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COLLABORATIVE DAMAGE MAPPING FOR EMERGENCY RESPONSE: THE ROLE OF COGNITIVE SYSTEMS ENGINEERING

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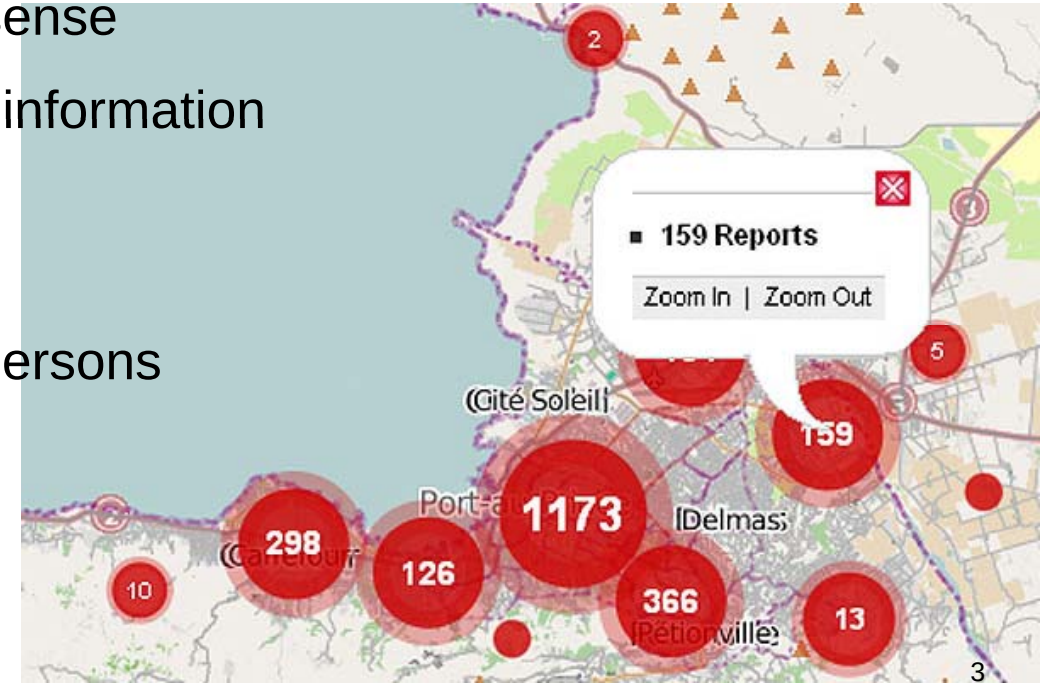
ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

POINTS OF DEPARTURE

- Growing importance of image data in disaster response – diverse data sources and growth in number and diversity of information users
- Increasing mashing of satellite, airborne, and ground data
- The Disaster Charter *"Space and Major Disasters"* has matured (reached limit of capacity?)
- Operational disaster mapping is still mostly done manually

COLLABORATIVE MAPPING TRENDS

- Collaborative mapping is most significant recent development (Web 2.0 philosophy and tools)
- Begin in 2008 (Nargis and Wenchuan)
- 2 main approaches:
  - Mapping in traditional sense
  - Visualizing of provided information (e.g., Ushahidi)
- 2 main mapping types
  - Open mapping by lay persons
  - Mapping by experts



