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Investigating Inter-Organizational Collaboration during the Haiti Relief Effort from a Macrocognition Perspective

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21-23 June 2011

Monterey, California
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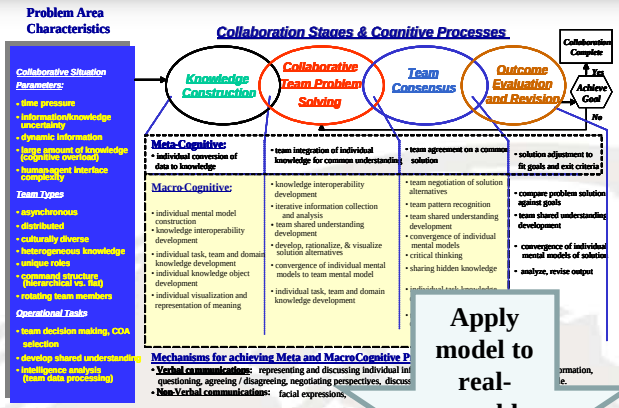
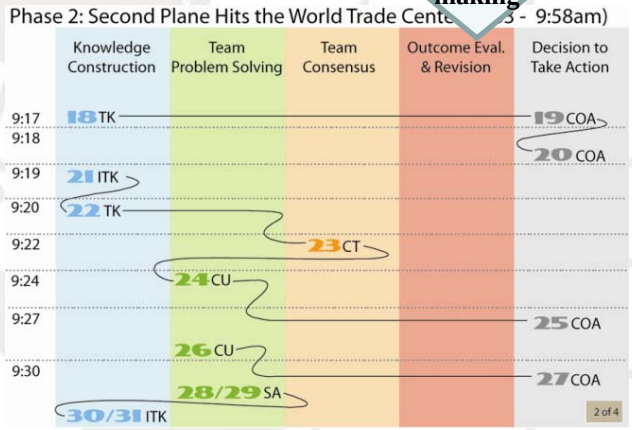
Background
Objective

- Evaluate CKI measurement model of team collaboration
  - Based upon analysis of real-world complex decision-making events
  - Determine which macrocognitive processes are used and, if necessary, refine the model based on empirical analysis
  - Develop a better understanding of the cognitive processes employed when teams collaborate to solve problems
- Test the current coding scheme included in the model of team collaboration
  - Apply definitions of macrocognitive processes included in CKI model of team collaboration
  - Schemes for coding communications should be mutually exclusive, exhaustive, and equivalent
- Examine a range of real-world task domains

Method

- **Macrocognition** - emerging field within cognitive engineering that describes the way cognition occurs in naturalistic, or real-world, decision-making events (Cacciabue & Hollnagell, 1995)
- **Macrocognition in teams** expands the concept by considering group cognition and the collective (team) cognitive processes that enable the externalization of internalized knowledge building. (Letsky et al., 2008)
- **Focus on cognition in collaboration contexts**
  - Focuses on contextually-bound processes
    - Sensemaking, managing uncertainty, and related cognitive processes entailed in responding to emerging events that occur in dynamic decision-making situations
  - Teams collaborate on **short-term situations which require rapid action to be taken against specific missions**
- **Content analysis –** analyze, code team comm's
  - Unique, information-rich, ambiguous, time-compressed scenarios





