Useful and *Usable*

Geovisualization for Crime Analysis

Penn State Coffee Hour
State College, PA: 18 March 2011

Robert E. Roth
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GeoVISTA Center

GeoVISTA *CrimeViz*

http://www.geovista.psu.edu/CrimeViz

an extensible web-based geovisualization application that supports exploration of & sensemaking about criminal activity in space & time

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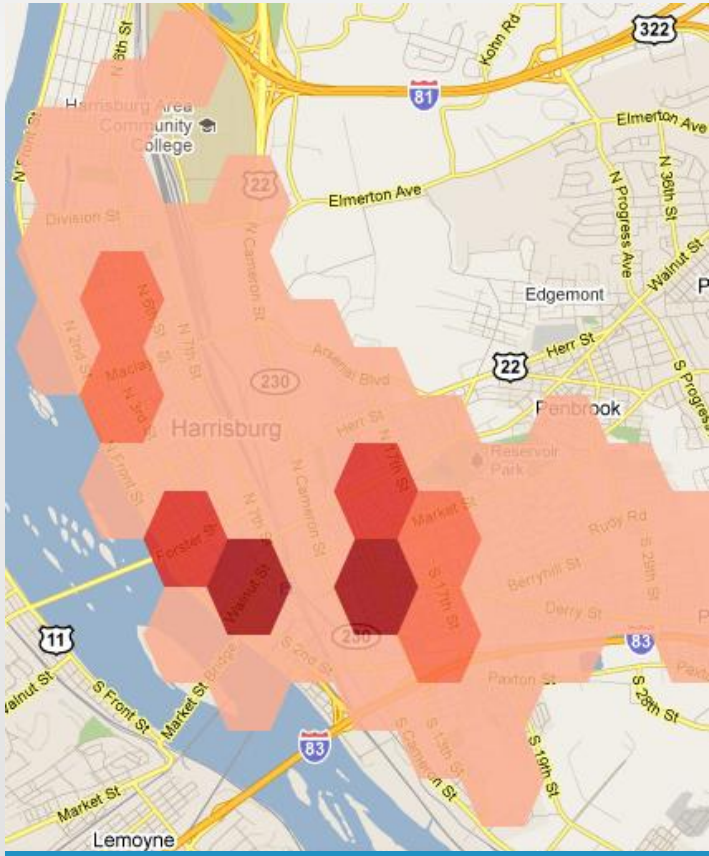

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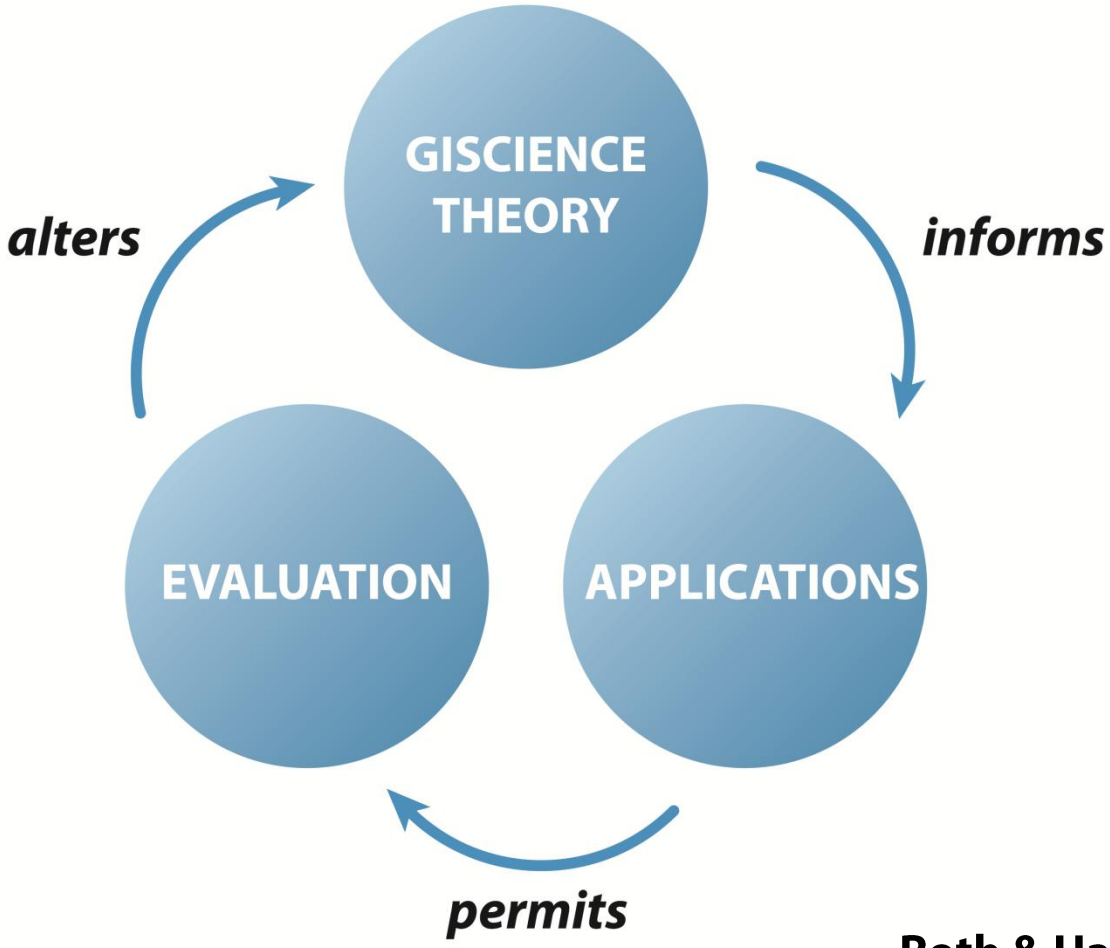
THEORETICAL & APPLIED GISCIENCE



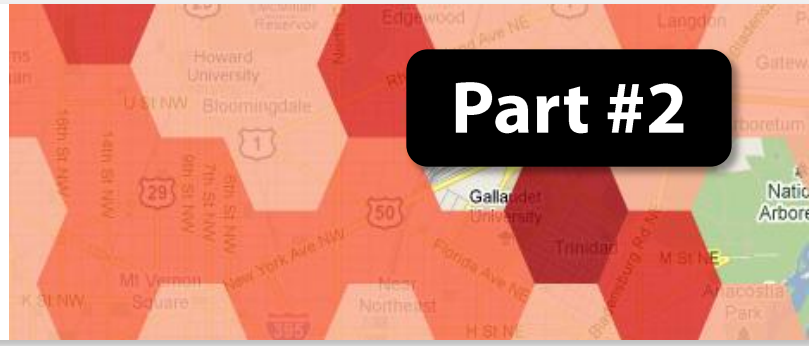
Roth & Harrower (2008)
Addressing map interface usability

PRESENTATION STRUCTURE

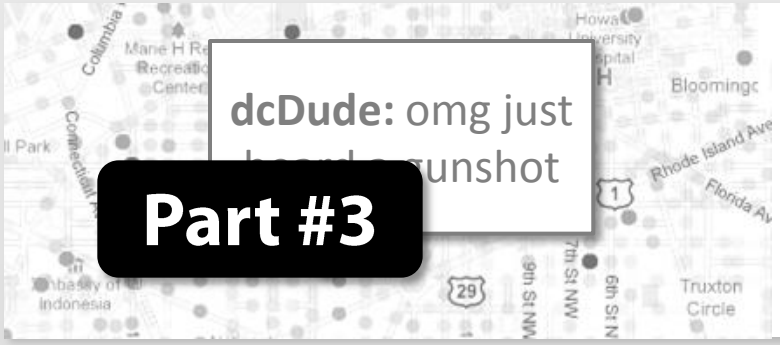
Part #1

***Useful* and *Usable* Geovisualization**

Geovisualization for Crime Analysis



Part #2



Part #3

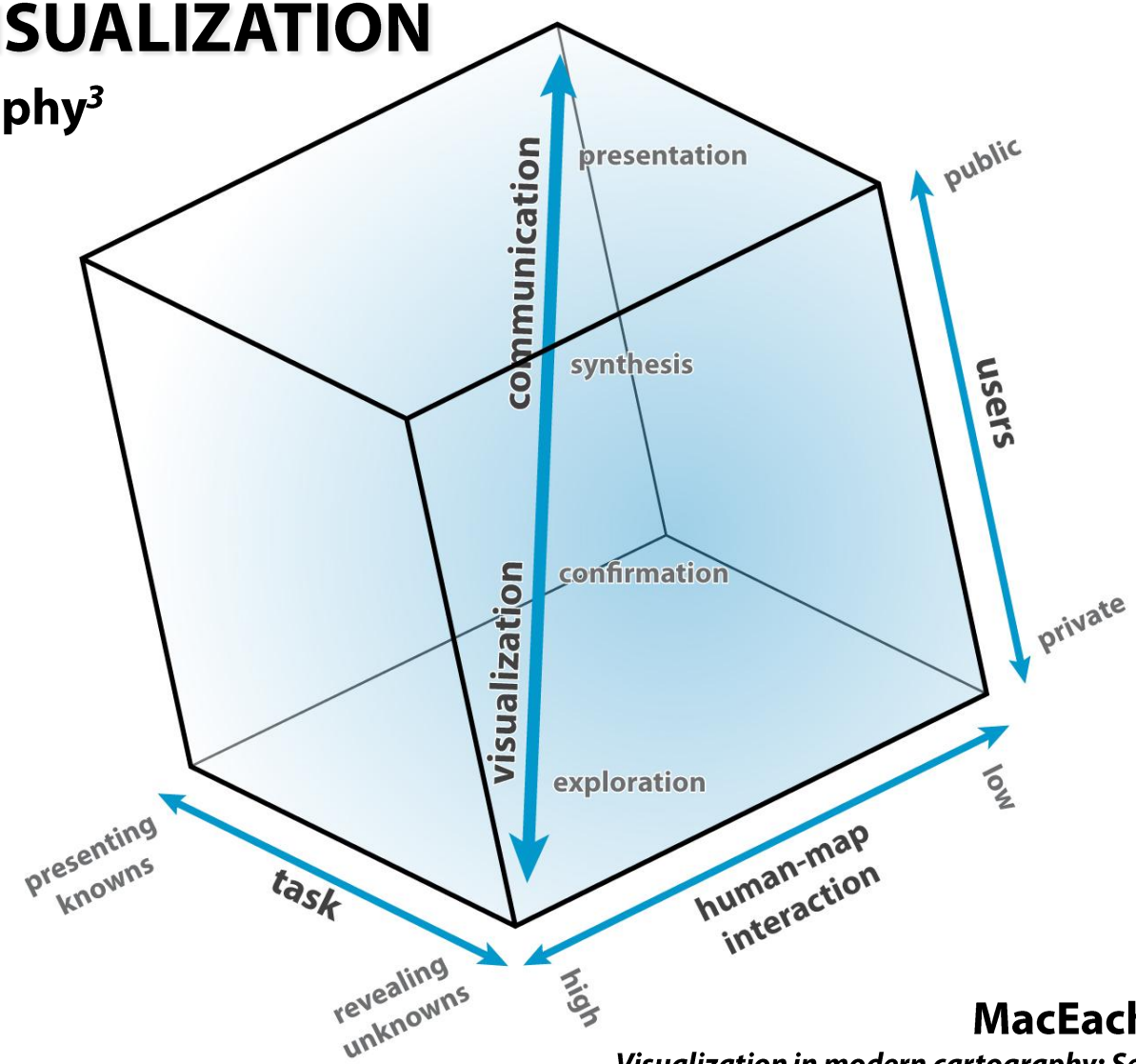
Tech Transition & the Mission of Science

Part 1: Background

Useful and Usable Geovisualization

GEOVISUALIZATION

Cartography[3]

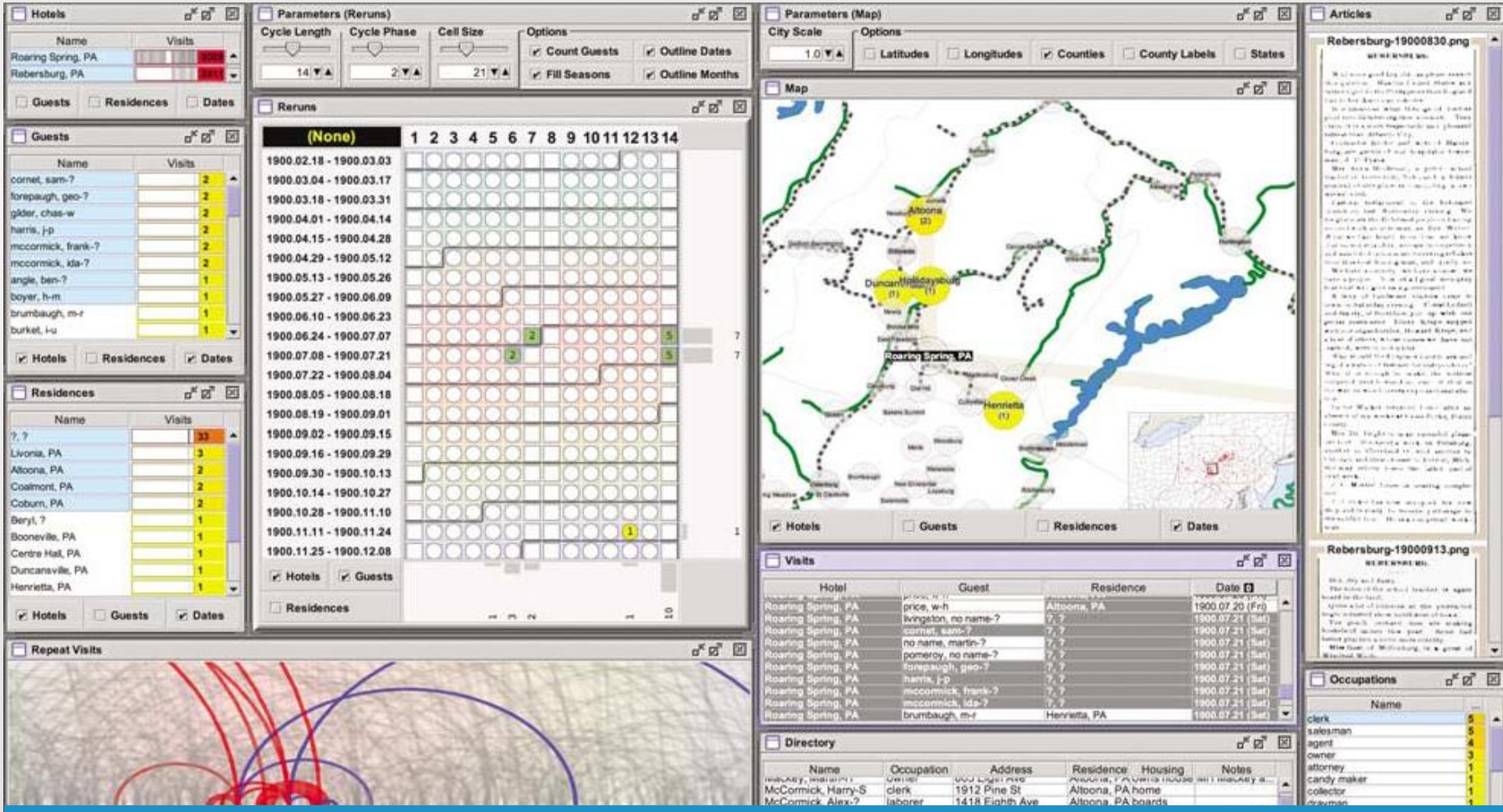


MacEachren (1994)

