



Center of Technology and Systems



# Collaborative Cyber Physical Systems for Disaster Management in Smart Communities

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## CHALLENGE: 11 SUSTAINABLE CITIES AND COMMUNITIES



# SUSTAINABLE DEVELOPMENT GOAL 11

Make cities and human settlements inclusive, safe, resilient and sustainable



Among different targets, two important ones are directly related to Disaster management:

**"significant reduction of the number of deaths and the number of people affected by disasters"**

and

**"substantial increase in resilience to disasters".**

Guidelines to have holistic disaster risk management at all levels could be seen in Sendai Framework.

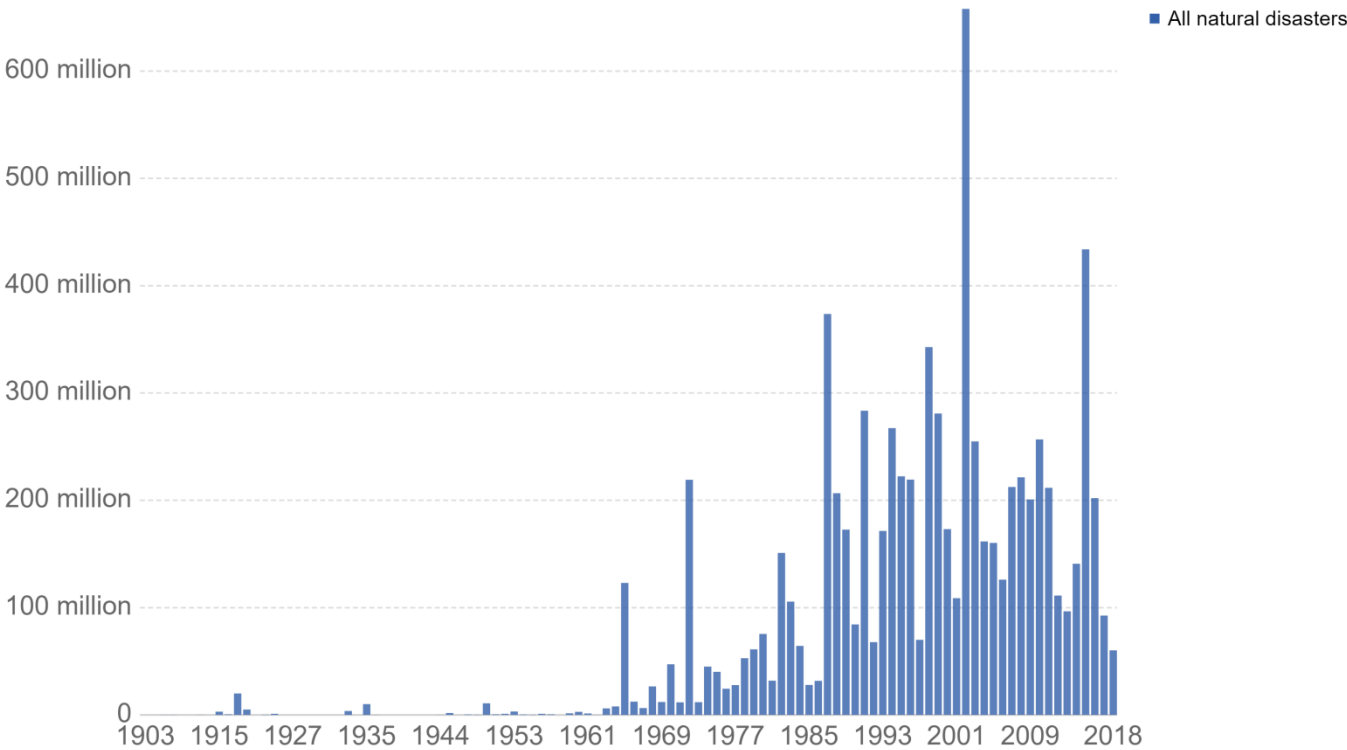
Sendai Framework  
for Disaster Risk Reduction  
2015 - 2030