Technical Approach

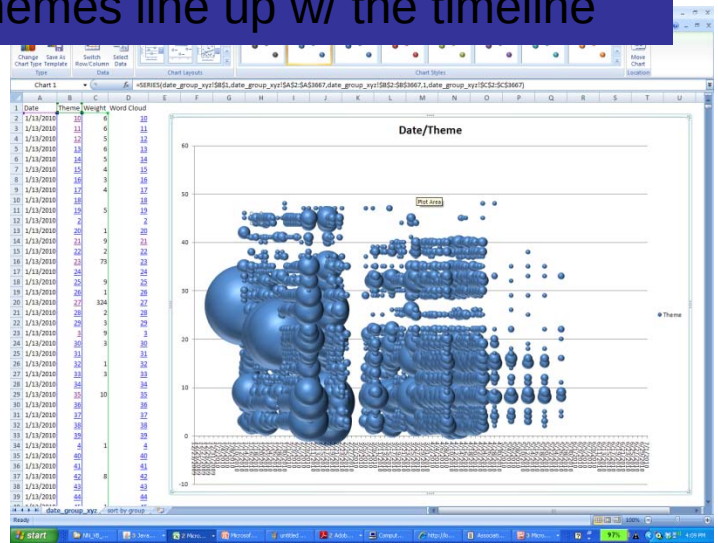
- Analyzed APAN data from the Haiti HA/DR effort in FY11
  - Communications between air, ground, and ocean-based assistance crews were recorded in the All Partners Access Network (APAN) collaboration system
  - Internet-based tool designed for information sharing during disaster relief efforts
    - » Wikis, blogs, forum, file sharing, chat, …
  - > 1,700 individuals used APAN during relief effort
  - Multinational partners, NGOs, and US Federal and State agencies
  - Period covered: Jan 13, 2010 – May 26, 2010
- Lexical link analysis was performed on APAN data
  - Identified terms that emerged and organizations involved over the course of the Haiti HA/DR operation
  - MSSQL database included: 1173 Forum posts and 3900 Blog messages
- Systematic way to select a subset of the vast amount of data in APAN data set
  - Provided a way to isolate all communications related to a particular topic, such as 'hospital,' 'water,' 'logistics,' and 'security'
- Applied definitions of macrocognitive processes included in the model

Technical Approach

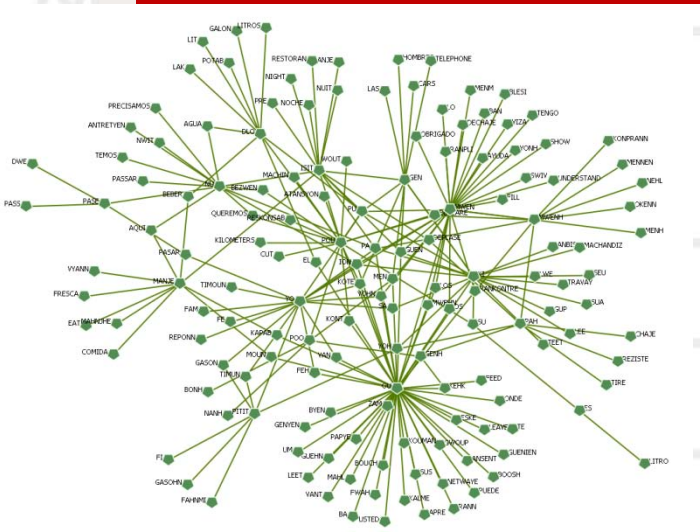
Lexical Link Analysis

- Analysis of structured and unstructured text files (Gallup & Wood, 2010)
  - Automated parsing of documents
  - Develops themes for examined database based on frequency of occurrence of key words
- Lexical analysis – text mining, word pairs extracted from documents, e.g., Blog and Forum (Zhao, 2010)
- Link analysis – reveals relationships between two objects
  - Discovers and displays a network of word pairs
- Generated 40 themes using LLA

Themes line up w/ the timeline



Theme – Language Basic Skills



Collaboration

- Collaboration occurs
  - "When a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain" (Wood & Gray, 1991, p.11)
- Interactive process performed in a collaborative team environment
  - *Collaborative* defined as the "cognitive aspects of joint analysis or problem solving for the purpose of attaining shared understanding sufficient to achieve situational awareness for decision making or creation of a product" (Letsky & Warner, 2008, p. 4).
- Benefits afforded by inter-organizational collaboration
  - Better decision-making as a result of shared information
  - Enhanced coordination among dispersed units
  - Innovation resulting from the cross-pollination of ideas
  - Cost savings produced by sharing resources and the transfer of smart practices (Hansen & Nobia, 2004; Mankin & Fitzgerald, 2004).