Visualization in modern cartography: Setting the agenda

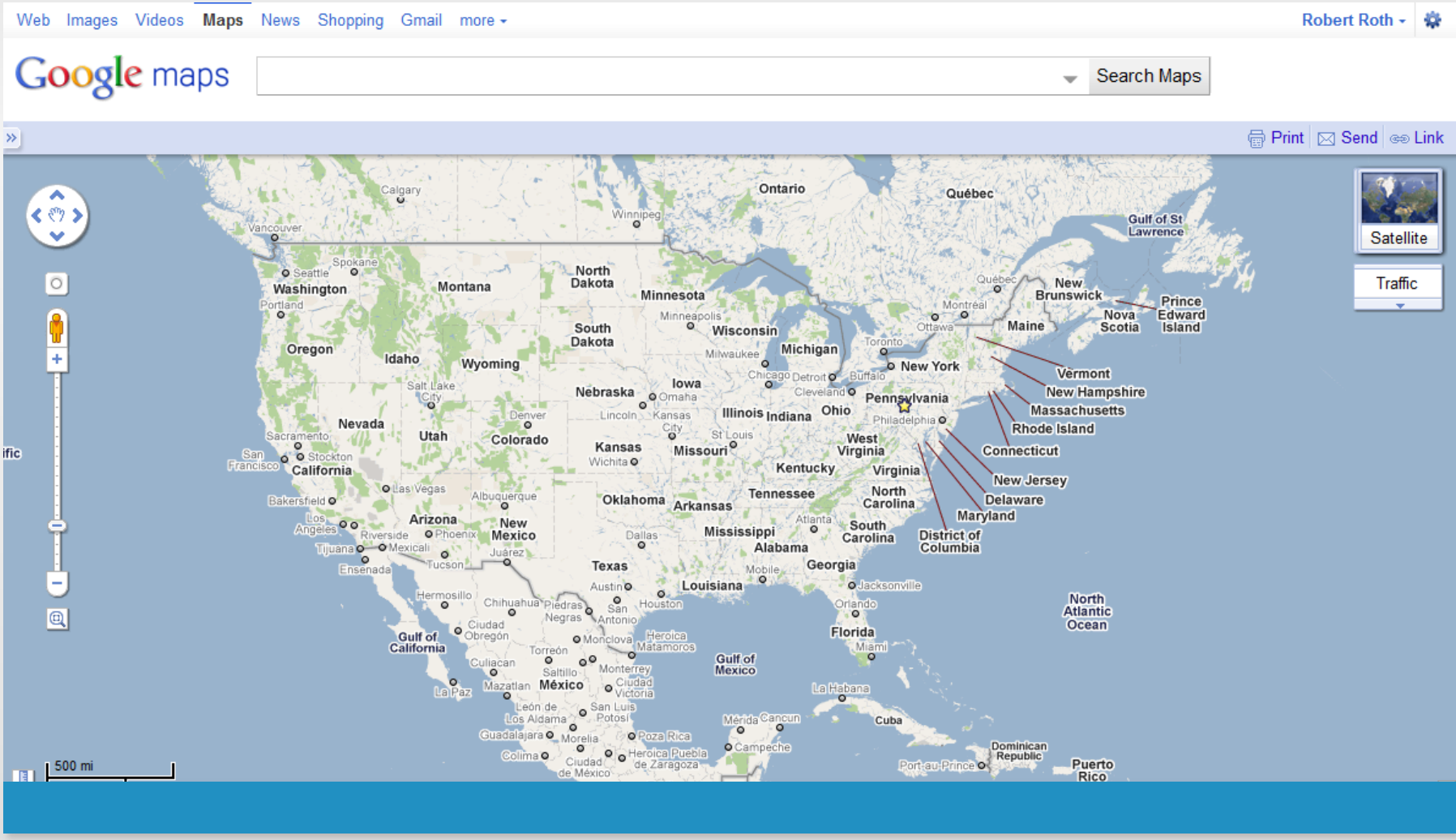
IMPROVISE
multiple, coordinated views

Weaver et al. (2007)
Visual exploration and analysis of historic hotel visits



GOOGLE MAPS

one entry point



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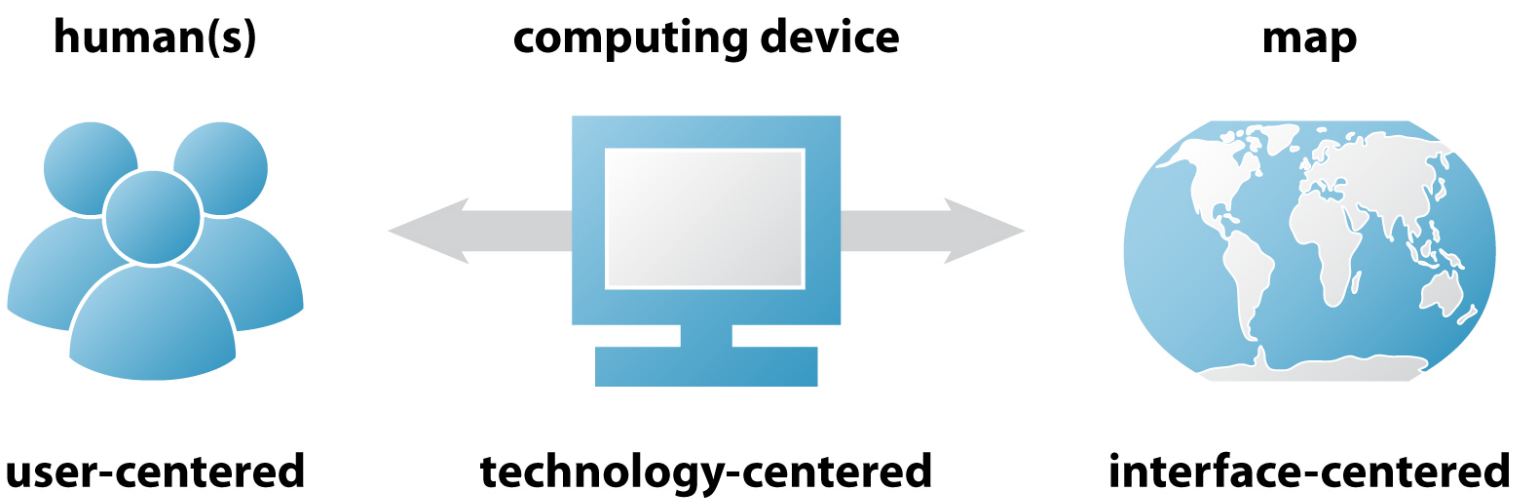
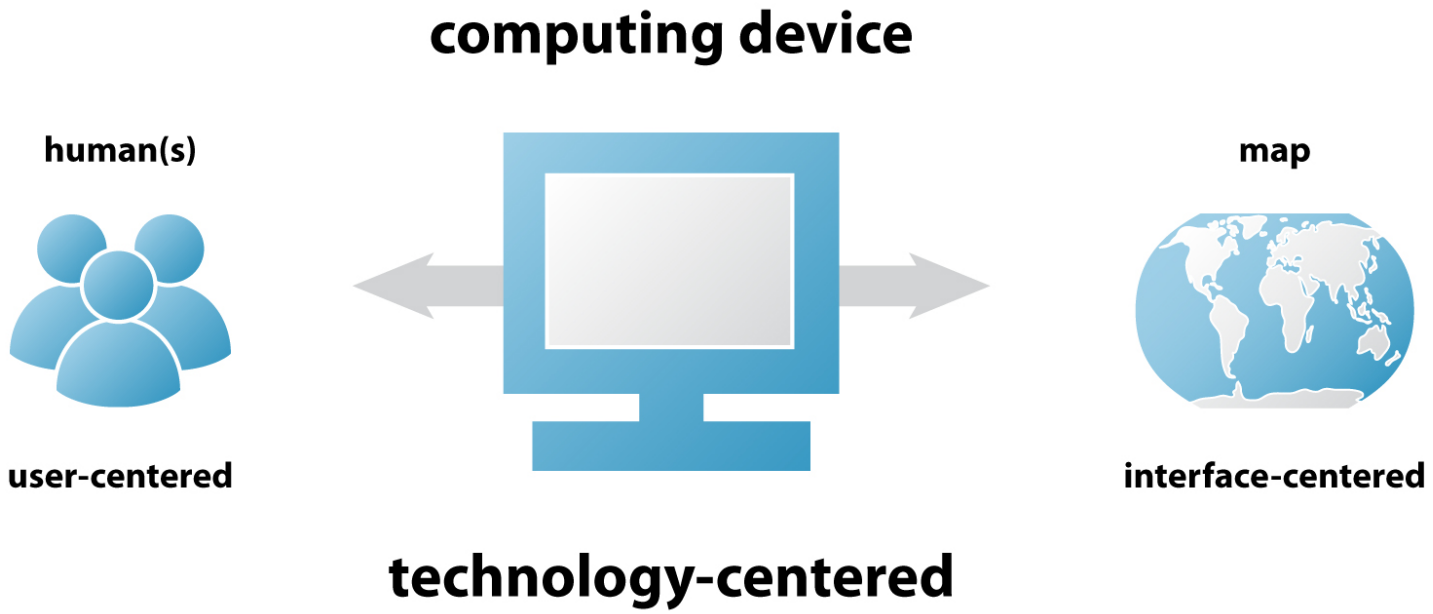
CARTOGRAPHIC INTERACTION

the dialogue b/w a human and a map mediated through a computing device



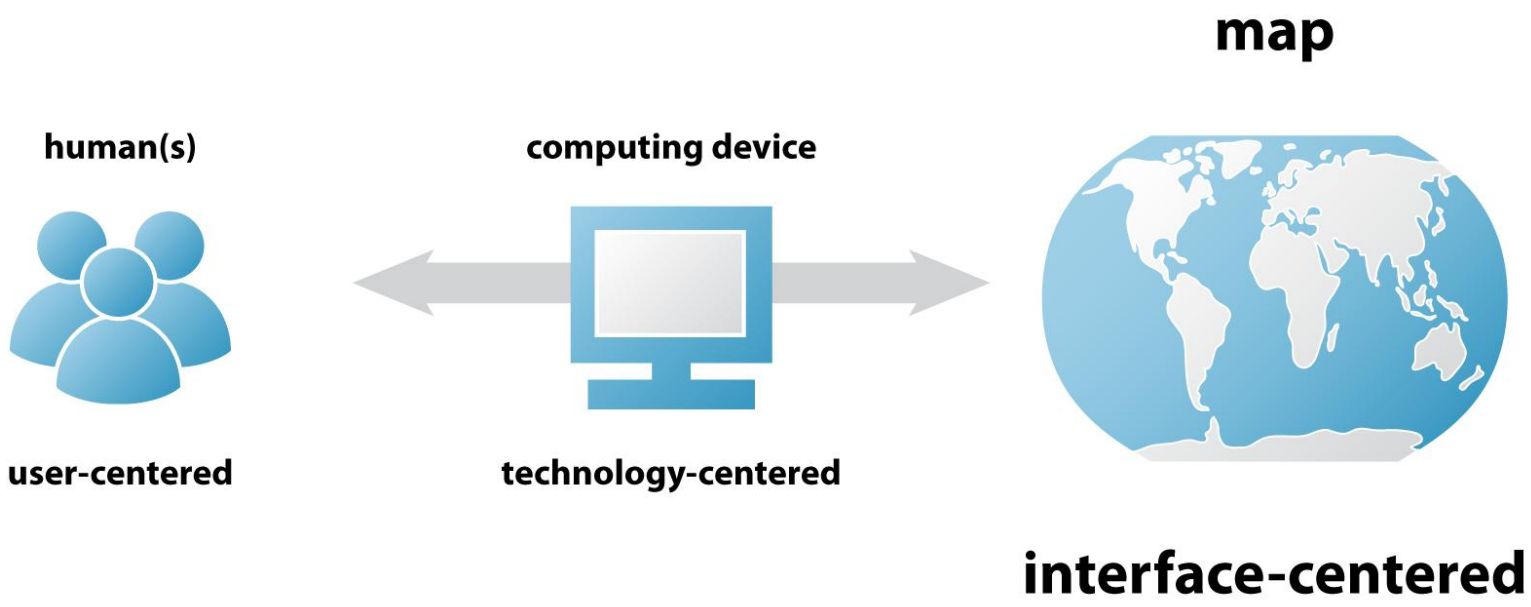
CARTOGRAPHIC INTERACTION: Tech-centered

emphasis on the platform (hardware) on which interaction is provided



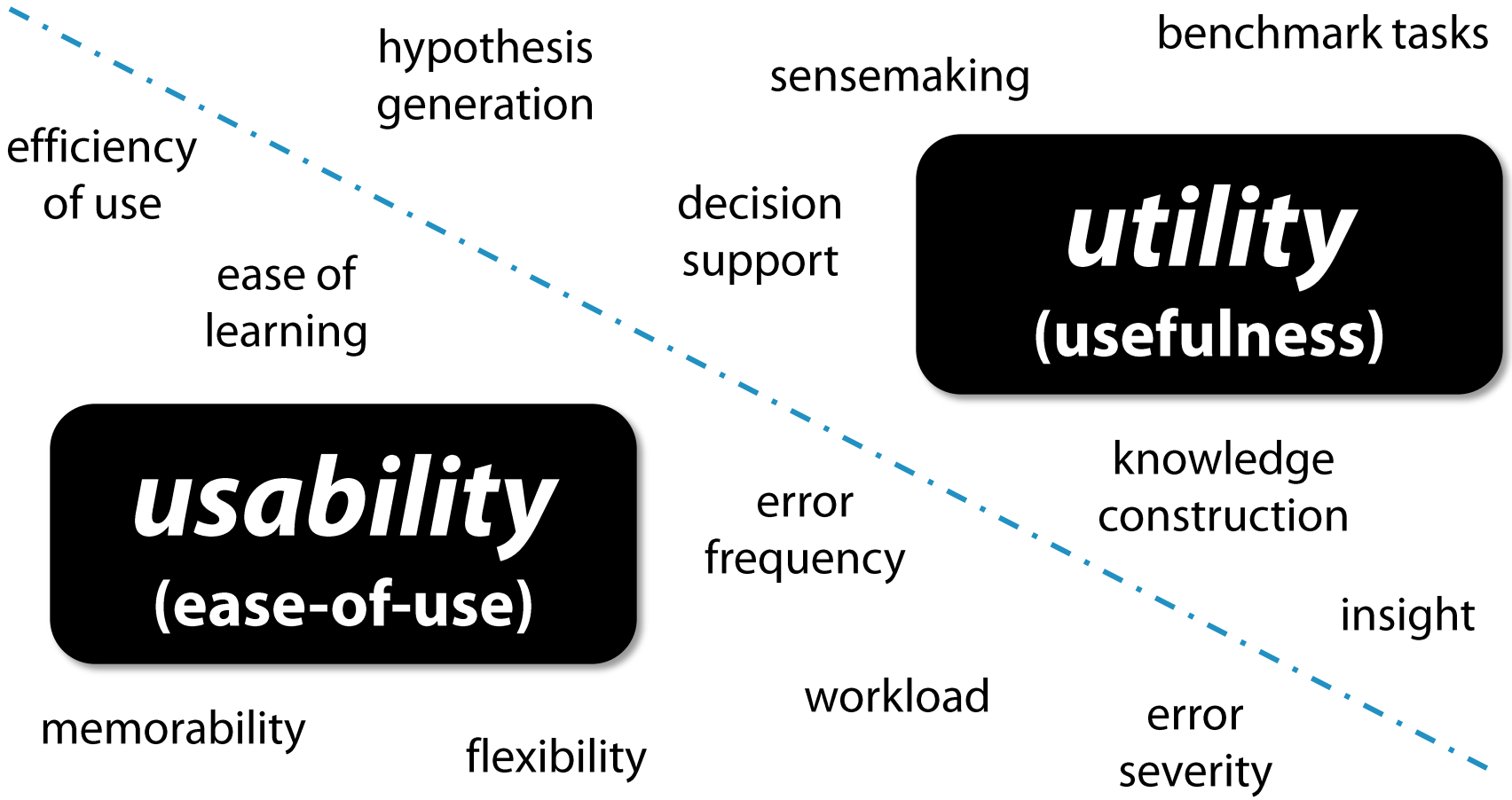
CARTOGRAPHIC INTERACTION: UI-centered

emphasis on the digital tools (software) through which interaction is provided



USABILITY vs. UTILITY
from usability engineering

Fuhrmann et al. (2005)
Making useful and usable geovisualization



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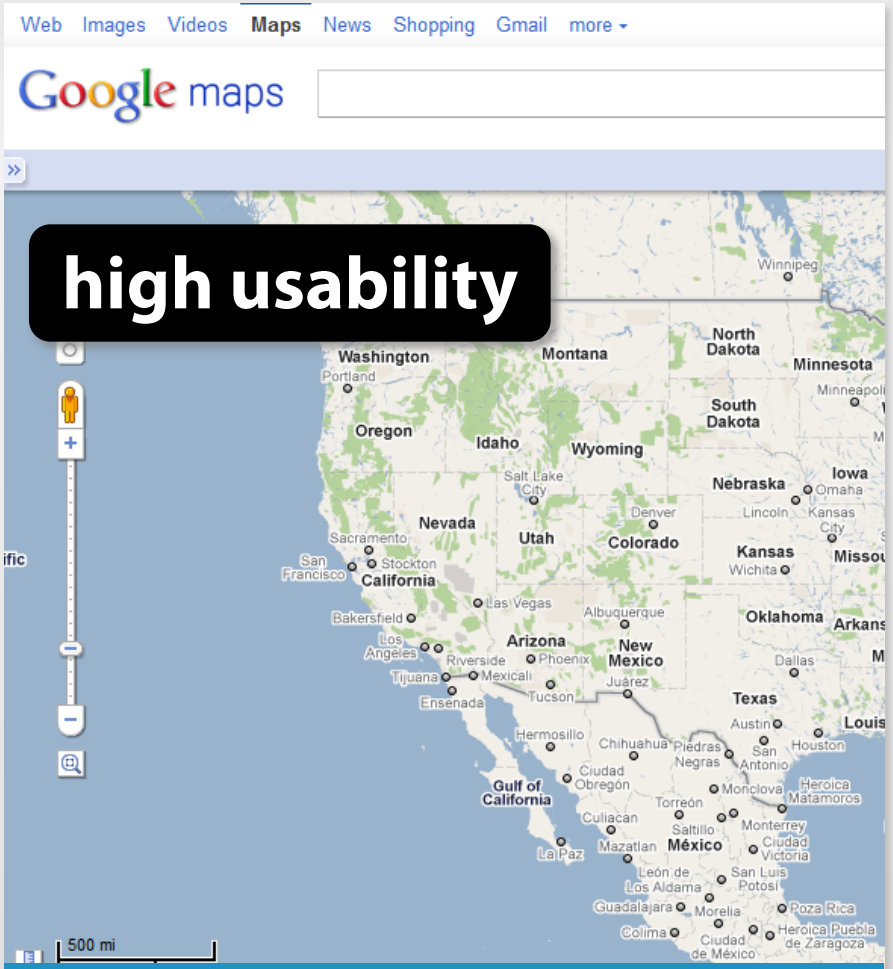
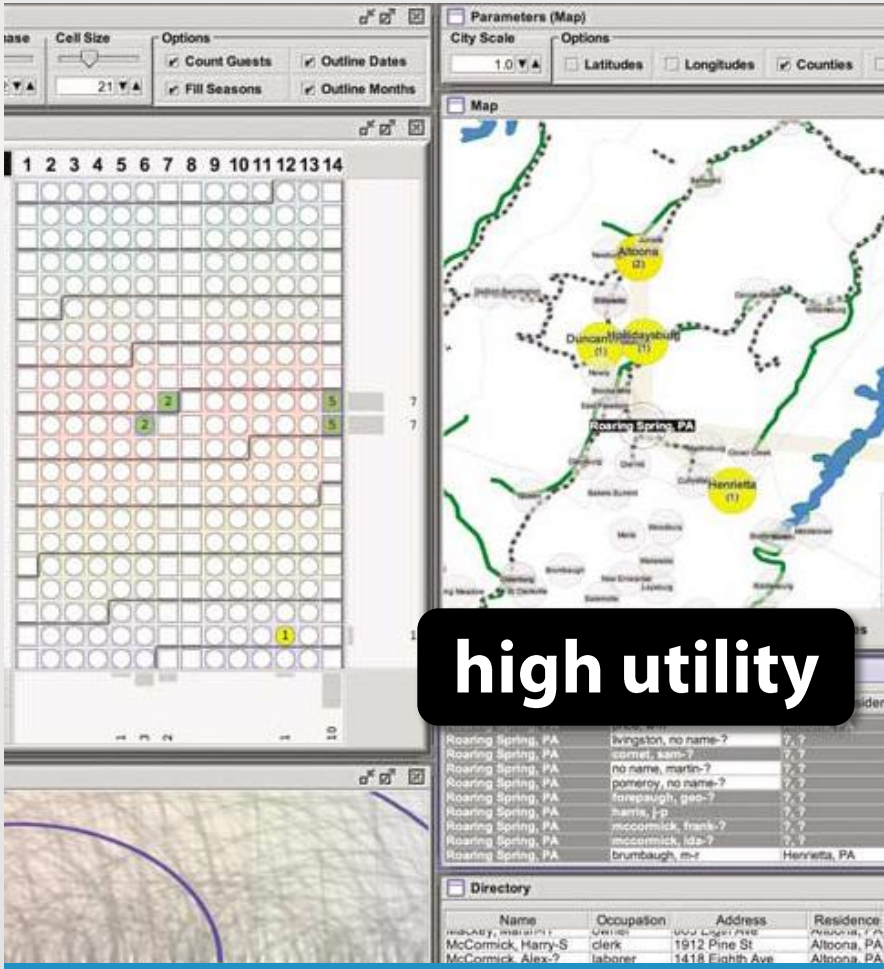


