Comparing Apples and Oranges

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Reference

- This is a preliminary version of the paper: ***Comparing Apples and Oranges: How to Select the Most Probable Targets*** that will be presented at the ***2009 IEEE International Conference on Technologies for Homeland Security*** that will be held May 11-12, 2009 in Westin Massachusetts.
- The paper will be available after that date from the author.

The Problem of Limited Resources

- In a world with limited resources, people must deal with tradeoffs
- When it comes to protecting assets people want to prioritize them in some way so that they can have a rational scheme for distributing defensive resources
- Generally, people want a **total or linear ordering**, which means that for any two assets people can determine whether A ≥ B or A ≤ B
- Want to avoid ties as much as possible
- A trivial linear ordering just says any two assets are equal

The Problem of Limited Resources

- When it comes to protecting some asset it is helpful to have some idea of which assets deserve **"MORE"** protection than other assets
- Any time you see the words ***more*** or ***less*** you are dealing with an ordering of some sort
- Let's look at one system that guides people in making choices

CARVER2™
Critical Infrastructure Analysis Tool

www.ni2cie.org

CARVER2

- Critical Infrastructure Analysis Tool
- Simple, non-technical, PC-based tool that ranks critical infrastructure in order of importance
- Provides basis for making appropriate decisions on protecting infrastructure
- Only tool that provides for "cross-sector" scoring and ranking
- Based on recognized methodology used by Secret Service and U.S. military
- Provided free-of-charge to government agencies

CARVER2

- 35 states currently using CARVER2 PC version
- Over 100 local jurisdictions in U.S. and Canada using CARVER2 PC version
- Interest from U.S. Army Corps of Engineers for national application
- Web-based version in development
  - Secure data-base
  - Unlimited data-entry points
  - Real-time mapping capability via *MapsOnLine*
  - Web-based version will also be free-of-charge to government agencies

CARVER2

- **C**riticality
- **A**ccessibility
- **R**ecoverability
- **V**ulnerability
- **E**spyability (Notoriety)
- **R**edundancy

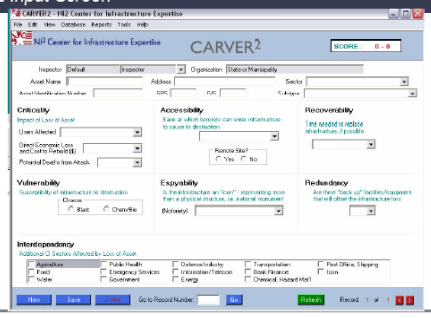
Cross-Sector Comparison

- Traditional analysis tools:
  - Can't compare assets across sectors
  - Are sector-specific
  - Are highly technical, requiring specialized engineering training and experience
  - Require significant staffing to complete evaluations of large numbers of assets

Solution

- CARVER2 compares across sectors
- Measures the same data for all assets, producing consistent results
- Sets clear priorities for allocation of protective resources
- Non-technical
- Quick and easy-to-use
- Validated
- Free

CARVER2 Input Screen



Criticality

Impact of Loss of Asset

Users Affected

Direct Economic Loss and Cost to Rebuild ($)

Potential Deaths from Attack

Direct Economic Loss and Cost to Rebuild ($)

N/A
50 Billion
25 Billion
1 Billion
750 Million
500 Million
250 Million
100 Million