# Disasters are an integral part of Human life

## Global number affected by natural disasters, All natural disasters

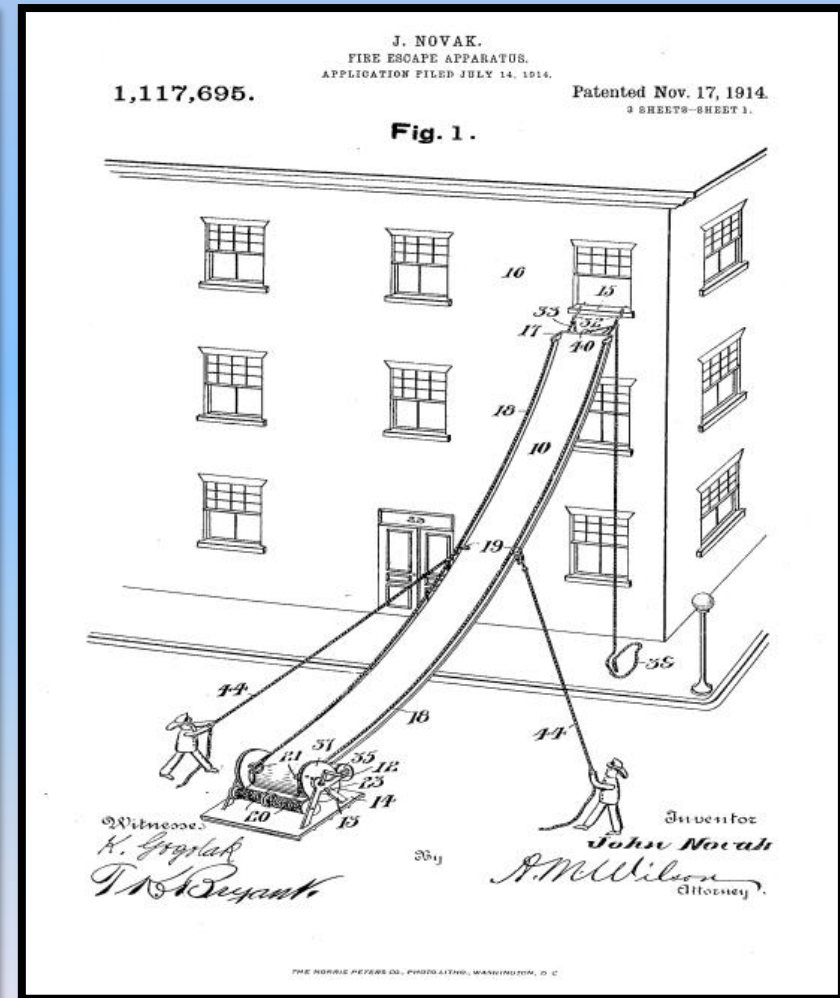
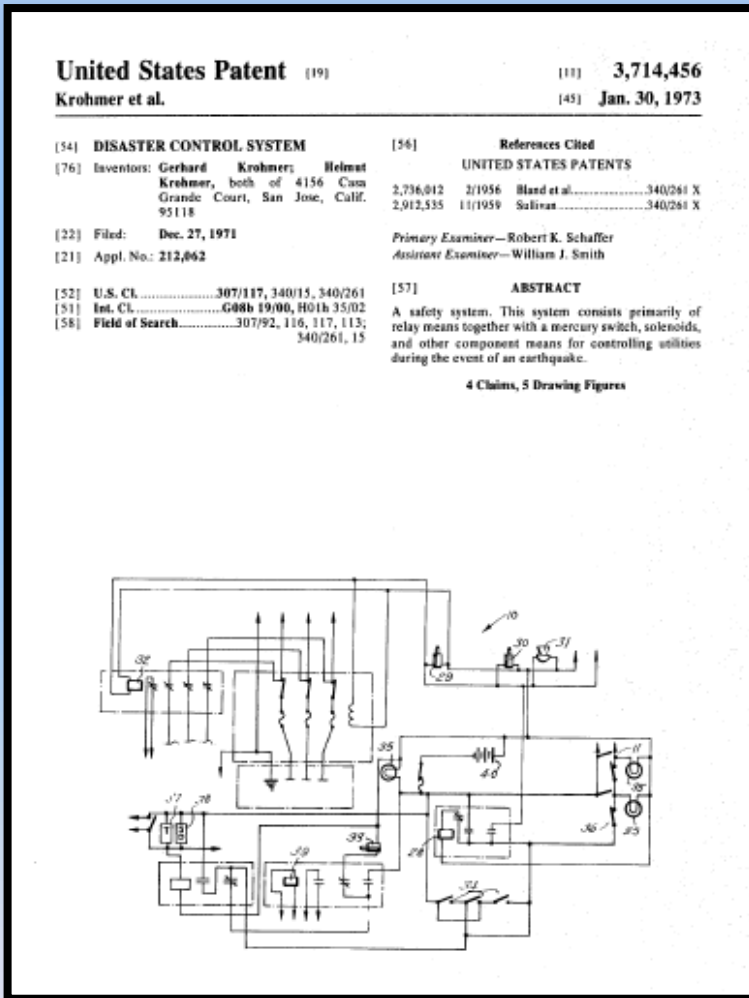
Global total number of people affected by natural disasters. This is defined as the sum of the injured, affected and those left homeless after a disaster.

Our World  
in Data



Source: EMDAT (2019): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium  
OurWorldInData.org/natural-disasters/ • CC BY

Holistic Disaster Risk Management has a long history enjoying a rich knowledge and vast experience in Human life, in which a wide range of researchers from different disciplines are involved



But something is wrong!

Every year over 150 Million people are affected by Disaster

Total economic loss is estimated to be more than hundreds of Billion of Euros.