Google Maps



Improvise

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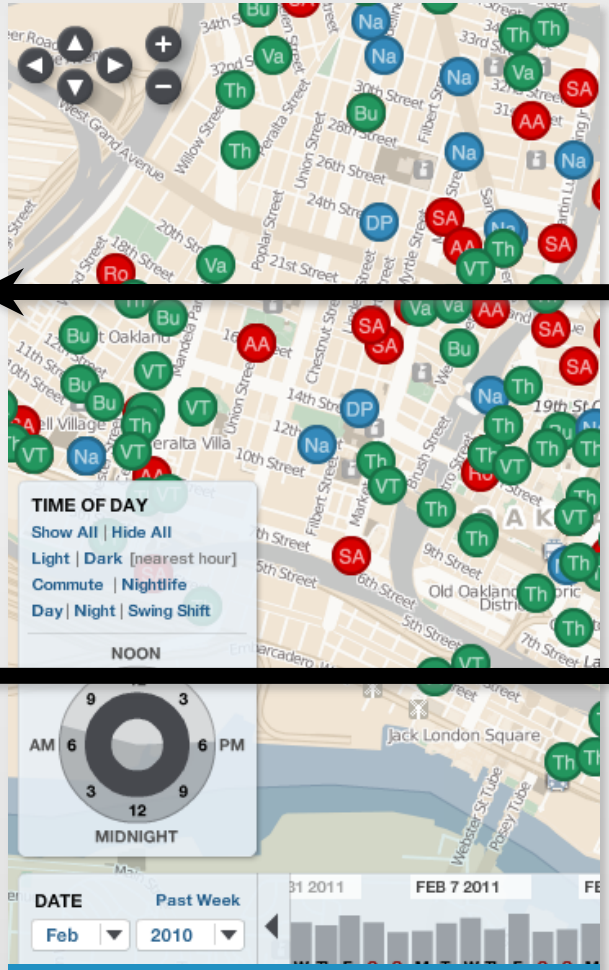
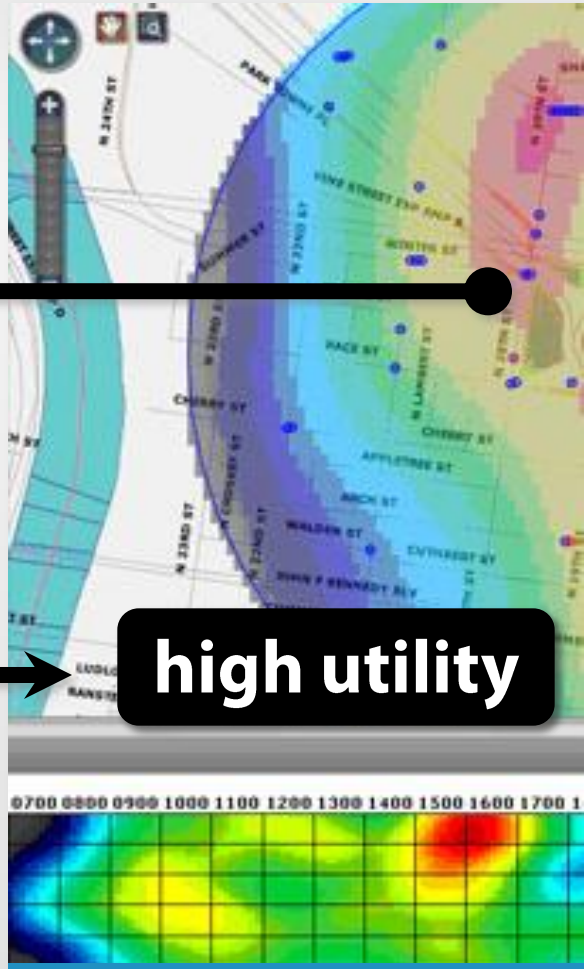
USABILITY vs. UTILITY

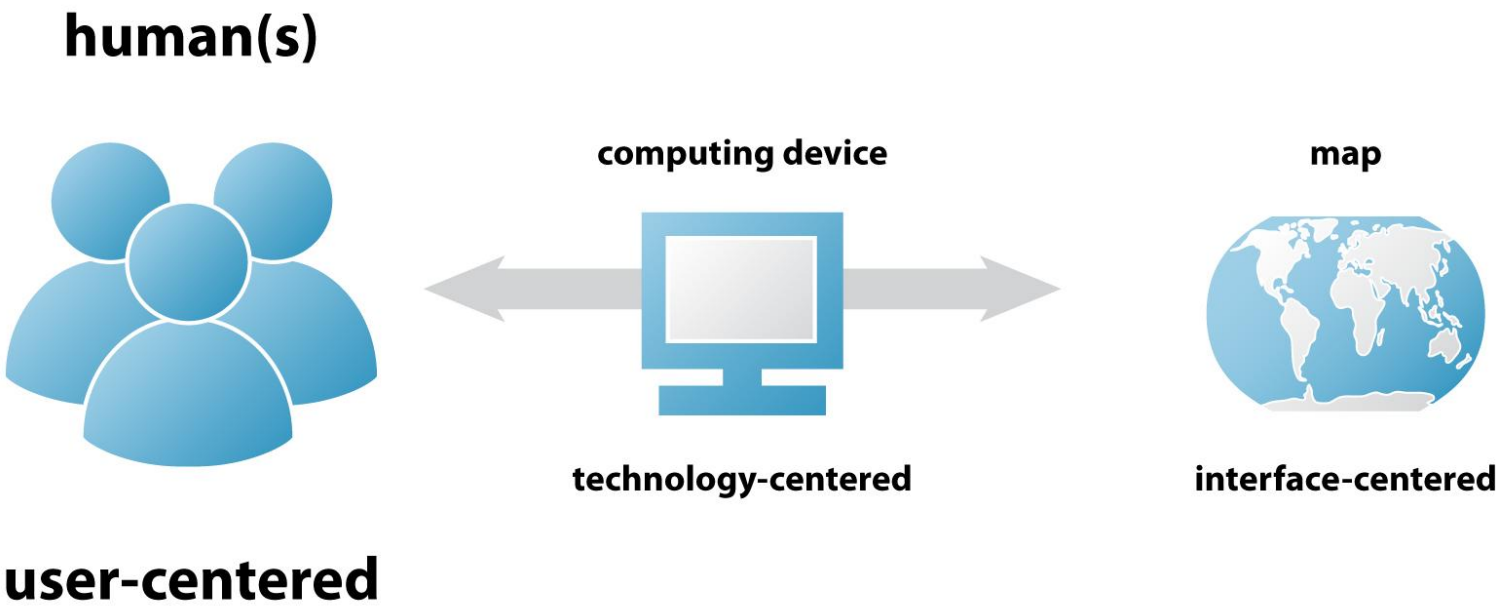
spatiotemporal crime mapping tools



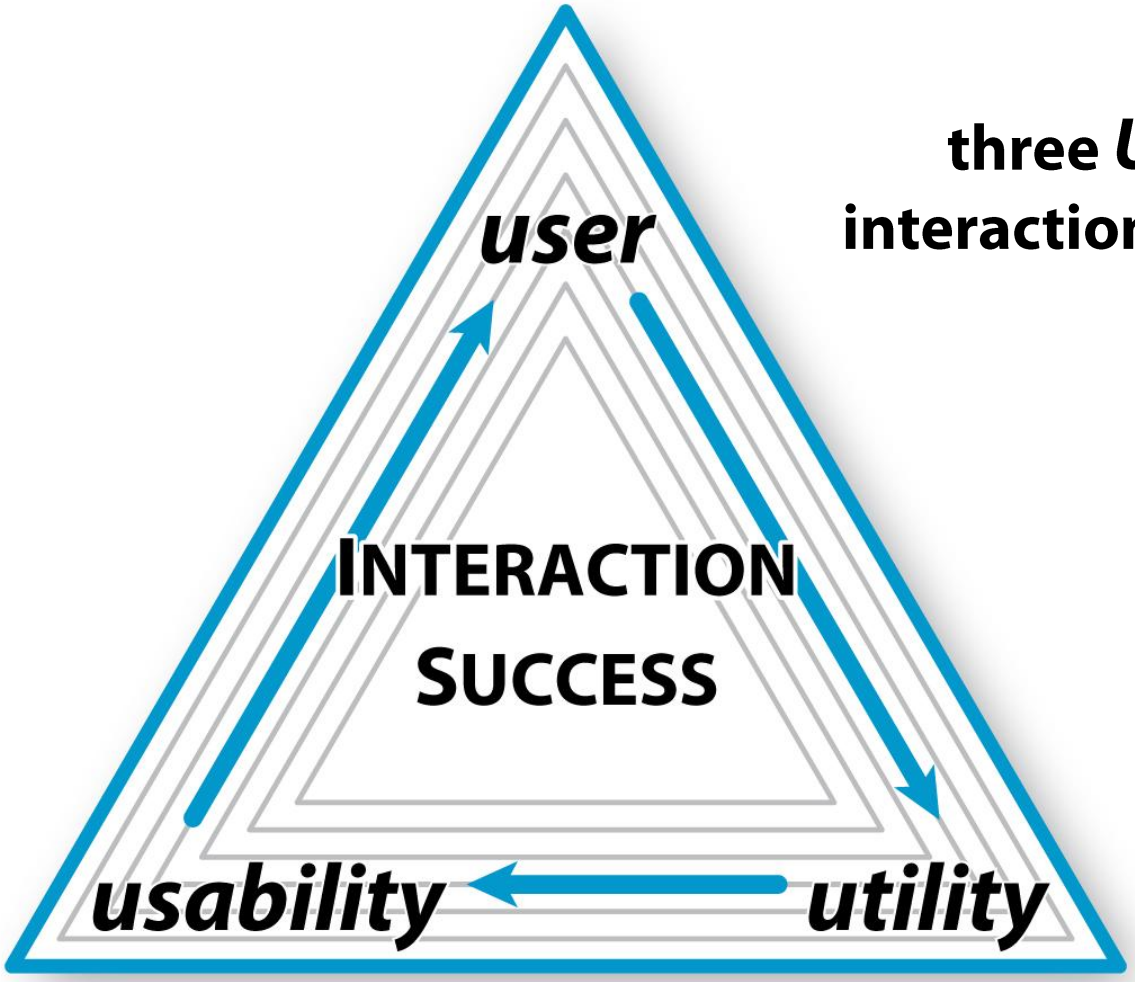


CARTOGRAPHIC INTERACTION: User-centered

emphasis on user's intentions (needs/goals) for initiating interaction

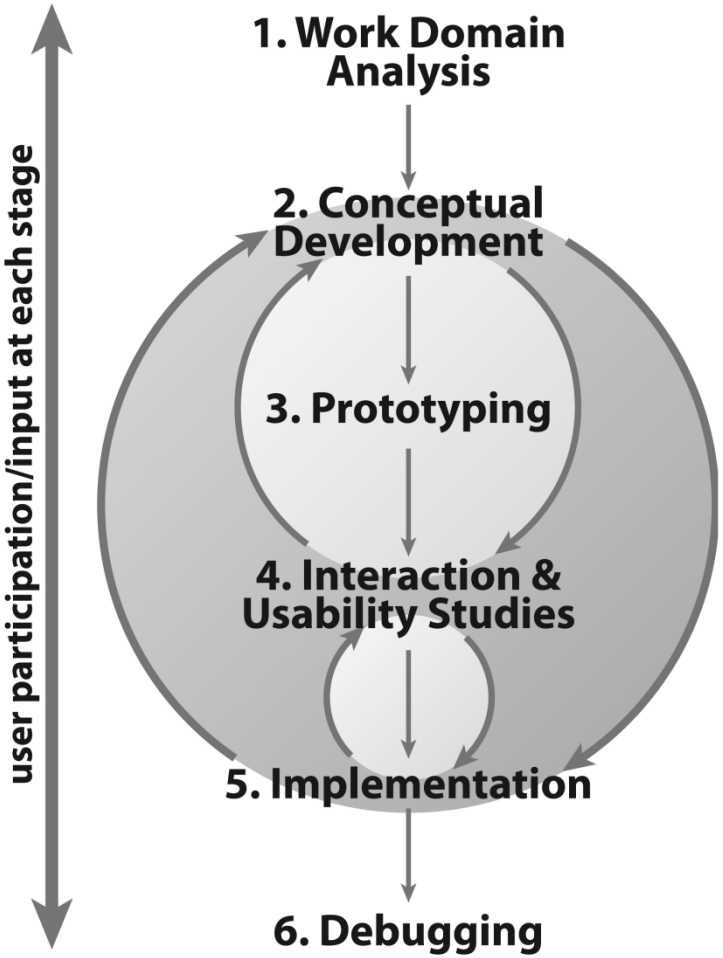


INTERACTION SUCCESS



three *U's* of interaction success

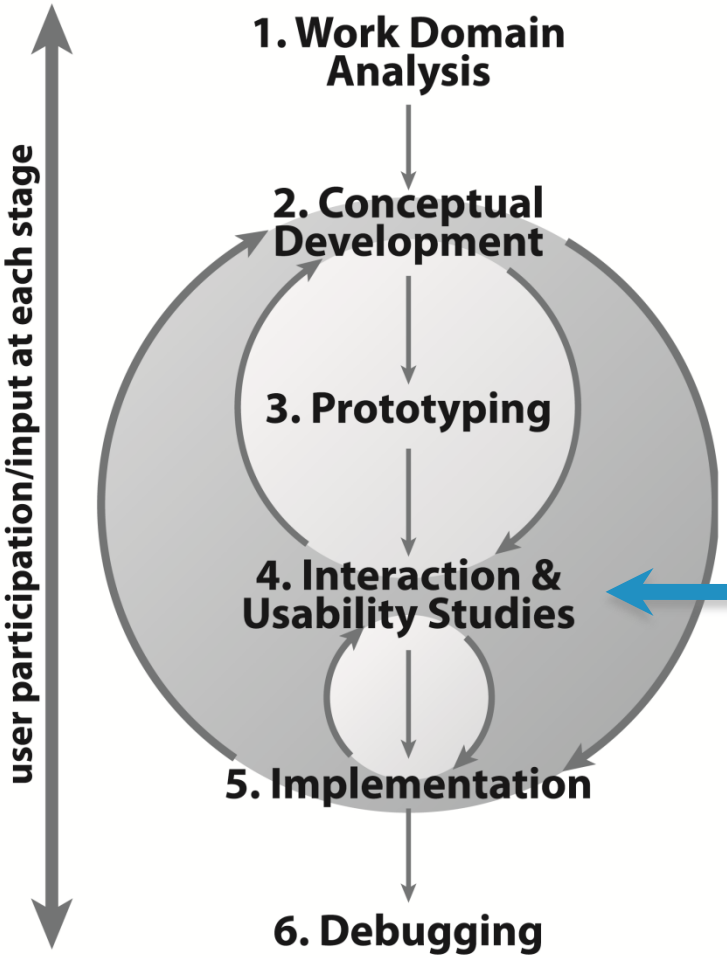
USER-CENTERED DESIGN (UCD)



interface design that includes numerous iterations of **end user evaluation** and subsequent interface revision to improve its usability and utility

Robinson et al. (2005)
Combining Usability Techniques to Design Geovisualization Tools for Epidemiology

USER-CENTERED DESIGN (UCD)



'Discount' Interface Evaluation Methods

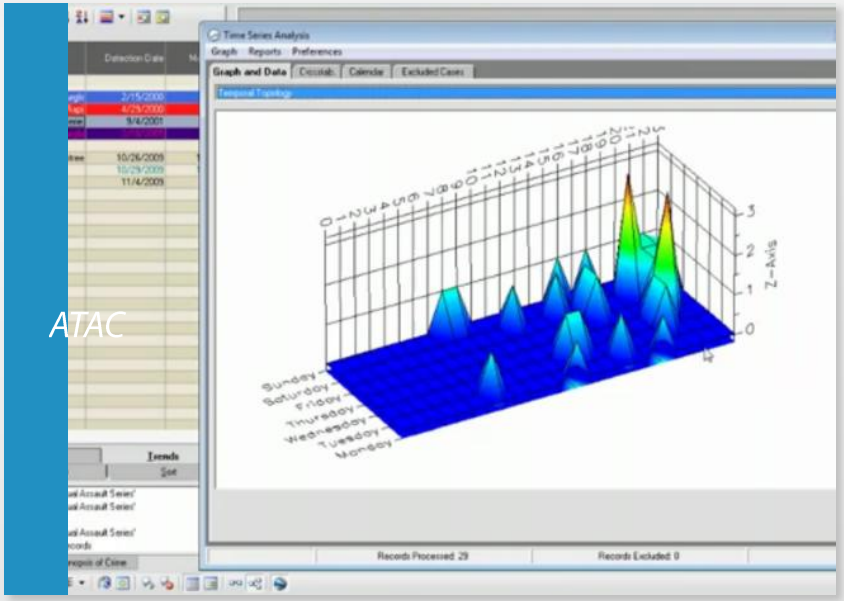
Robinson et al. (2005)
Combining Usability Techniques to Design Geovisualization Tools for Epidemiology

