



Design and Development of a Virtual Emergency Operations Center for Disaster Management Research, Training and Discovery

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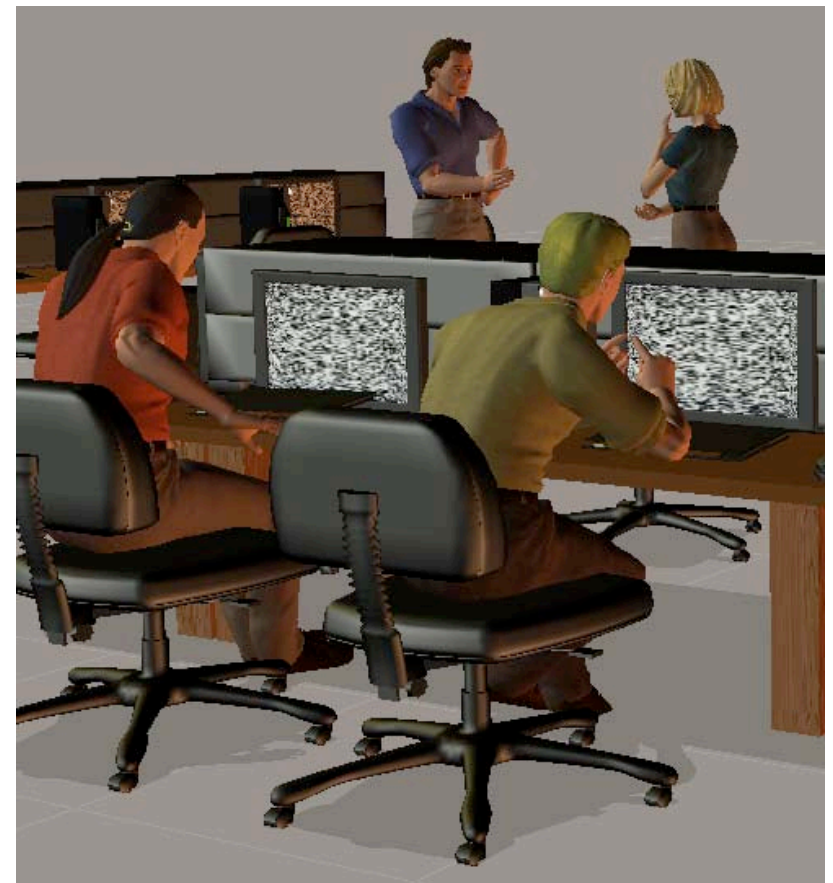
***Supported in part by NSF, Computer, Information Science & Engineering (CISE), Computer & Network
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Collaborators

- Universities
 - University of Notre Dame, Florida International University , Emory University, University of Puerto Rico, MIT
- Government
 - Miami/Dade EOC
 - City of Miami
- Industry
 - IBM
 - Florida Power & Light

Virtual Emergency Operations Center (vEOC)

- Design & Prototyping stage
- Planned applications
 - Research platform
 - Training and education
 - Knowledge management
 - Test bed for software development



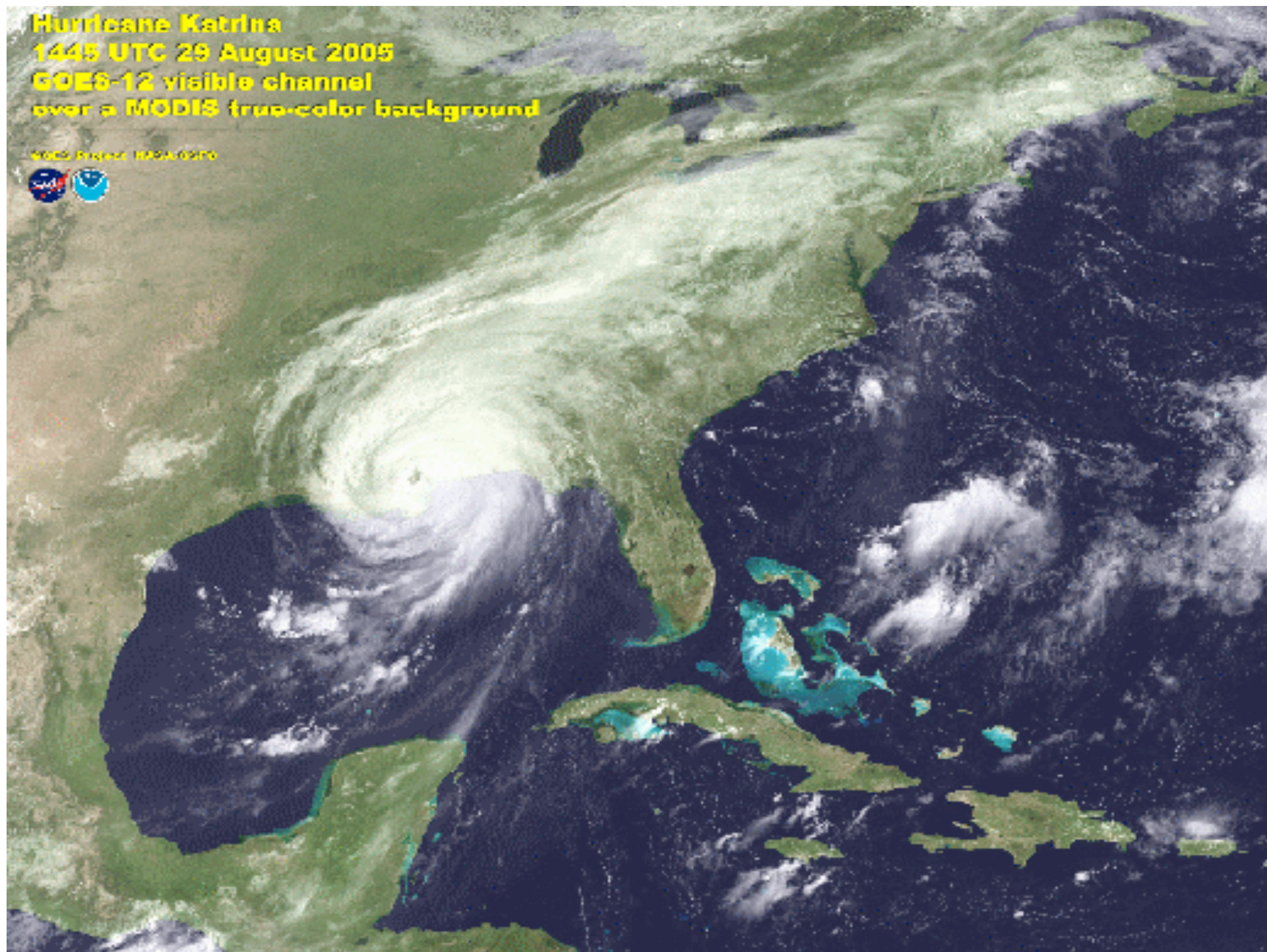
Design and Prototyping

- Business process mapping & analysis, and standard operating procedures (SOPs)
- Historic data, scenarios/scripts
- Distributed Infrastructure
- Desktop VR
 - Problem: collaboration over a network
 - Synchronization
 - Atomicity
 - Croquet
 - Full-featured CVE
 - Solves synchronization/atomicity



