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 → Shifts in Passenger & Freight Transport
- Rise in sea levels & associated increase in storm surges (frequency & intensity) → Coastal flooding; Beach erosion
- Shifts in weather patterns → Infrastructure disruption; Delays, detours, cancellations
- Precipitations → Affect road safety; Increase Congestion

Consequences on Transport Networks (II)

All the above, plus :

Impact on **Generalized Costs** of various Transport Modes

↓

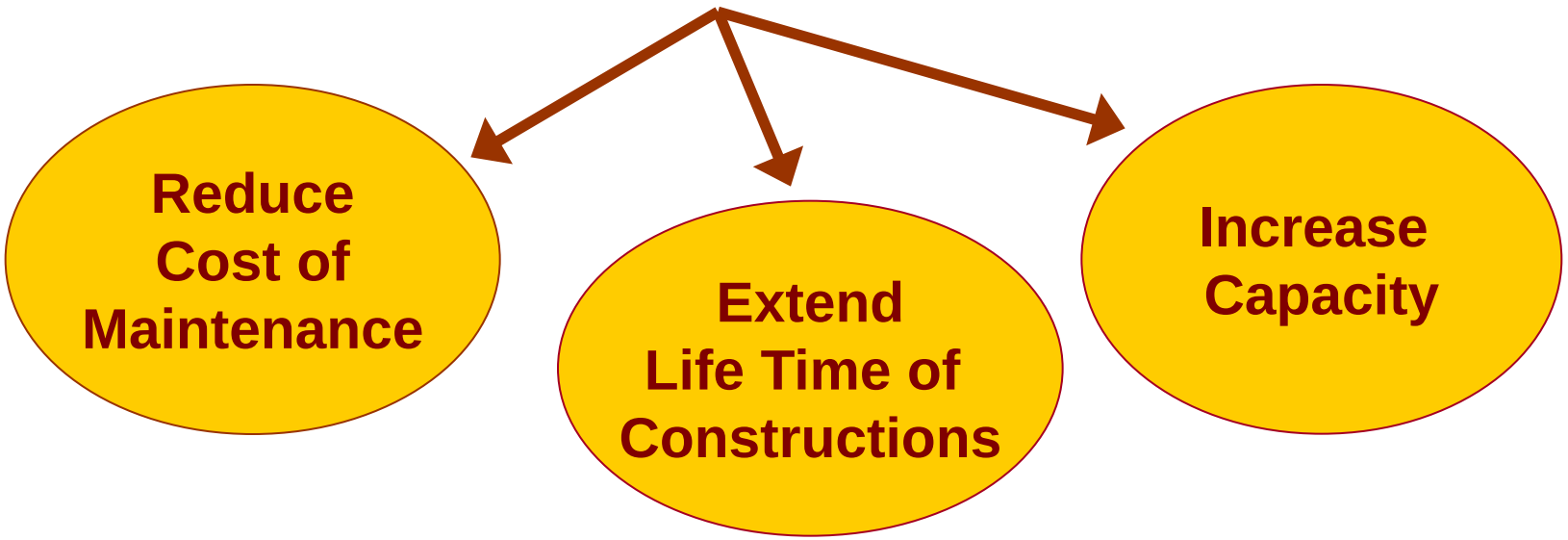
Climate Change causes **Large GDP Losses**

↓

STRONG, EARLY ACTION NEEDED TO OUTWEIGHT THE COSTS

THE TARGET:

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



How ?

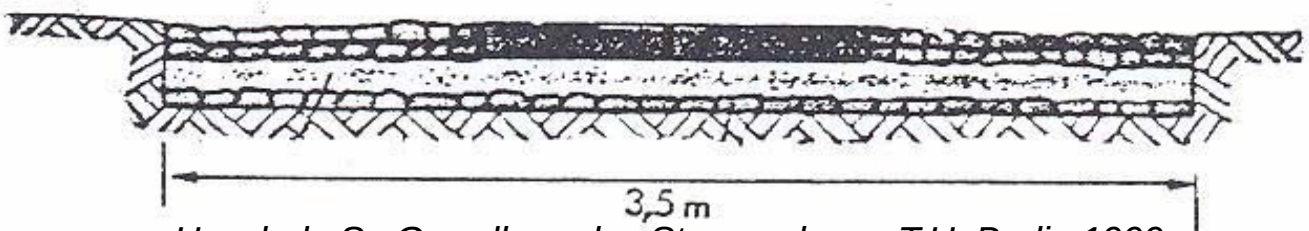
- Innovative & Practical Solutions
- Technological Integration &
- Adaptation of Lessons Learnt

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.