Criticality

Impact of Loss of Asset

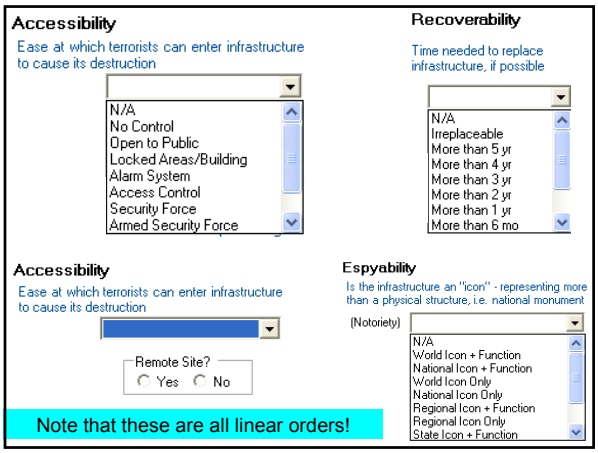
Users Affected

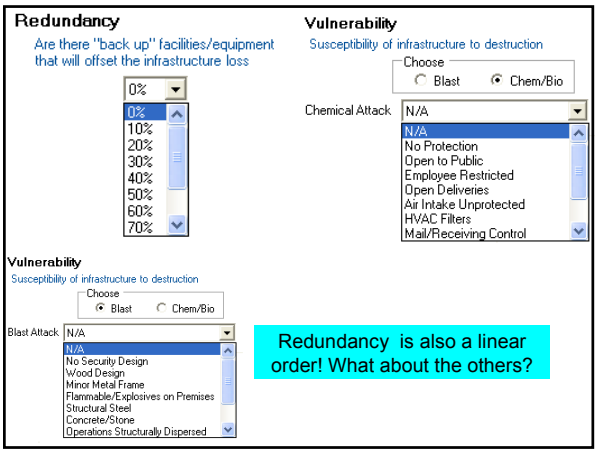
N/A
More than 5 Million People
More than 2.5 million People
More than 1 million People
More than 500,000 People
More than 100,000 People
More than 50,000 People
More than 25,000 People

Potential Deaths from Attack

N/A
100,000+
50,000
10,000
5,000
1,000
500
250

Note that these are all linear orders!





Apples and Oranges

- How do you compare the various factors?
- Here is where the title of the talk comes in
- How do you compare apples and oranges?

Name	Total	Criticality	Accessibility	Recoverability	Vulnerability	Espyability	Redundancy
Monument	396	56	80	100	80	80	0
Small Monument	290	20	90	50	80	50	0
RR Station	276	56	80				
Bridge 1	260	80	40	70	20		
Tunnel 1	220	70	20	80	10		
Chem Plant	190	70	40	50	70		
Bridge 2	163	53	60	50	50	40	90
Bridge 3	150	60	30	60	60	20	80

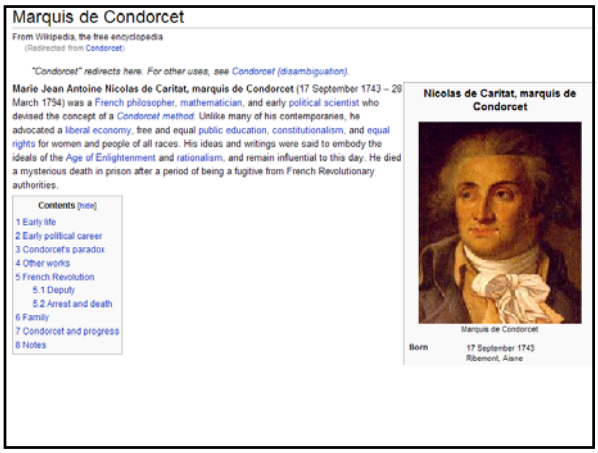
Potential Deaths from Attack
N/A
100,000+
50,000
10,000
5,000
1,000
500
250

Total = Crit + Access + Recov + Vuln + Espy - Redun

Do the results make sense?

Combining Factors

- How can we combine different factors consistently?
- What do we mean by consistently?
- Let's take a look at a long standing problem and its surprising solution



Marquis de Condorcet

From Wikipedia, the free encyclopedia

(Redirected from Condorcet)

"Condorcet" redirects here. For other uses, see Condorcet (disambiguation).

Marie Jean Antoine Nicolas de Caritat, marquis de Condorcet (17 September 1743 – 29 March 1794) was a French philosopher, mathematician, and early political scientist who devised the concept of a *Condorcet method*. Unlike many of his contemporaries, he advocated a liberal economy, free and equal public education, constitutionalism, and equal rights for women and people of all races. His ideas and writings were said to embody the ideals of the Age of Enlightenment and rationalism, and remain influential to this day. He died a mysterious death in prison after a period of being a fugitive from French Revolutionary authorities.

