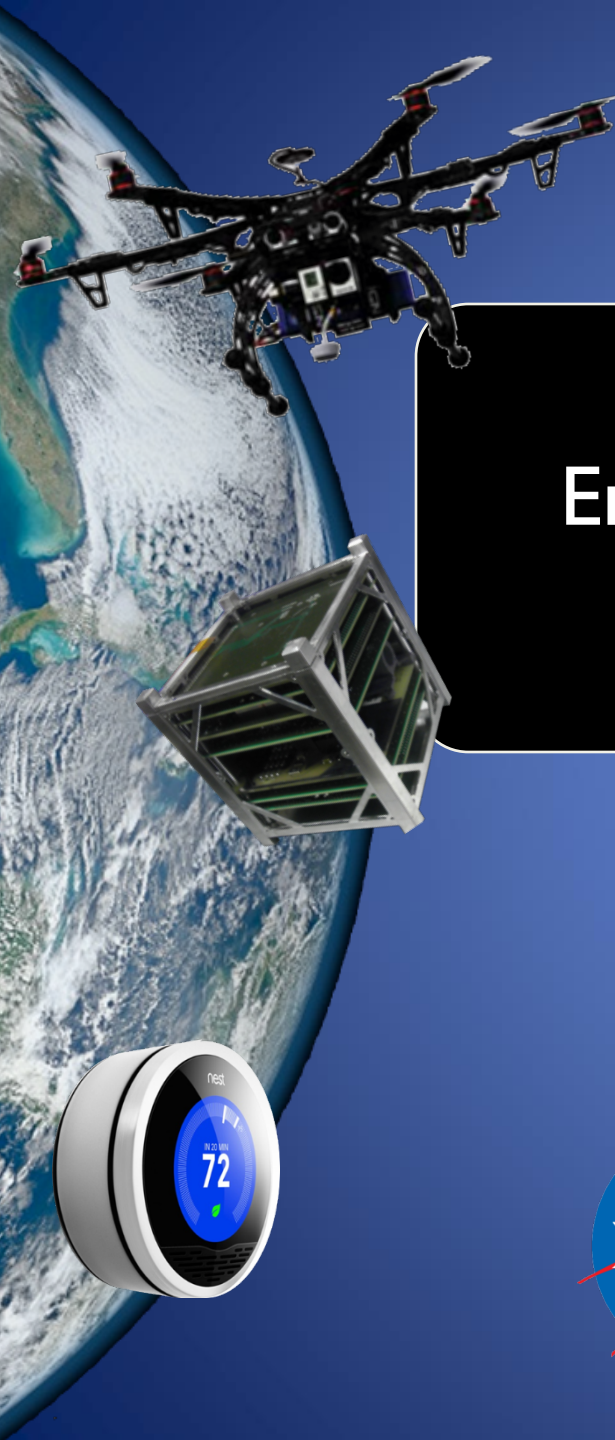




# Emerging Earth Science Technologies in Disaster Risk Management

John D. Evans

Global Science & Technology, Inc. (GST)  
Greenbelt, Maryland



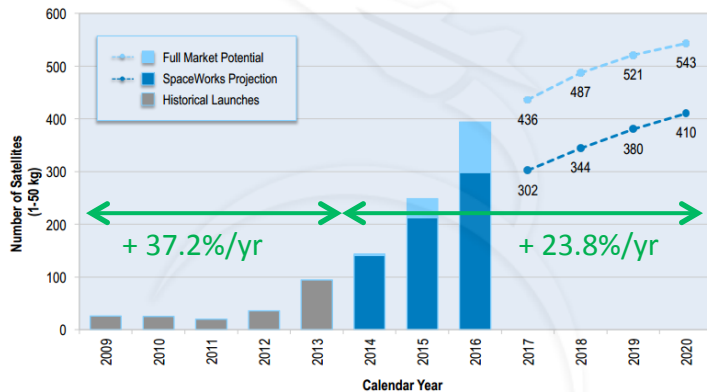
# Overview

- Review emerging earth science technologies
  - Small Satellites; Drones
  - Crowdsourcing; Location-Based Services
  - Direct Broadcast; Sensor Web; Internet of Things
  - Big Data Analytics; Model Webs; Cloud Computing
  - Collaboration & Semantic Services
- Analyze their roles in Disaster Risk Management
  - Using GEOSS Architecture for Disasters / GA.4.D
  - Ingredients of streamlined integration
  - Working towards technology roadmaps

# Small Satellites

## Nano/Microsatellite Launch History and Projection (1 - 50 kg)

Projections based on announced and future plans of developers and programs indicate between 2,000 and 2,750 nano/microsatellites will require a launch from 2014 through 2020



The Full Market Potential dataset is a combination of publicly announced launch intentions, market research, and qualitative/quantitative assessments to account for future activities and programs. The SpaceWorks Projection dataset reflects SpaceWorks' expert value judgment on the likely market outcome.

\* Please see End Notes 1, 2, 4, 5, and 6.

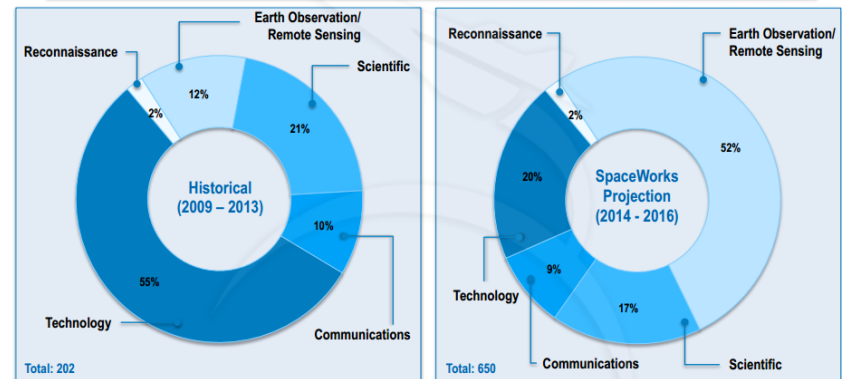


Copyright 2014, SpaceWorks Enterprises, Inc. (SEI)

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## Nano/Microsatellite Trends by Purpose (1 - 50 kg)

Over half of future nano/microsatellites will be used for Earth observation and remote sensing purposes (compared to 12% from 2009 to 2013)



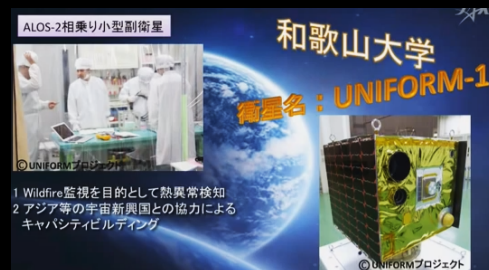
A smaller proportion of technology development/demonstration nano/microsatellites will be built in the next few years (20% vs. 55% from 2009 to 2013)

\* Please see End Notes 2, 6, and 7.