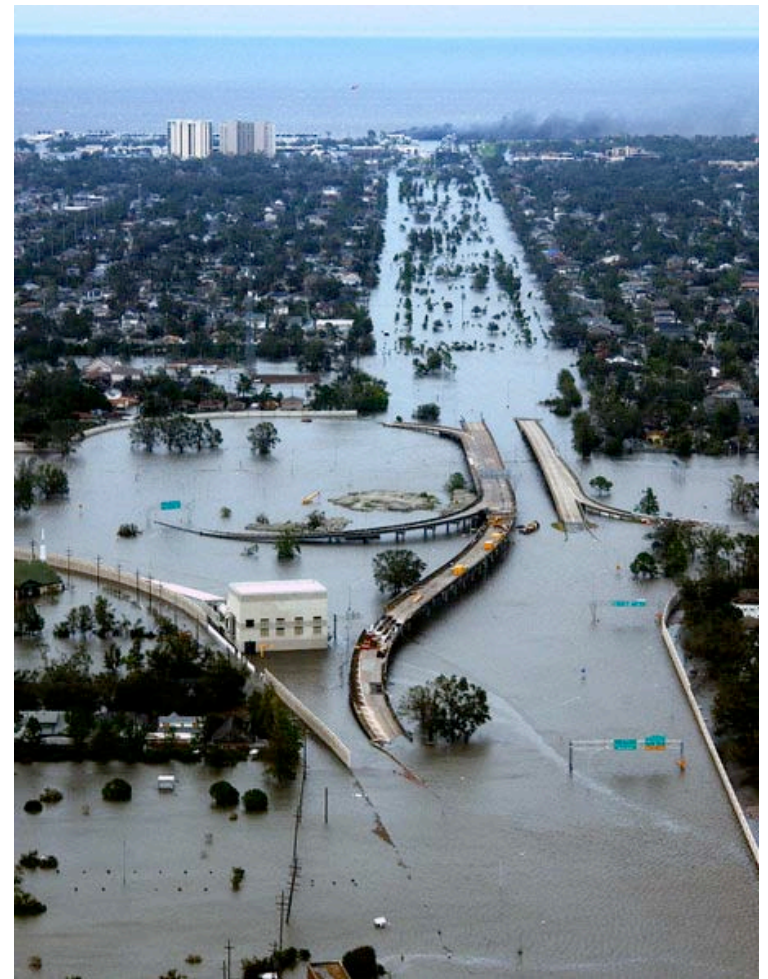
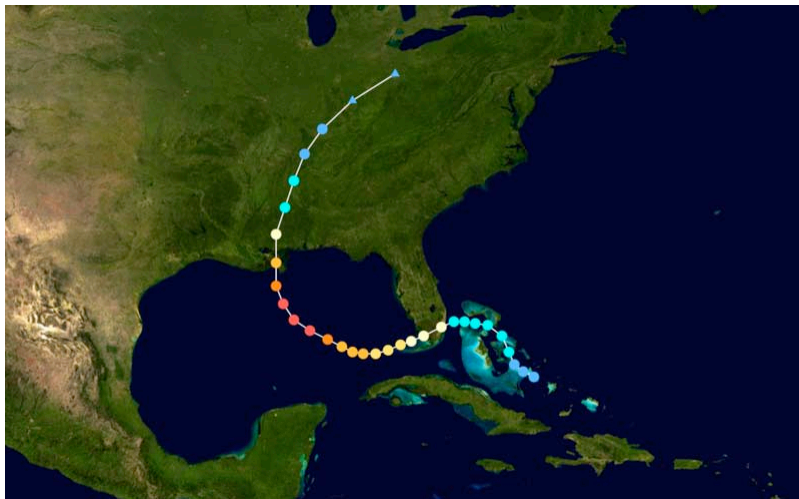
Hurricane Katrina
1445 UTC 29 August 2005
GOES-12 visible channel
over a MODIS true-color background

GOES Project: NASA/GSFC



Hurricane Katrina (2005)

- Fatalities
 - 1,836 total
- Damage
 - \$81.2 billion (2005 USD)
 - \$89 billion (2008 USD)



US Department of Homeland Security (DHS) Report: Hurricane Katrina

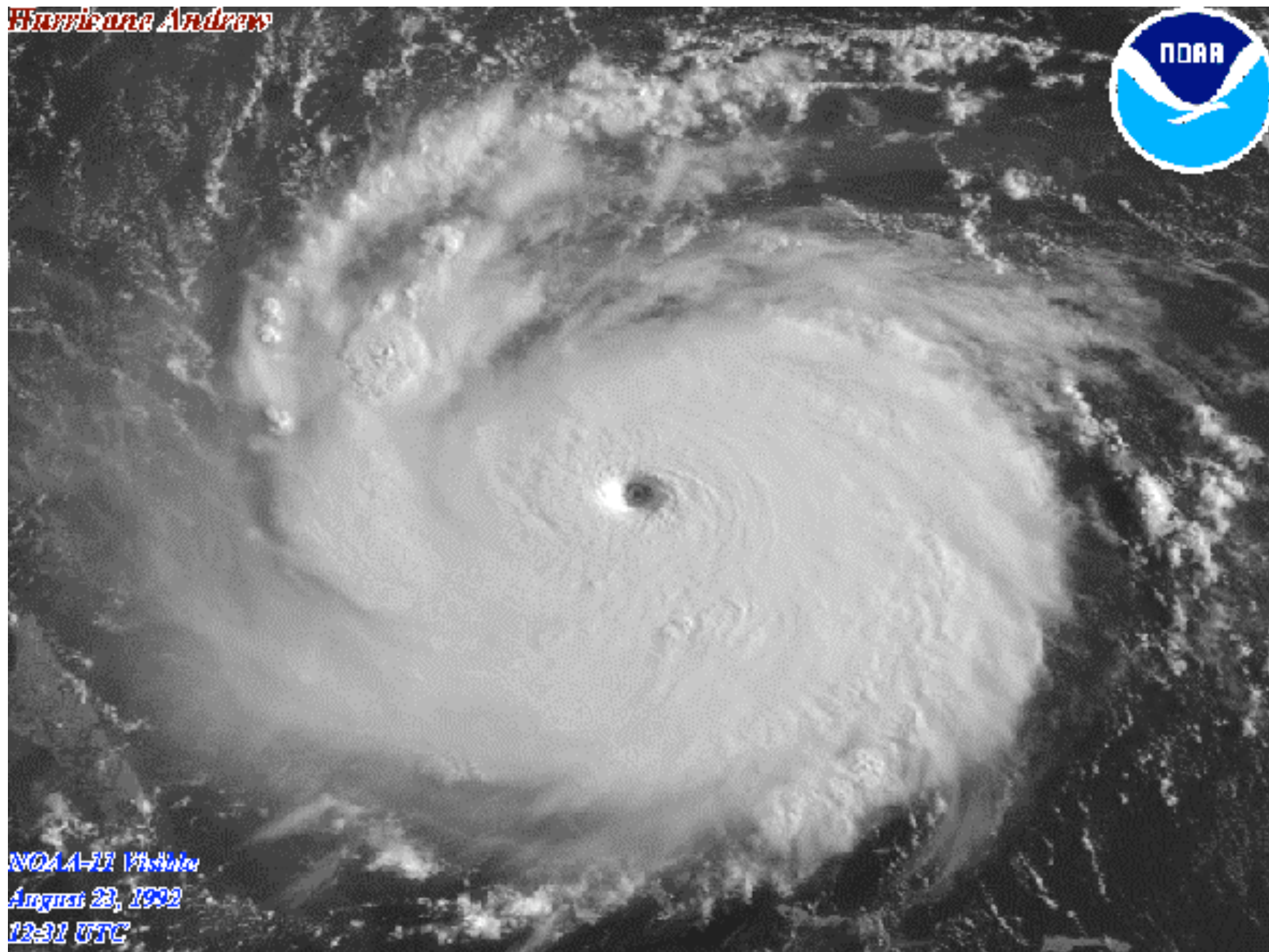
- 1) Long-term warning went unheeded and government officials neglected their duties to prepare for forewarned catastrophe;
- 2) Government officials took insufficient actions or made poor decisions in the days immediately before and after landfall;
- 3) Systems on which officials relied on to support their response efforts failed; and
- 4) Government officials at all levels failed to provide effective leadership.

