Benefit-Cost Analysis of Tools, Technologies, and Knowledge Products (TTKPs)

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Customs and Border Protection - Advanced Developments
Encompassing Processes and Technologies (CBP-ADEPT) Workshop 2:
Advanced Development and Processes for Tomorrow

Overview

- Space: *Applying risk and economic analysis for decision-making*
- Problem: *Conducting Benefit-Cost Analysis (BCA) and Return-on-Investment (ROI) of R&D projects across a spectrum of outputs*
- Solution: *Develop consistent methodology and analysis process(es), applicable across diverse fields*
- Results: *Developed four types of BCA/ROI classifications and nine calculational models, and demonstrated examples*
- Benefit to CBP: *Can use methods and models to prioritize projects*
- TRL: *5-6, system-level demonstration in relevant environment*

- Contact me at *imaya@usc.edu, 213-949-6292*

- Presentation follows results of study conducted by USC/CREATE researchers Detlof von Winterfeldt, Scott Farrow*, Richard John, Jonathan Eyer, Adam Z. Rose, and Heather Rosoff
 *University of Maryland Baltimore County

The National Center for Risk and Economic Analysis of Terrorism Events

- First Center of Excellence funded by Office of University Programs of DHS S&T

- Focus:
  - Risk analysis +
  - Economic analysis =>
  - To improve Homeland Security (HS) decisions and operations

The USC name will go atop the AT&T Center in downtown LA later this year. (Artist's rendering by Sheharaz.
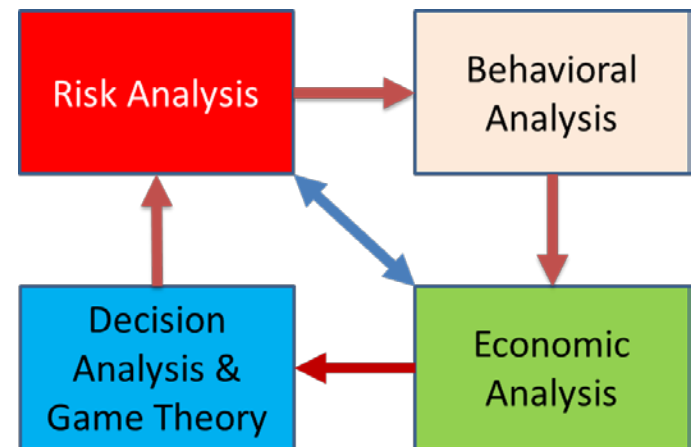
Research and Analysis Framework

Decision Analysis & Game Theory Projects

Dirty Bomb Attacks on Harbors

Randomized Searches & Patrols

September 28, 2007

Newsweek National News

The Element of Surprise
To help combat the terrorism threat, officials at Los Angeles International Airport are introducing a bold new idea into their arsenal: random placement of security checkpoints. Can game theory help keep us safe?

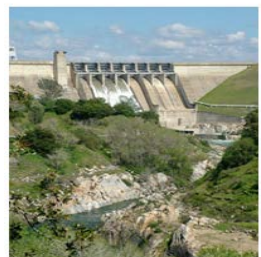Security forces work the sidewalk at LAX

MANPADS Countermeasures
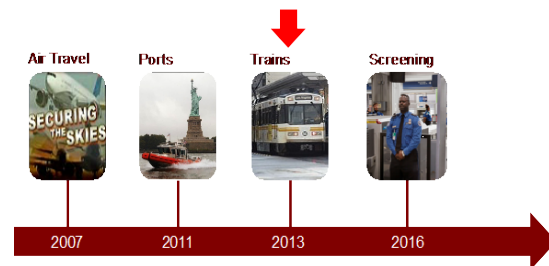
Infrastructure Protection

Chemical
Dams
Commercial

Advanced Radiation Detection

More Security Games

Infrastructure Security Games

Air Travel   Ports   Trains   Screening

2007   2011   2013   2016

Benefit-Cost Analysis of Homeland Security Research Project Results

Two primary questions:

- Can we quantify the costs and benefits of OUP-funded research projects (TTKPs)?