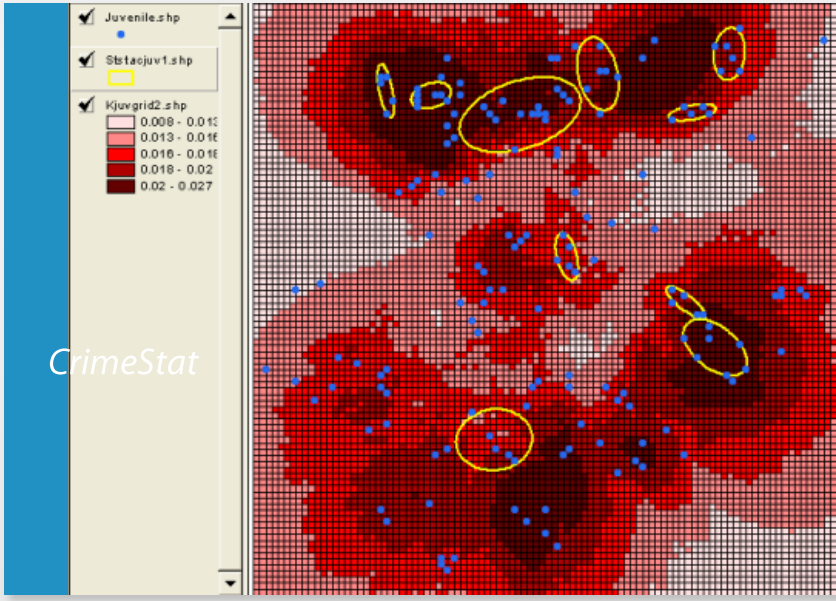
Part 2: GeoVISTA CrimeViz

Geovisualization for Crime Analysis

CRIME ANALYSIS

the systematic collection, preparation, interpretation, and dissemination of information about criminal activity to support the mission of law enforcement





"At present, the most under-researched area of spatial criminology is that of **spatio-temporal crime patterns**"

Ratcliffe (2009: 14)

Crime Mapping: Spatial & Temporal Challenges

ROUTINE ACTIVITY THEORY

Cohen & Felson (1979)

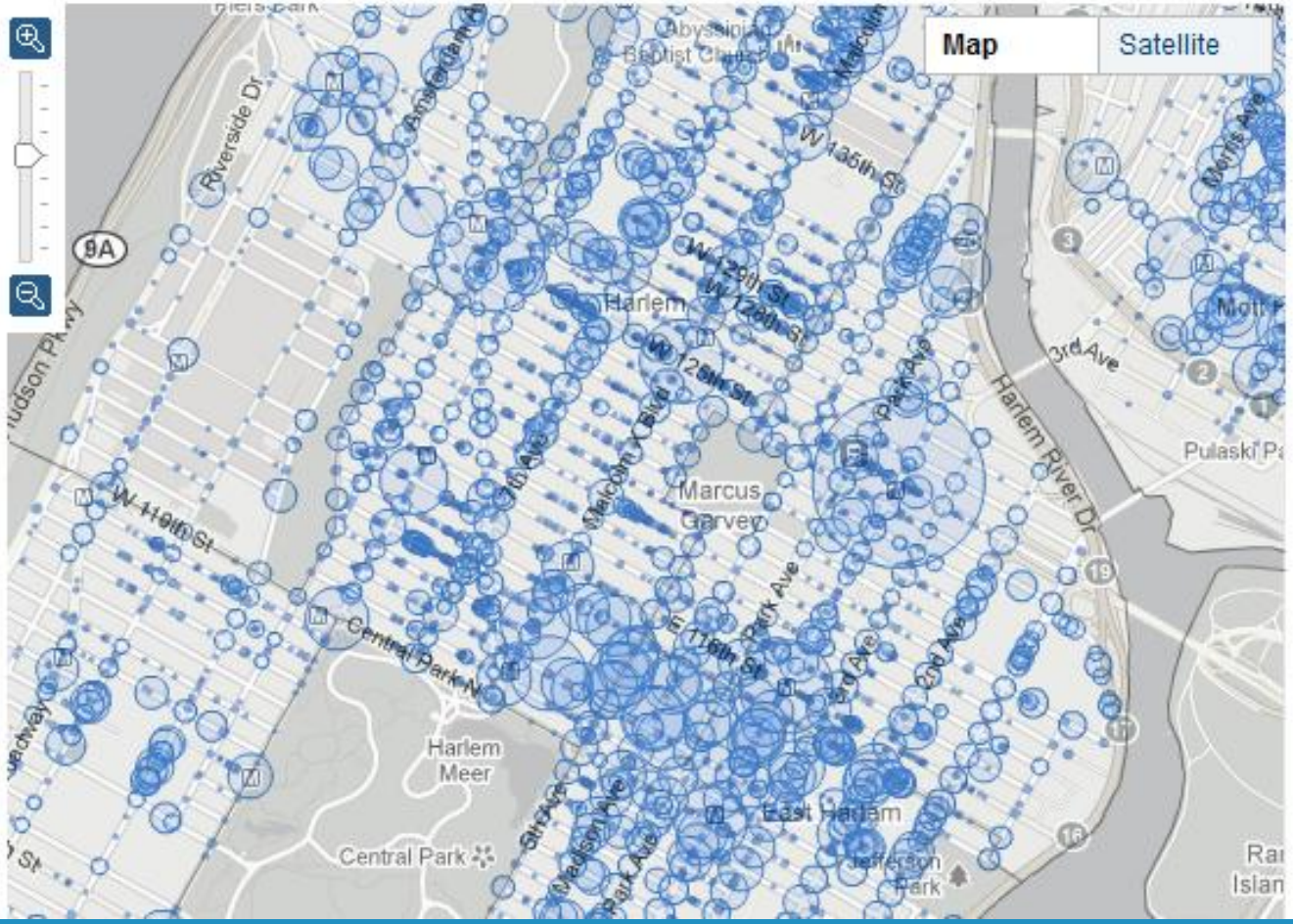
Social change & crime rate trends: A routine activity approach

SOCIAL-DISORGANIZATION THEORY

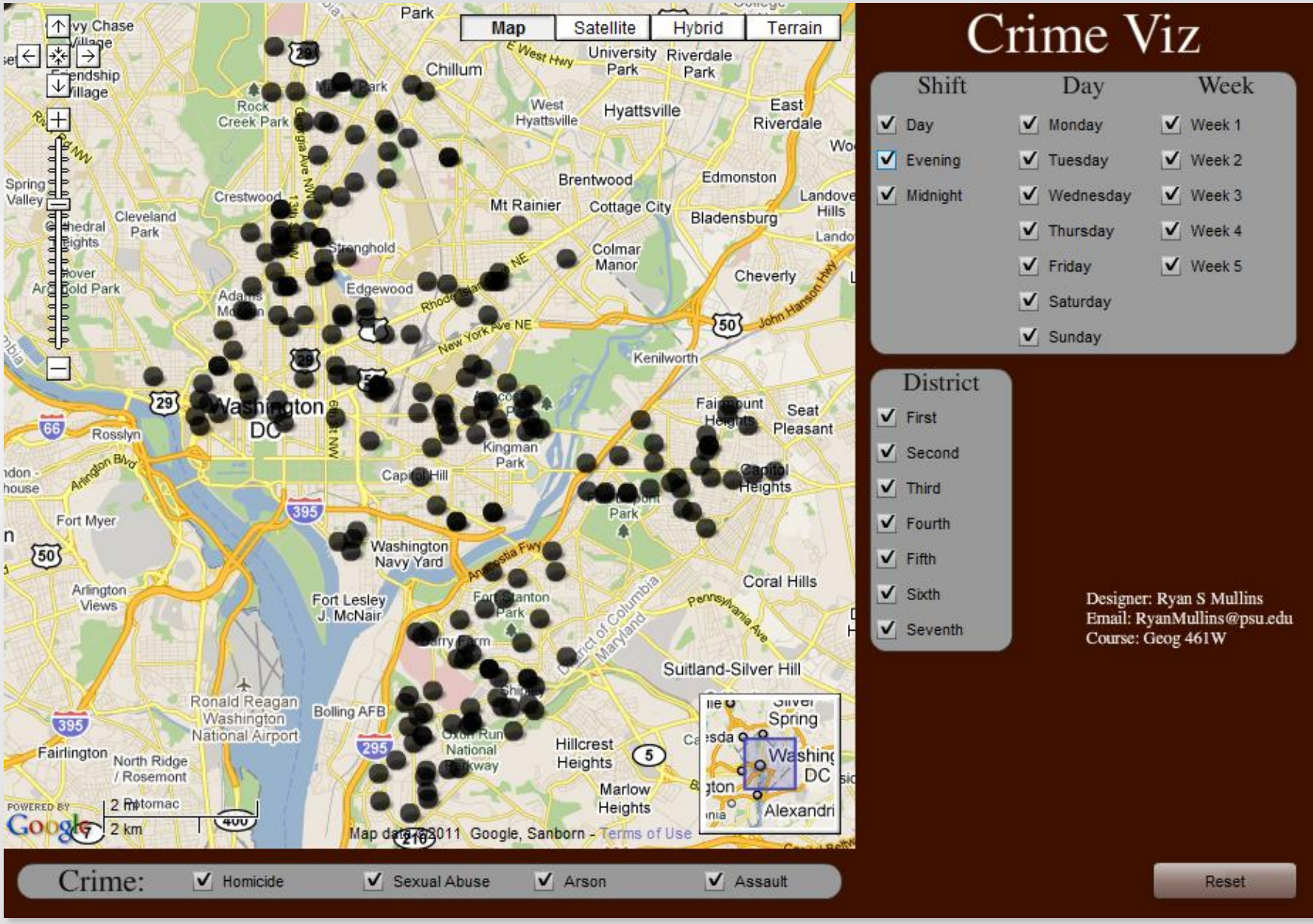
Shaw & McKay (1942)

Juvenile delinquency and urban areas

- Entire City
- **Central Harlem**
- Lower East Side
- South Bronx
- Fulton Street, Brooklyn
- Brownsville, Brooklyn
- Jackson Heights, Queens
- Northeast Queens
- Staten Island



"Stop & Frisk" — The New York Times



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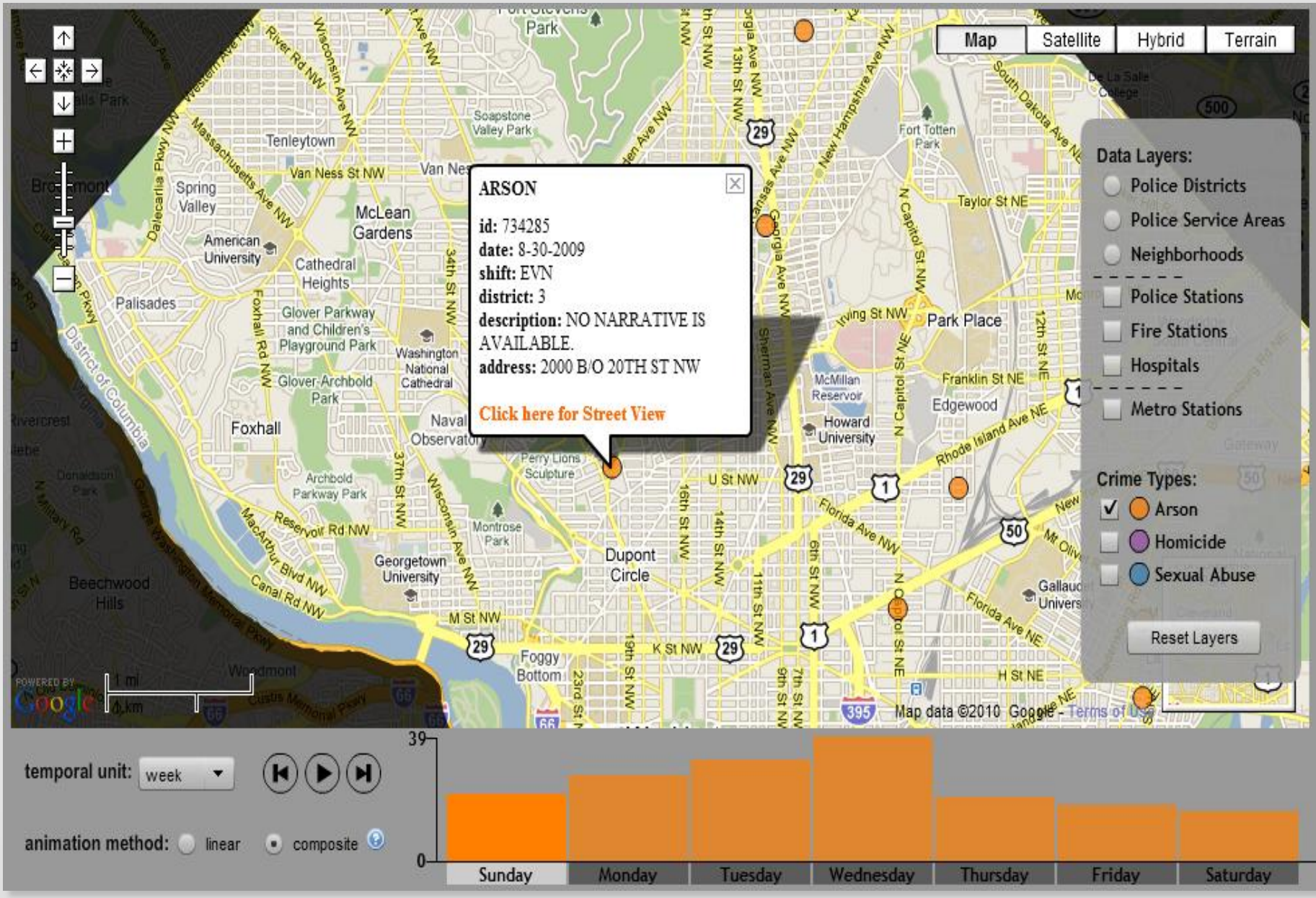

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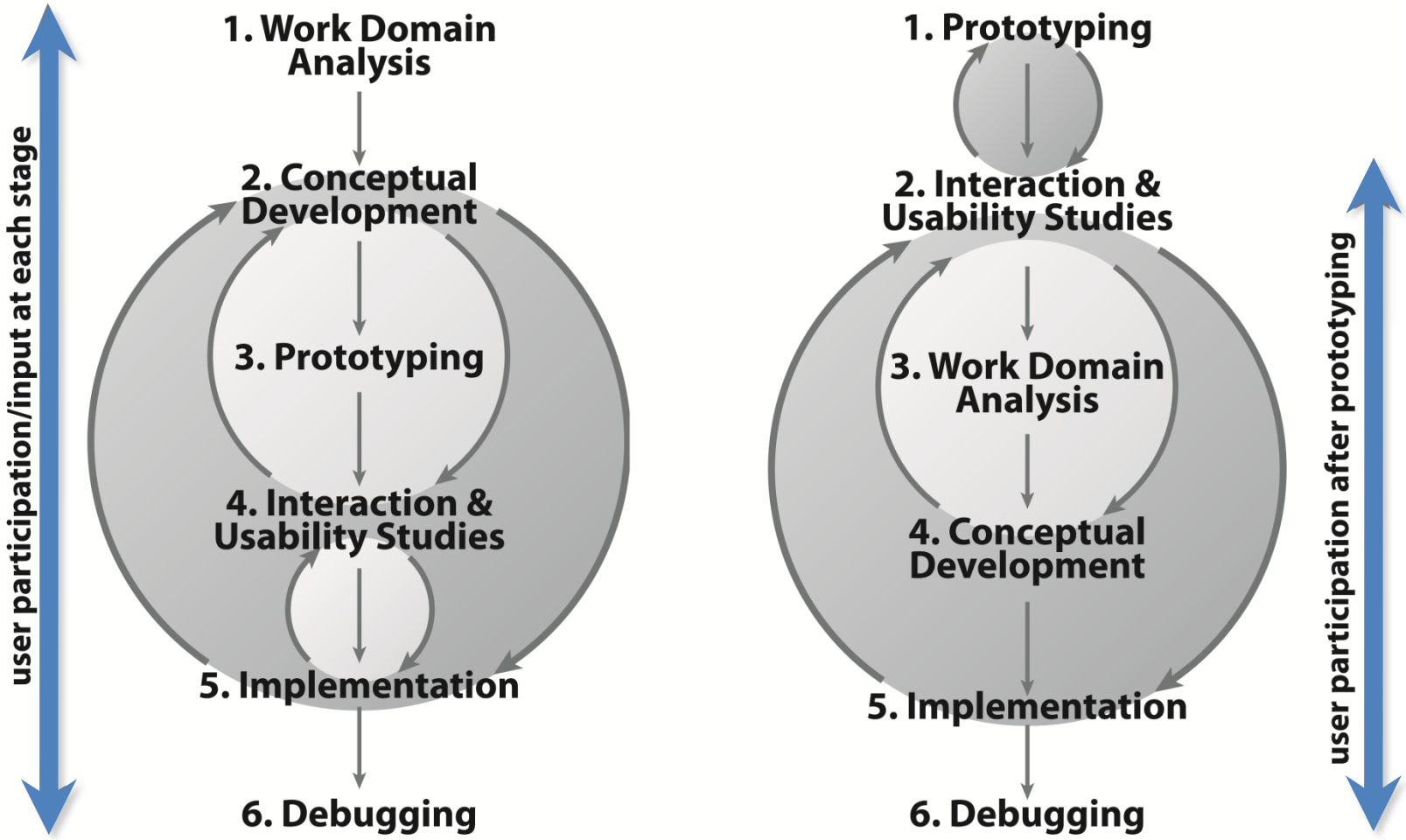
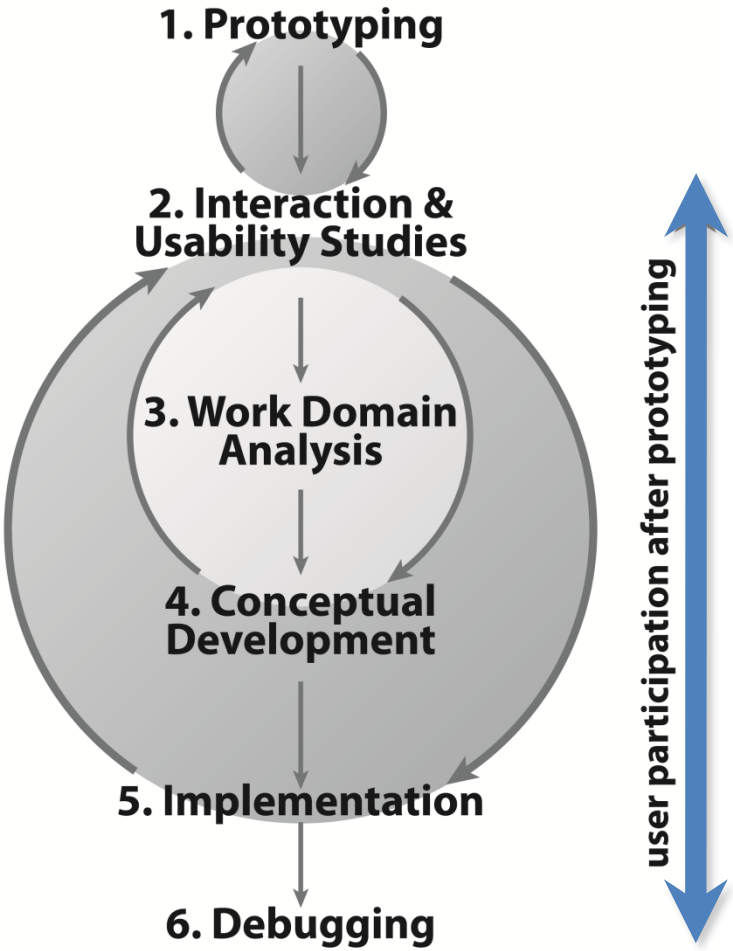