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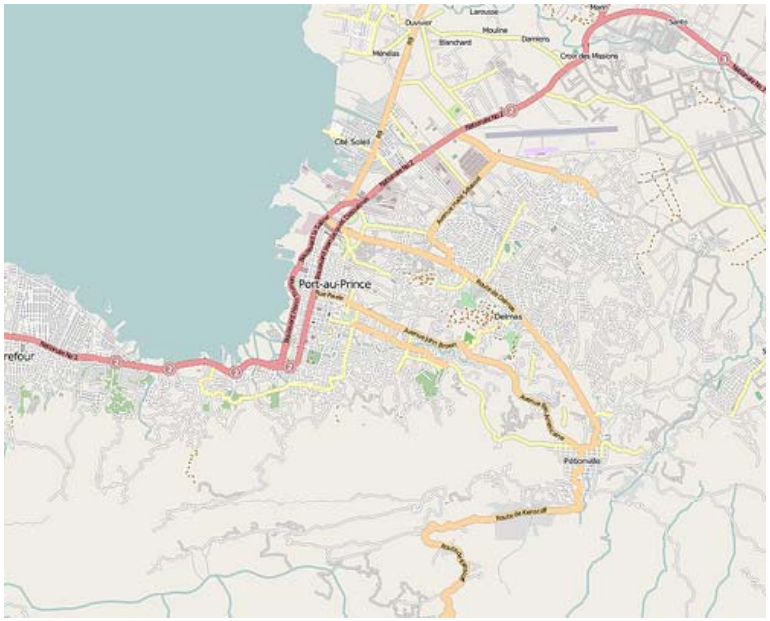
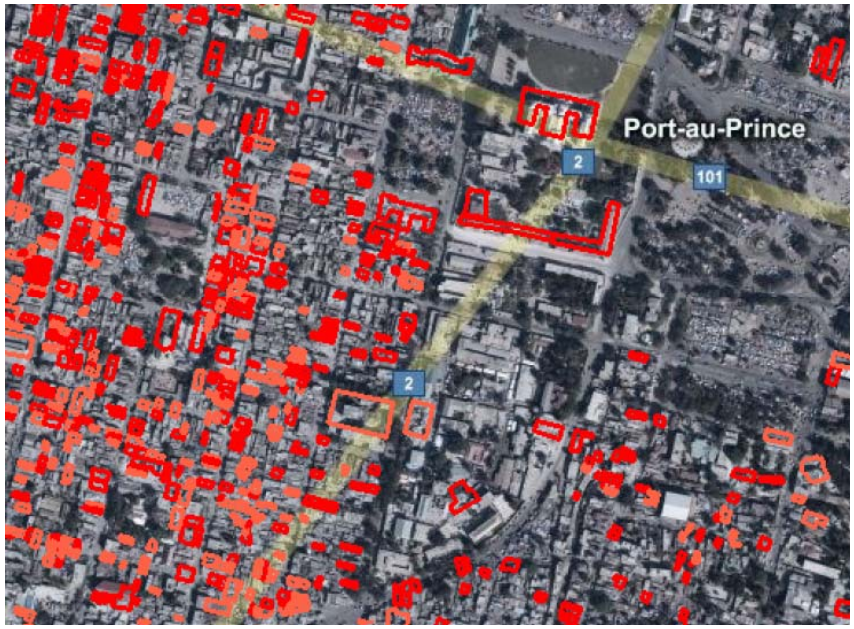
GOOGLE MAP MAKER VS GEO-CAN*

- Largely base mapping with GMM/OSM
- Detailed and accurate

- ‘Closed’ community of ca. 600 experts in GEO-CAN
- Building damage mapping in different phases





* Global Earth Observation-Catastrophe Assessment Network

SUCCESS OF GEO-CAN

- GEO-CAN work is widely seen as a success
  - 600+ volunteers
  - Rapid mapping
  - See Barrington et al. (2011)*
- Validation with JRC and UNOSAT
  - Internal screening and error checking, integration and validation (see Ghosh et al., 2011)#

* Barrington, L., Ghosh, S., Greene, M., Har-Noy, S., Berger, J., Gill, S., Lin, A.Y.M., Huyck, C., 2011. Crowdsourcing earthquake damage assessment using remote sensing imagery. Annals of Geophysics 54, 680-687.

Ghosh, S., Huyck, C.K., Greene, M., Gill, S.P., Bevington, J., Svekla, W., DesRoches, R., Eguchi, R.T., 2011. Crowdsourcing for rapid damage assessment: the Global Earth Observation Catastrophe Assessment Network (GEO-CAN). Earthquake Spectra 27, S179-S198.