- If so, what is the return on investment of OUP's investment in HS research?

Process of Benefit Cost Analysis (1 of 2)

- Selection of TTKPs
  - Transition probability
  - Beneficial impacts, if successfully transitioned
- Familiarization with the TTKP
  - Interviews with PM, PI, user(s)
  - Background research
- Baseline analysis
  - How the operation or decision is currently done
  - Current costs and performance data
- Cost Analysis
  - Detailed cost template
  - Count all pre- and post-COE funding
  - Estimate capital and O&M costs
  - Inflate past and discount future costs to 2017 dollars

Process of Benefit-Cost Analysis (2 of 2)

- Benefits Analysis
  - Identify benefits model and parameters
  - Base-case estimate of benefits

- Sensitivity and uncertainty analysis
  - Identify ranges for parameters of benefits model
  - Conduct tornado analysis
  - Conduct Monte Carlo analysis

- Results
  - Net benefits
  - Benefit/cost ratio and return on investment (ROI)
  - 5th, 50th, and 95th percentile of net benefits

Nine Benefits Models

- Cost savings with the same risk level
  - Savings in operational costs (ARMOR, E-CAT)
  - Savings by stretching expenses (CGSARVA)
- Increased security at same cost
  - Reduction of threat (HOAX Calls)
  - Reduction of vulnerability (PROTECT, BOARD)
  - Reduction of negative consequences (TraffiCop)
- Improved signal detection
  - Reduction of false alarm rates (3D CT Scans)
  - Improvement of detection rates (Engineered Swabs)
- Value of information
  - Reduction of uncertainty (GeoXray)
  - Improvement of decision quality (ADCIRC)

Application to U.S. Coast Guard:
Selecting Research Products

U.S. Coast Guard staff members reviewed 200 TTKPs funded by OUP and rated them on two criteria:

1. **The likelihood of a successful transition. (Transitioned and used = 1)**

2. **The impact on the USCG, if successfully transitioned**

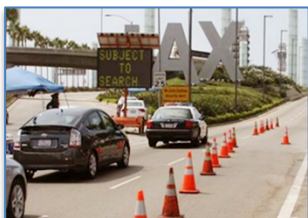Note: Selections are not representative of all OUP-funded projects

Ten Selected Research Products

- **ADCIRC - ADvanced CIRCulation**

  Next generation modeling suite to predict coastal flooding

  CHC - Coastal Hazards Center of Excellence

- **ARMOR - Assistant for Randomized Monitoring Over Routes**

  Software that randomizes schedules, plans, or actions for security agencies

  CREATE – Center for Risk and Economic Analysis of Terrorism Events

- **BOARD - Bus Operator Awareness and Research Development**

  Training program for bus operators to respond to security threats

  NTSCOE – National Transportation Security Center of Excellence

- **CgSARVA – Coast Guard Search and Rescue Visual Analytics**

  Interactive analysis of trends, patterns, anomalies, and distribution of Search and Rescue cases

  VACCINE – Visual Analytics for Command, Control and Interoperability Environments