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# CubeSats



Interorbital Systems Test Launch Mar. 2014



STRaND-I





Planet Labs 'Dove' CubeSats launched from ISS Feb. 2014

## Start-Ups Aim to Conquer Space Market

By QUENTIN HARDY and NICK BILTON MARCH 16, 2014



Planet Labs, a San Francisco aerospace start-up, is launching 100 of its small satellites into orbit this year where they will photograph the Earth every single day.

 **INTERORBITAL SYSTEMS**   
TubeSat Satellite Kit

**\$8,000 TubeSat KIT INCLUDES FREE LAUNCH!**

Interorbital Systems' TubeSat satellite kit can be assembled into a low-cost satellite bus or a fully functioning satellite. The price of the TubeSat kit includes a guaranteed launch into low-Earth orbit on an Interorbital NEPTUNE modular rocket. Launches are scheduled to begin in 2014.



IMAGE © PLANET LABS INC. ALL RIGHTS RESERVED.

- Cheap to develop & launch
- Tolerate higher risk, shorter lifecycles
- Small form factors; limited power budgets
  - Deployable optics; Nanolayer synthetics



# Unmanned Aerial Vehicles (drones)



NASA's Ikhana UAV

## Facebook Looking Into Buying Drone Maker Titan Aerospace

Posted Mar 3, 2014 by Sarah Perez (@sarahintampa), Josh Constine (@joshconstine)

55 Like 7.8k Twitter

## Google buys drone maker Titan Aerospace

BY HAYLEY TSUKAYAMA April 14 at 5:13 pm



amazon.com

Price: \$299.99 & f



DHL



MatterNet

# Unmanned Aerial Vehicles (drones)



UNEP Global Environmental Alert Service (GEAS)

Taking the pulse of the planet; connecting science with policy

Website: [www.unep.org/geas](http://www.unep.org/geas)

E-mail: [geas@unep.org](mailto:geas@unep.org)

MAY 2013

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Thematic focus: Climate change, Ecosystem management, Environmental governance

## A new eye in the sky: Eco-drones

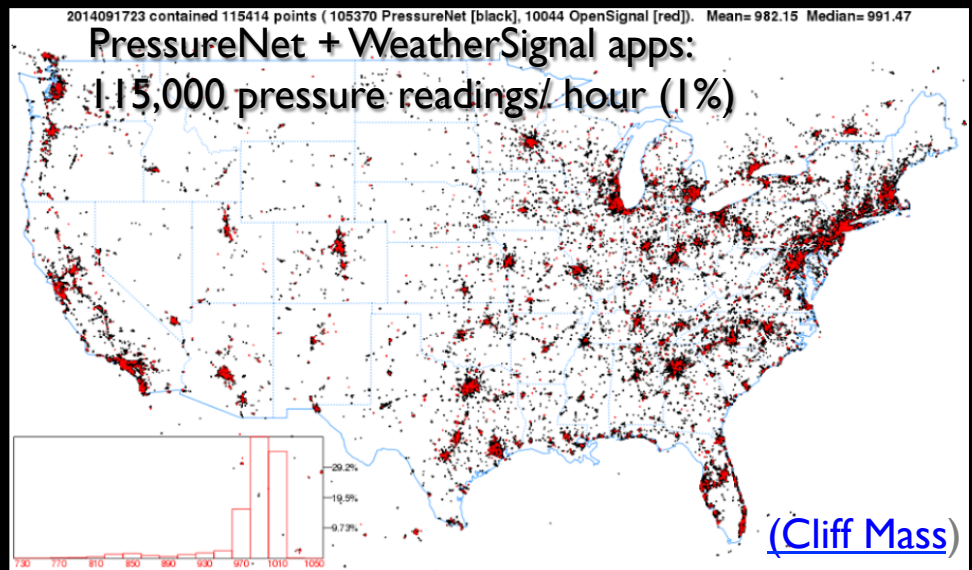
A drone is generally thought of as a military weapon or surveillance tool. Commonly referred to as an unmanned aerial vehicle (UAV), unmanned aerial system (UAS) or remotely piloted aircraft (RPA), a drone can also provide a low-cost and low-impact solution to environmental managers working in a variety of ecosystems. Drones used for these purposes are referred to as 'eco-drones' or 'conservation drones.' Their agility and quality imaging abilities make them advantageous as a mapping tool for environmental monitoring, but there are still several challenges and concerns to be surmounted.