USER-CENTERED DESIGN (UCD)

- only have initial seed money for a limited prototype
- a design or consulting firm joins midway through a project
- lack of initial access to targeted end users
- targeted audience is poorly defined (or does not yet exist)
- initial application was designed for a constrained set of users and purposes but must now be made more general or transitioned to other domains



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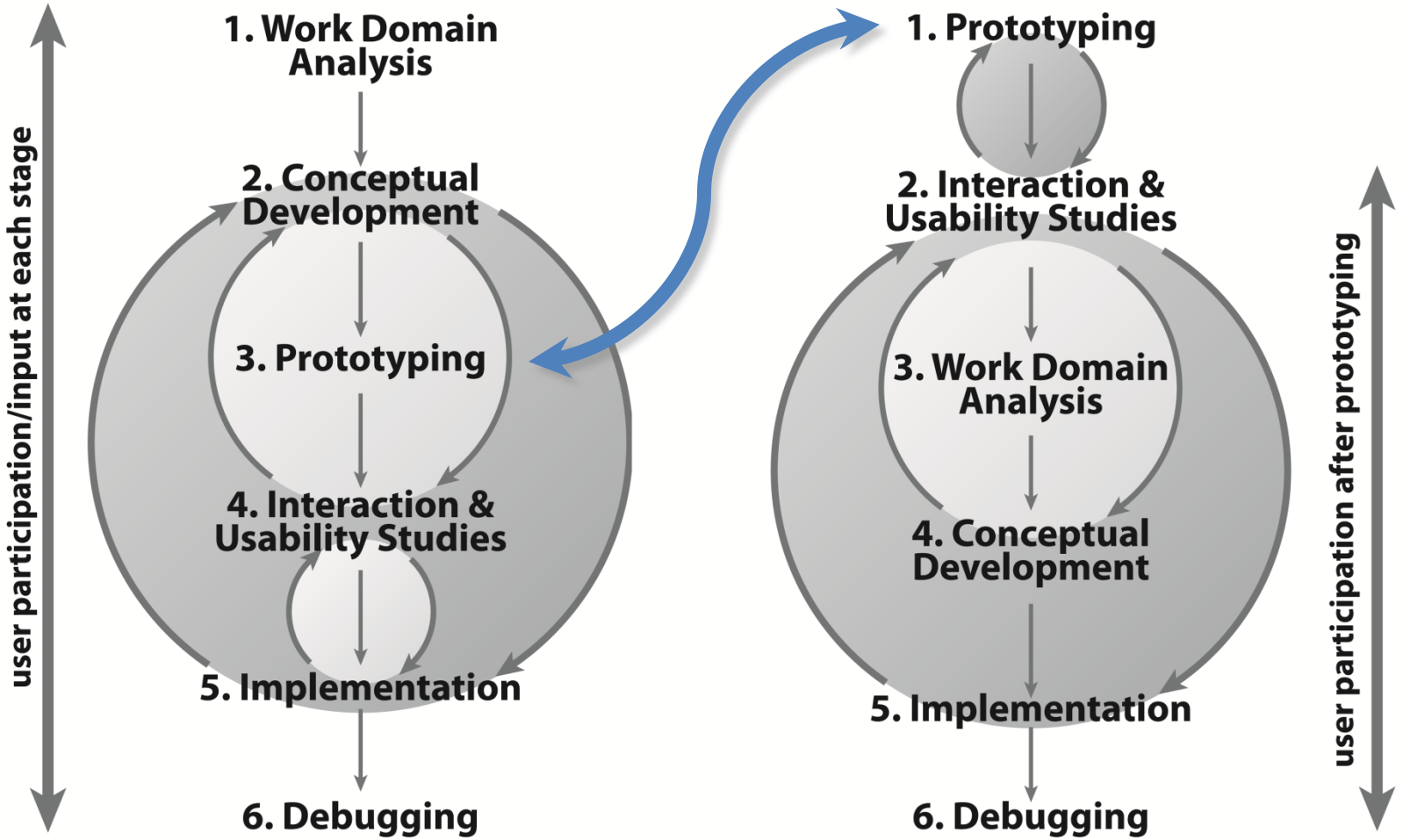

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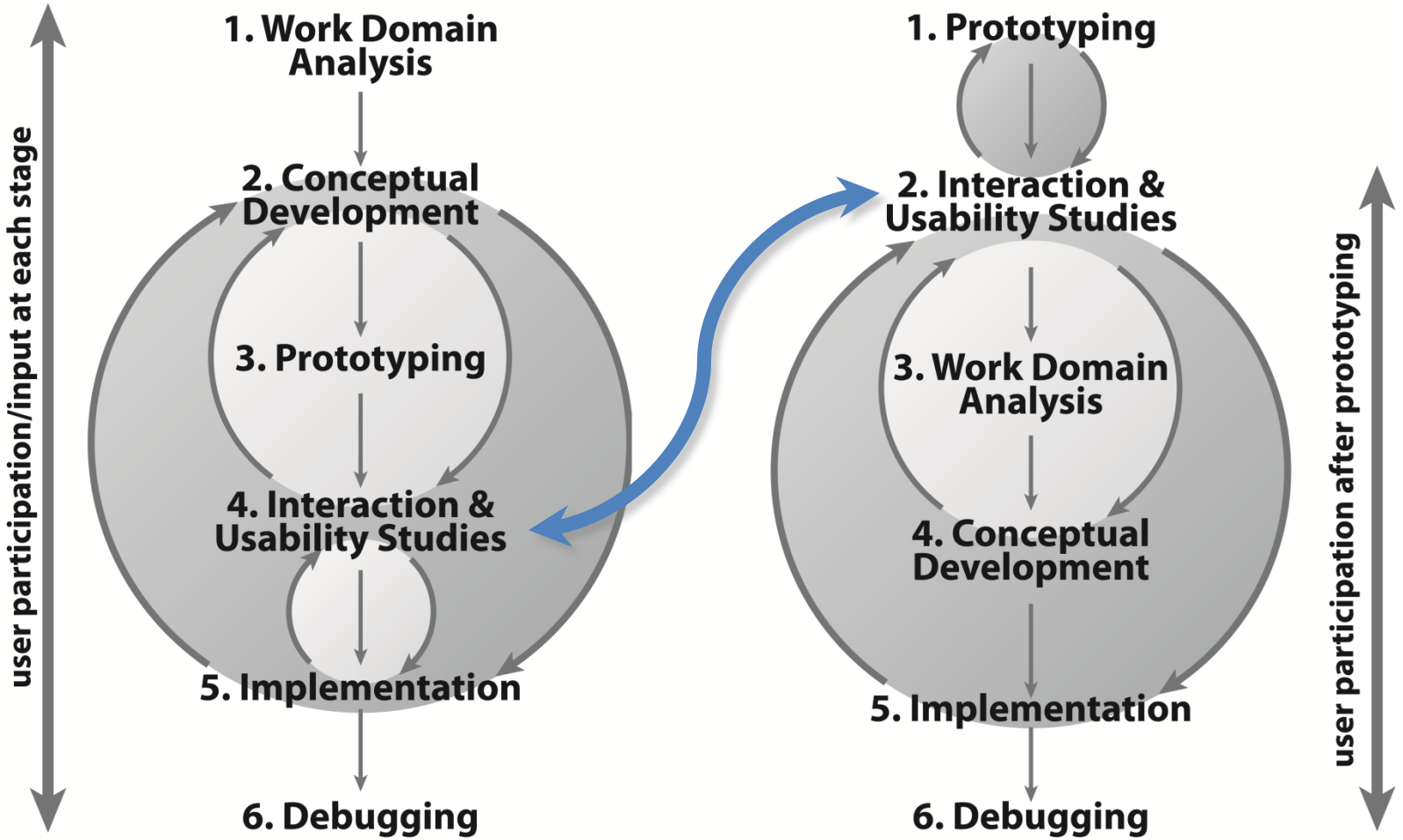

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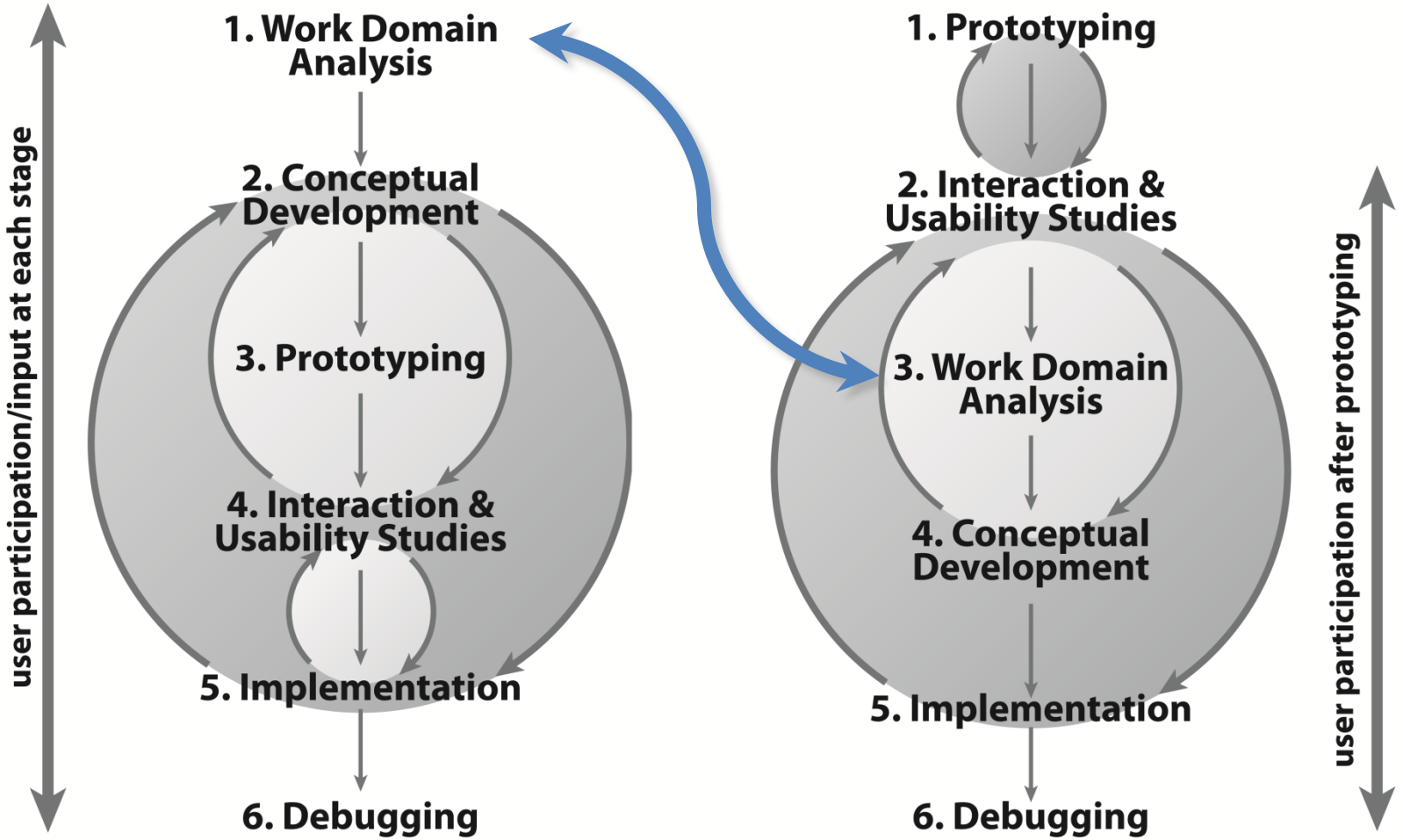

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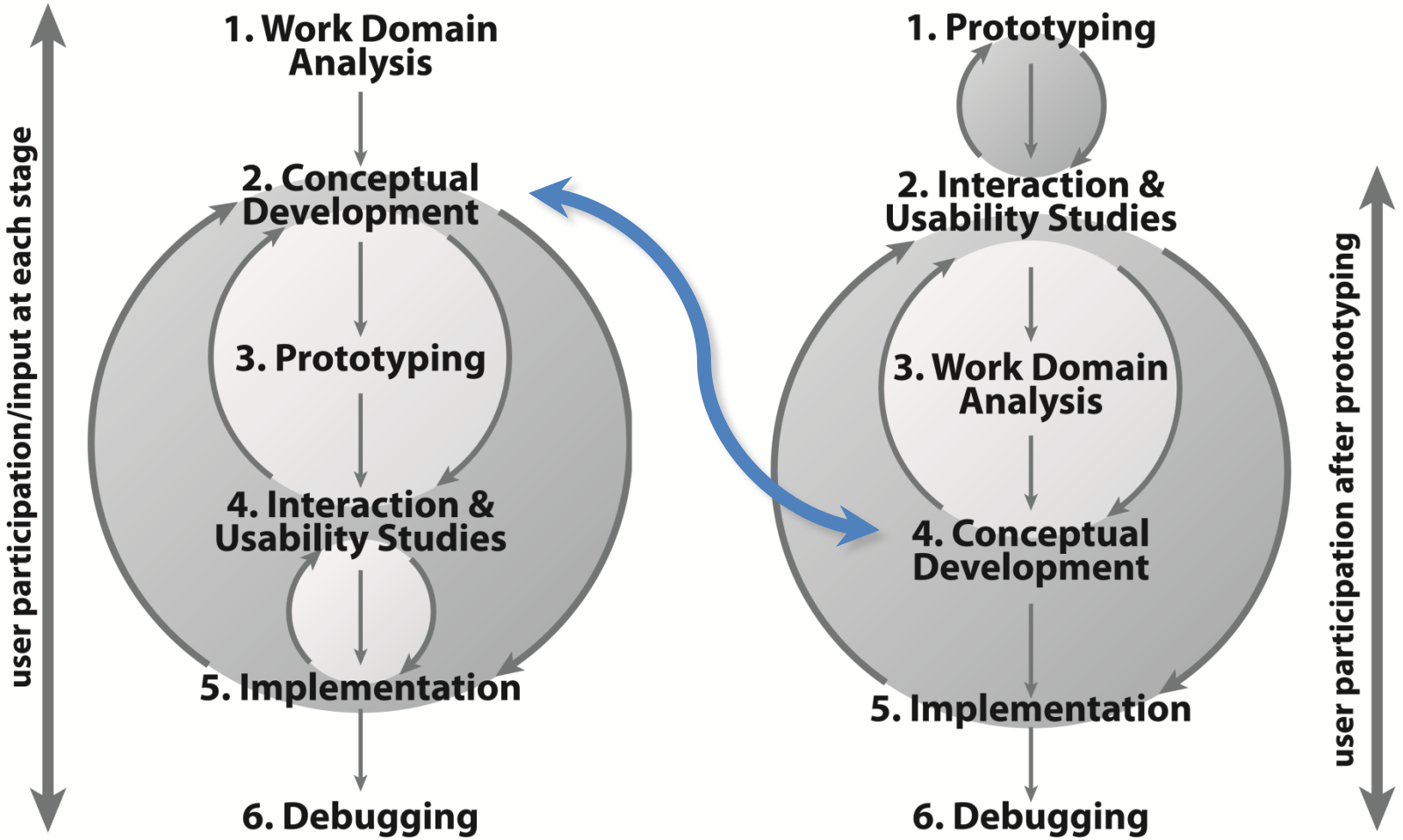