- **E-CAT – Economic Consequence Analysis Tool**

  Provides rapid estimates of economic impact of threats

  CREATE – Center for Risk and Economic Analysis of Terrorism Events

Summary of Costs and Benefits of TTKPs

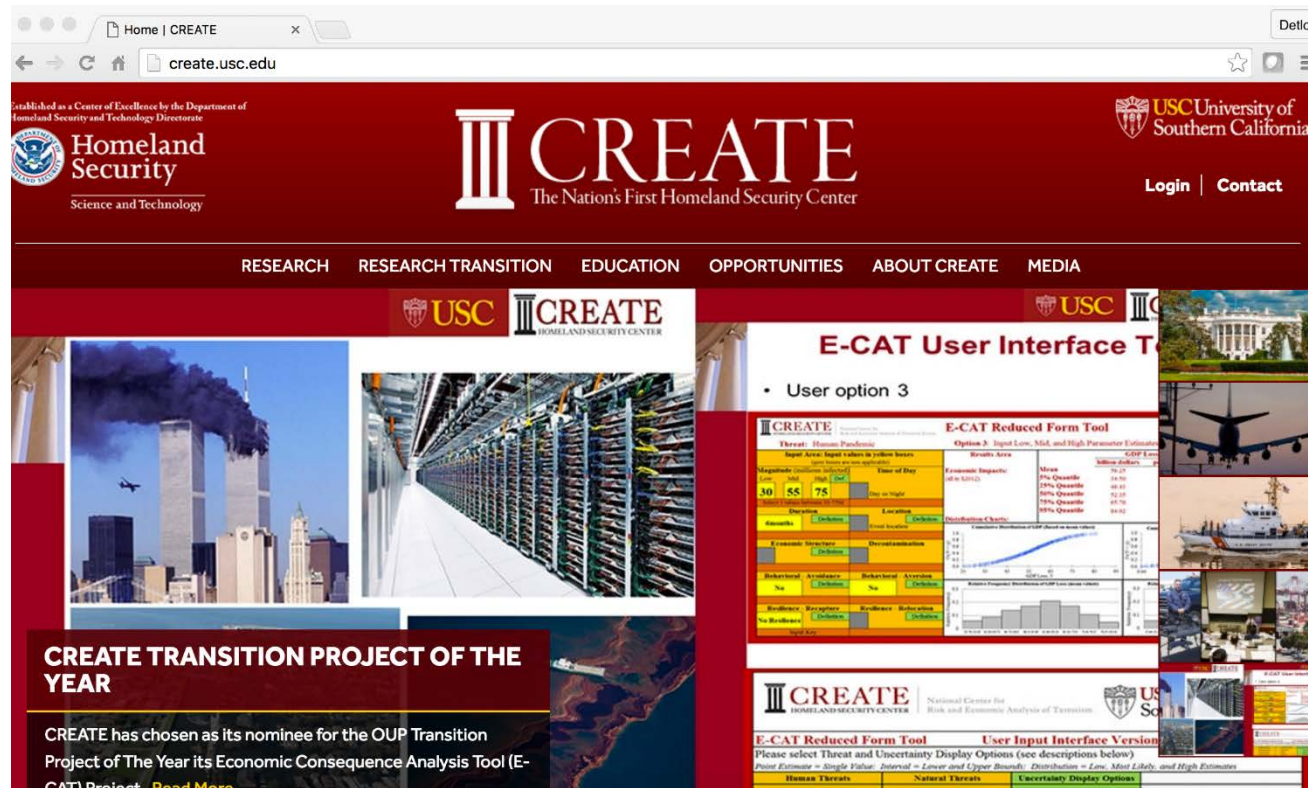| Tool, Technology, or Knowledge Product (TTKP)	Cost (in Thousands, in 2017 $)	Median Net Benefit (50th Percentile)	Years of Use for Net Benefit Calculations
TTKPs with Past Applications			
PROTECT	$710	$35,505	6 Past & 4 Future Years
ARMOR	$1,057	$28,969	10 Years, Past Use
CgSARVA	$803	$5,247	One Time (Sandy)
TTKPs with Potential Future Applications			
ADCIRC	$36,893	$256,411	10 Years, Future Use
Engineered Swabs	$1,867	$22,528	10 Years, Future Use
GeoXray	$273	$18,404	10 Years, Future Use
TraffiCop	$1,413	$10,444	10 Years, Future Use
HOAX Calls	$183	$4,646	10 Years, Future Use
BOARD	$1,018	$2,435	10 Years, Future Use
E-CAT	$942	$806	10 Years, Future Use
TOTAL	**$45,161**	**$386,395**	**ROI=856%**

Application to CBP Projects

- Start thinking about benefits early
  - Who is the user of the TTKP?
  - How can the TTKP improve decisions and operations?
- Identify the benefits model
  - Choose the model
  - Identify the benefits criteria
- Identify baseline
  - How are the decisions or operations currently performed?
  - What is the current performance on the benefits criteria?
- Identify data needs
  - What data do we need to collect for the baseline?
  - What additional data do we need for the benefits analysis of the TTKP?