(Department of Homeland Security (DHS), "Hurricane Katrina: A Nation Still Unprepared - Executive Summary: Report of the Senate Committee on Homeland Security and Governmental Affairs," May 2006.)

Hurricane Andrew

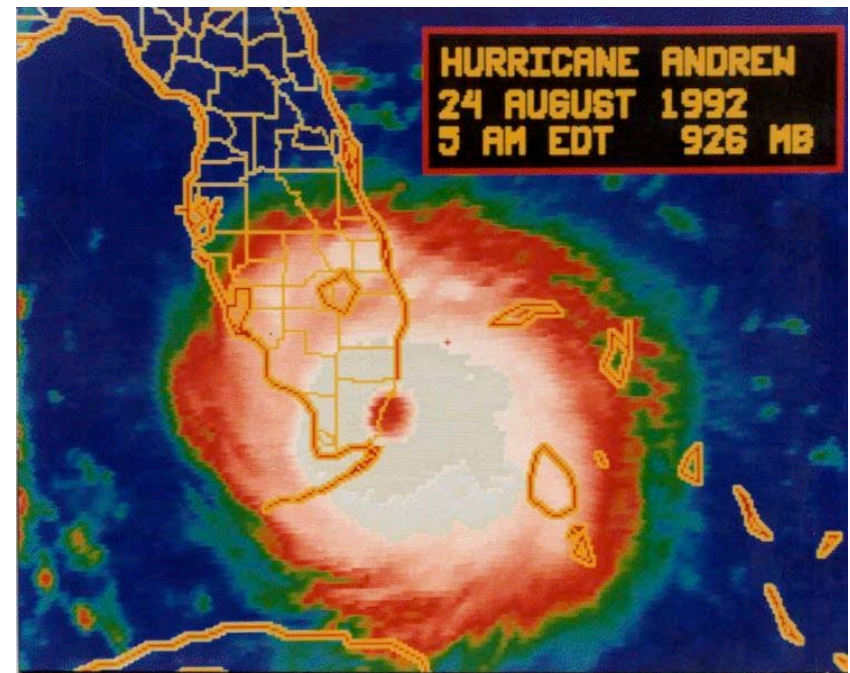
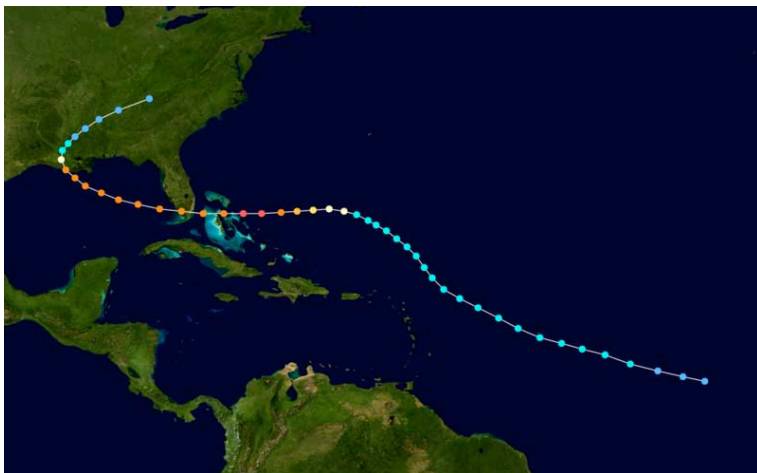


*NOAA A-11 Pictor
August 23, 1992
12:31 UTC*



Hurricane Andrew (1992)

- Fatalities
 - 65 (26 direct, 39 indirect)
- Damage
 - \$26 billion (1992 USD)
 - \$40 billion (2008 USD)



Lessons Learned from Andrew Same as Katrina!

- 1) Clearly defining and communicating leadership roles, responsibilities, and lines of authority for catastrophic response in advance of such events,
- 2) Clarifying the procedures for activating the National Response Plan and applying them to emerging catastrophic disasters,
- 3) **Conducting strong advance planning and robust training and exercise programs,**
- 4) Strengthening response and recovery capabilities for a catastrophic disaster

(GAO, "Hurricane Katrina: GAO's Preliminary Observations Regarding Preparedness, Response, and Recovery," Government Accountability Office 2006)

Disaster Management

Problems

- Communities have complex infrastructures that provide key capabilities (public and private)
- Disasters disrupt community capabilities
- How can such disruptions be “managed to stability”

Issues

- No enduring management structures exist
- No enduring routines exist (institutional or individual)
- No enduring memory exists (institutional or individual)
- No enduring control exists

Environment

- Complex, ill-defined, non-recurring often unique (interacting) contexts and events
- Causal structures uncertain or masked
- Results in reactive triage management that can “thrash”
- Results in a variety of dynamic, emergent structures that can interfere with each other

Disaster Management Research

Strategy ... answer questions like ...

- Where are the loci of key decisions?
- When are these made and what are the consequences?
- Who knows what? Who talks with whom? When? Why?
- What and where are the fragilities?
- How can this be discovered and demonstrated?

Solution ... a virtual EOC

- Create a configurable communication and computational infrastructure
- Includes real-time engagement, simulation & interoperability capabilities, and data/knowledge mining components
- Simulation & Training
- Research Platform
- Test Bed
- Knowledge Management: articulation, sharing, repository

Disaster Management

- **Florida** → one of the most effective in disaster management
- **Miami-Dade County Office of Emergency Management (OEM)**
 - Lead agency in an emergency event
 - The Emergency Operations Center (EOC) is the central site for all of the emergency management operations
 - Participating agencies organized by **function ...**
 - Public Safety
 - Human Services
 - Infrastructure

The Miami-Dade Emergency Operations Center (EOC)

- The **Public Safety Functional Group Branch** includes:
 - US Coast Guard, National Park Service, Miami-Dade Fire Rescue Dept., Florida Dept. of Law Enforcement, Florida National Guard, Miami-Dade Police Dept, Florida Fish and Wildlife Conservation Commission, Miami-Dade Corrections Dept., Florida Highway Patrol, Animal Services, Department of Environmental Resources Management (DERM), *and others*

The Miami-Dade Emergency Operations Center (EOC)

- The **Public Safety Functional Group Branch**
- The **Human Services Group Branch**
includes:
 - Dept. of Human Services, American Red Cross, Miami-Dade County Public Schools, Miami-Dade Voluntary Organizations Active in Disaster (VOAD), Dept. of Mental Health, Miami-Dade County Health Dept., Team Metro, Salvation Army, Greater Miami Convention and Visitors Bureau, Miami-Dade Housing Agency, Florida Dept. of Children and Families, Florida Agency for Health Care Administrators (AHCA), and the Miami-Dade Fire Rescue Emergency Management Services *and others*