OPEN ISSUES

- 2 types of main problem
  - Image-based damage mapping *per se*
  - The collaborative approach of GEO-CAN

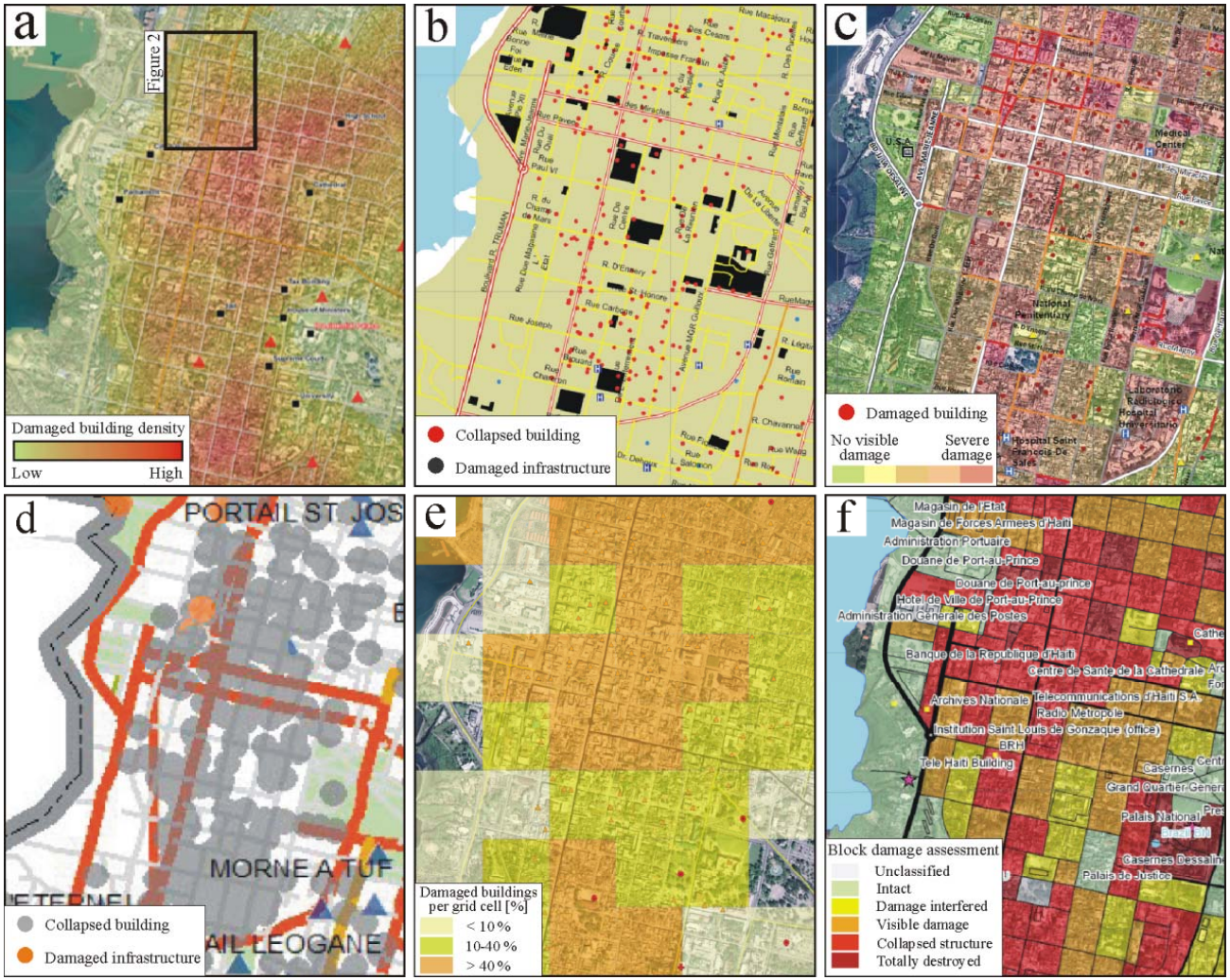
OPEN ISSUES

Problems with image-based damage mapping

- Lack of universal map standard
- Growing number of map makers (duplication, confusion)
- Static Charter maps (pdf format)
- Manual mapping
- Typically limited or no validation
- Limits as to what can be mapped (in *any* image type)
- Lack of understanding of map users and their needs