Method

Selecting data

- Large set of real-world data with all the characteristics of interest for conducting an empirical evaluation of the model of team collaboration
  - Ad hoc teams are quickly assembled to deal with an emerging event that requires a collaborative effort to deal with the problem-solving event
- Data representing four themes was selected based on LLA
  - Water, hospital, security, logistics

Data analysis and coding

- One pair of coders coded two themes: Water, hospital,
- Second pair of coders coded two themes: Security, logistics
- Cohen's kappa used to calculate percentage agreement
  - 72% and 70% agreement for water and hospital themes

Organizing data

- Data unitized by separating each thought unit on separate line
  - A thought unit refers to a **"sequence of a few words conveying a single thought"** (Welden, Jehn, & Pradhan, 1991, p. 559)
  - **"the smallest message unit that can stand alone"** (Keyton & Beck, 2010, p. 336)

Method

Practice coding

- Coders independently coded 200 lines from separate data set
- Raters discussed respective coding w/ researcher to calibrate their use of the macrocognitive process categories
- Then completed additional practice coding 200 lines of APAN data on a separate theme

Independently coded data from forum and blogs for their two themes

- Reviewed respective coding, calculated percent agreement, resolved any differences in coding

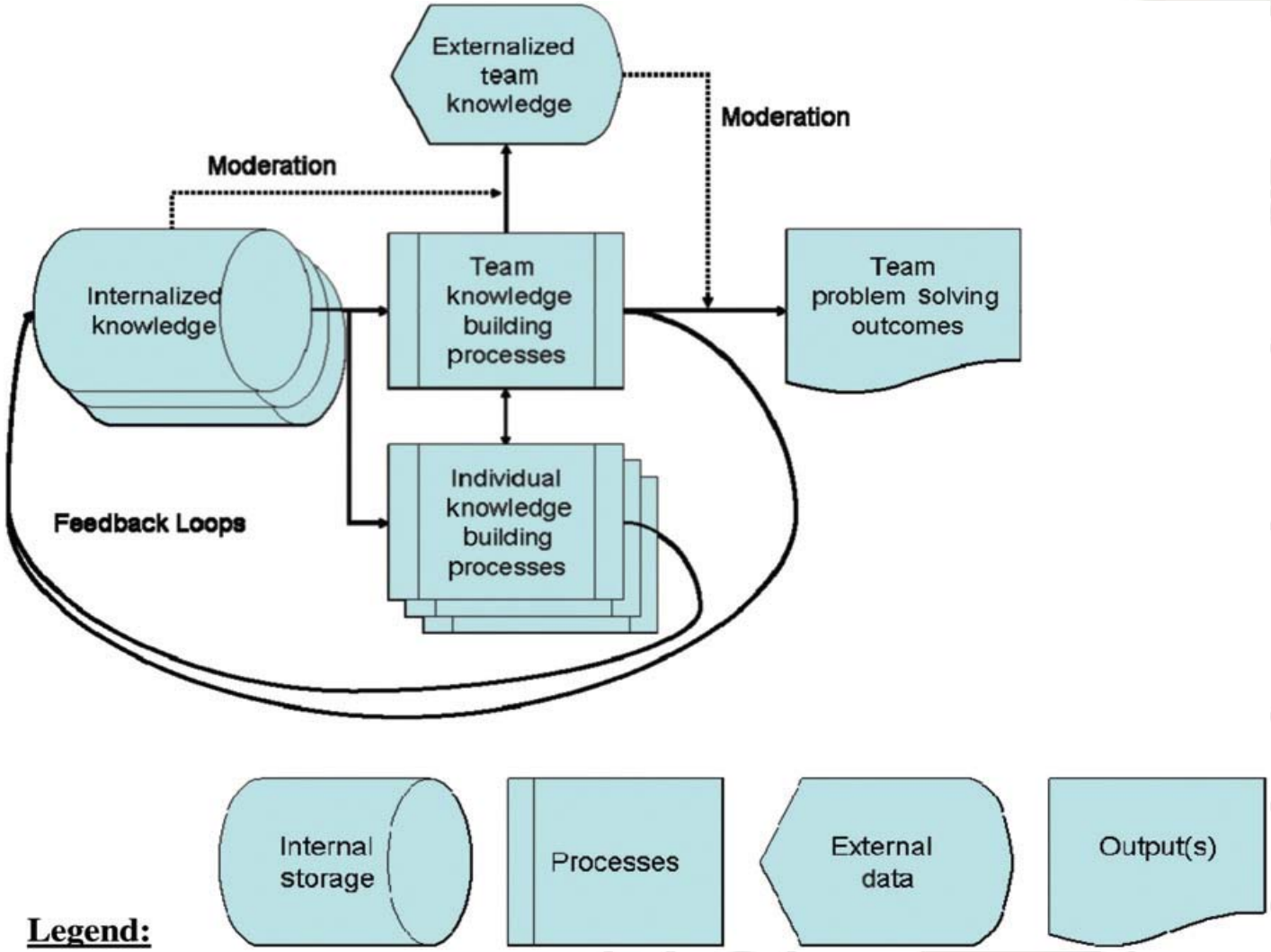
Motivated to unpack the macrocognitive category that contained the majority of team communications, *Team Information Exchange* (TIE)