Huschek, S.: Grundlage des Strassenbaus, T.U. Berlin 1999

1. Road Networks (I.a)

- What engineers had found in 4000 BC was that :

→ Multiple – Layer construction, as well as

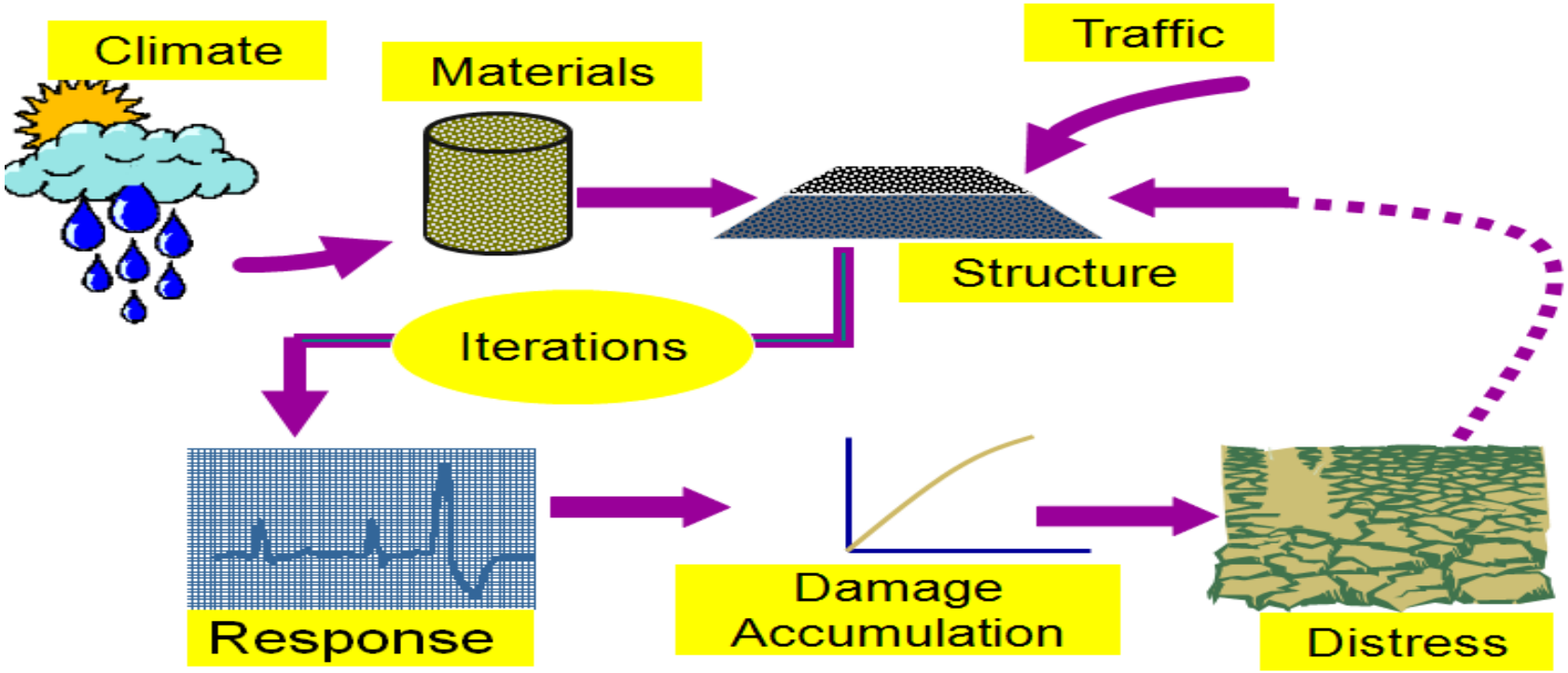
→ Adequate Drainage System,

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 occuring 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.


Climate
Materials
Traffic
Structure
Iterations
Response
Damage
Accumulation
Distress

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

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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 (eg : 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 @ risk of failure

Results in :