OPEN ISSUES

Examples of damage maps for Port-au-Prince



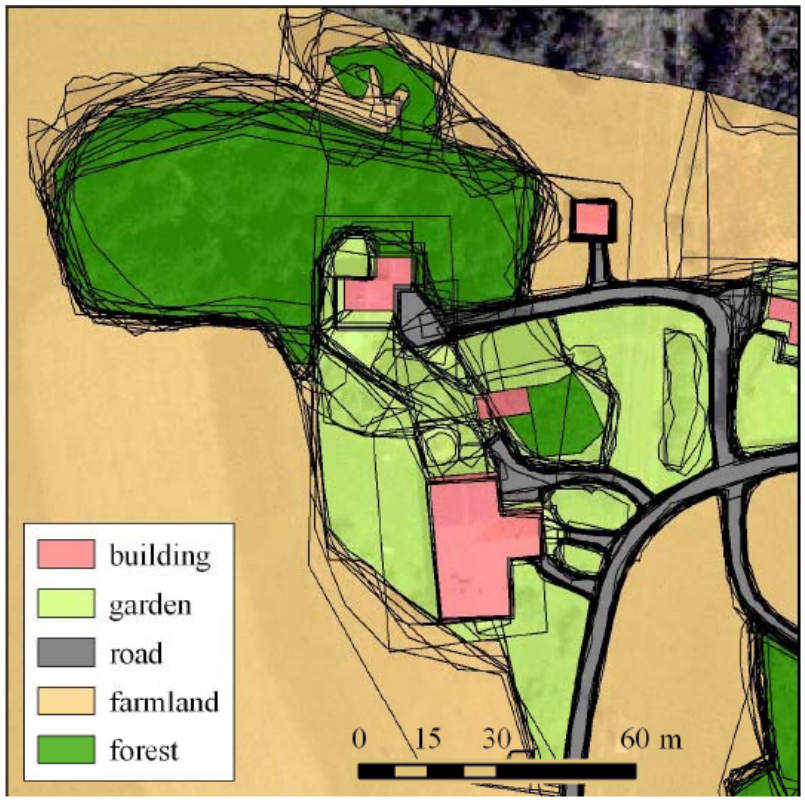
OPEN ISSUES

Problems with collaborative mapping

- How do we best instruct volunteers?
- How can organizers know that mappers understand the instructions and implement them optimally?
- How best to merge and validate results?
- There are 3 factions involved: mapping organizers, volunteer, and map user. Neither understands much about the other 2