The Miami-Dade Emergency Operations Center (EOC)

- The **Public Safety Functional Group Branch**
- The **Human Services Group Branch**
- The **Infrastructure Group Branch** includes:
 - Miami-Dade Solid Waste Dept, Miami-Dade Water and Sewer, Miami-Dade Transit Evacuation, South Florida Water Management District, Miami-Dade Transit-Regular Services, Miami-Dade Public Schools, Miami-Dade Public Works, Florida Dept. of Transportation, BellSouth, Agriculture Extension, City Gas Comcast, Miami-Dade Enterprise Technology Services Dept. (ETSD), and Florida Power & Light, the airports, and the Port of Miami *and others*

The Miami-Dade Emergency Operations Center (EOC)

- The **Public Safety Functional Group Branch**
- The **Human Services Group Branch**
- The **Infrastructure Group Branch**
- **Additional Interacting Organizations** include:
 - Florida Division of Emergency Management (DEM), neighboring county's emergency management liaisons (including Monroe County, Broward County, Florida City, Martin County, and Collier County), the Divisional EOCs (Miami Beach, North Miami, North Miami Beach, Homestead, Coral Gables, Hialeah, and the city of Miami), and representatives from Homestead Air Force Reserve Base and FEMA

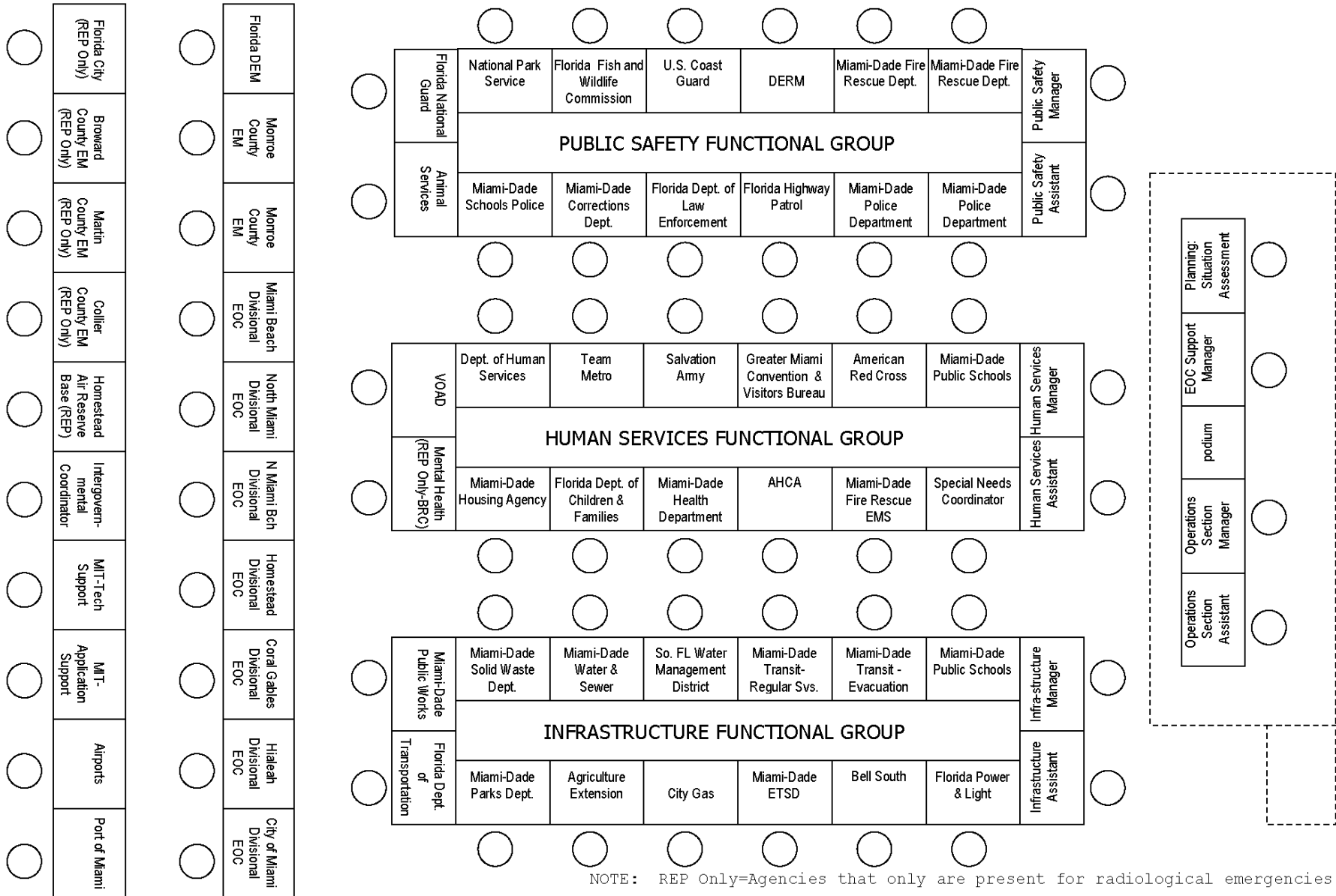
The Miami-Dade Emergency Operations Center (EOC)

- The **Public Safety Functional Group Branch**
- The **Human Services Group Branch**
- The **Infrastructure Group Branch**
- **Additional Interacting Organizations**
- Facilities for **Situational Awareness, Coordination, Communication, Decision Making, Resource Allocation, and Documentation** include:
 - GIS/Mapping, Press Room, Answer Center (911/311), Special Needs Support Center, News Feeds (TV/Cable), WorkStations/Phones, Logistics Support Center, E-Team, Weather, e-Mail, etc.
 - Modes: Synchronous, Asynchronous, Face2Face, Remote