Thank you!

For more on CREATE, go to

create.usc.edu

Backup Slides

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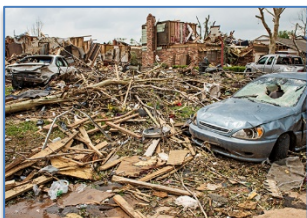 **Training program for bus operators to respond to security threats**

  NTSCOE – National Transportation Security Center of Excellence

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- **Engineered Detection Swab**
  Swabs to improve detection of trace explosives on luggage and persons
  ALERT - Awareness and Localization of Explosives-Related Threats

- **GeoXray**
  Tool to display geographic area and overlay relevant emergency response
  CCICADA – Command, Control and Interoperability Center for Data Analysis

- **HOAX Calls**
  State-of-the-art tool for identifying hoax emergency calls
  CCICADA – Command, Control and Interoperability Center for Data Analysis

- **PROTECT – Port Resilience Operational/Tactical Enforcement to Combat Terrorism**
  Software to randomize schedules in a port environment
  CREATE – Center for Risk and Economic Analysis of Terrorism Events

- **TraffiCop**
  Analysis of Twitter and social media to detect human trafficking
  CCICADA – Command, Control and Interoperability Center for Data Analysis

Example : ARMOR - Assistant for Randomized Monitoring Over Routes
Software that randomizes location and timing of patrols and check points

The Costs of ARMOR

- Pre-funding by the National Science Foundation
- COE funding provided by OUP
- COE cost share
- OUP oversight costs
- Transition and implementation costs by client at LAX
- Upgrade and maintenance cost

Cost Calculations for ARMOR

Cost Category	Start	End	Amount	Source
Pre-project costs (COE)				
Pre-project costs (other funding)	7/1/03	6/30/05	$100,000	NSF
Project costs (COE)	8/15/05	8/14/07	$200,000	CREATE/OUP
Project costs (university cost share)	8/15/05	8/14/07	$30,000	USC
Oversight cost at the COE*	8/15/05	8/14/07	$40,000	CREATE/OUP
Oversight cost at OUP**	8/15/05	8/14/07	$40,000	OUP
Transition development cost	7/1/07	6/30/08	$28,000	CREATE/OUP
Implementation start up cost	7/1/07	6/30/08	$100,000	LAX Police
AVATA upgrade in 2014	1/1/14	1/1/15	$250,000	AVATA/LAX Police
AVATA annual fee for 3 years	1/1/14	12/31/16	$150,000	AVATA/LAX Police
Implementation cost (other users)				
TOTAL COST (Real and Inflation Adjusted)			**$938,000**	**$1,056,460**

* 20% of the COE project cost
** $20,000 per year

The Benefits of ARMOR

- Reduces the staffing needs for LAX checkpoints and patrols by 50%

- Confuses potential terrorists by "smart" randomness

- Increases the capture of illegal weapons and drugs

September 28, 2007

Newsweek National News

The Element of Surprise
To help combat the terrorism threat, officials at Los Angeles International Airport are introducing a bold new idea into their arsenal: random placement of security checkpoints. Can game theory help keep us safe?