INSTRUCTING A VOLUNTEER

- Image-based mapping is challenging, even for simpler features



Here 22 students mapped basic landcover features at a fixed scale

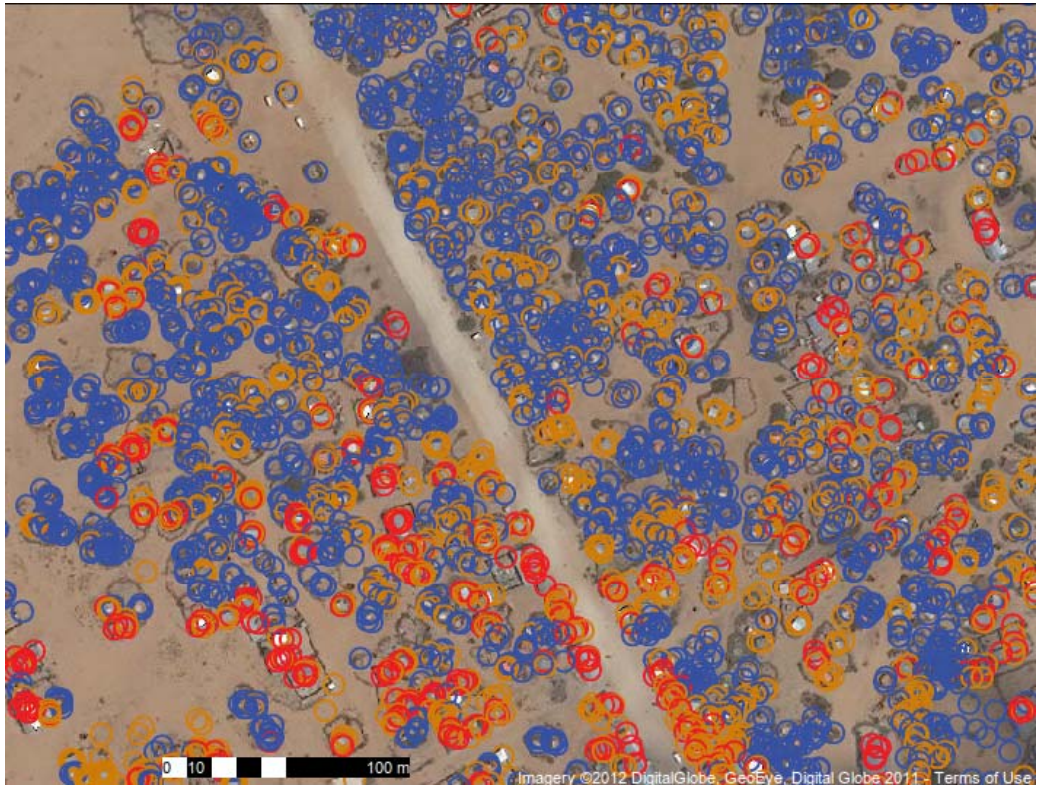
Albrecht, F., Lang, S., Hölbling, D., 2009. Spatial accuracy assessment of object boundaries for object-based image analysis, VALgEO, JRC, Ispra, Italy.

INSTRUCTING A VOLUNTEER

- Tomnod (tomnod.com) gets some of these issues right
- Focus on refugee shelter mapping

INSTRUCTING A VOLUNTEER

- CrowdRank tests reliability of mapper



© Tomnod

- Live instruction/discussion/feedback document

CHALLENGES IN DAMAGE MAPPING

- Structural damage mapping is substantially more difficult
  - "Damage" is a concept
  - Heavy use of proxies (e.g. changes in shadow)
  - Reliance on both saliency and semantics

Characteristic rubble (left) vs. misleading texture/pattern (right)