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Nicolas de Caritat, marquis de Condorcet

Marquis de Condorcet

Born 17 September 1743
Ribemont, Aisne

Condorcet's Paradox

- Condorcet studied how you might decide elections that have 3 or more candidates
- He tried to determine what would be the right method for deciding such elections
- His research was driven by his discovery of a paradox

Condorcet's Paradox

- There are six orders of preference for 3 candidates (A > B > C), (A > C > B), (B > A > C), (B > C > A), (C > A >B), and (C > B > A)
- Suppose we have 60 voters as follows:

A	A	B	B	C	C
B	C	A	C	A	B
C	B	C	A	B	A
23	0	2	17	10	8

Condorcet's Paradox

- If you count just first place votes you would get
- A – 23; B – 19; C – 18.
- A first, B second, C third.

A	A	B	B	C	C
B	C	A	C	A	B
C	B	C	A	B	A
23	0	2	17	10	8

60 voters total

Condorcet's Paradox

- If you looked at A vs B only, you would get
- A – 33; B – 27.
- A beats B!

A	A	B	B		
B		A		A	B
	B		A	B	A
23	0	2	17	10	8

60 voters total

Condorcet's Paradox

- If you looked at B vs C only, you would get
- B – 42; C – 18.
- B crushes C!
- Consistent with A > B > C

		B	B	C	C
B	C		C		B
C	B	C		B	
23	0	2	17	10	8

60 voters total

Condorcet's Paradox

- Now consider A vs C – you get
- A – 25; C – 35.
- C crushes A!
- What happens to A > B, B > C?

A	A			C	C
C	C	A	C	A	A
23	0	2	17	10	8

60 voters total

Condorcet's Paradox

- Thus, we have a group of perfectly rational voters preferring A to B, preferring B to C, and preferring C to A
- These choices are logically inconsistent

A	A	B	B	C	C
B	C	A	C	A	B
C	B	C	A	B	A
23	0	2	17	10	8

60 voters total

Condorcet Cycles

- We call any situation where A ≥ B, B ≥ C, and C ≥ A (where A, B and C are distinct) a **Condorcet cycle**
- Condorcet cycles can be longer A ≥ B ≥ C ≥ D … ≥ Z ≥ A, etc.
- The key point is that you end up finding a contradictory cycle

Condorcet's Paradox

- Condorcet struggled to find a method to guarantee consistent choices
- He failed
- He failed for the following reason

ARROW'S THEOREM

- The only selection method that avoids inconsistency is dictatorship by a logically consistent individual.
- In other words, you get consistency if and only if you pick one voter and let that voter choose
- Where does that leave us with CARVER2 and other such systems?

Name	Criticality	Accessibility	Recoverability	Vulnerability	Espyability	Redundancy
Monument	56	80	100	80	80	100
Small Monument	20	90	50	80	50	100
RR Station	56	80	40	60	90	50
Bridge 1	80	40	70	20	100	50
Tunnel 1	70	20	80	10	90	50
Chem Plant	70	40	50	70	10	50
Bridge 2	53	60	50	50	40	10
Bridge 3	60	30	60	60	20	20

Imagine that each column is an expert and let the majority rule – Can we find any Condorcet cycles?

Name	Criticality	Accessibility	Recoverability	Vulnerability	Espyability	Redundancy
Small Monument	20	90	50	80	50	100
RR Station	56	80	40	60	90	50

Small Monument ≥ RR Station (4 to 2)

Top > Bottom

Top < Bottom

Top = Bottom

Name	Criticality	Accessibility	Recoverability	Vulnerability	Espyability	Redundancy
RR Station	56	80	40	60	90	50
Tunnel 1	70	20	80	10	90	50

RR Station ≥ Tunnel 1 (Tie 2-2-2)

Top > Bottom

Top < Bottom

Top = Bottom

Name	Criticality	Accessibility	Recoverability	Vulnerability	Espyability	Redundancy
Small Monument	20	90	50	80	50	100
Tunnel 1	70	20	80	10	90	50

Tunnel 1 ≥ Small Monument (Tie 3-3)