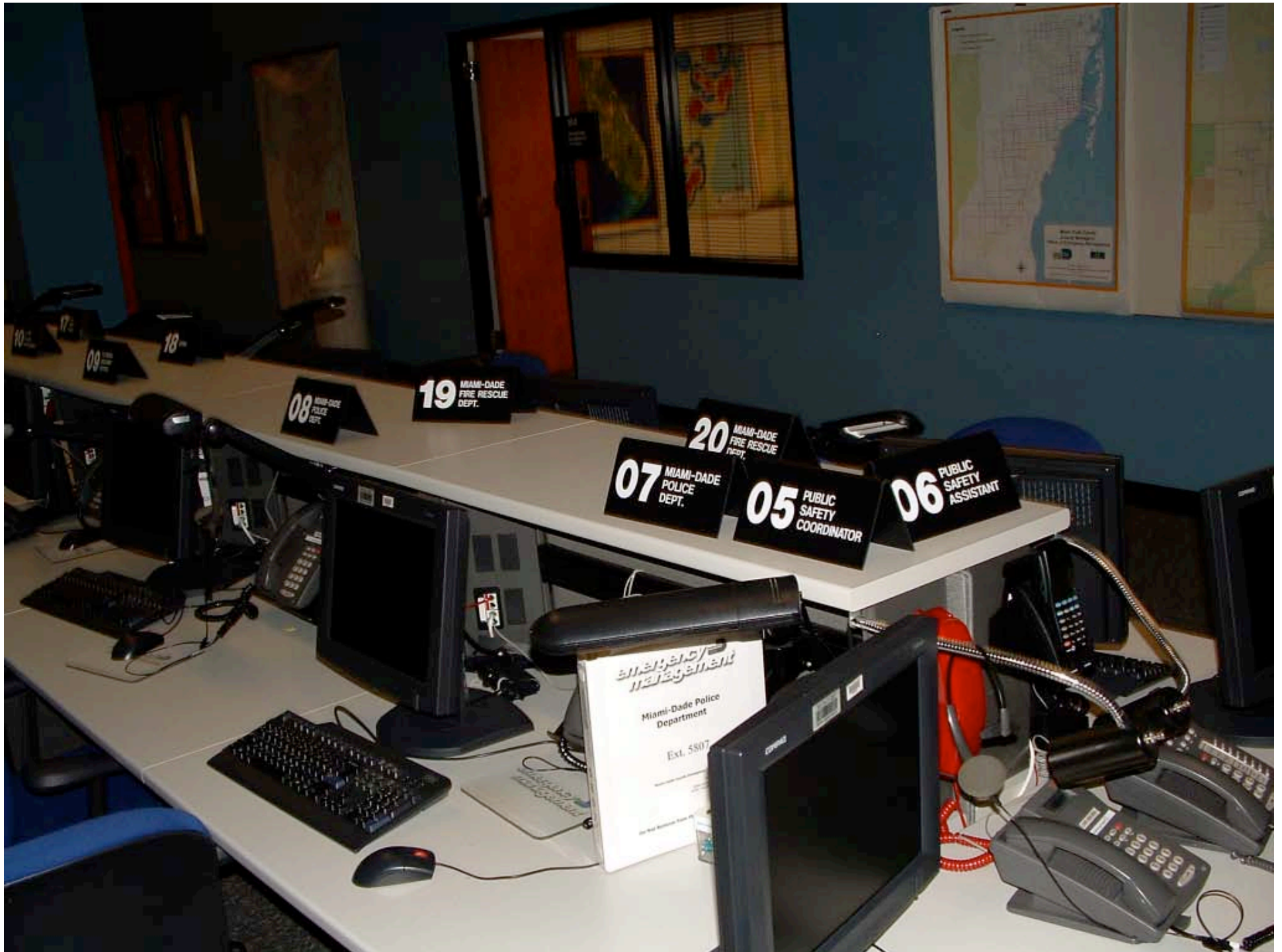


Miami-Dade Emergency Operations Center

Activation floor plan







Miami-Dade EOC

Full Activation Drill - Situational Awareness Briefing - May 2007



Decision-making ...

Resource Requests & Commitments

Historic Data (E-Team) - Wilma

Resource Request by Event/Incident/Activity

This screen last updated (dd:hh:mm:ss) 00:00:00:19

AutoRefresh Off On

Refresh
 Next
 Previous
 Expand All
 Collapse All
 Search
 New Report

Type	Priority	Status	Qty	Units	Est. Cost	Resource No.	No. %	Requestor	Responsible Agency
E - Wilma					173,903		235 100.0%		
Equipment - Other	High	Red-Action Required	1	lot	10,903	Res-032315-680-102605		Logistics Section	NR
Repair auth for state owned equipment	High	Red-Action Required	1	n/a	NR	Res-071116-890-102905		Homestead Divisional EOC	NR
MRE	High	Red-Action Required	1	truck	NR	Res-082419-577-110105		Miami-Dade EOC	MD Office of Emergency Mgmt. (OEM)
Police-Security	High	Red-Action Required	1	NR	NR	Res-083100-525-110205		Logistics Section	NR
Police Officer Unit	High	Red-Action Required	1	NR	NR	Res-084911-891-110105		Florida Power & Light (FPL) (ESF-12)	NR
Ice	High	Red-Action Required	1	truck	NR	Res-090349-100-110105		North Miami Divisional EOC	NR
Other	High	Red-Action Required	1	Traffic Message Board	NR	Res-091048-917-103005		Miami-Dade EOC for Biscayne Park	Miami-Dade EOC
Fuel-Gasoline	High	Red-Action Required	1	NR	NR	Res-092457-676-103005		MD Parks & Rec Dept. (ESF-3)	NR
Meals	High	Red-Action Required	1	each	NR	Res-092811-536-102705		Hialeah Divisional EOC	Miami-Dade EOC
Generator	High	Red-Action Required	1	each	NR	Res-094815-835-102605		Hialeah Divisional EOC	Logistics Section Manager
Fuel-Diesel	High	Red-Action Required	1	NR	NR	Res-102213-114-102705		Hialeah Divisional EOC	Miami-Dade EOC
Forklift	High	Red-Action Required	1	NR	NR	Res-105821-496-103105		Miami-Dade EOC	NR
Pump Station repair	High	Red-Action Required	1	NR	NR	Res-112735-507-102605		City of Miami Divisional EOC	Miami-Dade EOC
Ice	High	Red-Action Required	1	Truckload	NR	Res-113022-262-103105		City of Miami Divisional EOC	Logistics Section Manager
Pump Station Repair	High	Red-Action Required	1	NR	NR	Res-114559-636-102605		City of Miami Divisional EOC	Miami-Dade EOC

Decision-making at the EOC ... Complexity!

- **“Normal” organizational learning** → not possible
- **Participation** → fluid, carries little organizational knowledge or history
- **Events** → rare and diverse
- **Prior decisions** → (mostly) documented via after-action reports
- **Decisions** → components, rational etc. may sometimes be unknown, unavailable, or both
- **Critical decisions** → cross-organizational and cross-agency coordination
- **Interactions** → within and between organizations is high and time-sensitive, and the pressures and risks are enormous
- **Coincidental events** of opportunity → Masked risk