# It's time to change thanks to Incredible changes in Technology!

## Disaster management: findings from a systematic review

Emanuele Lettieri, Cristina Masella and Giovanni Radaelli  
*Department of Management, Economics and Industrial Engineering,  
Politecnico di Milano, Milan, Italy*

## Shift Paradigm!

## A smart disaster management system for future cities

Alazawi, Z., Alani, OYK , Abdjabar, MB, Altowajiri, S and Mehmood, R 2014, 'A smart disaster management system for future cities', in: *Proceedings of the 2014 ACM international workshop on Wireless and mobile technologies for smart cities - WiMobCity '14*, ACM Digital Library, New York, pp. 1-10.

2017 IEEE 2nd International Conference on Big Data Analysis

## Using Big Data to Enhance Crisis Response and Disaster Resilience for a Smart City

Chuanjie Yang, Guofeng Su, Jianguo Chen

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Procedia Engineering 71 (2014) 403 – 409

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## Big data and disaster management: a systematic review and agenda for future research

Shahriar Akter<sup>1</sup> · Samuel Fosso Wamba<sup>2</sup>

## Simulation of Pedestrian Evacuation in a Room under Fire Emergency

Shu-chao Cao, Wei-guo Song\*, Xiao-dong Liu, Nan Mu

*State Key Laboratory of Fire Science, University of Science and Technology of China, Hefei 230027, China*

## Smart Disaster Detection and Response System for Smart Cities

Azzedine Boukerche and Rodolfo W. L. Coutinho  
School of Electrical Engineering and Computer Science (EECS)  
University of Ottawa, Ottawa, ON, Canada

Email: boukerch@site.uottawa.ca, rodolfo.coutinho@uottawa.ca

## Pervasive Emergency Support Systems for Building Evacuation

Avgoustinos Filippoupolitis, Gokce Gorbil and Erol Gelenbe

*Department of Electrical & Electronic Engineering*

*Imperial College London*

*London, UK*

{afil, g.gorbil, e.gelenbe}@imperial.ac.uk

## A Smart Disaster Management System for Future Cities

Zubaida Alazawi, Omar Alani  
School of Computing Science and Engineering  
University of Salford  
Manchester, UK  
e\_zubaida97@yahoo.com  
o.y.k.alani@salford.ac.uk

Mohammad B. Abdjabar  
School of Engineering  
Al-Mustanseriyah University  
Baghdad, Iraq  
mbakr67@yahoo.com

*International Symposium on Engineering, Technology and Mechanical Engineering (EAME 2015)*

## Intelligent Space for Building Fire Detection and Evacuation Decision Support

DESIGN OF AN INTELLIGENT INDIVIDUAL EVACUATION MODEL  
FOR HIGH RISE BUILDING FIRES BASED ON NEURAL NETWORK WITHIN  
THE SCOPE OF 3D GIS

U. Atilla<sup>a</sup>, I. R. Karas<sup>b</sup>, M. K. Turan<sup>c</sup>, A. A. Rahman<sup>d</sup>

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<sup>c</sup> Department of Computer Engineering, Karabuk University, Karabuk, Turkey - [mkanalt@gmail.com](mailto:mkanalt@gmail.com)

<sup>d</sup> Department of Geoinformatics, Universiti Teknologi Malaysia, Johor, Malaysia - [alias.fkg@gmail.com](mailto:alias.fkg@gmail.com)



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Procedia Engineering 71 (2014) 397 – 402

