through a **holistic approach**:

- State-of-the Art Infrastructure Inspection
- Assessment of Infrastructure
- Rehabilitation Technologies
- Whole-Life-Cycle Cost Analysis scenarios

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2. Railway Networks (III.a) : SmartRail

**Elements Required:**
- An embedded sensor network
- State of the art Structural Health Monitoring (SHM)
- A suite of low-cost remediation measures that are region-specific
2. Railway Networks (III.b) : The SmartRail project

**How it works?**

(i) Monitoring establishes current condition  
(ii) SHM defines reliability/safety  
(iii) Remediation required?  
(iv) LCA quantifies cost and benefit
2. Railway Networks (III.c) : SmartRail

Monitoring and Inspection
- Network of embedded sensors
- Instrumented slope – Site chosen – instrumentation installation imminent
- NDT testing to investigate slopes
- Identifying bridge scour

Assessment & Modeling
- Probability-based approaches
- Use of sensor data to analyze current state
2. Railway Networks (Ill.d)
2. Railway Networks (III.e) : SmartRail

• Remedial measures for steep slopes
2. Railway Networks (IV)

• **Conclusion:**

The Innovative SMARTRAIL models will allow the Infrastructure Manager to make rational decisions, best use of the limited funding, and long-term maintenance of the rail infrastructure networks.
3. Ports & Coastal Areas (I) : the problem

- Rise of Sea level
- Extreme weather conditions
- Coastal flooding
- Storm surge
- Wind surge → Waves
3. Ports & Coastal Areas (II) : The case of Greece

- 16,300 km of Shoreline
- More than 1,000 ports & shelters
- Relatively small rise in Sea Level anticipated
- Wind Surge → Wave surge
- Coastal Flooding
3. Ports & Coastal Areas (III)

The Ancient Inland Ports – “KOTHONES”

- Protected basins, connected with the sea through narrow channels. Ancient Greeks drove their ships there, in order to protect them against weather & piracy.

- **Falasarna** in the west coast of Crete and **Lehaion** in Korinthos, Peloponese had such establishments.
3. Ports & Coastal Areas (IV)

- Beach flooding / erosion: a (bad) lesson learnt

In the case of engineering constructions against wave surges (breakwaters, seawalls, gabions), their own hydrodynamic behavior affects the wave environment, often causing:

- Erosion or alluviation
- Beaches to dissipate, rendering them useless to beachgoers
- Inappropriate measures, in many cases, have solved coastal erosion locally but exacerbated erosion problems at other locations, up to tens of km away.

Better assessment & design is required
3. Ports & Coastal Areas (V)

Coastal Engineering – the Past

• Starts with the development of ancient civilizations - together with the origin of maritime traffic (perhaps before 3500 BC).
• Harbour works were built by hand, often in a grand scale.
3. Ports & Coastal Areas (VI)

Coastal Engineering – the Future

21st Century: Need sustainable means for dissipating wave energy & protecting coastal development:

• **Coastal Management**
• **Coastal Zones Monitoring**: wireless sensor networks can be deployed to set up a coastal erosion monitoring system, scaled accordingly

  - Video-based Monitoring
  - Event-Warning Systems (tsunami, storm surge, close floodgates)
  - Shoreline Mapping (dynamic nature)
3. Ports & Coastal Areas (VII)

- **Catalunians did it:** Polytechnic University of Catalonia (UPC) have developed a method for evaluating the vulnerability of coastal regions to the impact of storms!!!
Conclusions:

Early Action
- Increases Capacity
- Extends Life-Time of Constructions
- Safe & Reliable Transport
- Saves Money

Holistic Approach
- Whole-Life Cycle Analyses
- Integrate Successful Practices
- Climate Parameters in Design

Innovation & Technology
- Early Warning Systems
- New tools for Strategic Planning
- Dynamic addressing of Cl. Ch. consequences

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Policy Adjustment Measures (I)

- **Definition of Functionality**
  - Operational?
  - Safe?

(According to criticality, in order to determine the respective strategy)

- **Future Design**
  - Integrate Climate Change parameters
  - Develop Networks in safe areas

- **Promote Practical Innovative Solutions in order to**
  - Reduce Cost,
  - Optimize Transport

- **Decide Strategic Land Use**
  - Move economic & Transport activities away from vulnerable areas, especially in future design
Policy Adjustment Measures (II)

• Integration among Sectors / Between Nations

• Decide Strategic Land Use & Networks: Move economic & Transport activities away from vulnerable areas, especially in new design.

• Foster the European Model Law for Coastal Management (UNEP) as a guideline

• Climate Change Observatory: Transport oriented
Any Questions?

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