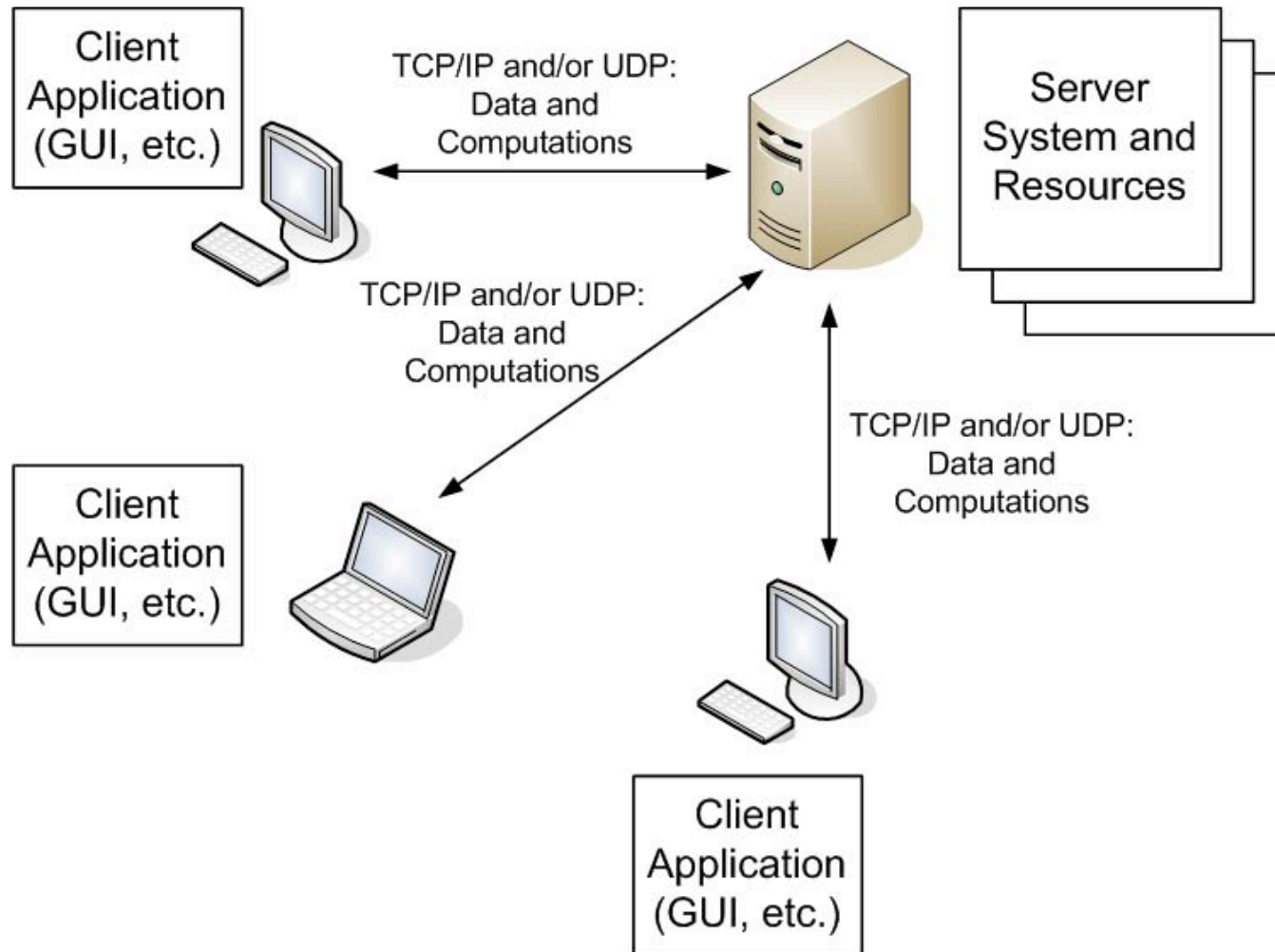
vEOC Components/Features

- Collaborative vEOC “room”
- Scenarios / training scripts
 - Generator
 - Execution engine
- User accounts: authentication and roles
- Process tracing / post-simulation analysis
- Where possible, Open-Source, open-standards
- Options for desktop-VR: support for collaboration

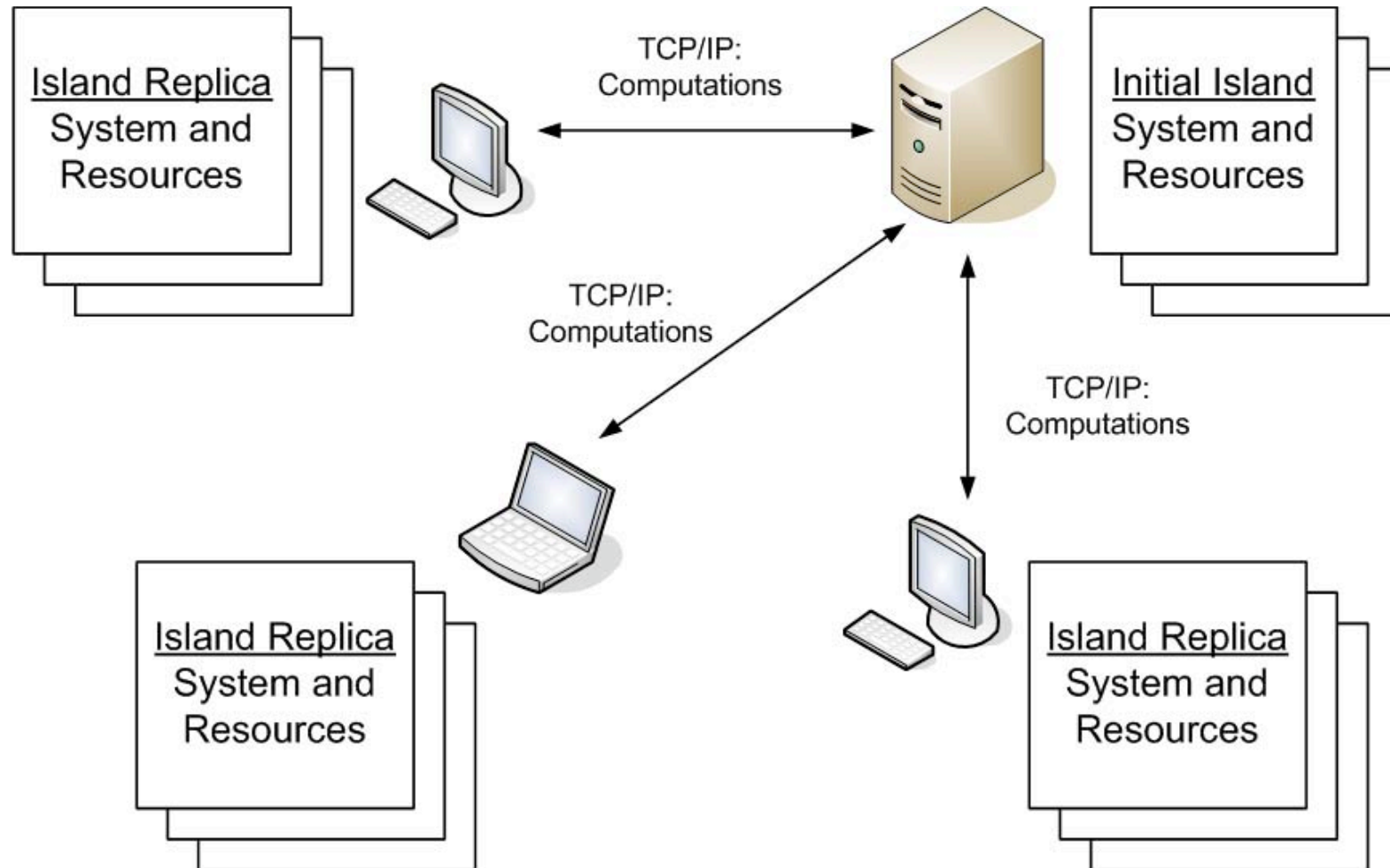
About Croquet

- A software development kit written in Squeak
- Cross-platform (Windows, OS X, Linux)
- Peer-to-Peer
 - Most CVEs use a client-server approach
 - Croquet turns this tried-and-true method onto its head