Change Mapping	Disaster Risk Management	Disaster Risk Mitigation	Illegal Activity	Monitoring
River erosion	Flooding risk	Map impacted areas	Poaching	Migration patterns
Deforestation	Landslide risk	Broadcast messages	Illegal fishing	Endangered species status
Urban expansion	Volcano eruption risk	Monitor forest fire spread	Illegal trade	Agriculture

"Eco-drone" applications (per UNEP Global Alert Service, May 2013)

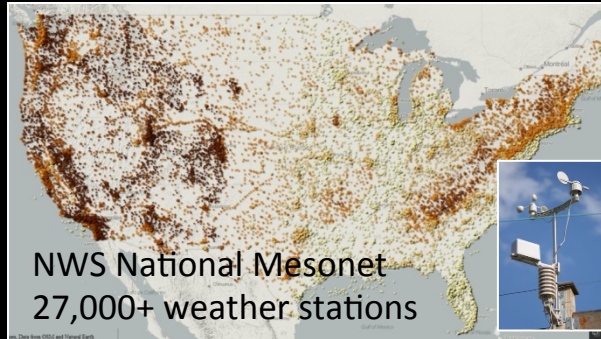
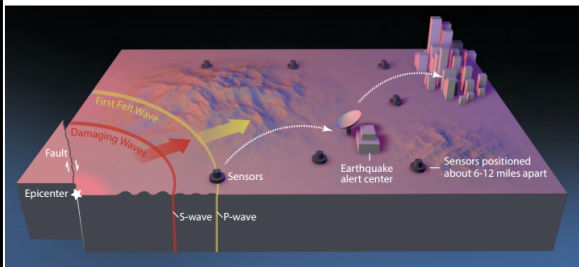
# Crowdsourcing via mobile devices



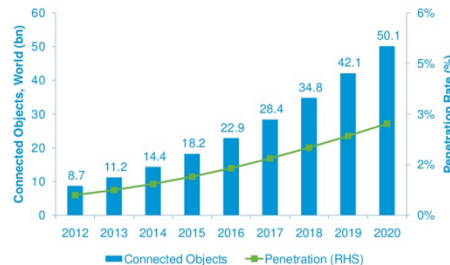
# Sensor Web & “Internet of Things”

- Sensor-based detection of earthquakes, severe weather, forest fires, oil spills, volcanic gas plumes, drought

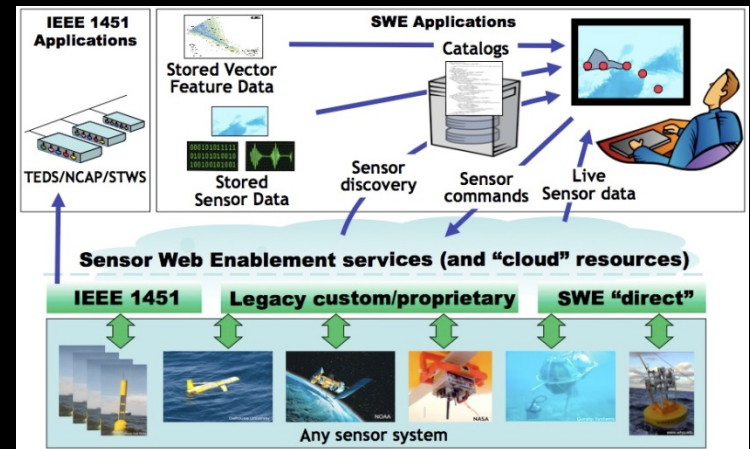
**ShakeAlert—An Earthquake Early Warning System for the United States West Coast**



**Number of Connected Objects Expected to Reach 50bn by 2020**



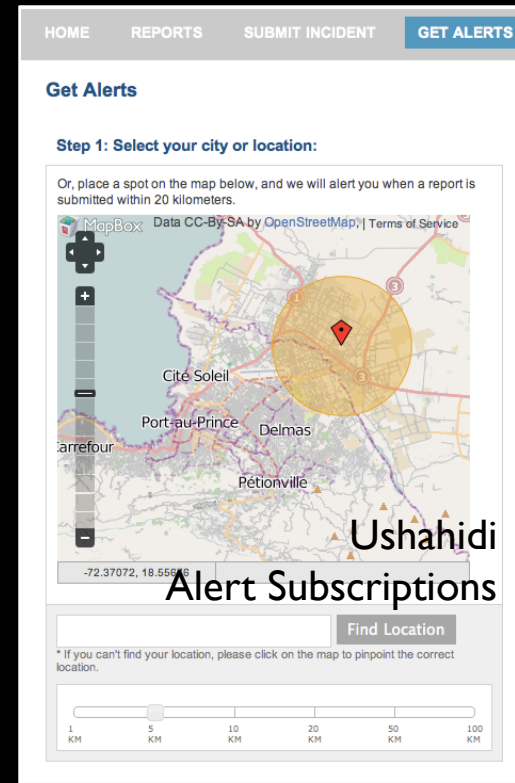
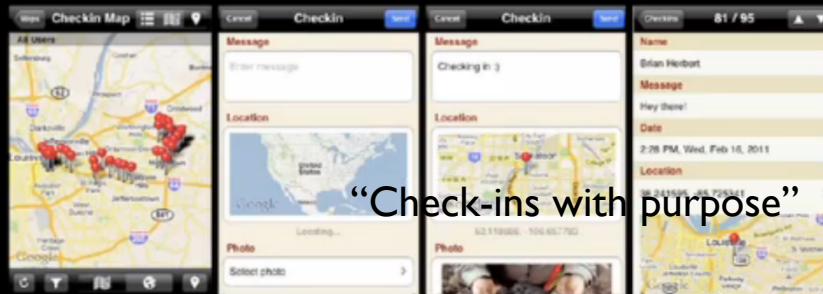
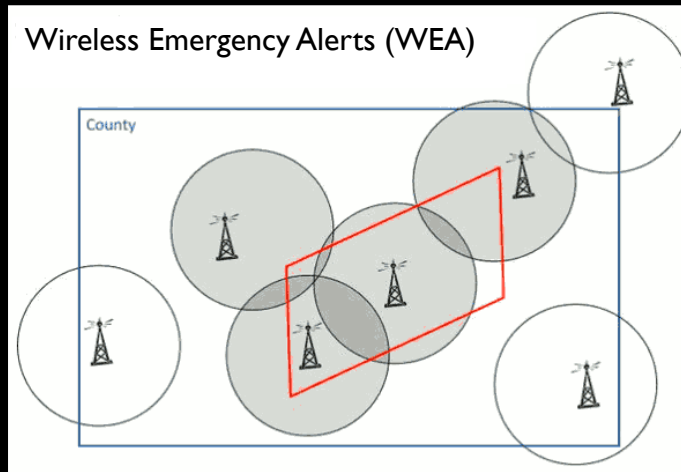
(Cisco) Penetration of connected objects in total 'things' expected to reach 2.7% in 2020 from 0.6% in 2012