Small Monument ≥ RR Station ≥ Tunnel 1 ≥ Small Monument

Top > Bottom

Top < Bottom

Top = Bottom

Initial Analysis

	MN	SM	RR	B1	T1	CP	B3	B2
MN	1	1	1	1	1	1	1	1
SM	0	1	1	1	1	1	1	1
RR	0	0	1	0	1	0	1	1
B1	0	1	1	1	1	1	1	1
T1	0	1	1	0	1	1	1	1
CP	0	0	1	0	1	1	1	1
B3	0	0	0	0	0	0	1	0
B2	0	0	0	0	0	0	1	1

1 means A ≥ B – put 1 in both boxes if they are tied

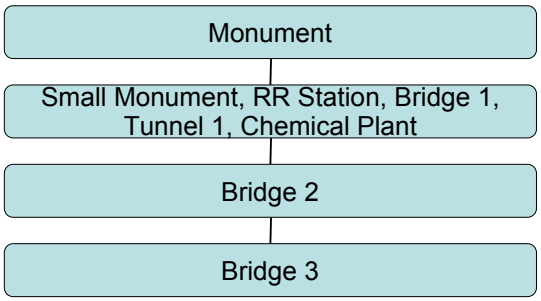
Final Analysis

	MN	SM	RR	B1	T1	CP	B3	B2
MN	1	1	1	1	1	1	1	1
SM	0	1	1	1	1	1	1	1
RR	0	1	1	1	1	1	1	1
B1	0	1	1	1	1	1	1	1
T1	0	1	1	1	1	1	1	1
CP	0	1	1	1	1	1	1	1
B3	0	0	0	0	0	0	1	0
B2	0	0	0	0	0	0	1	1

Final Analysis

	MN	SM	RR	B1	T1	CP	B3	B2
MN	1	1	1	1	1	1	1	1
SM	0	1	1	1	1	1	1	1
RR	0	1	1	1	1	1	1	1
B1	0	1	1	1	1	1	1	1
T1	0	1	1	1	1	1	1	1
CP	0	1	1	1	1	1	1	1
B3	0	0	0	0	0	0	1	0
B2	0	0	0	0	0	0	1	1

The Best Order



Automating the Process

- I have written a small program that can process data given in the form of a CSV file and determines the blocks
- This program will be available from my website to anyone who is interested

Sample Input and Output

```
NAME,Criticality,Accessibility,….
Bridge 3,53,60,50,50,40,10
Small Monument,20,90,50,80,50,100
Railroad Station,56,80,40,60,90,50
Tunnel 1,70,20,80,10,90,50
Monument,56,80,100,80,80,100
Chemical Plant,70,40,50,70,10,50
Bridge 2,60,30,60,60,20,20
Bridge 1,80,40,70,20,100,50
```

Assumes all columns ordered the same way so you need to fix the redundancy column.

```
**************************
BLOCK 1 CONSISTS OF
Monument
**************************
BLOCK 2 CONSISTS OF
Small Monument
Railroad Station
Tunnel 1
Chemical Plant
Bridge 1
**************************
BLOCK 3 CONSISTS OF
Bridge 2
**************************
BLOCK 4 CONSISTS OF
Bridge 3
```

Some Conclusions

- No good way to compare apples and oranges
- Can process tables of results for Condorcet cycles
- Once you find the cycles, you can group targets together into more realistic groupings

Some Conclusions

- Pick one criterion and use it to guide your selection
- Figure out which criterion was used by your enemy
- What criteria or criterion was used by the September 11 attackers?

September 11 Targets

- World Trade Center 1
- World Trade Center 2
- Pentagon
- Congress or White House (?)
- Which criteria were being used?
  - Criticality, Accessibility, Recoverability, Vulnerability, Espyability, Redundancy

Are Systems Such As CARVER2 Useful?

- The short answer is
- YES!!!
- Security is a process, and anything that makes you think about it seriously is a good thing
- Consider multiple criteria – how do you know you are looking at the correct ones?
- Not all threats come from terrorists: hurricanes, accidents

Are Systems Such As CARVER2 Useful?

- In working through a CARVER2 demo with a class, people realized when discussing blast vulnerability that a school was located right near a large gasoline storage tank
- These tanks do blow up on occasion
- Perhaps the school should be relocated