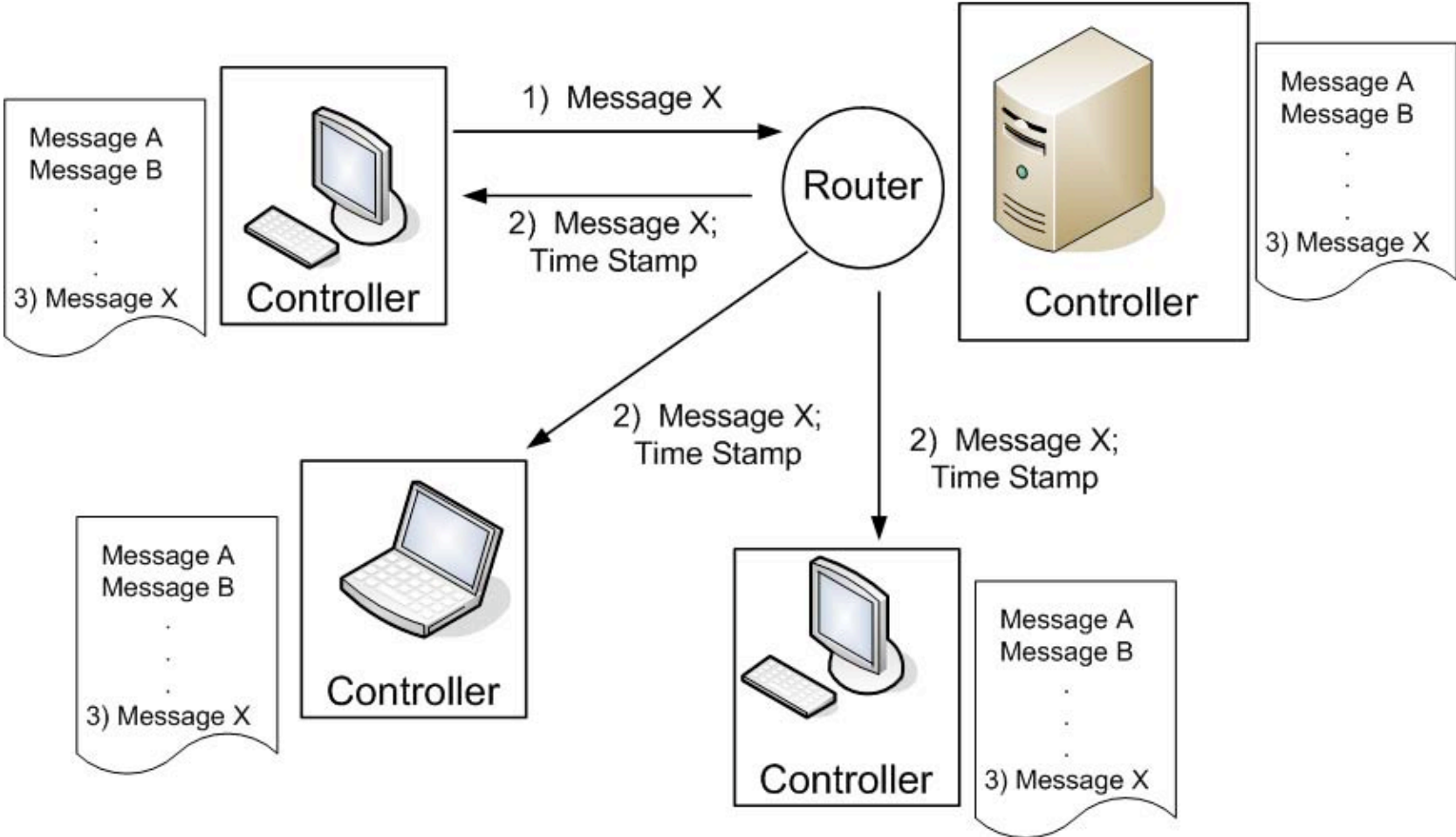
Prototypical Client-Server Model



Croquet Peer-to-Peer Model (TeaTime): Joining an Island



Message Passing in TeaTime



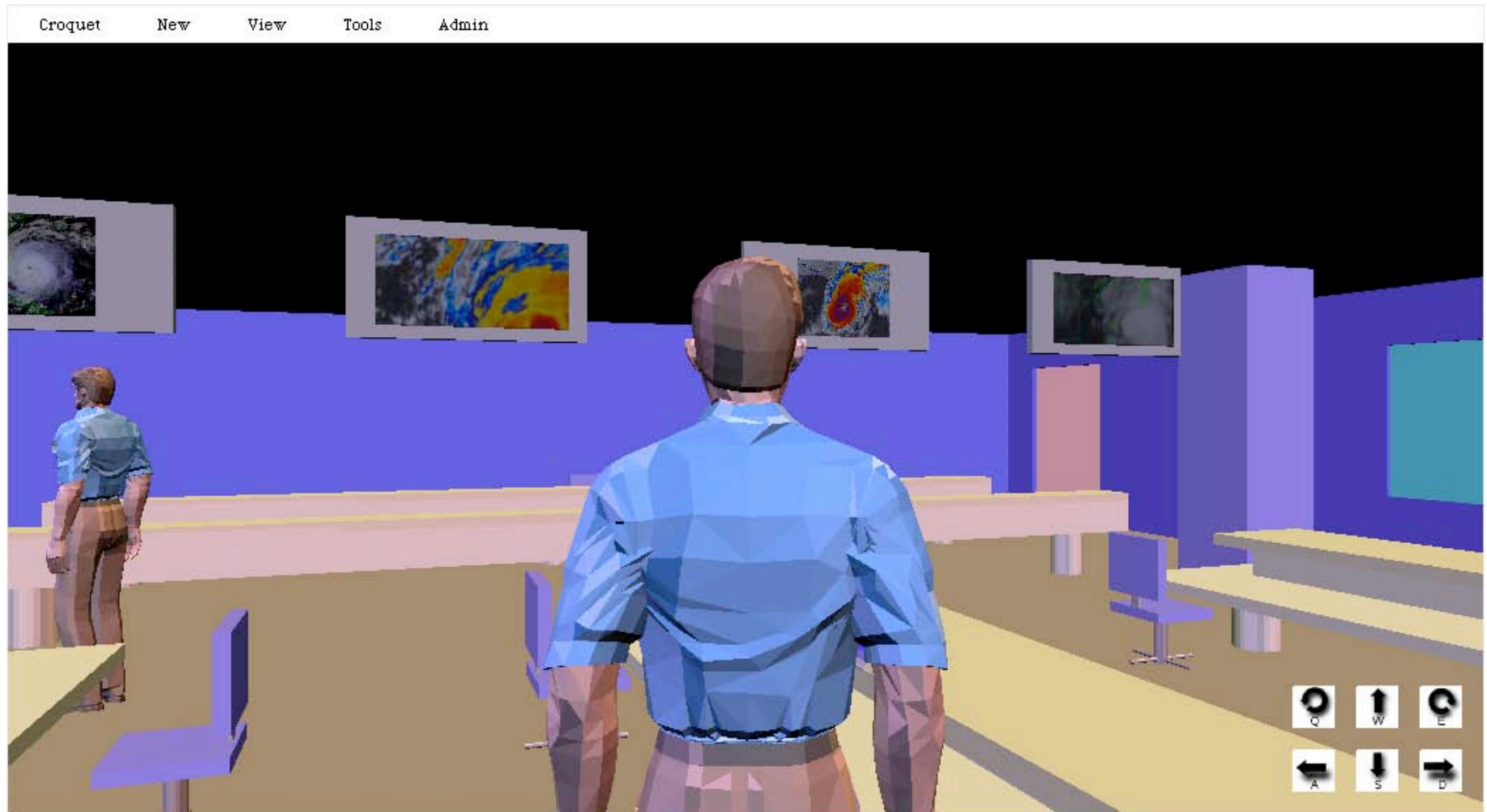
The vEOC

- Goals for Initial Prototype
 - Fully synchronized collaboration mechanisms
 - XML interface to uniformly specify tests/simulations
 - 3D virtual environment with programmable video and photo displays

Synchronized Collaboration

- Already built into Croquet!
 - TeaTime architecture for island communication
 - Text messaging
 - Text white boards
 - OpenGL 3D and avatar support
 - Also a synchronized collaboration mechanism
 - Enables interaction and realism