CHALLENGES IN DAMAGE MAPPING

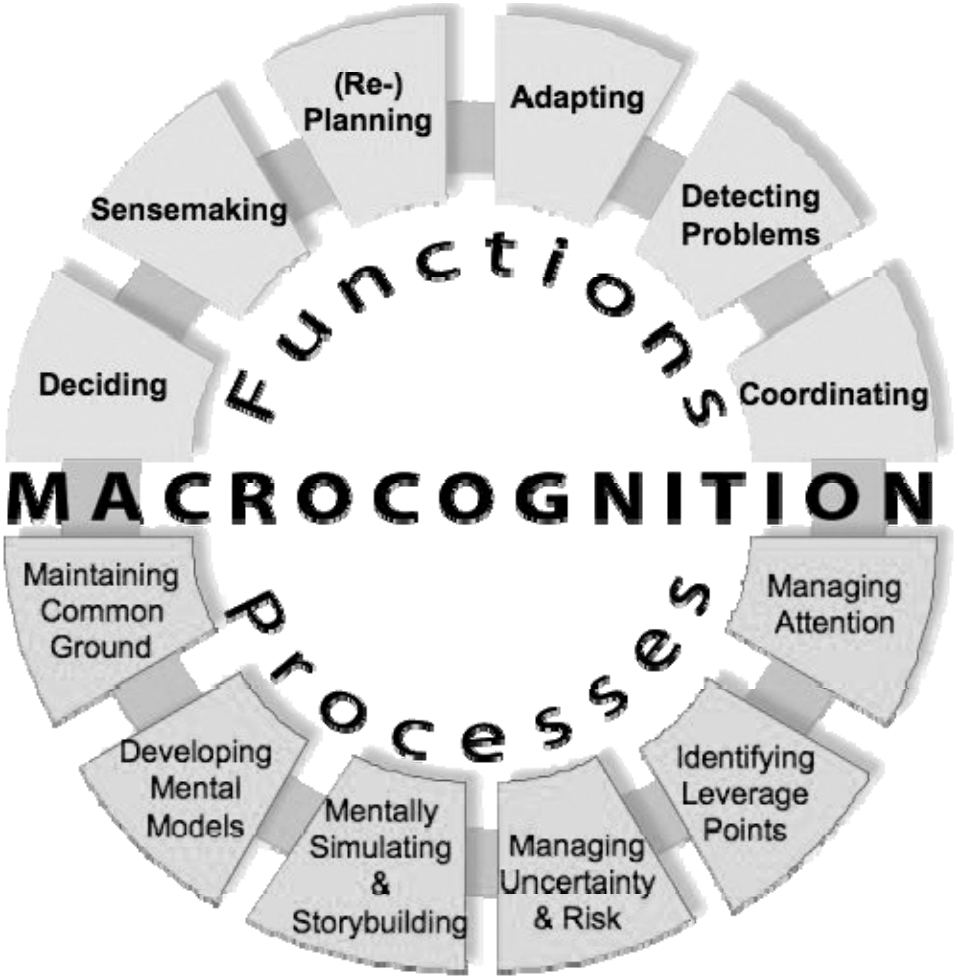
- 3D phenomenon largely reduced to 2D
- Use of a scale (EMS98*) designed for ground-based assessment
- Instructing for such mapping is a challenge

* European Macroseismic Scale of 1998

THE ROLE OF COGNITIVE TASK ANALYSIS (CTA)

- All 3 factions engaged in complex cognitive work
  - Map users have specific views, experiences, preferences – may or may not understand the map content, legends, etc.
  - The volunteer has variable experience; may or may not understand instructions; forced to make a decision in absence of corrective feedback
  - Organizers have assumptions about what damage information the user needs and understands, and about the volunteers and his/her abilities to map
- Study and design of complex cognitive systems in **Cognitive Systems Engineering**

WHAT IS COGNITION?



Specifically in damage mapping:

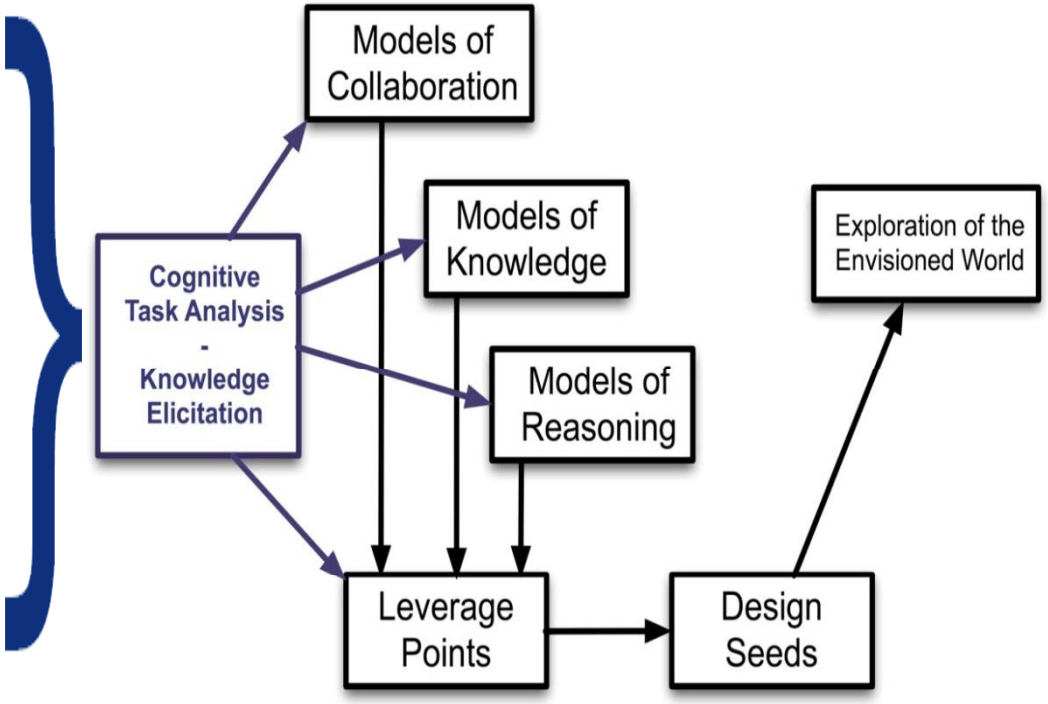
Motivation
Reasoning strategies
Sensemaking
Causal understanding
Mental modeling
Projection to the future
Goal orientation
Pattern perception skills

GOALS AND PURPOSES OF CTA

- Requirements analysis
- Function analysis
- Task (job) design
- Software interface design
- Training (design, evaluation)
- Team design & distance collaboration
- Knowledge capture (preservation, recovery, sharing)