Security forces work the sidewalk at LAX

ARMOR has been featured by various national media outlets

Benefit Calculations of ARMOR

| Variable	Base Case
Numbers of Years in Use (original from 2008-2013, AVATA from 2014-2017)	10
Pre-ARMOR Cost per Year for 4 Teams at Regular Pay Rate	$5,390,028
Post-ARMOR Cost per Year for 2 Teams at Regular Pay Rate	$2,695,014
Drug Seizures Value – Increase of 15 Seizures/Year at $1,000/Seizure	$130,000
Weapon Seizures Value – Increase of 15 Seizures/Year at $1000/Seizure	$15,000
Pre-ARMOR Cost per Year for 4 Teams at Overtime Rate	$8,085,042
Post-ARMOR Cost per Year for 2 Teams at Overtime Rate	$4,042,521
Percent Overtime	25%
Annual Benefits	**$3,176,891**
Ten Year Benefits (2008-2017)	**$31,768,908**
Net Benefits (2017 Dollars)	**$30,712,448**

Costs vs. Benefits of ARMOR
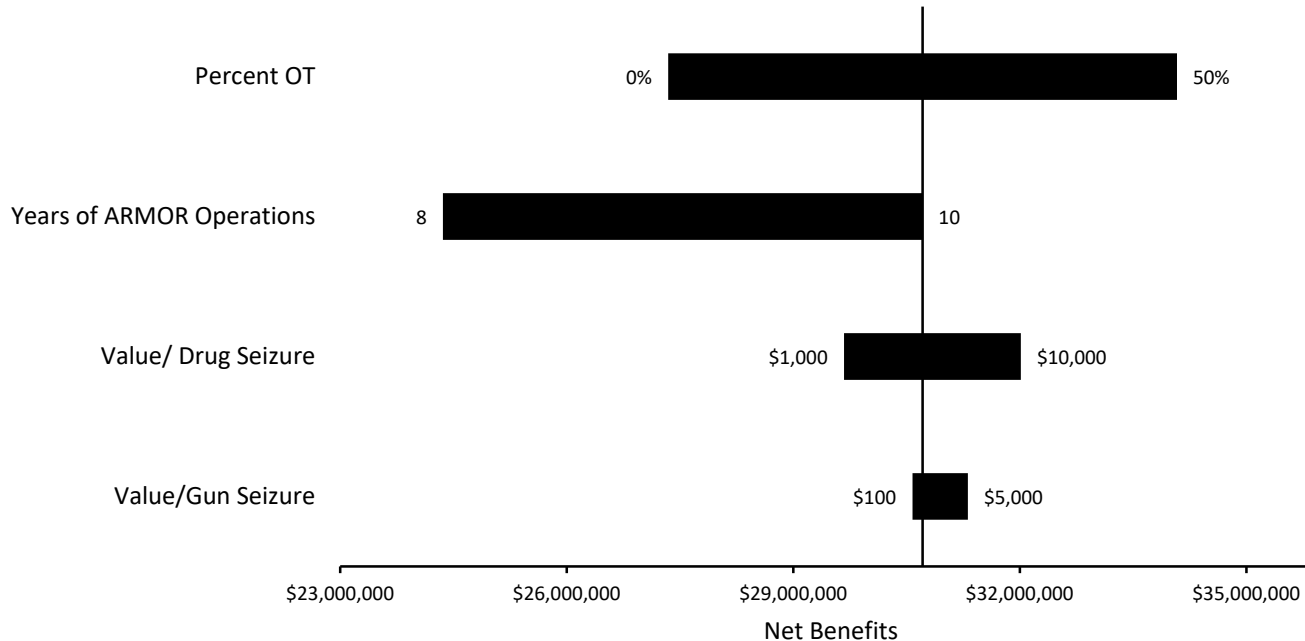

Median Benefit (50th Percentile)