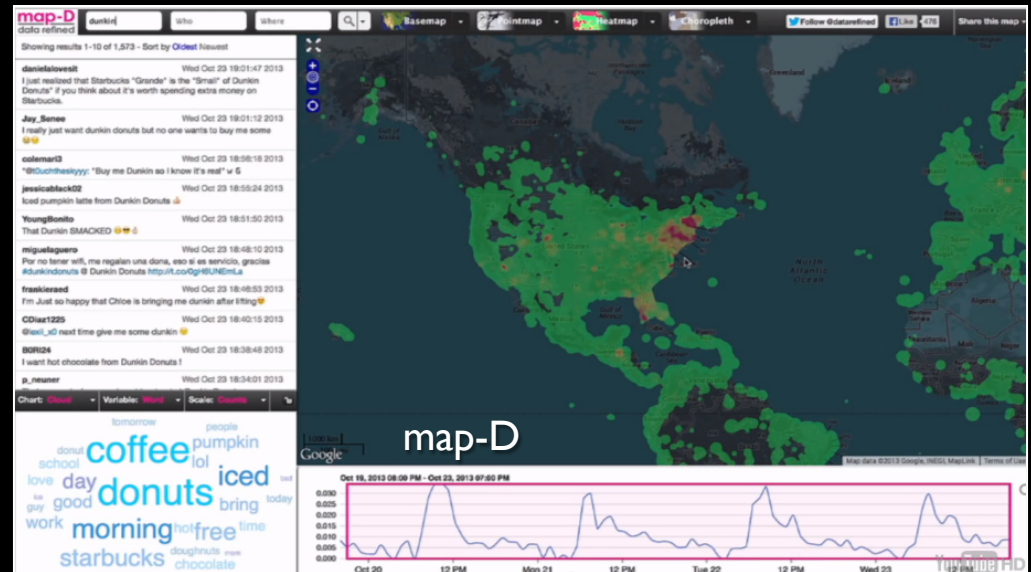
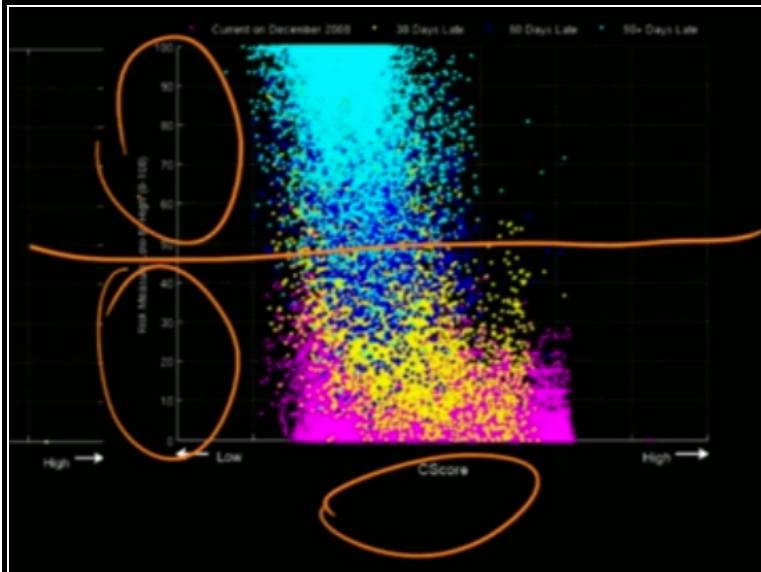
# Location-based services

- Geographically targeted advisories
- Location-specific information access / subscriptions
- Check-ins → real-time maps



# Big Data analytics

- Patterns & correlations
- Ensemble simulations → Risk envelopes
- Machine learning



# Collaboration Services

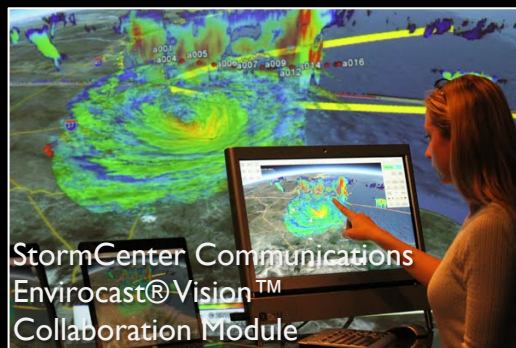
- Centralized or distributed



**OSPREY - Maryland Emergency Management Agency**

**Operations Message:** This text area will be used by MEMA to convey a message not covered by the alerts below. A link to further information may be provided: MEMA website

REGION	WESTERN	CAPITAL	CENTRAL	SOUTH	UPPER EASTERN SHORE	LOWER EASTERN SHORE
POWER	[Lightbulb icon]	[Lightbulb icon]	[Lightbulb icon]	[Lightbulb icon]	[Lightbulb icon]	[Lightbulb icon]
WEATHER	[Cloud icon]	[Cloud icon]	[Cloud icon]	[Cloud icon]	[Cloud icon]	[Cloud icon]
TRAFFIC	[Car icon]	[Car icon]	[Car icon]	[Car icon]	[Car icon]	[Car icon]
HOSPITALS	[Cross icon]	[Cross icon]	[Cross icon]	[Cross icon]	[Cross icon]	[Cross icon]
SHELTERS	[Bed icon]	[Bed icon]	[Bed icon]	[Bed icon]	[Bed icon]	[Bed icon]
FLOOD	[Waves icon]	[Waves icon]	[Waves icon]	[Waves icon]	[Waves icon]	[Waves icon]



**State of Emergency Declaration**

View the legend  
What do the colors mean?