- 81% of water and hospital theme thought units coded as TIE
- Research team reviewed the NDM literature related to sensemaking to determine additional cognitive processes that might be used to differentiate the large number of communications that were coded as TIE

Method

Measurement Model of Team Collaboration

(From Fiore, Rosen, Smith-Jentsch, Salas, Letsky, & Warner, 2010)



Method

- **A consistent pattern is evident across task domains** previously investigated where the majority of thought units were coded as representing two of the cognitive processes: *Team Information Exchange* (TIE) and *Team Knowledge Sharing* (TKS)
- ***Team Info Exchange:*** passing relevant information to the appropriate team member
- ***Team Knowledge Sharing*****:** explanations and interpretations shared between TMs

Percentage of Communications Coded as Team Information Exchange and Team Knowledge Sharing across Task Domains

Task Domain	Team Information Exchange	Team Knowledge Sharing
Firefighters 9-11	42.0[1]	27.0[2]
Maritime Interdiction Operation	60.0[1]	5.0[2]
Air Operations Center	51.5[1]	10.3[2]
NORAD	52.9[1]	3.7[2]
UAV Dynamic Re-planning	58.00	4.29
Haiti HA/DR Effort	81.00	5.90

Note: [1]In a previous version of the model this macrocognitive process was labeled *Task Knowledge Development*.
[2]In a previous version of the model this macrocognitive process was labeled *Team Knowledge Development*.

Include Sensemaking Processes

- Focus on tasks performed in "the wild" – culled from NDM literature related to sensemaking to develop additional list of macrocognitive processes that could be used for coding the present set of data
- **Sensemaking:** An essential cognitive function performed by a variety of domain practitioners across a wide range of real-world tasks (Klein, Phillips, Rall, and Peluso, 2007)
  - Begins when person becomes aware of a weakness in their current comprehension of a situation, often experienced as a surprise, in response to unexpected changes or as a failure of expectations
  - Sensemaking is a critical process for teams engaged in real-world domains where practitioners deal with complex, dynamic, evolving situations that are "rich with various meanings" (Klein, et al, 2007, p. 114)
    - Data practitioners use to develop an understanding of the situation are often highly ambiguous and very complex and the dynamic events require the decision maker to dynamically update their understanding as the situation evolves over time
  - The frame that is adopted by the practitioner will affect what data are attended to and how these data items are interpreted
    - When the practitioner notices data that do not fit the current frame, the sensemaking cycle of continuously moving toward better explanations is activated. Sensemaking incorporates consideration of the following criteria: plausibility, pragmatics, coherence, and reasonableness

Method

Macrocognitive Processes from the NDM Sensemaking Literature

Macrocognitive Process	Definition
Anticipatory Thinking (Klein, Snowden, & Lock Pin, 2007) (Weick & Sutcliffe, 2001)	A critical macrocognitive function of both individuals and teams. A form of sensemaking that is future oriented such as forming expectancies about future events. Active attention management where the operator focuses attention on likely sources of critical information is a key characteristic
Assessing Risk	Evaluation of the potential consequences for risk or a danger to reach a desired end-state
Problem Detection	A form of sensemaking that recognizes issues arising from the current situation where the outcome could be detrimental if not addressed
Planning and Re-planning	A process where team members build a list of actions that will be performed to solve a problem and adjust as developments occur
Sensemaking	The process of framing and reframing current inputs to the problem in a continuous process that helps filter and interpret the data
Using Analogues	Comparing the current situation with past experiences to solve the current situation