$31,768,908
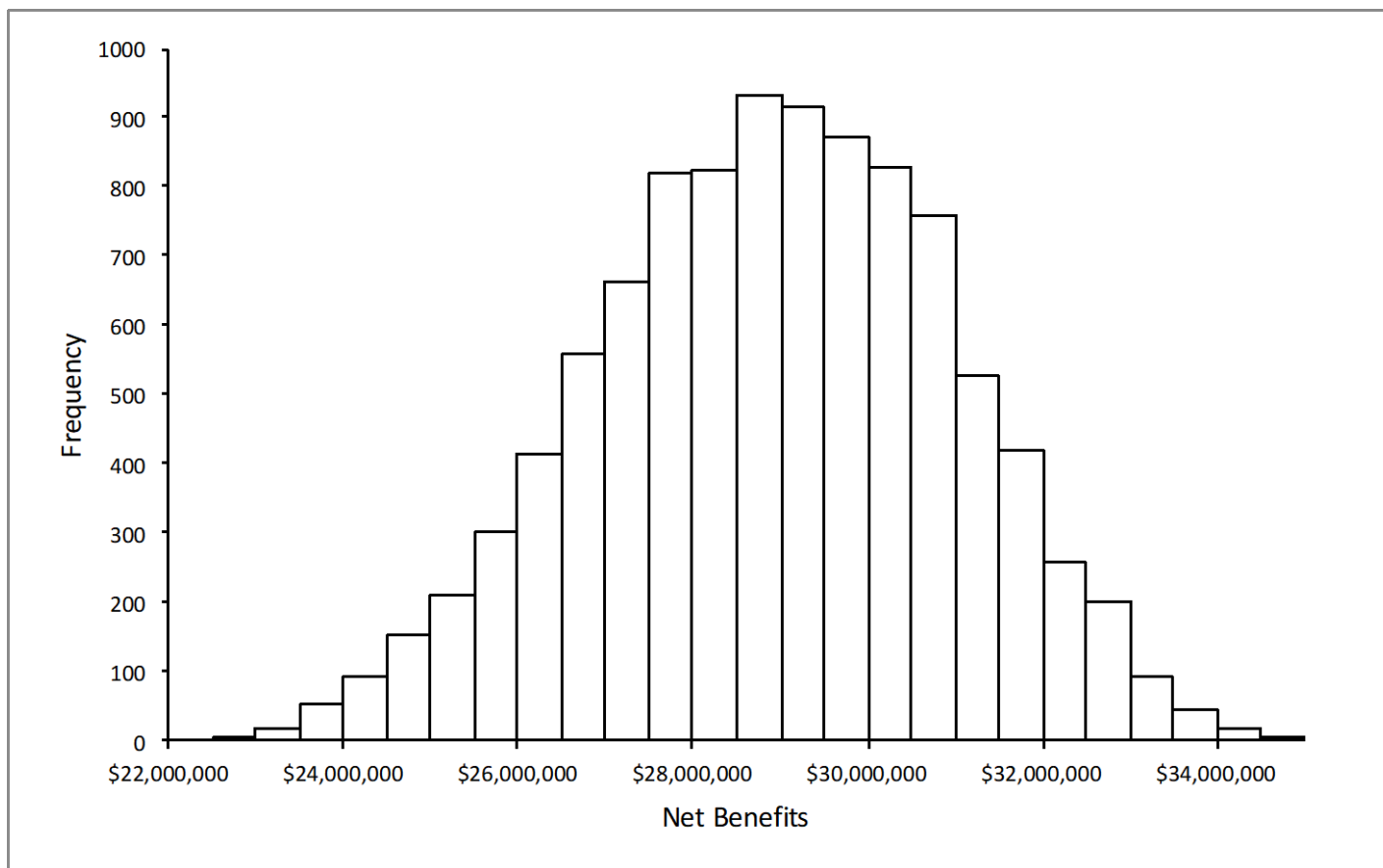
Cost (in 2017 $)