**MEMA region map**

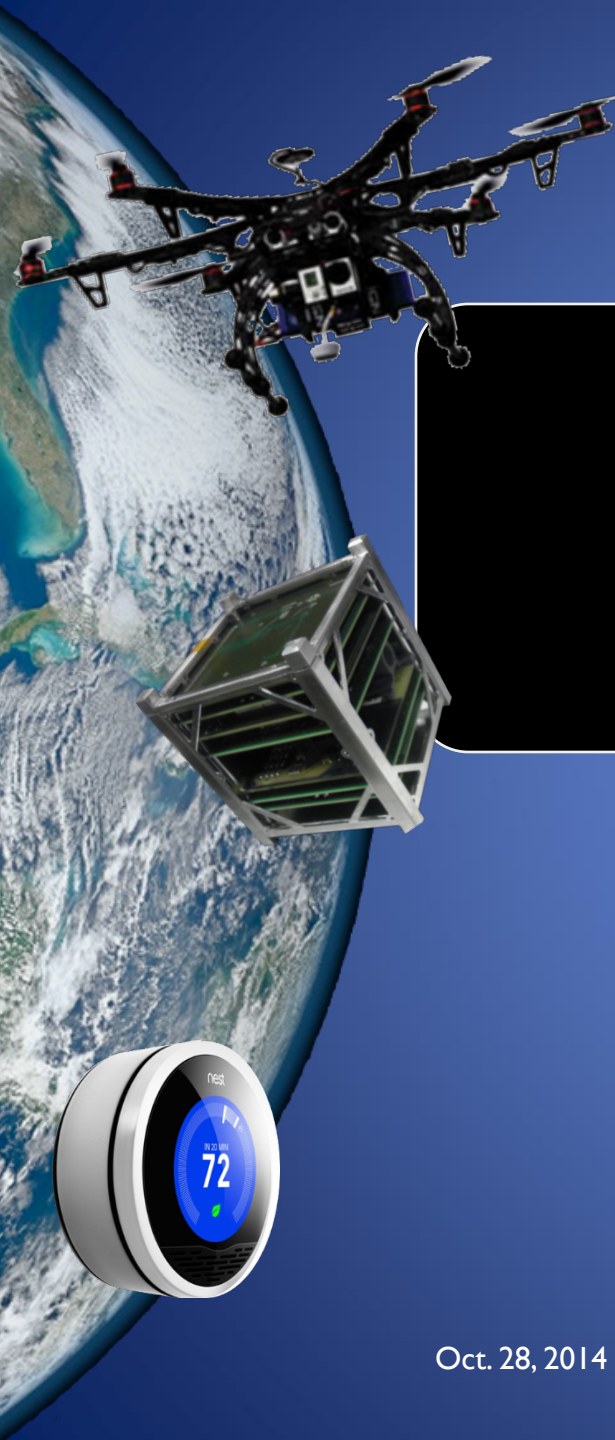
View site with live data

# Semantic Services

- Disaster-specific ontologies:
  - Disaster Response Ontology (E.U. “Disaster 2.0” project)
  - Management of a Crisis (MOAC) Vocabulary
  - Humanitarian Exchange Language (UN OCHA)
  - SoKNOS (German public safety agencies)
  - Others (*See also: UNISDR Terminology*)
- Standards for expressing and using semantics:
  - SPARQL Protocol and RDF Query Language (SPARQL, GeoSPARQL)
  - Web Ontology Language (OWL)
  - Web Service Modeling Ontology (WSMO)
  - Simple Knowledge Organization System (SKOS)

# Other potential game-changers

- Model Web / Modeling as a Service
- Cloud Computing
- Satellite Direct Broadcast / Direct Readout
- Gigabit networking?
- ...



# How to make sense of it all?

# CEOS / GEOSS Architecture for the use of Remote Sensing Products in Disaster Management and Risk Assessment (GA.4.D)

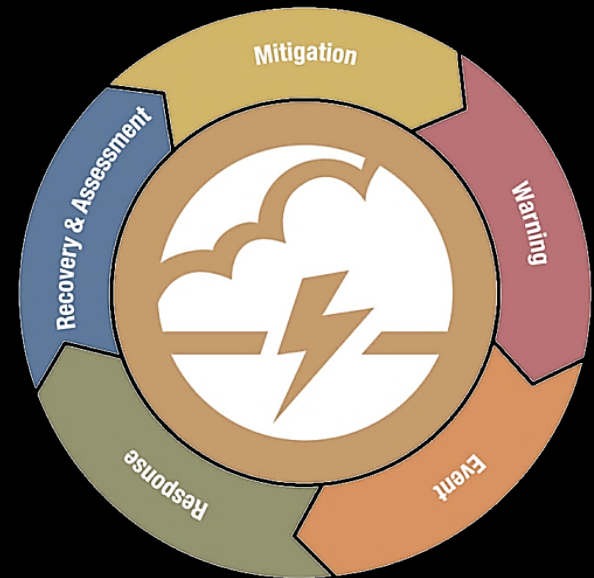
## GEOSS Architecture for the Use of Remote Sensing Products in Disaster Management and Risk Assessment



1. Executive Summary
  2. Introduction / Overview / Motivation
    - 2.a. Audience and scope
    - 2.b. Goals and Requirements
    - 2.c. Approach: Reference Model for Open Distributed Processing
    - 2.d. Approach: practitioner case studies
  3. Enterprise Viewpoint
    - 3.a. Purpose and scope
    - 3.b. Hazard types and disaster lifecycle phases
    - 3.c. Activities (Business Processes)
    - 3.d. Stakeholders
    - 3.e. Principles
    - 3.f. Enterprise view: points of comparison
  4. Information Viewpoint
    - 4.a. Overview
    - 4.b. Observations and parameters by disaster type
    - 4.c. Metadata needs in a disaster management context
    - 4.d. Data operations needed in a disaster management context
  5. Computation viewpoint
    - 5.a. Overview
    - 5.b. Service types needed for disaster management and risk assessment
    - 5.c. Constraints and requirements specific to disaster management
  6. Engineering and Technology Viewpoints
- References
- Appendix 1: Namibia Flood Pilot*  
*Appendix 2: China Sichuan / Wenchuan earthquake*  
*Appendix 3: Japan Sendai / Tohoku earthquake & tsunami*  
*Appendix 4: International Charter – Space and Major Disasters*  
*Appendix 5: (Alternative / Future) Case Study Candidates*  
*Appendix 6: Case Study Questionnaire*