Results

- **Previous research indicates non-exhaustive set of macrocognitive processes**
- **Decision making** – what we label *Decision to Take Action* (DTA) – **emerged during previous analyses of six task domains as a new macrocognitive process**
  - Decision making is an essential macrocognitive process when teams are involved in responding to many complex, real-world tasks
- **Dynamic decision-making tasks require decisions throughout the entire scenario** (Brehmer, 1992)
  - Deciding to take action is viewed as both a **macrocognitive *process*** and a ***product*** of team collaboration (Klein, 1993)
  - Decision maker continuously engaged in monitoring environment, reassessing the situation, and trying to understand what is unfolding until a decision is called for
    - This view sees **knowing <u>when</u> to act as critical as knowing <u>what</u> to do** (Warwick & Hutton, 2007)
- **Many task domains require an interleaving of knowledge building, decision making and taking action to accomplish the mission**
  - Opposed to the team making one final decision at the conclusion of the scenario
- **Analysis of range of task domains indicates types of tasks described by model typically involve team members making decisions as part of the team's collaborative problem solving.**

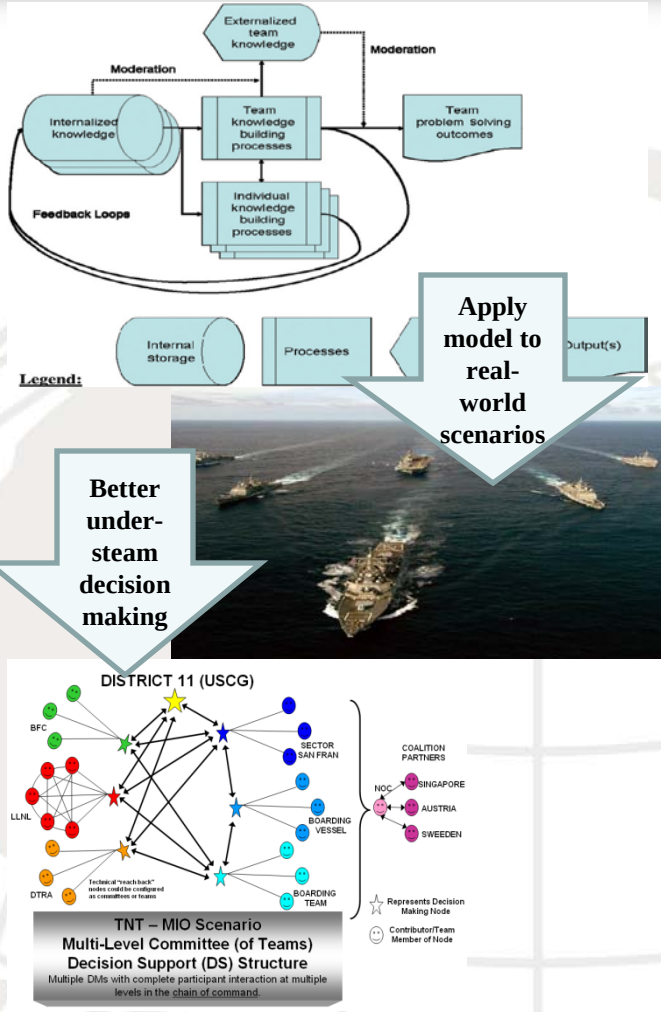
Decision Making is Part of Problem Solving

- **A decision** can be defined as a **"mental event that occurs at a singular point in time…that leads immediately or directly to action"** (Hoffman & Yates, 2005, p. 77).
  - From this perspective, a decision is a commitment to a course of action.
- **Decision making is an essential component of team collaboration for effective team problem solving when team is *performing* the task as opposed to *planning***
- Consistent finding across seven task environments analyzed:
  - Firefighters on Sept 11 responding to the attack on the world trade center
  - Air warfare teams on a Navy ship
  - Boarding team conducting a maritime interdiction operation
  - NORAD collaborating with the FAA on Sept 11 to ground all commercial air traffic
  - Air Force team responding during a time-sensitive targeting scenario
  - Experiment involving UAV real-time planning and execution

	FDNY	Air Warf	MIO	AOC	NORAD	Haiti
Course of Action (COA)	**12**	**22**	**2**	**4.7**	**1.2**	**--**
Request Take Action (RTA)	**7**	**5**	**9**	**2.8**	**4.1**	**7.4**
Total Percent	**19**	**27**	**11**	**7.5**	**5.3**	**7.4**