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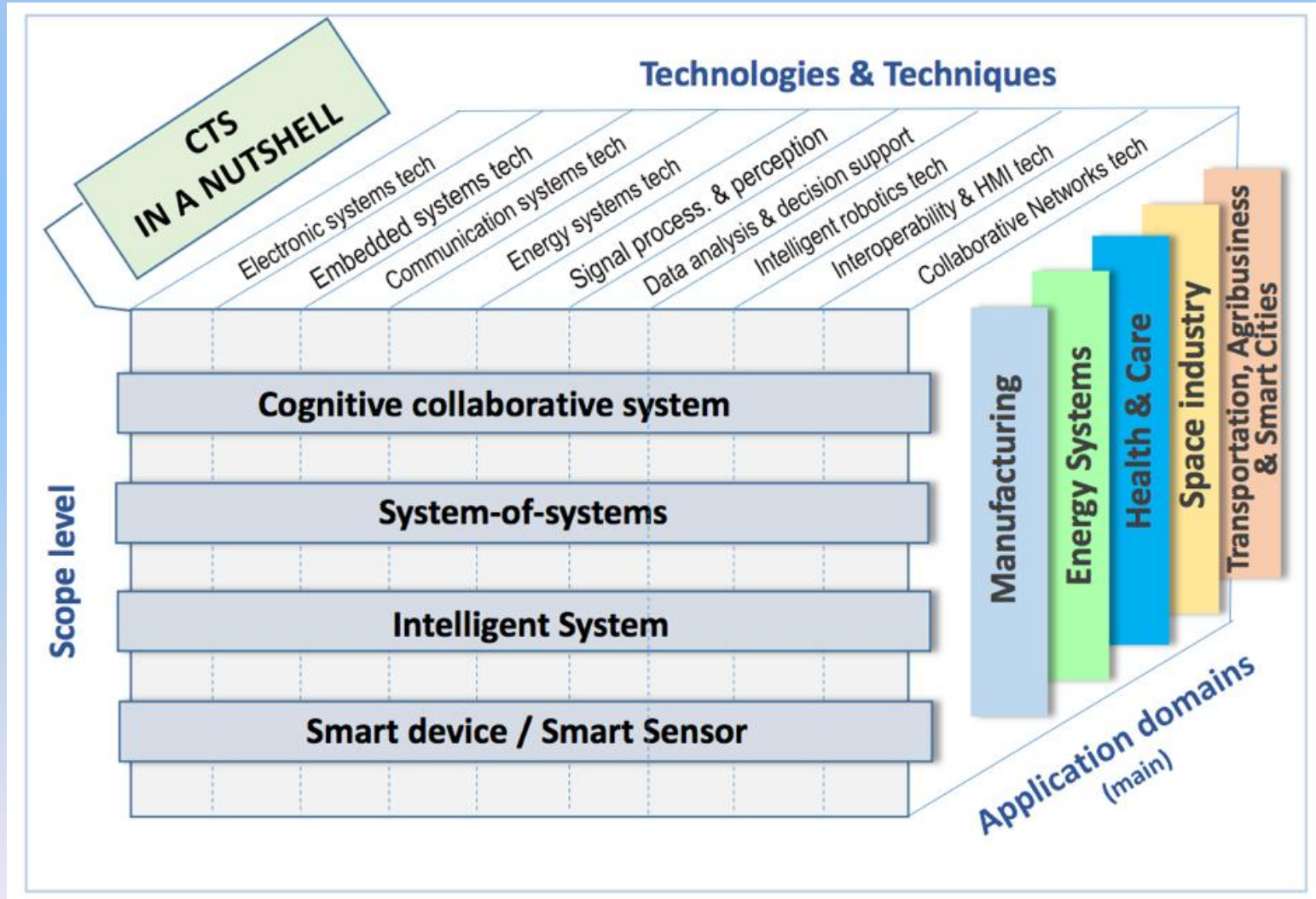
## New Framework of Intelligent Evacuation System of Buildings

Qian Zhang<sup>a,\*</sup>, Tao Chen<sup>b</sup>, Xian-zhi LV<sup>a</sup>

<sup>a</sup> Kunming fire fighting Command School, Kunming 650208, China

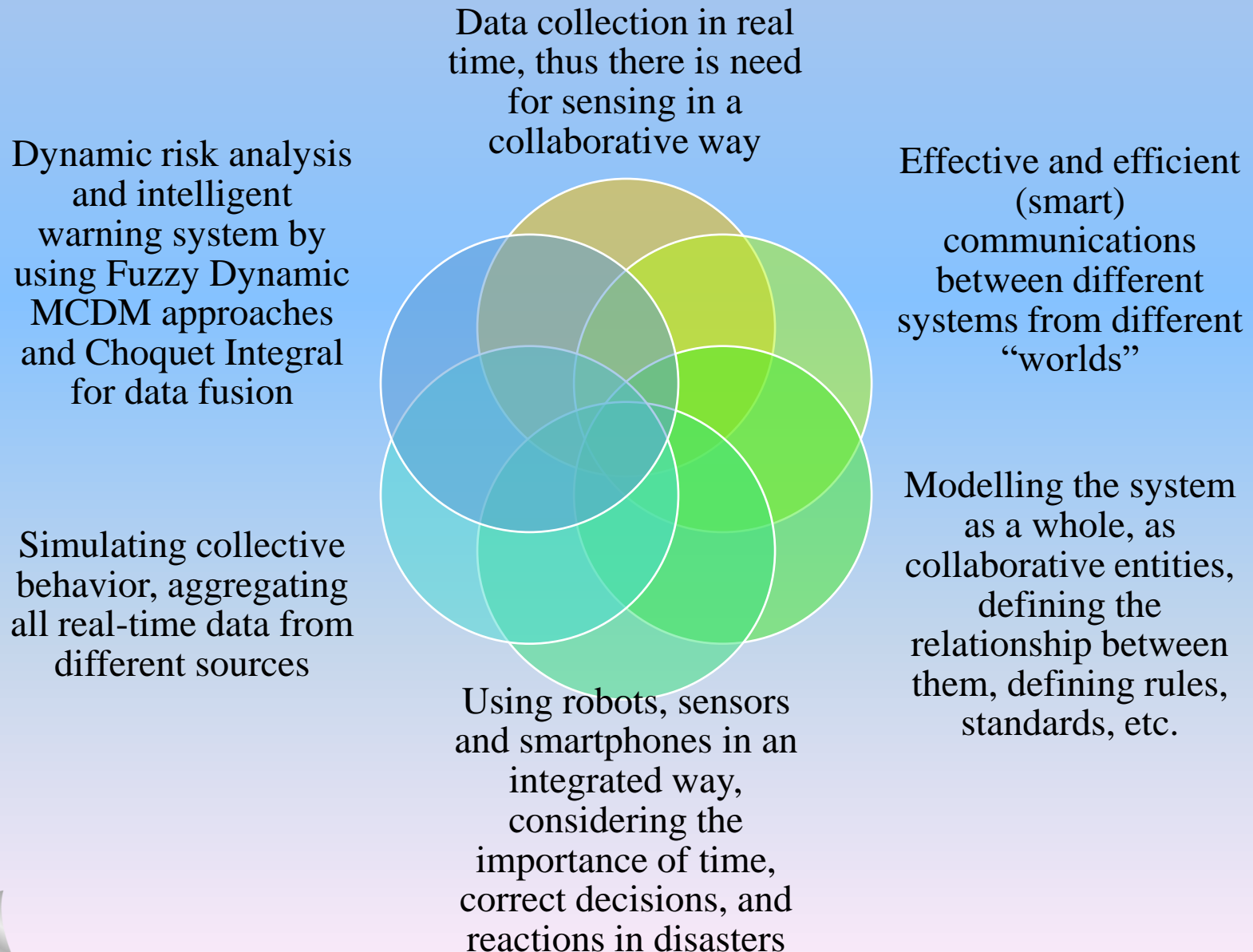
<sup>b</sup> Center for Public Security Research of Tsinghua University, Beijing 100084, China