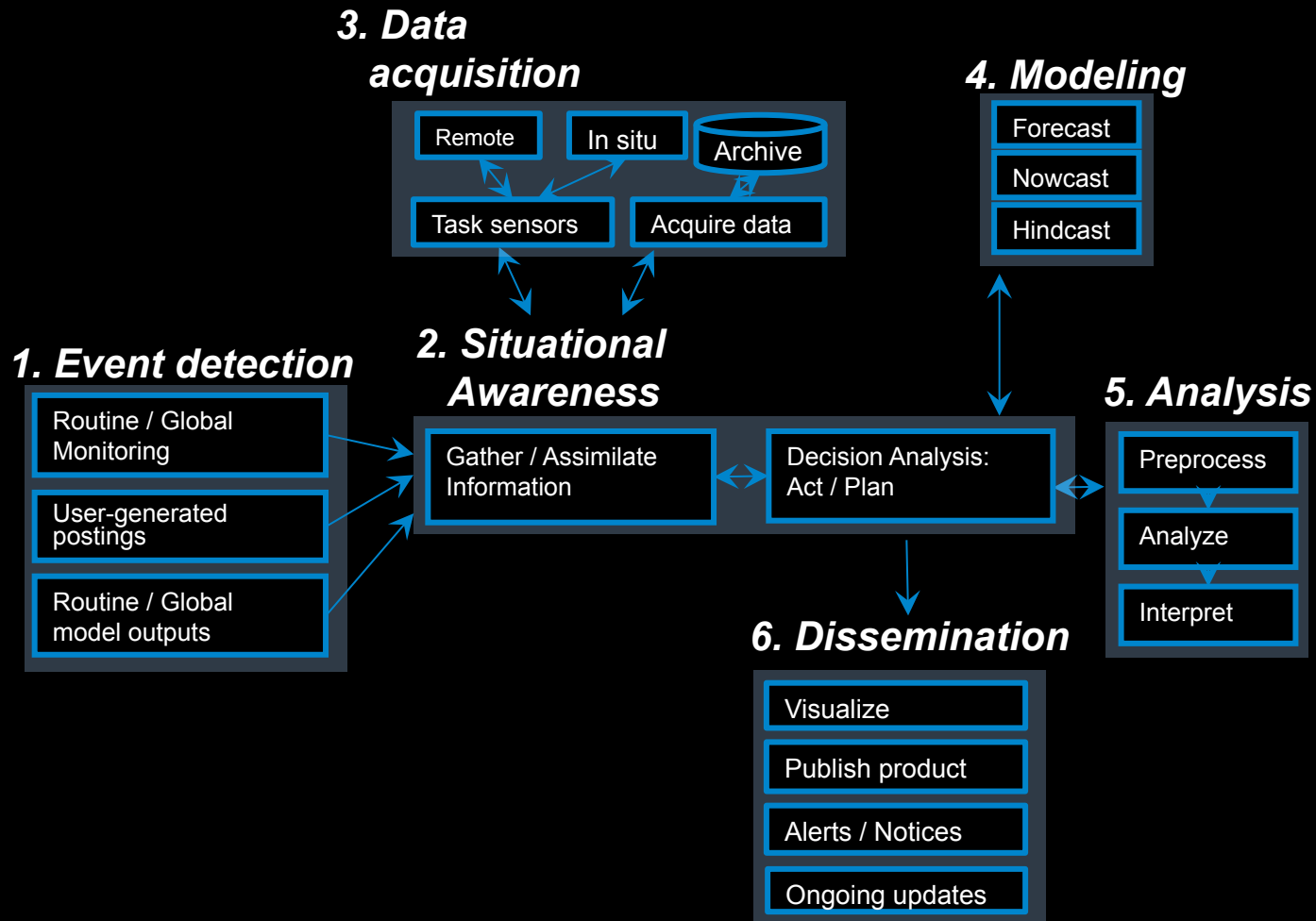
# Scope, purpose, structure

- Lifecycle phases
  - Mitigation
  - Warning
  - Response
  - Recovery
- Hazard types
  - Flooding
  - Earthquakes
  - Volcanoes
  - Drought
  - Windstorms
  - Landslides
  - Wildfires
  - Tsunamis
- Values and priorities (GEOSS, CEOS)
  - System of Systems
  - Data Sharing Principles
  - Interoperability Arrangements