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

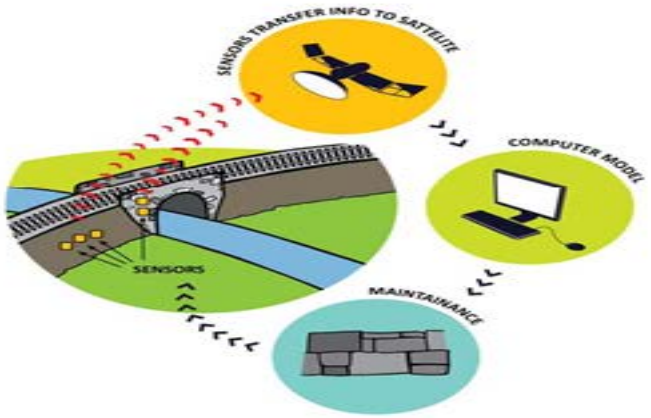
2. Railway Networks (III) : SmartRail

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

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

2. Railway Networks (III.a) : SmartRail



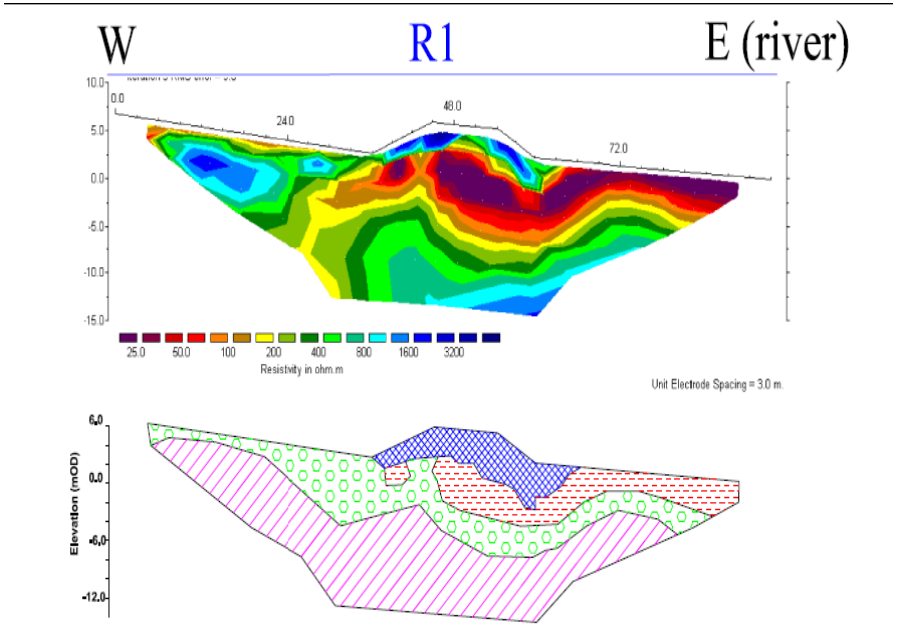
Elements Required :

- 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 (III.d)

2. Railway Networks (III.e) : SmartRail

- **Remedial measures for steep slopes**

2. Railway Networks (IV)

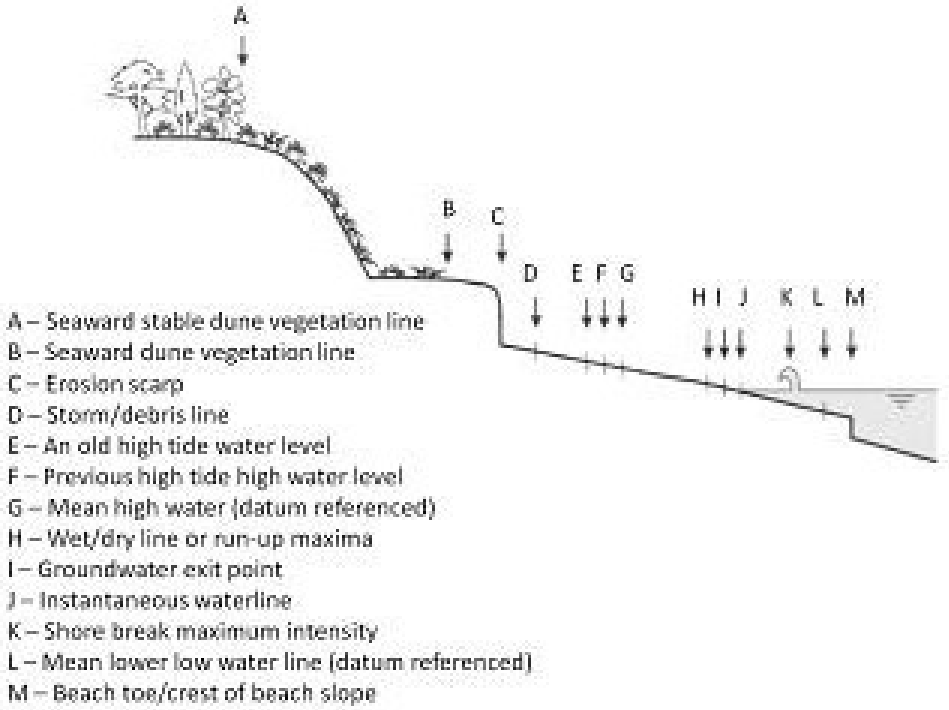
- **Conclusion :**

The Innovative SMARTRAIL models will allow the Infrastructure Manager

- to make rational decisions
- best use of the limited funding
- 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

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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 :

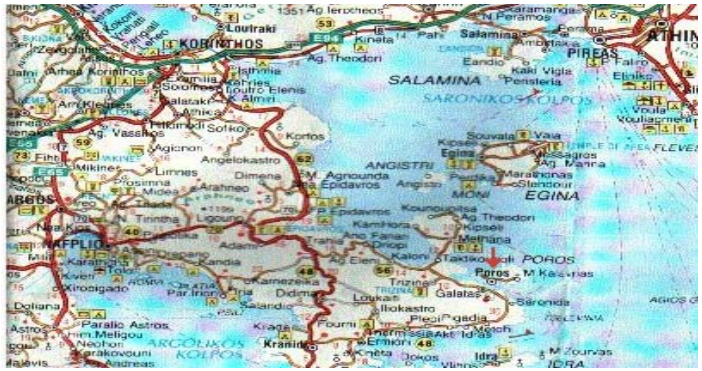
- Erosion or alluviation
- Beaches to dissipate, rendering them useless to beachgoers
- Inappropriate measures, in many cases, have solved coastal erosion locally but exacerbated erosion problems at other locations, up to tens of km away.

→ **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

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

HELLENIC REPUBLIC
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TRANSPORT AND NETWORKS

Any Questions?

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