$1,057,000
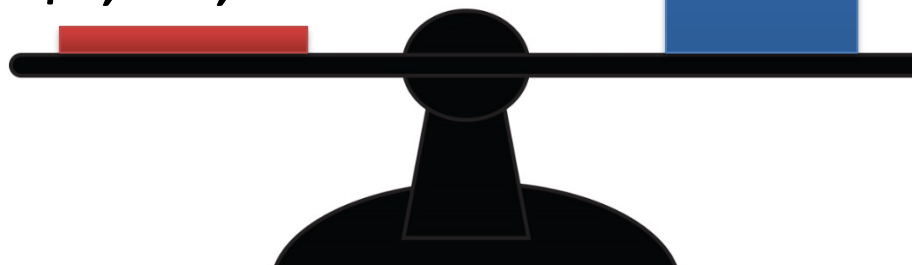
Sensitivity Analysis for ARMOR
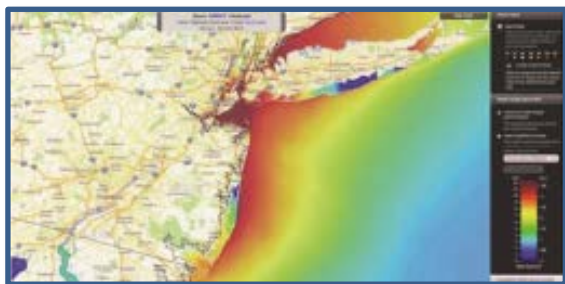
Uncertainty Analysis for ARMOR

- **Using wide ranges for all uncertain inputs (min, mode, max)**
- **Using triangular distributions for each input**

ADCIRC - ADvanced CIRCulation

Storm surge/inundation modeling

COE: CHC - Coastal Hazards Center of Excellence

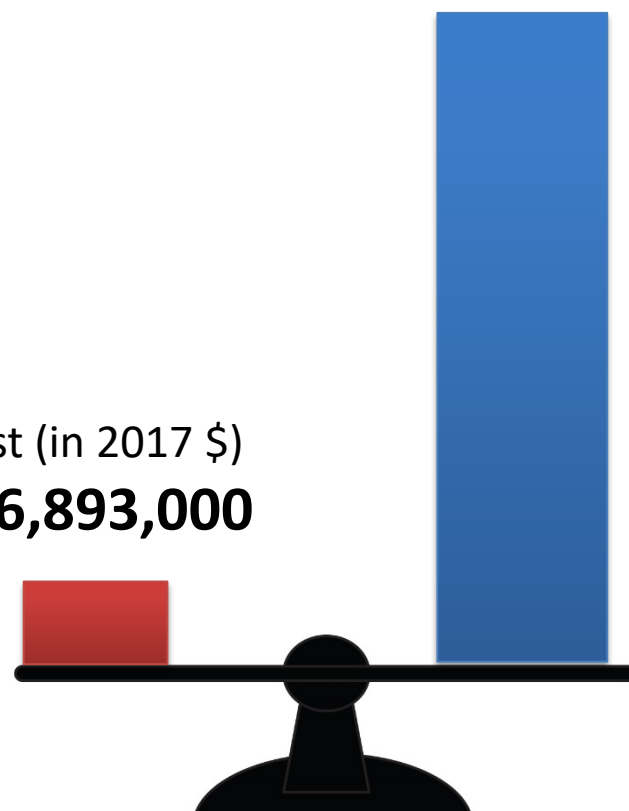Median Benefit (50th Percentile)

$293,804,000

- Storm surge model that combines rain, atmospheric pressure, and wind forecasts

- Predicts when, where, and to what extent flooding will inundate a coastal community

Cost (in 2017 $)

$36,893,000

24

E-CAT – Economic Consequence Analysis Tool

Rapid estimates of the economic impact of threats

COE: CREATE- Center for Risk and Economic Analysis of Terrorism Events

- Provides quick estimates of the economic impact of terrorist attacks, natural disasters, and technological accidents
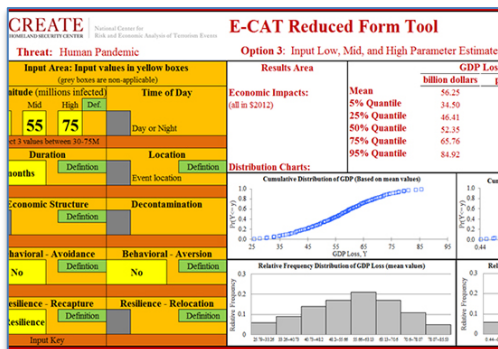
Median Benefit (50th Percentile)

$1,746,000

Cost (in 2017 $)

$942,000

25