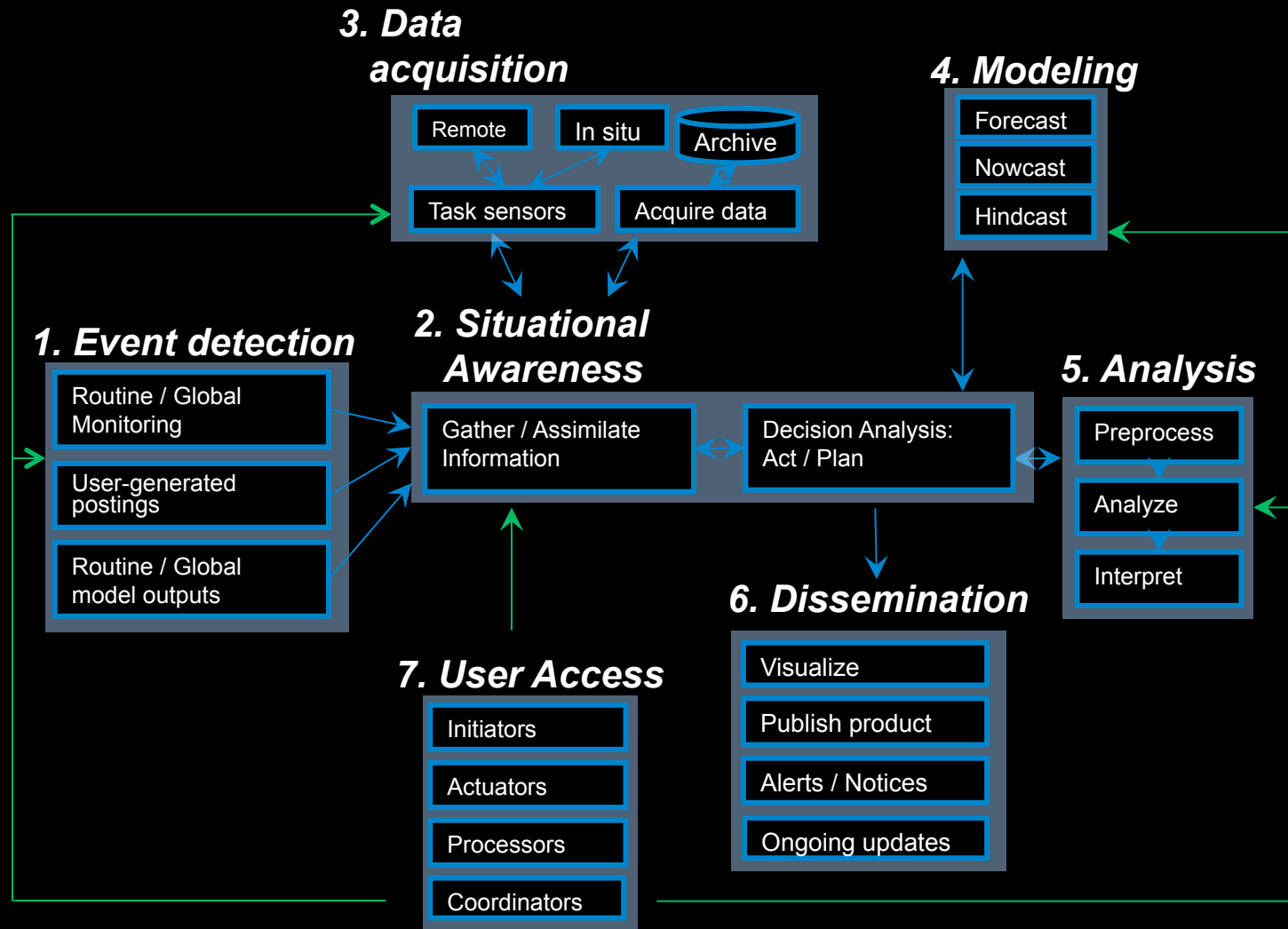




# Activities (business processes)



# Activities (business processes)



# Emerging technologies and architecture viewpoints

## *Information viewpoint*

- Small Satellites
- UAVs (drones)
- Direct Broadcast
- Semantic Services
- Mobile devices
- Internet of Things
- Crowdsourcing

## *Computation viewpoint*

- Big Data analytics
- Model Webs
- Cloud Computing
- Semantic services
- Mobile devices
- Location-based services
- Collaborative services

# Emerging Technologies and Disaster Lifecycle Phases

	Warning	Response	Recovery	Mitigation
Unmanned Aerial Vehicles (Drones)	•	•		
Small Satellites (incl. CubeSats)	•	•		
Satellite Direct Broadcast / Direct Readout	•	•		
Internet of Things / Sensor Web	•		•	•
Crowdsourcing	•	•	•	•
Big Data Analytics	•	•		•
Model Webs / Modeling as a Service	•		•	•
Cloud Computing		•	•	
Location Based Services	•	•		
Semantic Services		•	•	•
Collaboration Services	•	•		

# Emerging Technologies and Natural Hazard types

	Floods	Earthquakes	Volcanoes	Droughts	Windstorms	Landslides	Wildfires	Tsunamis	(Any)
Unmanned Aerial Vehicles (Drones)	•	•			•	•	•		•
Small Satellites (incl. CubeSats)	•			•	•		•	•	
Satellite Direct Broadcast / Direct Readout	•		•	•	•		•	•	
Internet of Things / Sensor Web	•	•		•	•		•		•
Crowdsourcing	•	•			•	•			
Big Data Analytics	•	•			•				•
Model Webs / Modeling as a Service									•
Cloud Computing									•
Location Based Services	•	•			•				•
Semantic Services									•
Collaboration Services									•

# Emerging Technologies and Disaster Mgmt. Activities

	Event detection	Situational awareness	Data Acquisition	Modeling	Analysis	Dissemina- tion	User Access
Unmanned Aerial Vehicles (Drones)	•	•	•				
Small Satellites (incl. CubeSats)	•	•	•				
Satellite Direct Broadcast / Direct Readout	•	•	•				
Internet of Things / Sensor Web	•	•	•				
Crowdsourcing	•	•	•			•	•
Big Data Analytics	•	•	•	•	•		
Model Webs / Modeling as a Service	•	•		•	•	•	•
Cloud Computing				•	•		
Location Based Services						•	•
Semantic Services	•	•	•		•		•
Collaboration Services		•					•

• = Documented

• = Plausible / Anticipated

# Emerging Technologies and Disaster Mgmt. Activities

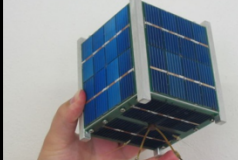
Direct Broadcast



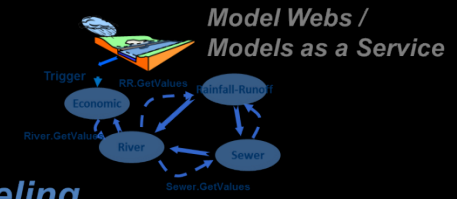
UAVs / Drones



Small Satellites

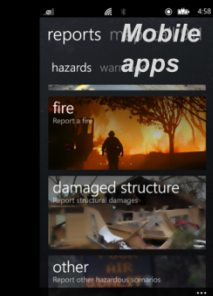


Internet Of Things

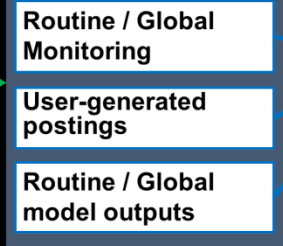


3. Data acquisition

4. Modeling



1. Event detection



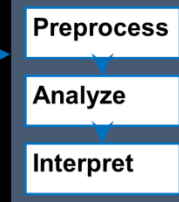
2. Situational Awareness

Gather / Assimilate Information



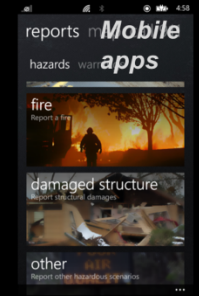
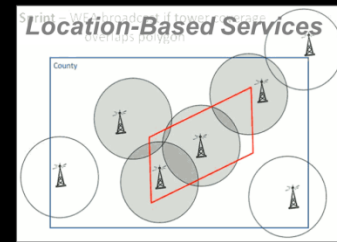
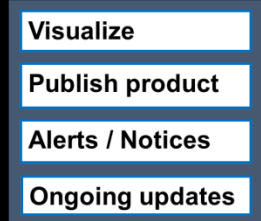
Decision Analysis: Act / Plan