**C&S** addresses fundamental research on Transformative Resilience and Antifragility on Collaborative Ecosystems.





# CTS Core competencies link to Collaborative Cyber Physical Systems for Disaster Management in Smart Communities



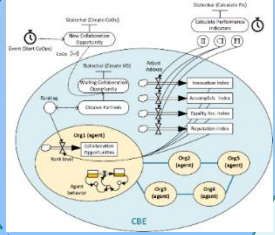
✓ Different groups in the CTS have developed technologies and prototypes applied in different domains.

## Examples.....

Projects in CTS (Ongoing & Concluded)	Challenge of Translating to Collaborative Cyber Physical Systems for Disaster Management in Smart Communities
<b>NOMDIS</b> New Operators for Monitoring and Diagnostic Intelligent Systems (ESA /Triangle Initiative project)	How could it be used for dynamic online risk assessment in case of disasters to support decisions in different fields?
<b>Robo-Partner</b> Seamless Human-Robot Cooperation for Intelligent, Flexible and Safe Operations in Assembly Factories of the Future	How could these robots be used in disasters to help and support potential victims and evacuees?
<b>HERIT-DATA</b> Sustainable Heritage Management towards Mass Tourism Impact, thanks to a holistic use of Big and Open Data	How to use the model and developed tools to deal with the affected people in disaster time?
<b>Goodman</b> Agent Oriented Zero Defect Multi-Stage Manufacturing	How to integrate and converge different technologies of measurement and control for data analysis and management in disasters?
.....	.....

**In More Details!**

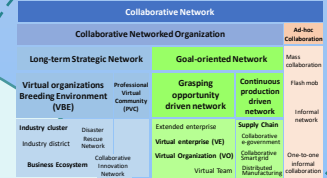
# Towards Resilient and Antifragile Smart Environments



## Collaborative Smart Build

Resilience /  
Antifragility

Collaboration  
Mechanisms



Collaborative  
Networks

## Antifragile Cities and Societies vs Hazards and Disasters

Catalog of  
Capabilities

- Agility
- Adaptability
- Cohesiveness
- Convexity
- Cognitive ability
- Creativity
- Diversity
- Dispersion
- ...

Destroying, Maintaining, or  
Transforming Stressors

- Identify **system's fragilities** that threaten survival of the system.
- Identify **design basis** for resilient/antifragile building ecosystems.
- Apply **coping strategies** to all phases: readiness, response, and recovery.
- Study the **role of collaboration** mechanisms in disaster management.
- Design **learning & control mechanisms** to detect & absorb shocks.

Catalog of  
Strategies

- Acceptance
- Barbel
- Buffering
- Collaboration
- Cost Minimization
- Customer Servicing
- Creating Disruption Management Culture
- Crisis Management
- Demand Managing
- ...



## Intelligent Transport Systems

- increase safety
- support a rescue scenario
- Monitor driving behaviour
- Provide information for safe driving



Translate the Technology to be used for Disaster Management in case of hazards

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ding

## Future Challenges & Opportunities



Exploitation of know-how for the safe integration and monitoring of vehicles and buildings