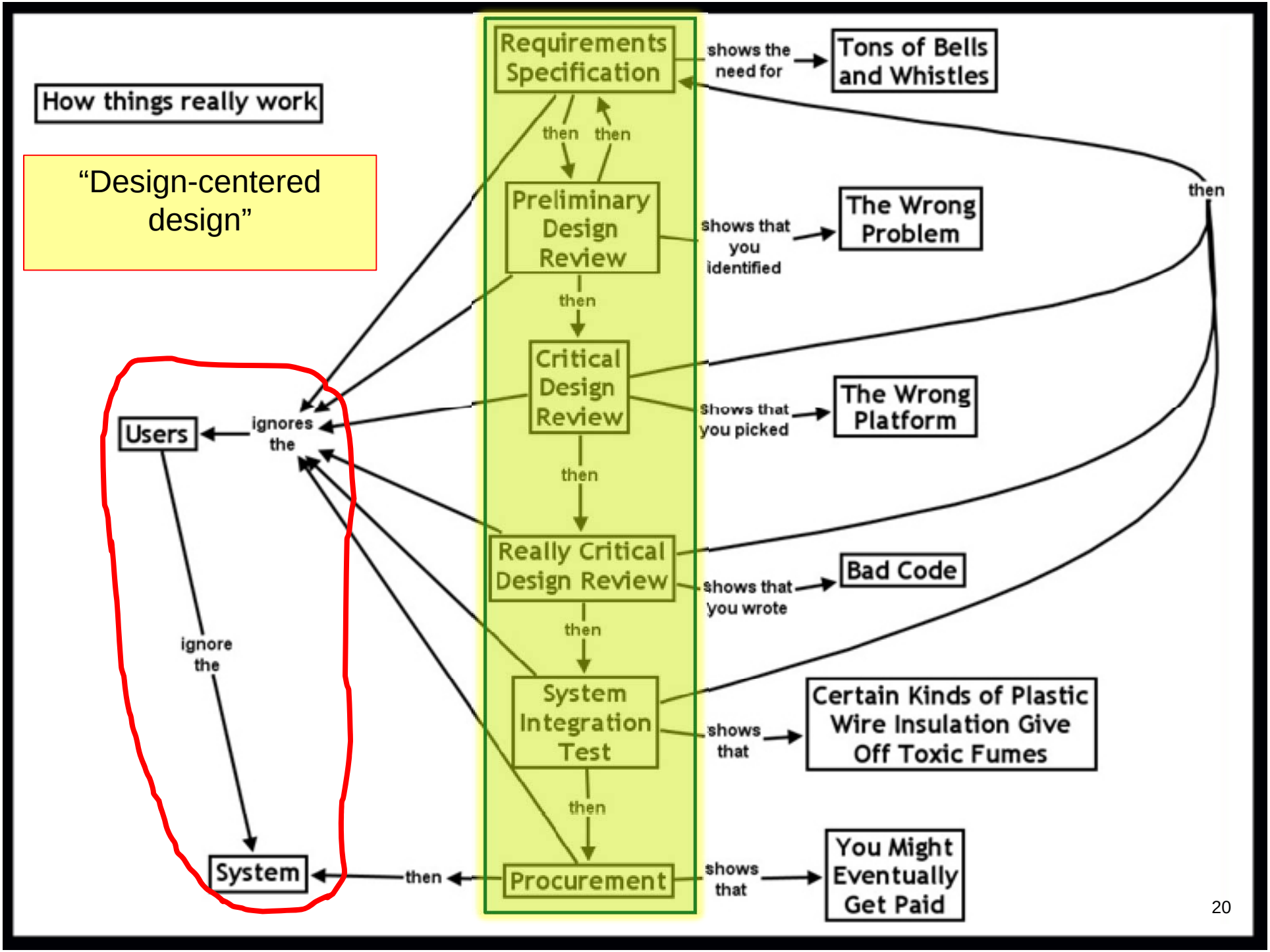
SPECIFIC CTA METHODS

Knowledge Audit
Critical Decision Method
Cognitive Modeling
Concept-Mapping
Think-aloud Problem Solving
Situation Awareness Test
Documentation Analysis
Recent Case Walkthrough
Workspace Analysis
Work Patterns Analysis



MAPPING IS NOT REALLY A TASK…

- Task: order/command; fixed series of steps
- GEO-CAN is a sociotechnical system. Here
  - People don’t conduct tasks
  - Instead they engage in knowledge-driven, context-sensitive choices


How things really work
"Design-centered design"
Requirements Specification
shows the need for
Tons of Bells and Whistles
then
then
then
Preliminary Design Review
shows that you identified
The Wrong Problem
then
Critical Design Review
shows that you picked
The Wrong Platform
then
Really Critical Design Review
shows that you wrote
Bad Code
then
System Integration Test
shows that
Certain Kinds of Plastic Wire Insulation Give Off Toxic Fumes
then
Procurement
shows that
You Might Eventually Get Paid
then
Users
ignores the
ignore the
System
then

DESIGN-CENTERED DESIGN

- Force the human user [mapping volunteer] to execute the designer's plan
- Computers limit users' ability to explore and integrate information
- VirtualDisasterViewer/GEO-CAN provides no corrective feedback
- We need a **work-centered design** instead

WORK-CENTERED DESIGN

- CTA methods can be used to understand
  - How the volunteers interpret instructions
  - How they allow the job to be performed (or hinder it)
  - How communication and corrective feedback can be integrated
  - Whether working in virtual teams (possible with a coach for several mappers) is useful
- understand better the map user and the organizer
- not always easy to get the user to tell you how the system should work

NEXT STEPS

- Design a set of experiments involving former GEO-CAN volunteers
- Focus on understanding of instructions and provision of feedback
- For details see:

  Kerle, N. and Hoffman, R.R., Collaborative damage mapping for emergency response: The role of Cognitive Systems Engineering, in press for *Natural Hazards and Earth System Sciences (NHESS)*

AUTUMN OF CROWDSOURCING

- New COST Action started last week: *Mapping and the Citizen Sensor* (organized by Giles Foody at Uni Nottingham)

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

- 8th Gi4DM at University of Twente, The Netherlands (13-15 December)

THANK YOU