Interior of vEOC



Text Messaging



Text White Board



XML Interface

- Language for building test/simulation
 - Injection (aka “inject”) messages—one-way, for now: message records
 - Video/photo images: resource records
- Uniform, portable
- Modeled after Miami-Dade EOC test script format
- Croquet supports document type definitions (DTDs)

Injects - Manual Drill

Time	Inject #	Receiving Agency	Sender	Message Type	Message Text	Expected Action	EXPLAN Obj
0000	1	M Beach Divisional	Simulation - M Beach EOC	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
0000	2	North Miami Beach Divisional	Simulation - N. Miami Beach EOC	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
0000	3	North Miami Divisional	Simulation N. Miami EOC	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
+0005	4	Homestead Divisional	Simulation Homestead	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
+0005	5	Coral Gables Divisional	Simulation C Gables EOC	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
+0005	6	Hialeah Divisional	Simulation Hialeah EOC	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
+0005	7	Miami Divisional	Simulation Miami EOC	Info Request	City Mayor and commissioners want to confirm when tropical storm force winds will arrive and which shelters will be open.	Access IAP or contact Municipal Branch Dir for info	4
+0010	8	Logistics	Simulation - State	Info Request	State wants location of PODs	Provide info	2
+0010	9	AHCA	Simulation - Mercy Hospital	Request	8 ICU nurses needed at Mercy Hospital – hospital has difficulty getting additional staff.	Describe response process & include in updated sitrep	1,4

vEOC XML Sample

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE simulationScript SYSTEM "vEOC-Sims.dtd">

<simulationScript>
  <rsrcRecord>
    <time offset="5" injectNum="1"/>
    <device type="video" devID="1"/>
    <file>Content/vEOC/Movies/hurr-bertha-vid.mpg</file>
  </rsrcRecord>
  <msgRecord type="infoUpdate">
    <time offset="10" injectNum="9"/>
    <sender>
      <agency>Miami Beach EOC</agency>
    </sender>
    <receiver>
      <agency>Miami Beach Divisional</agency>
    </receiver>
    <message>City Mayor and commissioners want to confirm when tropical-storm-force winds will arrive
and which shelters will be open.</message>
    <action>Access IAP or contact Municipal Branch Director for information.</action>
    <explanObj>4</explanObj>
  </msgRecord>
</simulationScript>
```

Scripted Inject Message

Croquet New View Tools Admin



Still Need to Resolve

* City MREs additional 500
* City 400 units road flares

Q W E
A S D

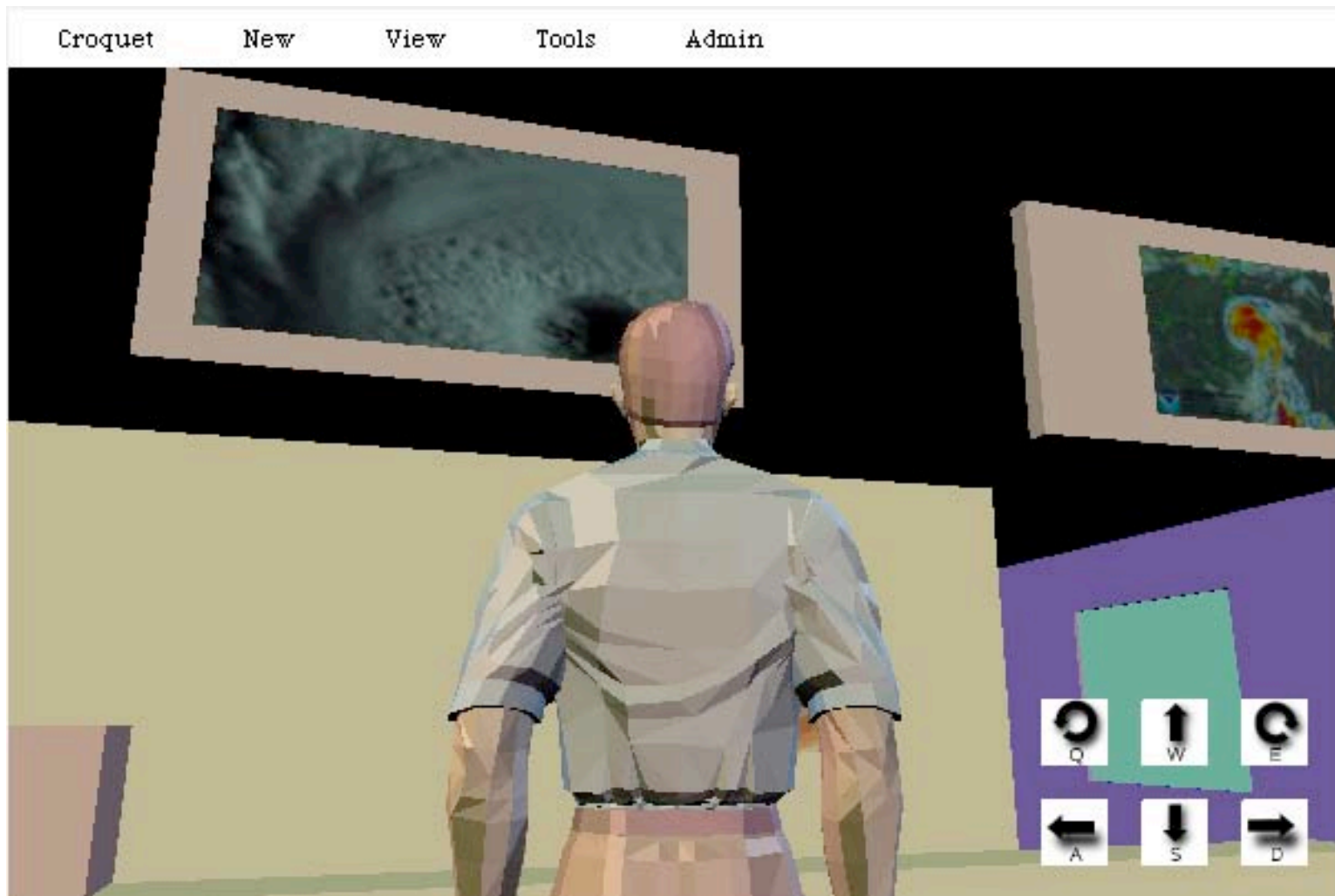
FROM : Miami Beach EOC
TO : Miami Beach Divisional
TIME : Sim +60
INJECT: 9

Fifteen patients at the special-needs shelter have arrived with their oxygen canisters. The nurse manager is concerned that they will be out of oxygen within the next 12 hours.

Video and Photo Displays

- Important to the collaboration process
 - Weather reports
 - News reports
 - EOC team updates
- Content timed with simulation/test
 - Four video (MPEG), four photo (JPEG/GIF) displays
 - Individually programmable via XML

Avatar watching a Video



Issues with the Prototype

- TeaTime: Synchronization and atomicity are great, but there's a catch!
- Message injects are a one-way street—need to solicit and critique participants
- Participant roles are lacking
- GIS is lacking
- Admin tools needed
 - Build/edit/maintain test/simulation XML
 - Manage participant accounts

Conclusion

- Ensayo is being developed in conjunction with the Miami-Dade Emergency Operations Center
- We envision that Ensayo will contribute to research and education to better allow, and even assist, EOCs
- Support from
 - NSF (CISE, grants CNS0452180 & CNS050348)
 - Mayor of Miami
 - Division Chief of Miami-Dade EOC
 - Other associated organizations in South Florida
 - Alexander Madey

Thank You!
Questions?