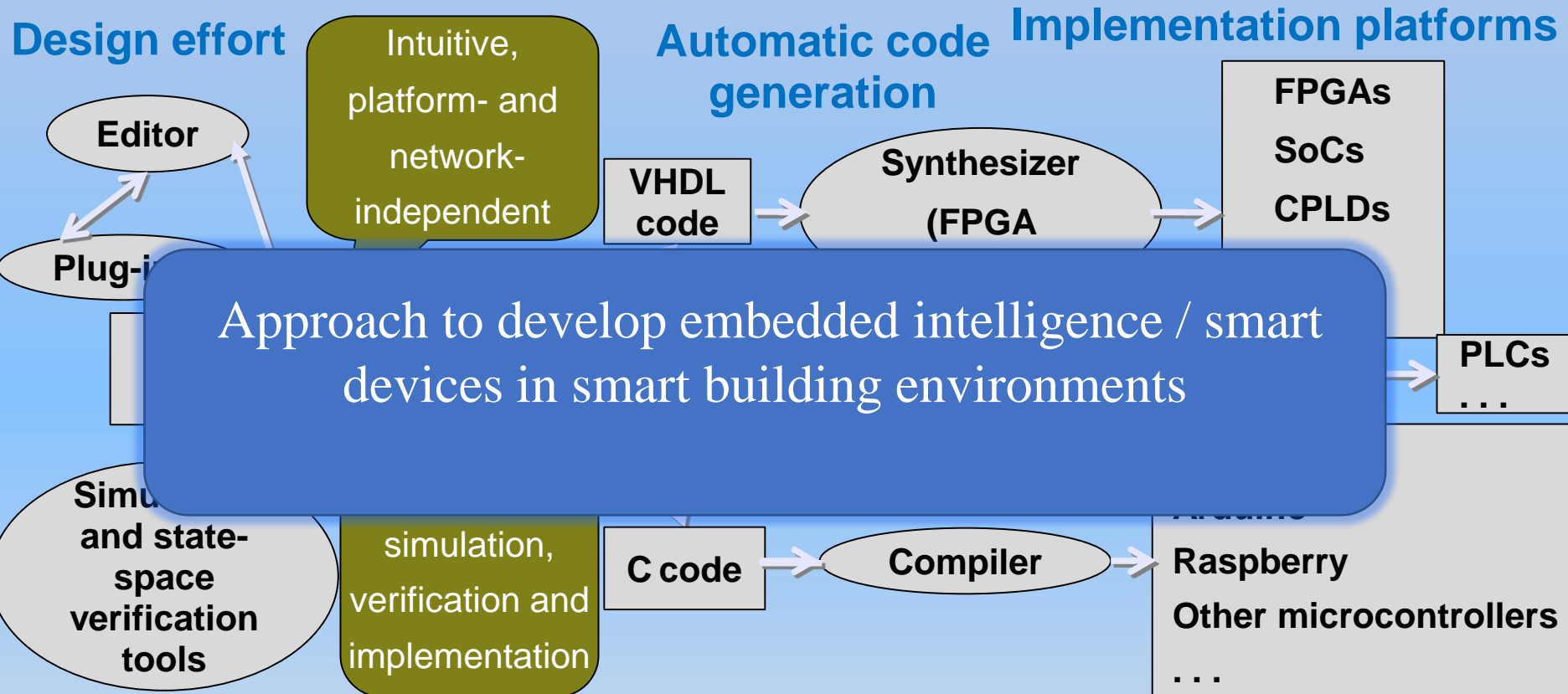
Enhancement of innovation capacity and creation of new opportunities for businesses

## Smart Buildings - Advanced Cooperative Storage Systems

- Providing energy to emergency and critical systems; enabling the development of:
  - advanced smart grid/buildings technologies
  - efficiency in communications and sharing information among equipment, electrical network management system and users



# Model-based Design for Embedded Controllers Using IOPT Petri-nets



## Tools are offered under a cloud-based user interface:

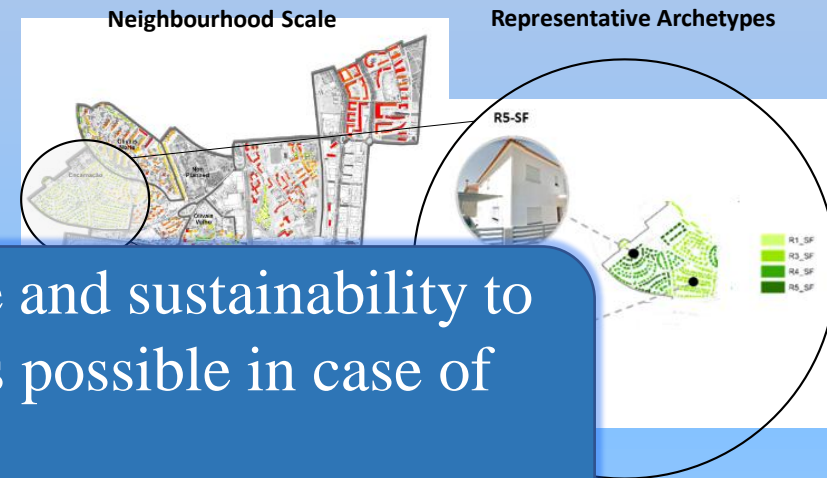
Web User Interface (<http://gres.uninova.pt/IOPT-Tools/>)

- Simulation
- Remote Debugger
- State Space Generation Tool
- Model-checking using a Query System
- AJAX Based IOPT Petri Net Editor
- Automatic C code generator
- Automatic VHDL hardware synthesis
- Automatic IL code generator for PLCs