Results

- **Examined a wide range of task domains**:
  - Firefighters on 9/11
  - Air warfare decision making on US Navy ship
  - Maritime Interdiction Operations (MIO)
  - NORAD/FAA on Sept 11, 2001
  - Air Operations Center Dynamic Targeting Exercise
  - UAV planning and execution
  - Haiti HA/DR Operation
    - Security -722 thought units; Relief Logistics 1,260
    - Water & Hospital - 1,220 thought units
- **High inter-rater reliability**:
  - Firefighters, 9/11 - 89.3%
  - Air Ops Center dynamic Targeting – 89%
  - FAA/NORAD – 77%
  - Haiti HA/DR – 72% and 70%,Water & hospital themes
- Results indicate **task environment will influence which processes are used**
  - C2 teams collaborate on situation assessment but often use RPD decision strategy to determine COA



A more complete model of team collaboration can guide designers of collaboration tools to facilitate decision making as part of the overall task.

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Results of analysis of APAN data for Water and Hospital Themes

Code	Macrocognitive Process Categories	Percentage of Thought Units	
	Individual Knowledge Building	**Water**	**Hospital**
IIG	Individual Information Gathering	**4.10**	**3.60**
IIS	Individual Information Synthesis	**0.00**	**0.00**
KOB	Knowledge Object Development	**0.00**	**0.00**
	Team Knowledge Building		
TIE	Team Information Exchange	**81.00**	**81.80**
TKS	Team Knowledge Sharing	**5.90**	**5.60**
TSOG	Team Solution Option Generation	**1.80**	**1.50**
TENA	Team Evaluation and Negotiation of Alternatives	**0.00**	**0.00**
	Decision to Take Action		
COA	DTA (Issue Course of Action)	0.00	0.00
RTA	DTA (Request Take Action)	**7.30**	**7.40**

TIE – passing relevant info to appropriate TMs at the appropriate time

Accomplishments

Examples from the 'Hospital' theme coded as Anticipatory Thinking.

	Thought Unit	Model Code	NDM Code
1.	We have **capacity for 10 patients immediately and probably 100 more in the coming days.**	TIE	AT
2.	At this point, like I was saying, **we have perhaps twelve hours of working materials to keep going.**	TIE	AT
3.	The use of CAP (combat air patrol) will avoid the logjam at PAP [Port-au-Prince] and is an effective innovation in putting the supplies and aid where they are needed.	TIE	AT

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Problem Detection: a form of sensemaking that recognizes an issue arising from the current situation where the outcome could be detrimental if not addressed

	Thought Unit	Model Code	NDM Code
1.	Improvement in delivery method will aid some and can be implemented immediately but the final solution will require **security** on the ground.	TIE	PD
2.	Unfortunately the situation is critical and although US choppers are flying overhead regularly there is **as yet no contact between one of the few remaining, standing hospitals** in the country and the US military.	TIE	PD
3.	We have **run out of antibiotics and analgesics.**	TIE	PD
4.	500 children 40 miles N/NE of Port-au-Prince that have about **24 hours of food and water left!!!**	TIE	PD
5.	The rumor is that **force protection** – a Force protection requirement – **is impeding aid delivery**.	TIE	PD
6.	Again, we have over a thousand patients that are ready for surgery.	TIE	PD
7.	The hospital administrator for Bernard Mevs Hospital located near the Port-Au-Prince airport has reported an **escalating number of pediatric malaria cases requiring treatment**.	TIE	PD
8.	The **hospital official noted** a **limited supply of anti-malarial pharmaceuticals available**.	TIE	PD
9.	From OCHA [*Office for the Coordination of Humanitarian Affairs*]: The Haiti emergency is also a high-risk environment for sexual exploitation and abuse.	TIE	PD
10.	At this point, like I was saying, we have perhaps twelve hours of working materials to keep going.	TIE	PD
11.	In these operating rooms, **we don't have oxygen, we don't have general anesthesia, we don't have narcotic pain medicines in enough quantity.**	TIE	PD
12.	Again, we have over a thousand patients that are ready for surgery.	TIE	PD
13.	"WEBSITE" does not seem to have contacts for hospitals in Haiti and seems to provide maps only in PDF format.	TIE	PD
14.	The problem we are facing is with discharge.	TIE	PD