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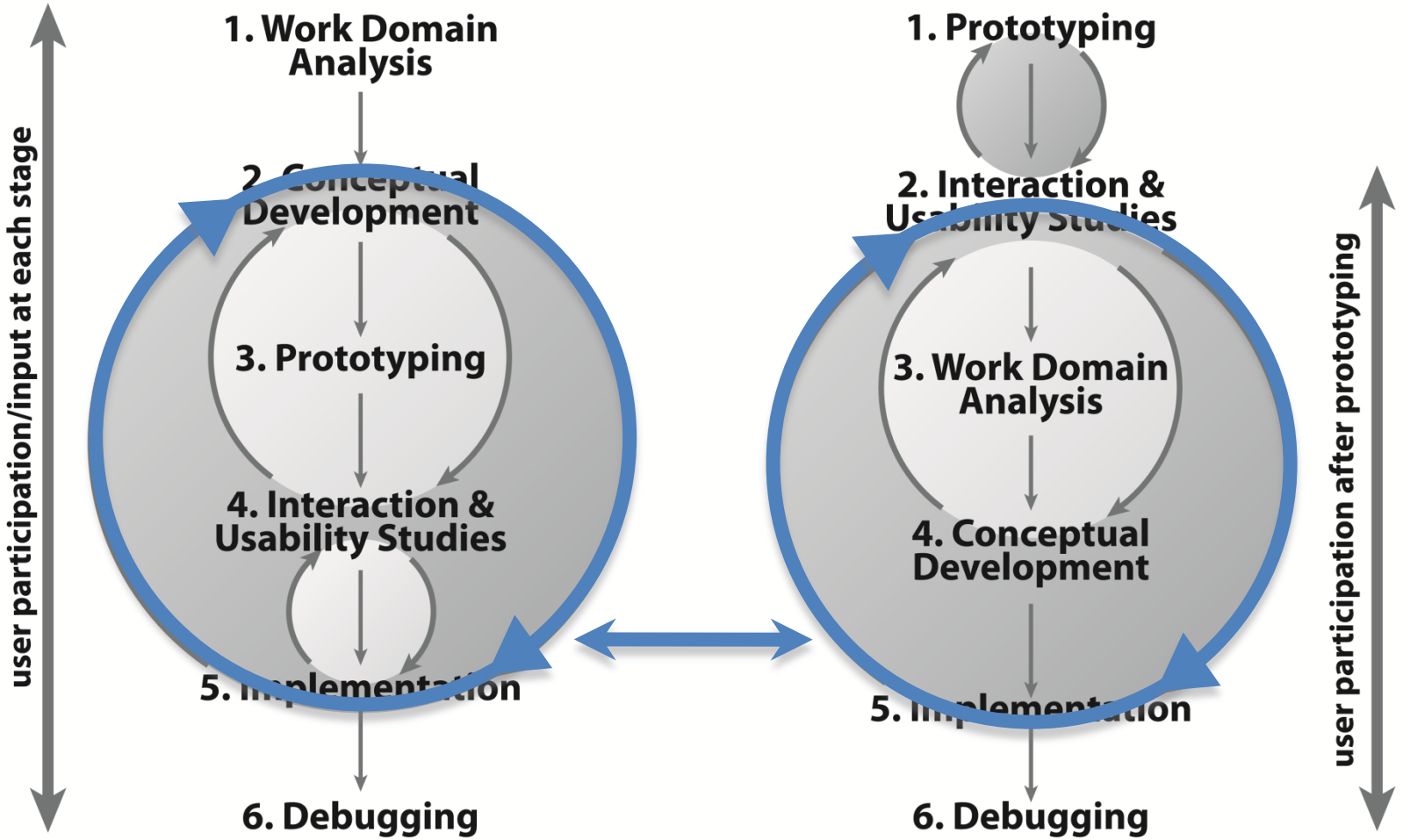

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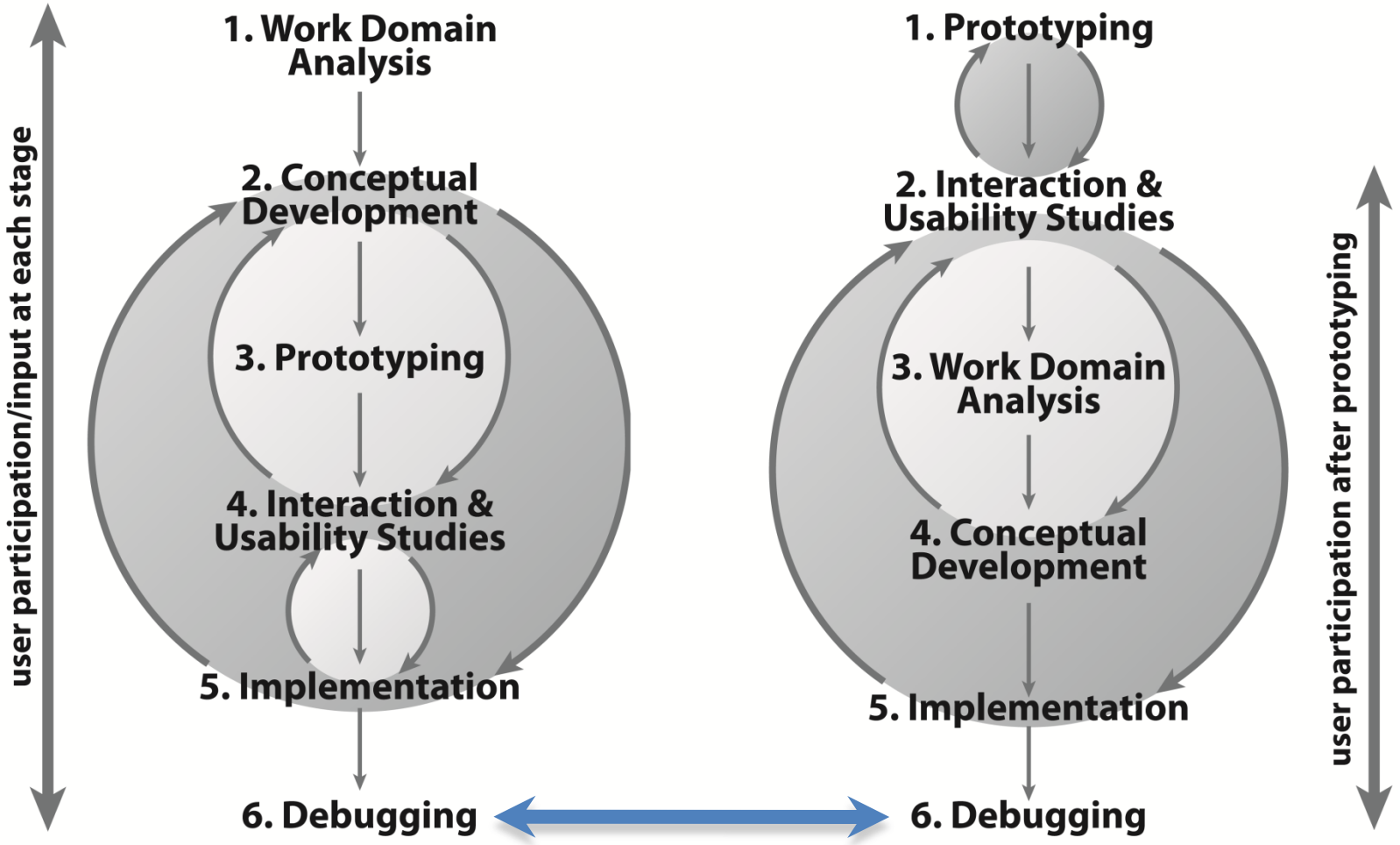

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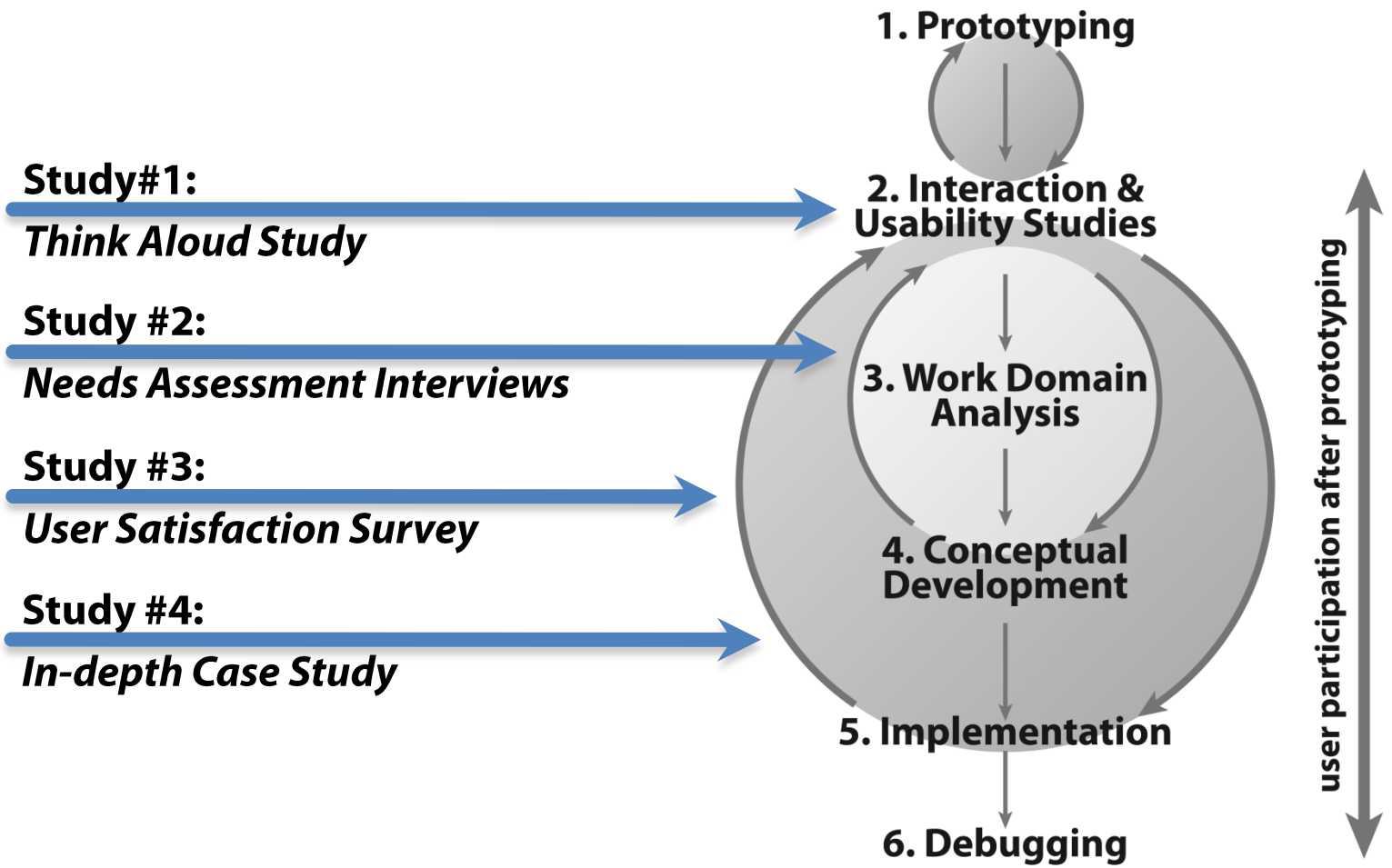


STUDY #1: Discount Think Aloud Activity

users are asked to complete a set of benchmark tasks with an application and to describe verbally why they are doing what they are doing

Participants: n=5, varying level of experience with spatiotemporal visualization

Data Collection: one administrator, two note takers recording critical incidents

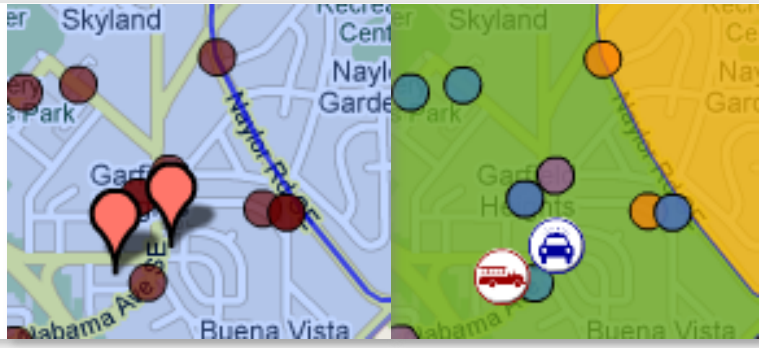
Think Aloud Protocol (60 minutes):

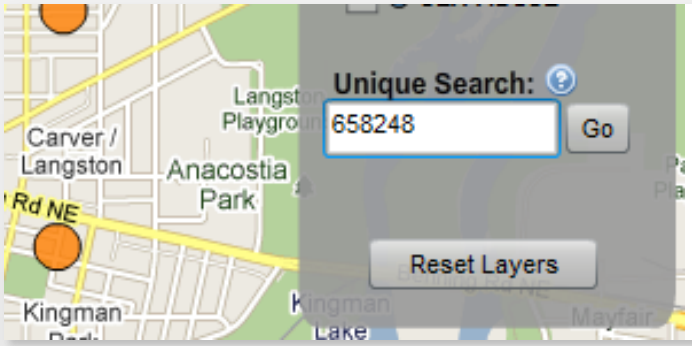
- Introduction (5 minutes)
- Opening (5 minutes)
- Tasks (35-40 minutes)
- Cognitive interview (10-15 minutes)

STUDY #1: Think Aloud Results (1 of 2)

Improvement #1:

Identify Missing Functionality or Key Impediments to Use



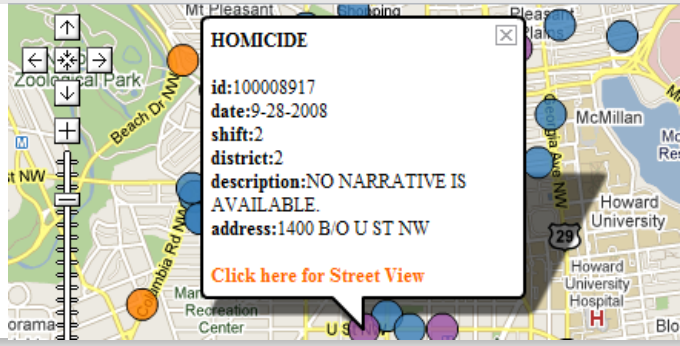


Improvement #2:

Adding Support for Each Anticipated Spatiotemporal Task

Improvement #3:

Where Possible, Follow Web Map Conventions



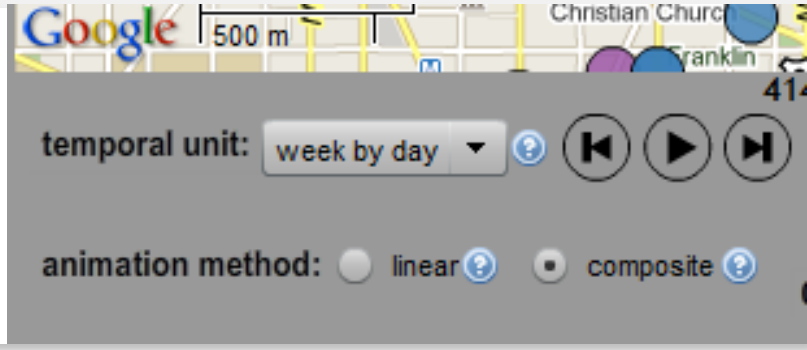
STUDY #1: Think Aloud Results (2 of 2)

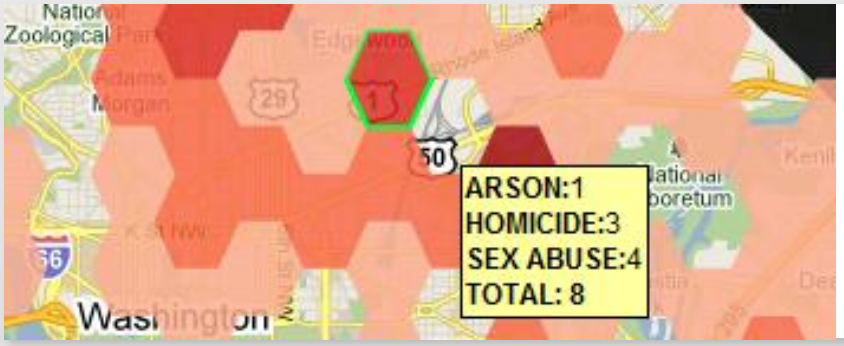
Improvement #4:

Suppressing Unneeded or Irrelevant Information

Improvement #5:

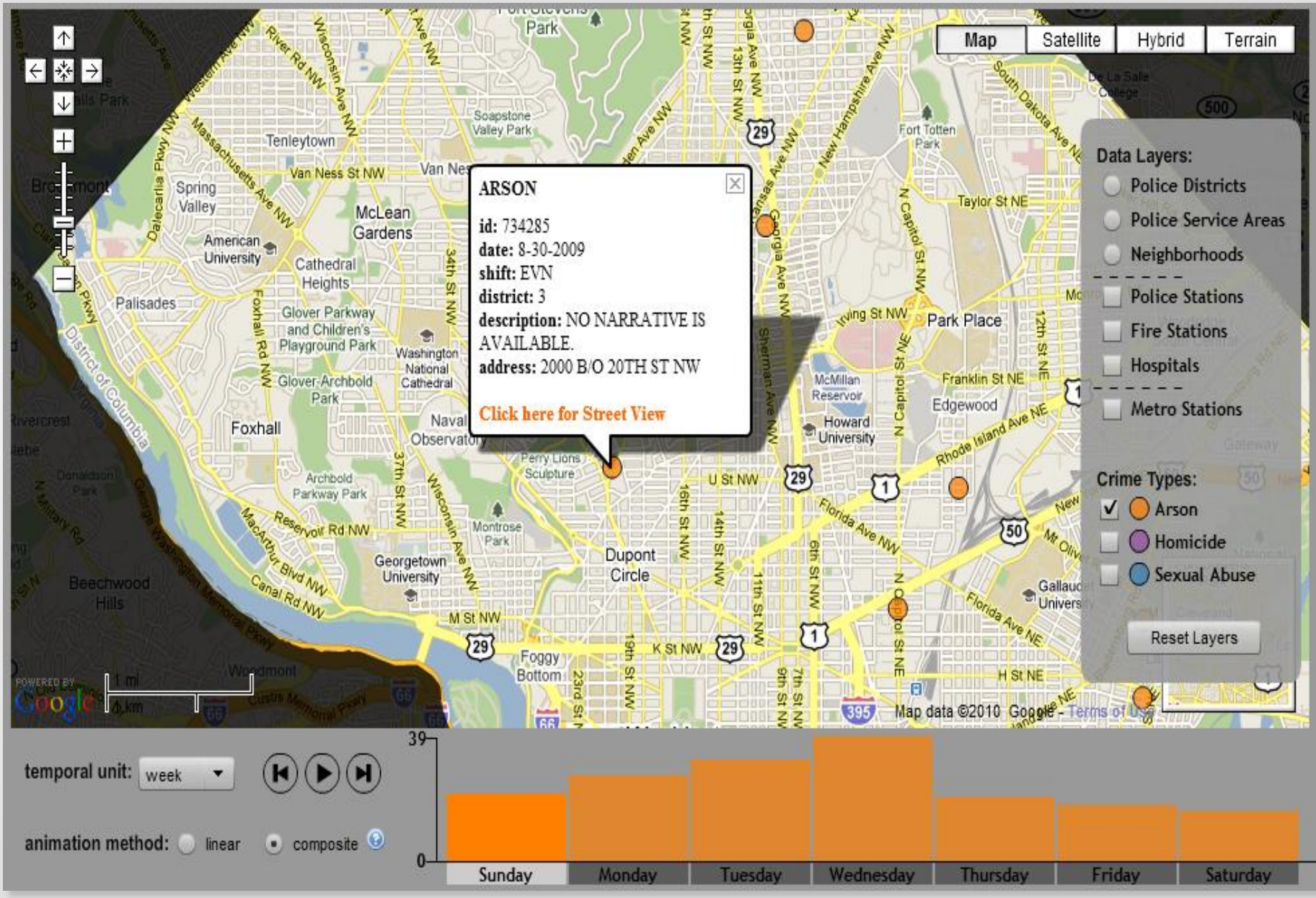
Providing Help and Documentation





Improvement #6:

Improving Scalability by Providing Spatial Aggregates



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STUDY #2: Needs Assessment Interviews

one-on-one interviews to assess the current crime analysis practice of law enforcement agencies, focusing on currently met and unmet needs

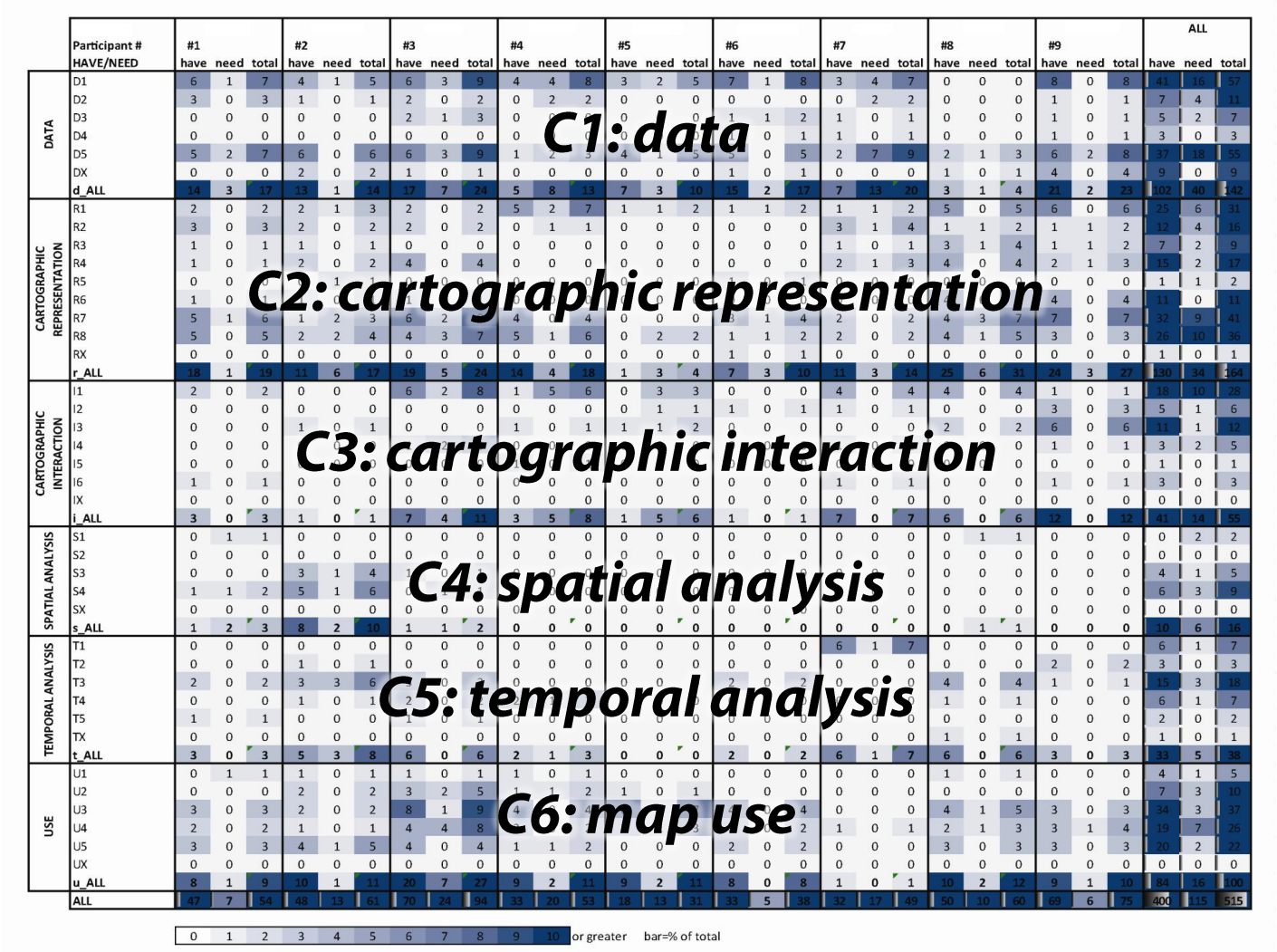
Participants: 9 analysts or decision-makers at 6 municipal and 1 federal law enforcement agency

Data Collection: one interviewer, audio recorded for later transcription/codification

Think Aloud Protocol (60 minutes):

- Introduction & Background Survey (10 minutes)
- Data Information Characteristics (5 minutes planned)
- Mapping and Analysis Practices (20 minutes)
- Use (10 minutes)
- Follow-up survey about the CrimeViz prototype

STUDY #2: Qualitative Data Analysis



	Participant #	#1			#2			#3			#4			#5			#6			#7			#8			#9			ALL		
	HAVE/NEED	have	need	total	have	need	total	have	need	total	have	need	total	have	need	total	have	need	total	have	need	total	have	need	total	have	need	total	have	need	total
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	D4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	1	0	1	3	0	3
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	R4	1	0	1	2	0	2	4	0	4	0	0	0	0	0	0	0	0	0	2	1	3	4	0	4	2	1	3	15	2	17
	R5	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	2
	R6	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	4	0	4	4	0	4	11	0	11
	R7	5	1	6	1	2	3	6	2	8	4	0	4	0	0	0	3	1	4	2	0	2	4	3	7	7	0	7	32	9	41
	R8	5	0	5	2	2	4	4	3	7	5	1	6	0	2	2	1	1	2	2	0	2	4	1	5	3	0	3	26	10	36
	RX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
	r_ALL	18	1	19	11	6	17	19	5	24	14	4	18	1	3	4	7	3	10	11	3	14	25	6	31	24	3	27	130	34	164
CARTOGRAPHIC INTERACTION	I1	2	0	2	0	0	0	6	2	8	1	5	6	0	3	3	0	0	0	4	0	4	4	0	4	1	0	1	18	10	28
	I2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	0	0	3	0	3	5	1	6
	I3	0	0	0	1	0	1	0	0	0	1	0	1	1	1	2	0	0	0	0	0	0	2	0	2	6	0	6	11	1	12
	I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	3	2	5
	I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	I6	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	3	0	3
	IX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	i_ALL	3	0	3	1	0	1	7	4	11	3	5	8	1	5	6	1	0	1	7	0	7	6	0	6	12	0	12	41	14	55
SPATIAL ANALYSIS	S1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	2
	S2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	S3	0	0	0	3	1	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	5
	S4	1	1	2	5	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	3	9
	SX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	s_ALL	1	2	3	8	2	10	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	10	6	16
TEMPORAL ANALYSIS	T1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	7	0	0	0	0	0	0	6	1	7
	T2	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	3	0	3
	T3	2	0	2	3	3	6	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	4	0	4	1	0	1	15	3	18
	T4	0	0	0	1	0	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	6	1	7
	T5	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
	TX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
	t_ALL	3	0	3	5	3	8	6	0	6	2	1	3	0	0	0	2	0	2	6	1	7	6	0	6	3	0	3	33	5	38
USE	U1	0	1	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	4	1	5
	U2	0	0	0	2	0	2	3	2	5	1	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	3	10
	U3	3	0	3	2	0	2	8	1	9	4	0	4	0	0	0	4	0	4	0	0	0	4	1	5	3	0	3	34	3	37
	U4	2	0	2	1	0	1	4	4	8	0	0	0	0	0	0	2	0	2	1	0	1	2	1	3	3	1	4	19	7	26
	U5	3	0	3	4	1	5	4	0	4	1	1	2	0	0	0	2	0	2	0	0	0	3	0	3	3	0	3	20	2	22
	UX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u_ALL	8	1	9	10	1	11	20	7	27	9	2	11	9	2	11	8	0	8	1	0	1	10	2	12	9	1	10	84	16	100
	ALL	47	7	54	48	13	61	70	24	94	33	20	53	18	13	31	33	5	38	32	17	49	50	10	60	69	6	75	400	115	515

0 1 2 3 4 5 6 7 8 9 10 or greater bar=% of total

C1: data

C2: cartographic representation

C3: cartographic interaction

C4: spatial analysis

C5: temporal analysis

C6: map use

STUDY #2: Interview Results (1of 2)

Data

- most datasets are maintained internally
- datasets are voluminous and multivariate
- geocoding varies, not always a requirement
- data quality hinges on reporting officer, often using paper forms
- use few external datasets

Representation

- "push-pin" maps are most common
- "hot spot maps" also common; preference for direct aggregation to a grid rather than a smoothing kernel
- choropleth maps specifically avoided
- time represented by coloring pins; composite small multiples common

Interaction

- overall limited, only employed by analysts
- positive view towards web mapping services, although little use
- filtering most common operator; others used rarely
- several agencies employ interactive maps for CompStat meetings

STUDY #2: Interview Results (2 of 2)

Spatial Analysis

- overall very limited due to time constraints of analysts
- buffering most common analysis applied
- several instances of journey-to-crime analysis
- one reported use of spatial scan statistics (SaTScan & GeoDA)

Temporal Analysis

- extreme variation across agencies
- most departments only generate time series info graphics for weekly reports
- two agencies regularly apply advanced analysis
- include aoristic analysis, predictive trend analysis, and spatiotemporal scan statistics with alerting

Map Use

- mostly tactical, gaining a situational awareness of current patterns (7-30 days only)
- only a subset of agencies have the personnel to conduct strategic analysis
- thus, tools must integrate into workflows and improve efficiency

STUDY #3: User Survey, Usability Results

professional crime analysts and decision-makers are asked to test out the tool on their own and respond to a series of Likert-based questions

	Strongly Disagree	(2)	(3)	No Opinion	(5)	(6)	Strongly Agree	Average
I thought CrimeViz was easy to use.	0%	0%	0%	10%	10%	10%	70%	**6.4**
I think that most people would learn to use the CrimeViz quickly	0%	0%	0%	10%	10%	30%	50%	**6.2**
I was often confused about what to click or where to look when using CrimeViz	50%	30%	0%	0%	10%	0%	10%	**2.3**
I think that I would need the support of a technical person to be able to use the CrimeViz prototype.	50%	30%	10%	10%	0%	0%	0%	**1.8**

STUDY #3: User Survey, Utility Results

professional crime analysts and decision-makers are asked to test out the tool on their own and respond to a series of Likert-based questions

	Strongly Disagree	(2)	(3)	No Opinion	(5)	(6)	Strongly Agree	Average
CrimeViz has all the necessary functions to explore incident data	0%	30%	10%	10%	20%	20%	10%	**4.2**
CrimeViz has all the necessary functions to analyze indicent data	10%	20%	20%	10%	10%	10%	20%	**4.0**
CrimeViz does not support the type of work that I typically do	50%	0%	0%	20%	20%	10%	0%	**2.9**
I do not think I would use CrimeViz frequently	20%	10%	10%	30%	10%	20%	0%	**3.6**

Part 3: Outlook

Tech Transition & the Mission of Science

IN-DEPTH CASE STUDY: Harrisburg, PA

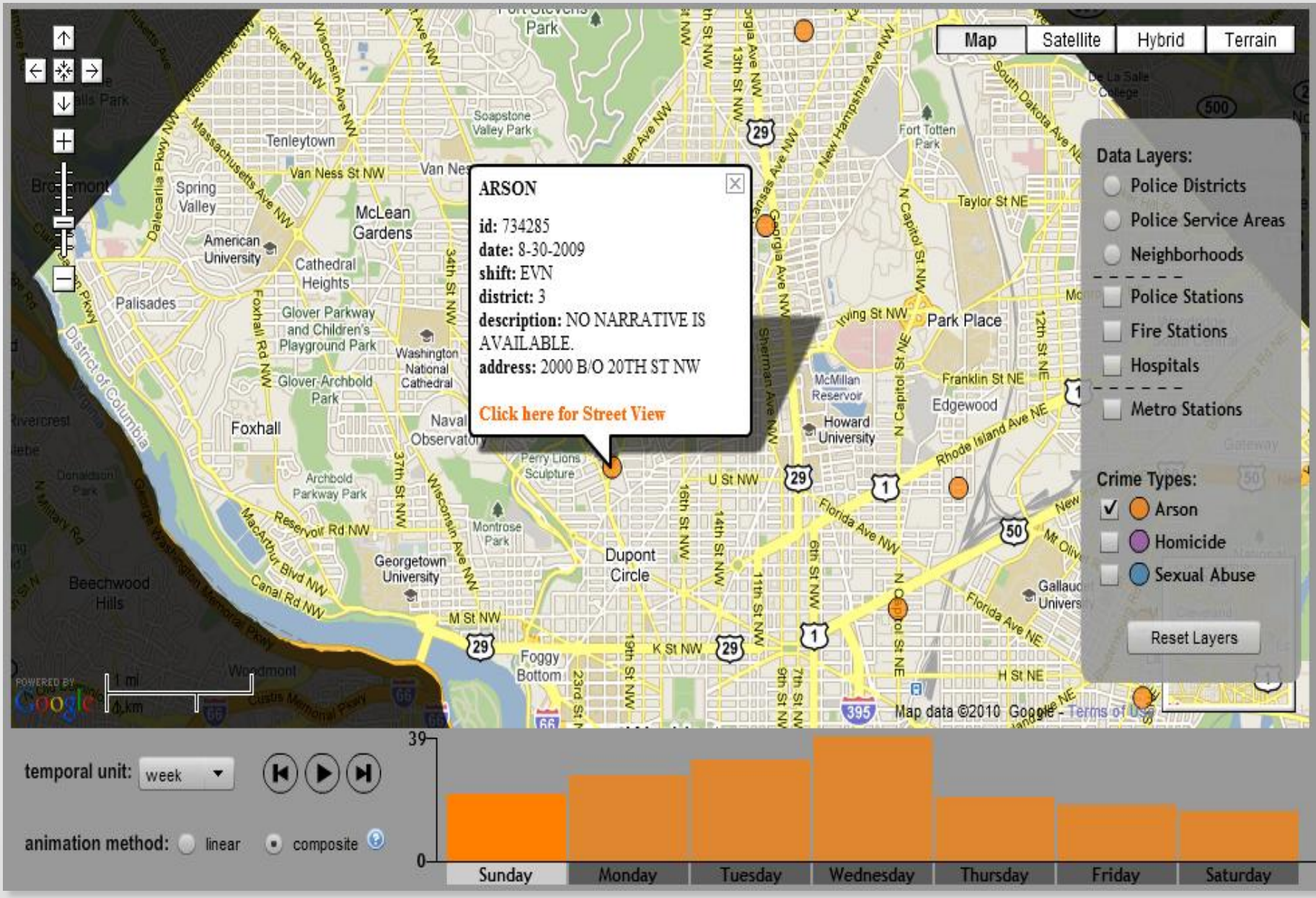
research and development collaboration with the Harrisburg (PA, USA) Police Department for the technology transition & continued evaluation of CrimeViz

Harrisburg PD Participants:

- 3 captains
- 2 supervising officers (corporal level)
- 3 information technology personnel
- 2 network personnel
- 1 GIS intern

Data Collection:

- ~monthly remote meetings that includes structured input on paper mockups and early prototypes
- participant observation (planned)
- interaction studies (planned)