## OBJECTIVES/RESEARCH ACTIVITIES

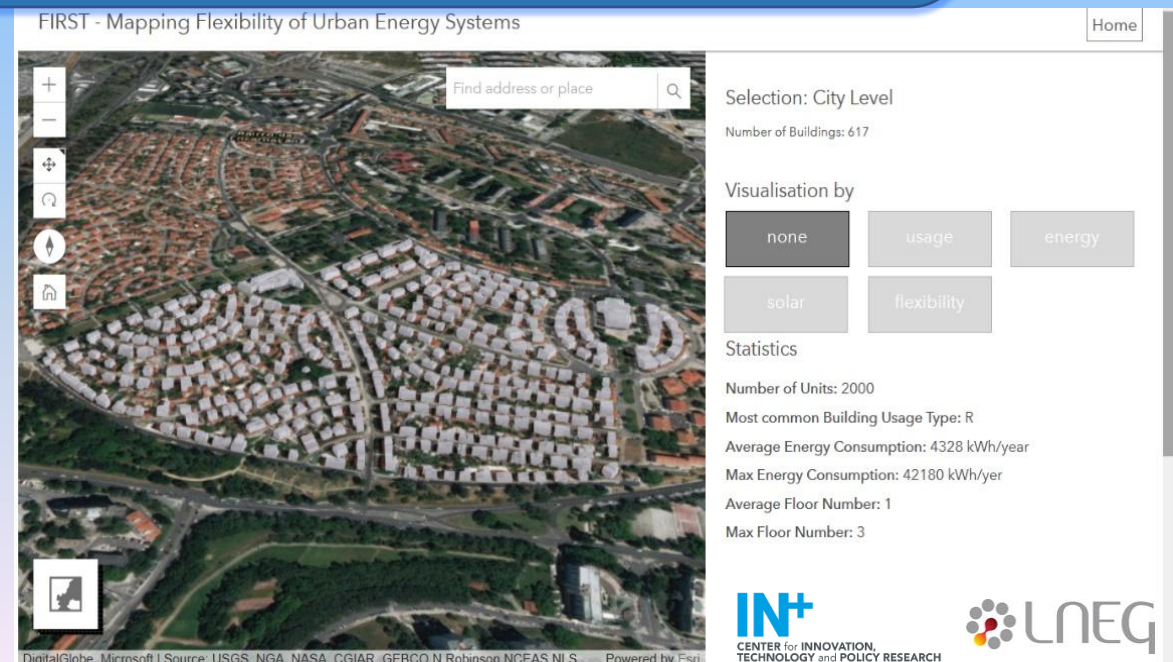
1. Study the potential for energy flexibility at individual building level (load shifting of typical building)
2. Study the potential for energy flexibility at community level (load shifting of typical community)
3. Map the potential for energy flexibility at city level (load shifting of typical city)

Increase the level of intelligence and sustainability to keep basic functions as long as possible in case of disasters