Results

Examples from APAN data Water Theme Coded as Problem Detection

	Thought Unit	Model Code	NDM Code
1.	The U.S. has **supply agreements** with Luxembourg (attached), though it appears they **exclude North America**.	TIE	PD
2.	At this moment my condition is very difficult with the orphans because we **can't have food, water, and medicines and food supplies** because we don't have money on hand to do that.	TIE	PD
3.	But the **roads are not yet all named** in the Montagne Noire area.	TIE	PD
4.	We safely dropped shelter boxes (emergency tent/filtration/blanket survival kits) Friday but gents, this is food and I fear for their safety.	TKS	PD
5.	Last contact with the orphanage revealed little to no food, no access to water and a deep concern about **possible criminal activity** in the area.	TIE	PD
6.	Jumping the water from US to Haiti is the only missing piece of our puzzle!	TIE	PD
7.	They didn't have radios, batteries or generators and the earthquake silenced landlines and mobile services, leaving Haitians in the dark in more ways than one.	TIE	PD
8.	MSC or airlift needed ASAP.	TIE	PD

Results

- Analysis of a range of task domains indicates that several macrocog processes cannot be measured during certain types of real-world problem solving
- Two explanations:
  - Many tasks require dynamic decision making (Montgomery, 1993; 1989)
    - Rapid responses are required to deal with the event
    - When TMs use RPD strategy, usually the situation itself either determines or constrains the response options and experienced decision makers make up to 90% of all decisions w/o considering alternatives (Klein, 1989)
    - If the situation appears similar to one that the decision maker has previously experienced, the pattern will be recognized and the course of action is usually immediately obvious.
    - Firefighters, as well as TMs in many other domains collaborate on the 'front end' of the problem, but do not collaborate on how to respond to an event due to time pressure.

Little evidence for *team evaluation and negotiation of alternatives* by team members during dynamic decision-making problem-solving task domains because many responses are guided by standard operating procedures, and the stored schemas of highly experienced operators.

Results

- Many cognitive processes included in the model are not amenable to measurement when working with real-world teams
  - Analyze chat logs or transcripts from large-scale real-world events and exercises
    - Typically not possible to administer surveys or collect data to measure many processes in model
  - See little evidence for many processes included in the model, such as Knowledge Object Development
- Some macrocognitive processes included in the *Internalized Team Knowledge Products Stage* (stage III) require direct interaction with team members to gather data required to measure certain processes.
  - *Teammate Knowledge Similarity*, *Shared Situation Awareness*, and *Task Knowledge Stock*, are amenable to measurement in lab settings but it is typically not feasible to obtain measurements during a or during a real-world event
- *Team Problem Solving Outcomes* (stage V) requires performance assessment metrics to assess the *Quality of the Plan/Problem Solving Solution*, *Efficiency of Planning Process*, and *Efficiency of Plan Execution*
- Performance metrics for the types of task domains we have studied do not exist
  - Developing measurement strategies to assess how the team performed overall, would require a major effort in itself

Conclusions

- Content analysis was used to investigate inter-organizational collaboration
- Added new processes to coding scheme in an effort to discover other macrocognitive processes that might be employed by collaborating teams
  - Specifically we were interested in cognitive processes that are currently coded as *Team Information Exchange*
- Exploratory effort to discover whether additional cognitive processes are employed during complex, information-rich, problem-solving events
  - Evidence for these additional processes, that is, sensemaking, anticipatory thinking, problem detection, assessing risk, planning and re-planning, and using analogues
- Developing a more comprehensive understanding of the macrocognitive processes involved in team collaboration has several practical advantages
  - Conceptualizations that provide the theoretical foundation for a model of team collaboration that take into account consistent findings based on empirical research in real-world work domains are likely to be more accurate
  - The way team cognitive processes influence team functioning was listed among the top ten critical research questions in team research (Salas & Wildman, 2009)
  - A more complete model of team collaboration can guide designers of collaboration tools to facilitate decision making as part of the overall task