Penn State Coffee Hour

State College, PA: 18 March 2011

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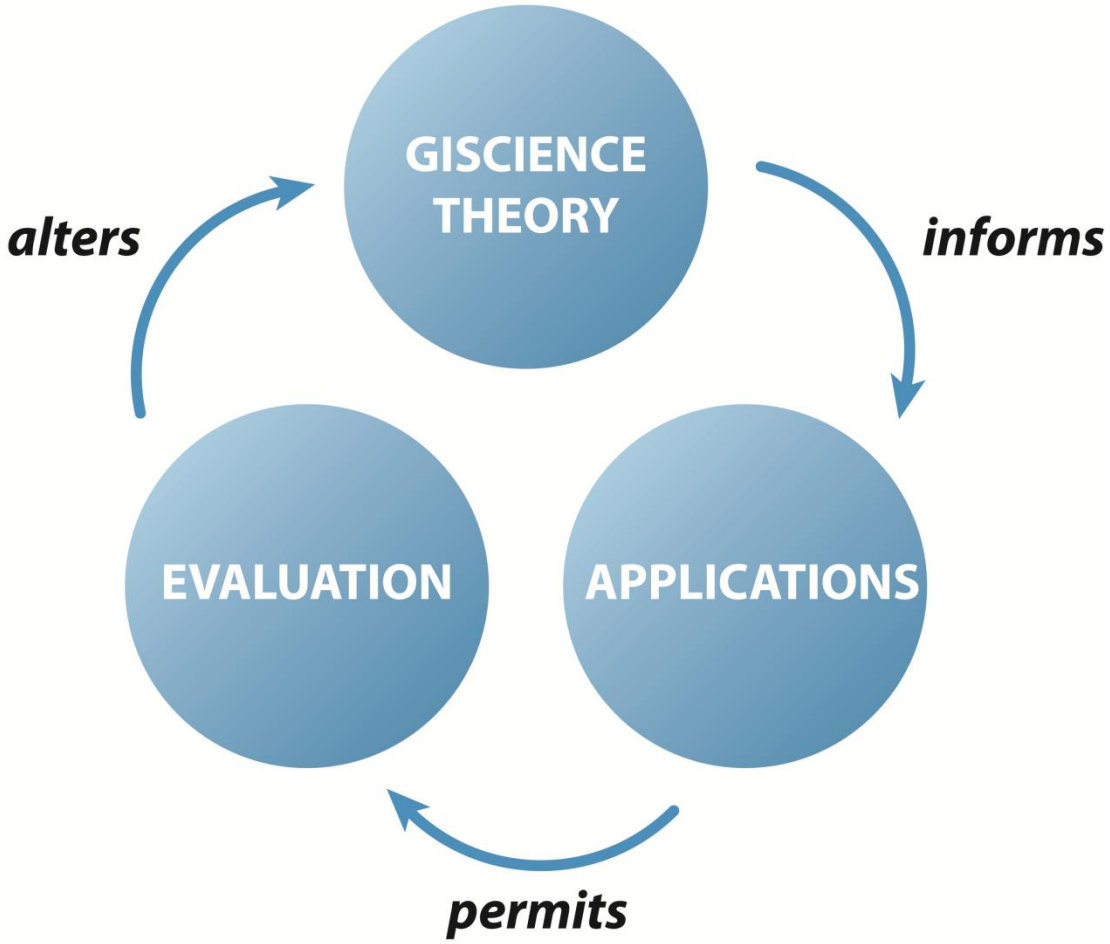
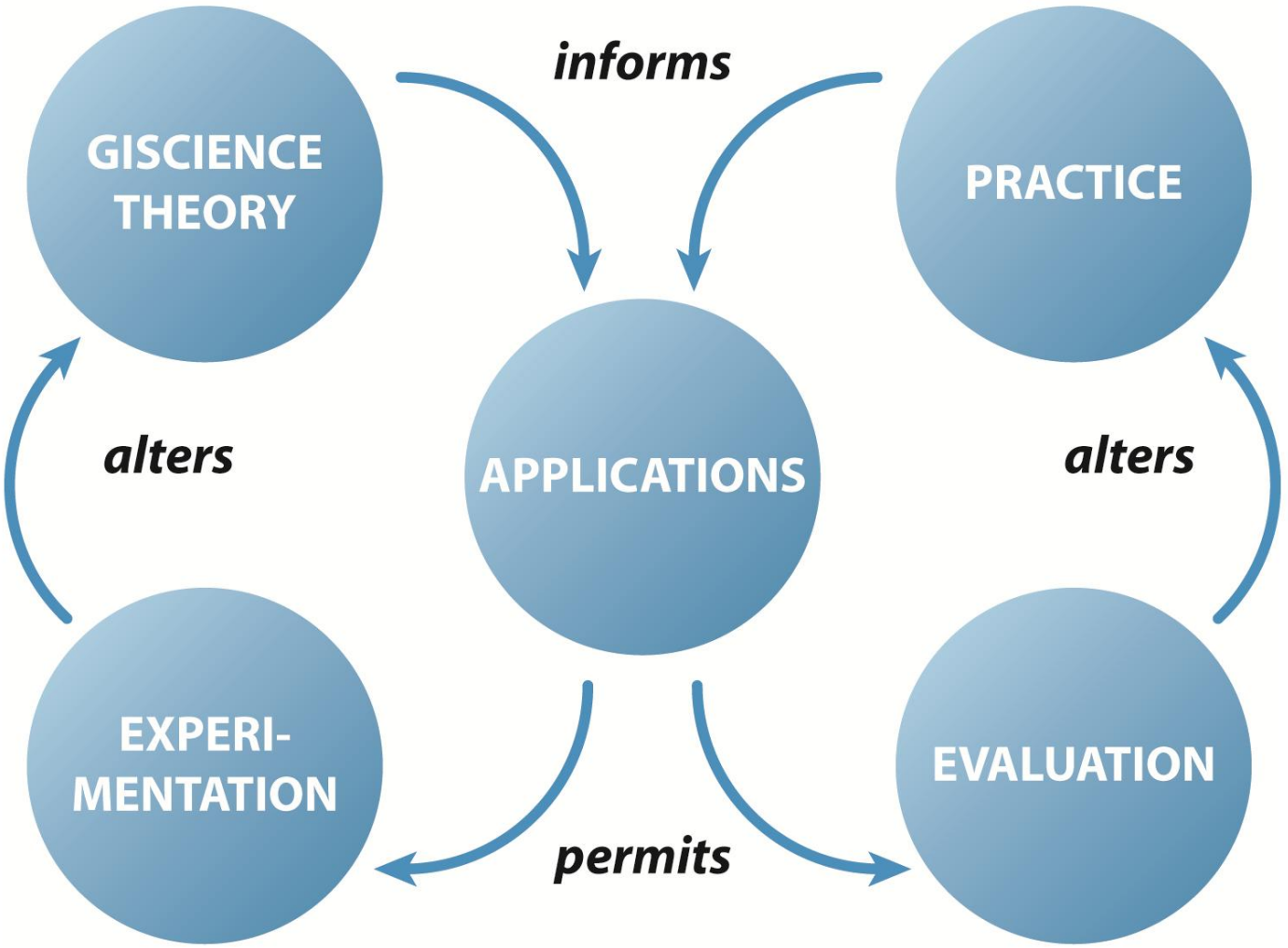
THEORETICAL & APPLIED GISCIENCE



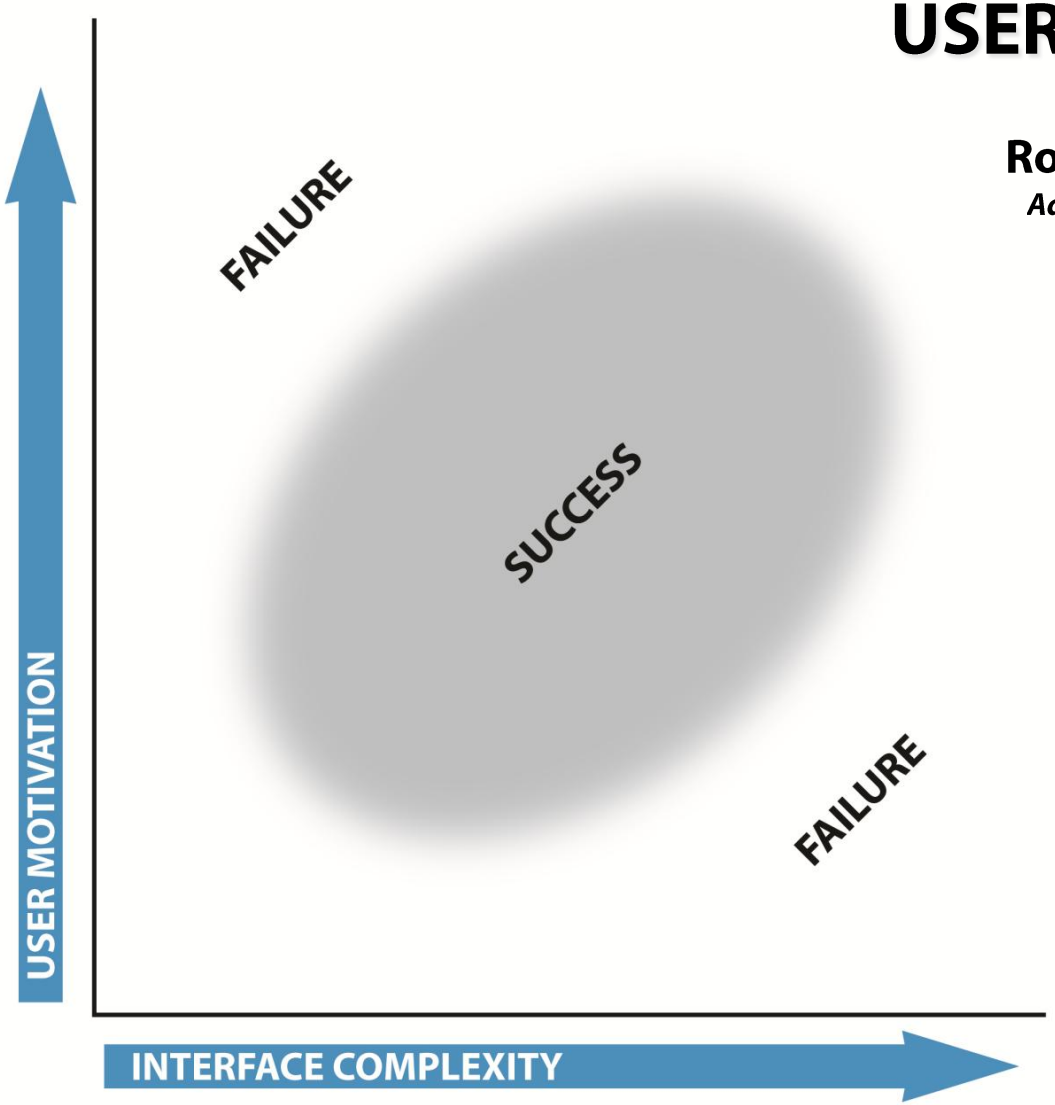
THEORETICAL & APPLIED GISCIENCE



USER MOTIVATION

Roth & Harrower (2008)

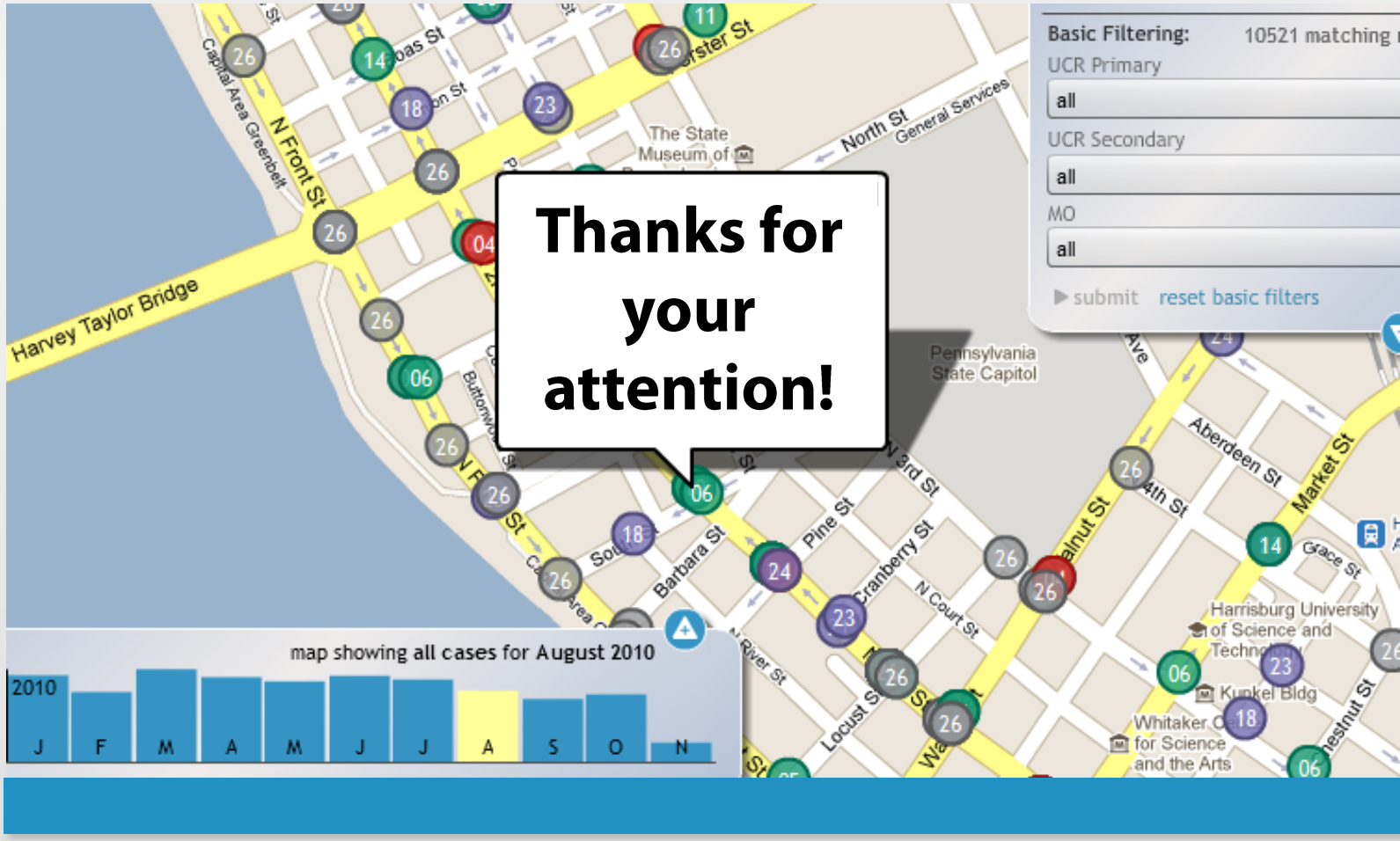
Addressing map interface usability



learn more about the project & try out the application at:

http://www.geovista.psu.edu/CrimeViz/

Robert E. Roth
reroth@wisc.edu



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INTERACTION QUESTIONS

Harrower & Sheesley (2005)

Designing better map interfaces: A framework for panning & zooming

Guest Editorial

Designing Better Map Interfaces: A Framework for Panning and Zooming

1 Introduction

Three basic questions underpin the development of all interactive mapping systems: (1) what type of interactivity is needed (*kind of control*), (2) how much interactivity is needed (*degree of control*), and (3) how should this interactivity be implemented (*method of control*)? In this essay, we examine existing approaches to panning and zooming controls found in 2D interactive maps (e.g. desktop GIS, Web-based map services) and present a task-based framework for systematically determining the relative advantages and disadvantages of each of these approaches based on criteria such as

CRIME ANALYSIS GOALS

1. **Tactical Analysis:** reactive investigation of recent crime spikes

2. **Strategic Analysis:** prospective investigation of long-terms crime trends and shifts

3. **Criminal Investigative Analysis:** targeted investigation of single offender or crime series

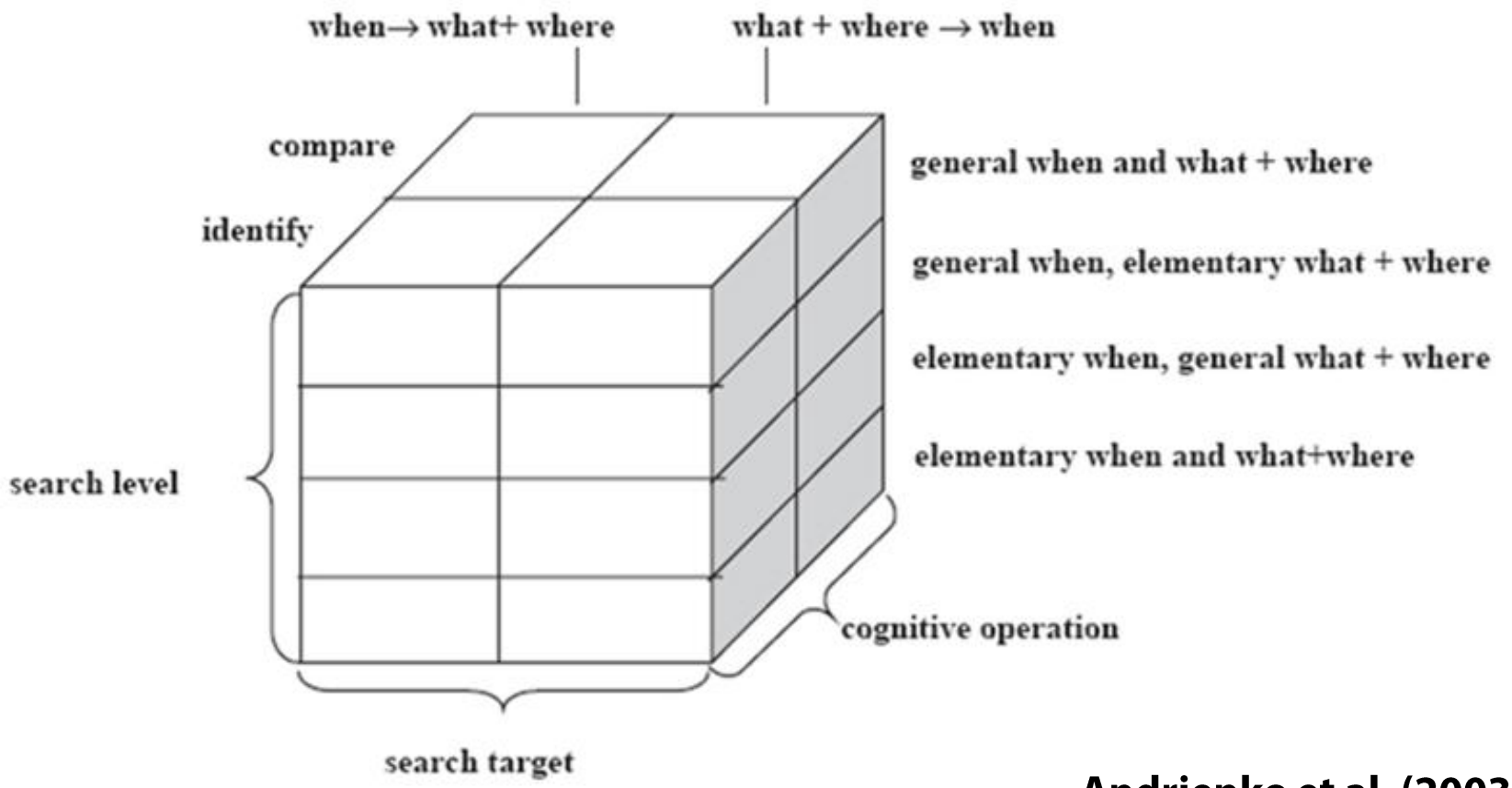
4. **Intelligence Analysis:** targeted investigation of broader crime syndicate

5. **Administrative Analysis:** evaluation of policing strategies and administrative policies

Boba (2005)

Crime analysis defined

STUDY #1: Spatiotemporal Task Taxonomy



Andrienko et al. (2003)

Exploratory Spatio-Temporal Visualization: An Analytical Review

STUDY #1: Balanced Task Scheme

Twelve tasks total = ~3 minutes per task

Identify

General

1. What and Where --> When
2. When --> What and Where
3. Where and When --> What

Elementary

1. What --> When and When
2. What and When --> Where
3. Where --> What and When

Compare

General

1. What --> When and When
2. What and When --> Where
3. Where --> What and When

Elementary

1. What and Where --> When
2. When --> What and Where
3. Where and When --> What