5. Analysis



7. User Access

6. Dissemination



Crowdsourcing



Big Data Analytics



# Integrating new technologies: Architecture

- Clarify data / analysis / communication needs
  - Semantic content; formats of files and data streams
  - Behavior & services; system interactions; component interfaces
- Articulate broadly-defined goals and practices
  - Get beyond current practice and *ad hoc* arrangements
  - Adopt new tools based on anticipated roles / benefits
  - Facilitate building flexible, sustainable capability
- Envision new capabilities enabled
  - Technologies may enable new goals (not just new methods)



# Integrating new technologies: Standards

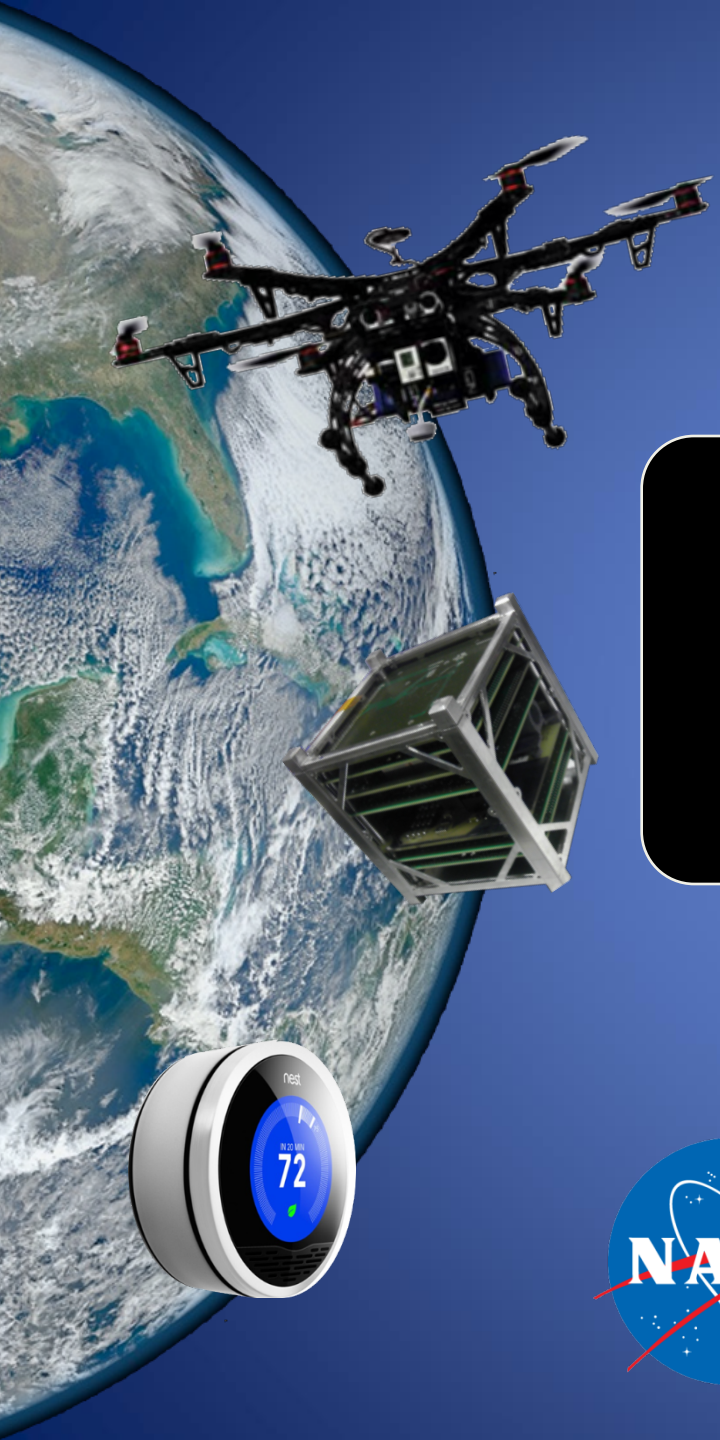
- Alleviate vendor lock-in; Allow creative repurposing
- Widely-adopted, consensus-based standards for
  - Information semantics
  - Service definitions
  - Data formats
  - Software interfaces
- Examples:
  - OGC SensorML (StarFL?), SOS, W\*S; OPeNDAP; IOOS; SPARQL; *etc.*
  - OpenMI, Eucalyptus, OpenStack, MapReduce, ...?
- Challenge: pace of technology adoption  
vs. pace of consensus processes

# Towards technology roadmaps

- **Mature (*integrate*)**
  - Cloud Computing
  - Direct Broadcast
- **Near term [2014-2016] (*accelerate, focus*)**
  - Smallsats, CubeSats
  - Drones
  - Big Data analytics
  - Location Based Services
  - Crowdsourcing
  - Collaboration Services
- **Medium term [2017-2020] (*support, shape*)**
  - Sensor Web, Internet of Things
- **Future [2020- ] (*investigate*)**
  - Models as a Service
  - Semantic services

# This is only a sketch

- Currently seeking input
  - From technology users, developers, experts
  - From practitioners in Disaster Risk Management
- Clarify and envision roles and impacts of these technologies in Disaster Risk Management
- Identify technology gaps or opportunities
- Roadmap, priorities for NASA, GEOSS, *et al.*



Your input is invited

[john.evans@gst.com](mailto:john.evans@gst.com)