## METHODOLOGY

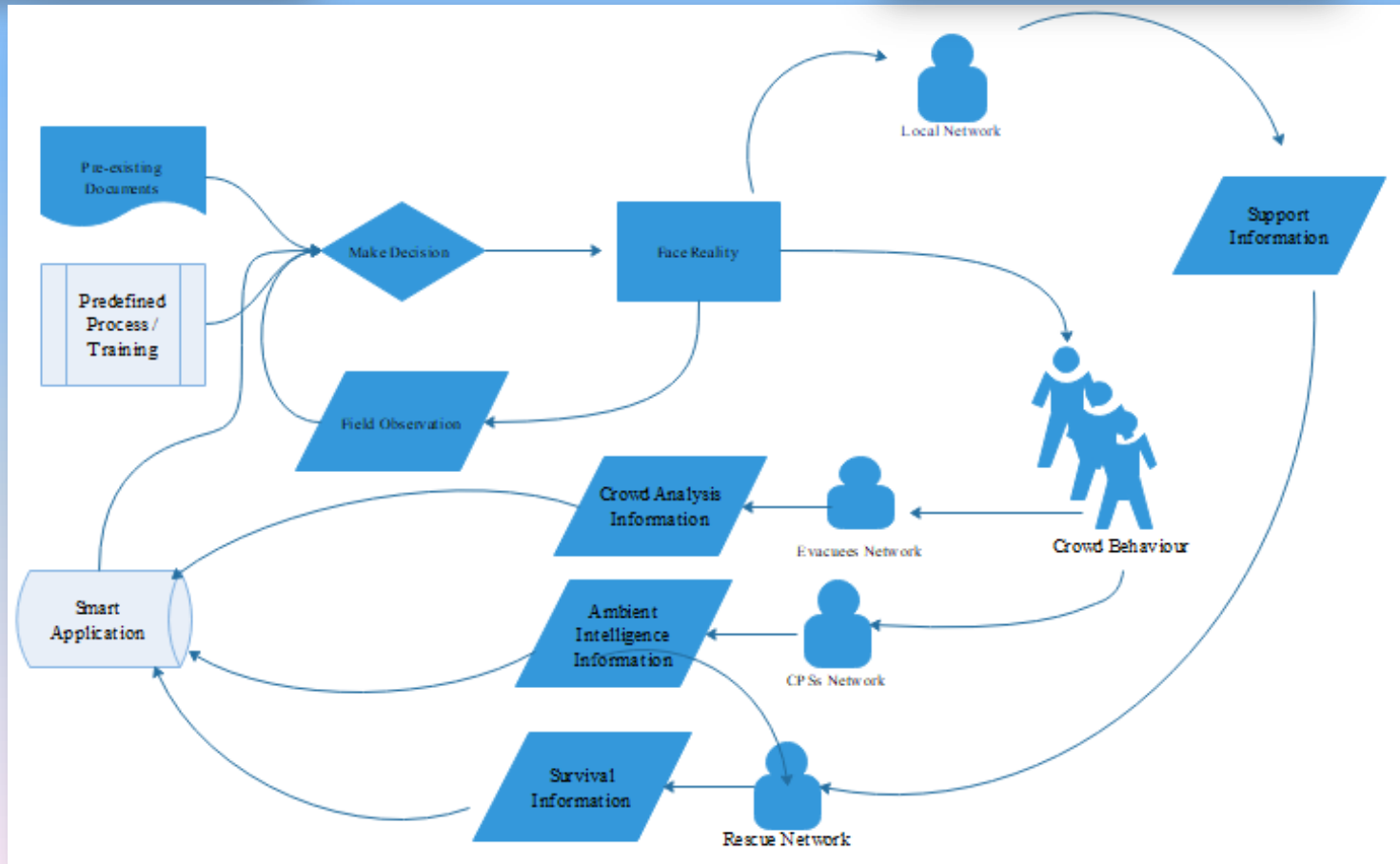
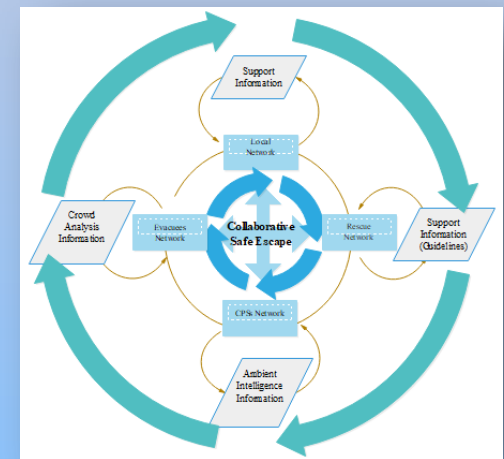
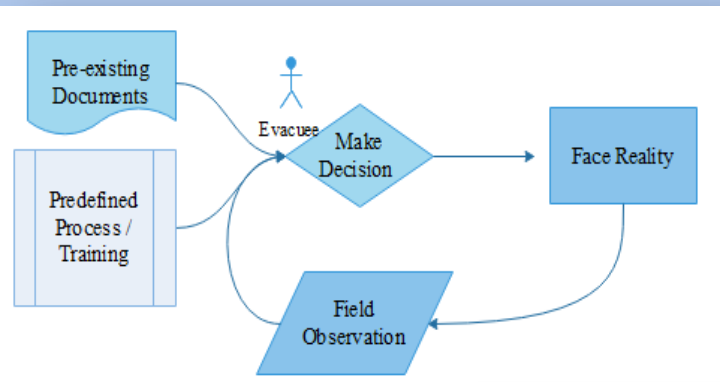
- Characterize the energy services use
- Physical Modelling using Eplus
- Data driven model using clustering on smart meter data
- Monitoring during Winter and Summer
- Data from Energy Certificates



5D (space-time-scale) GIS model reproduction of the testbed neighbourhood

# **Let's Follow a Scenario as a Case**

# Escape 4.0!!

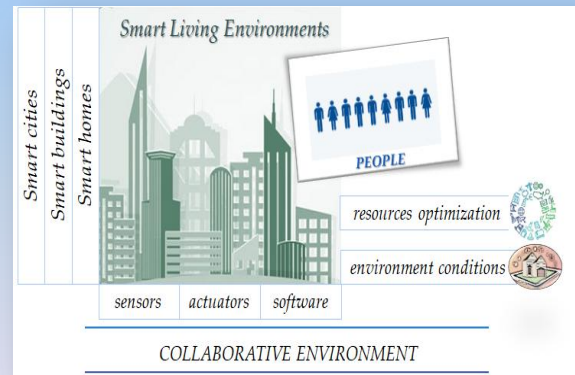


# Wrap Up

1. Challenge of “Sustainable Development Goal 11” requires a new approach employing Emerging technologies along with new concepts .
2. Our approach called “Collaborative Cyber-Physical Systems” concept combines contributions from two knowledge areas: Collaborative Networks and Cyber-Physical systems.




3. We would like to transfer existing CTS knowledge and experiences and develop new models to reduce the risk of Hazards and help to have a safe and resilient community.



4. There are some challenges such as Technology Infrastructure Failure in Disasters which are part of future works.



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To collaborate, we would like to invite  
you to contact us for further discussion  
and cooperation:

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**Thanks for your attention!**

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