Should We Protect Commercial Airplanes Against Surface-to-Air Missile Attacks by Terrorists?

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MANPADS - Weapons

US REDEYE --- 1967

USSR SA-7 --- 1968

Bad Guys

Close Call

MANPADS – Direct Consequences

- Fatalities
- Injuries
- Loss of Airplane(s)

MANPADS Indirect Consequences

- Aviation System Shutdown
- Reduced Airline Passenger Volume
- Fears and worries

MANPADS – Indirect Economic Impacts

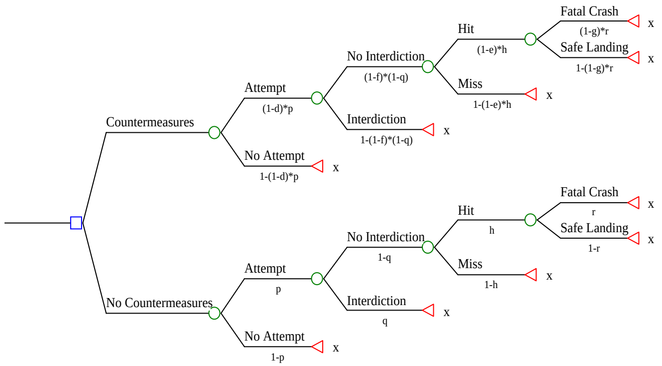
- Shutdown of all airports
  - Lave: $1.5 billion/day
  - USC model: $1 billion/day
- 9/11 economic impacts (2 years)
  - Santos and Haimes: $40-80 billion
  - USC model: $200 to 400 billion

MANPADS – Countermeasures

MANPADS – Countermeasures Costs

- **Capital Cost Estimates**
  - RAND: $10 billion for 5,000 planes
  - DHS: $1.97 billion dollars for 1,000 planes
- **Operation and Maintenance Cost**
  - RAND: $2.5 billion per year for 5,000 planes
  - DHS: $240 million per year for 1,000 planes
- **Total 10-year Life-Cycle Cost for 5,000 planes**
  - RAND: $35 billion
  - DHS: $22 billion

Summary of the Decision Analysis



- Standard decision tree analysis
- 17 variables
- Only three variables mattered:
  - Probability of an attack
  - Economic consequences
  - Lifecycle cost of countermeasures

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Should We Protect Commercial Airplanes Against Surface-to-Air Missile Attacks by Terrorists?

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This paper describes a decision tree analysis to assess the cost-effectiveness of MANPADS (Man-Portable Air Defense Systems) countermeasures. These countermeasures are electronic devices that can be installed on commercial airplanes to detect and deflect surface-to-air missiles (SAMs) fired by terrorists. The model considers a terrorist attempt to shoot down a commercial airplane with a heat-seeking SAM, and it evaluates the decision to install countermeasures, taking into account alternative modes of attack, probabilities of success, and consequences to the economy. All model variables were fully parameterized, using reasonable ranges based on open-source literature. Not surprisingly, the probability of an attack, the consequences of an attack to the economy, and the cost of countermeasures are the most important parameters. Surprisingly, some of the hotly disputed parameters, such as the probability of an airplane surviving a successful hit or the probability of a false alarm, have very little impact on the results. The analysis suggests that MANPADS countermeasures installed on planes can be cost-effective if the probability of such an attack is large (greater than about 0.40 in ten years), the economic losses are large (greater than about $75 billion), and the countermeasures are relatively inexpensive (smaller than about $15 billion). An economic analysis conducted as part of this analysis showed that the economic impacts can be as large as $250 billion, thus making countermeasures a possibly cost-effective option. More research is needed to determine the real costs of MANPADS countermeasures and how terrorists may shift their tactics, once countermeasures are installed.

Key words: terrorism risk; aviation system attacks; surface-to-air missiles; MANPADS; risk analysis; MANPADS countermeasures
History: Received on April 23, 2006. Accepted by Robert Clemen on June 21, 2006 after 2 revisions.

1. Introduction

The threat of attacks on U.S. and other western commercial aircraft using man-portable air defense systems (MANPADS)—heat-seeking or laser-guided surface-to-air missiles (SAMs)—has been recognized widely since 2001 (see for instance Bolkcom and Elias 2006, GAO 2004a, Shanker 2002, Phelps 2003, Hunter 2002).[1] In recent years, there have been publicized MANPADS attacks on large civilian aircraft, in Baghdad, Iraq (*Space Daily* 2003) and Mombasa, Kenya (*Jane's Intelligence Review* 2003)[2] which heightened fears of such attacks in the United States or overseas. It is estimated that at least 4,000 to 5,000 of these missiles may be accessible to anti-Western terrorist organizations (Bolkcom and Elias 2006).

The United States has engaged in efforts to purchase and destroy missiles in Iraq, Russia, and other regions (GAO 2005, Bolkcom and Elias 2006).[3] While this effort has been fairly successful, it is countered by additional production and distribution of new missiles, for example, by China (O'Sullivan 2004) and by the lack of international treaty regulations of missile trade.

[1] There were earlier warnings as well. See for instance Marvin B. Schaffer, "Concerns About Terrorists With Manportable SAMS," *RAND Corporation Reports*, October 1993.

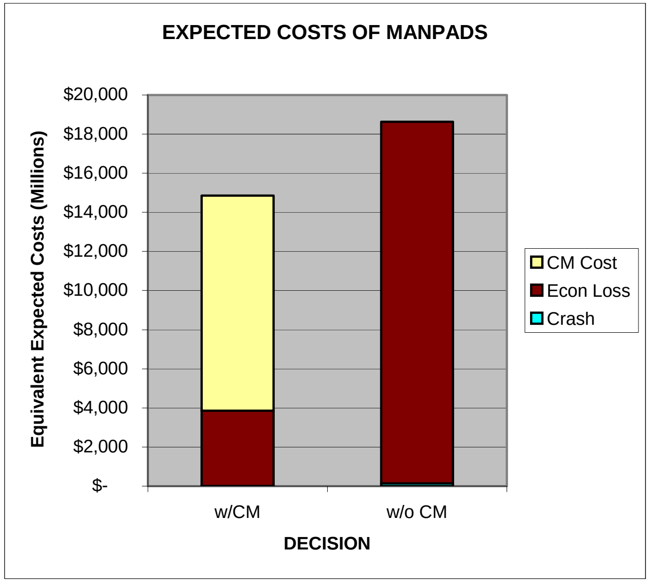
[2] The 2003 Baghdad DHL A300 cargo jet was attacked with a Russian-made SA-14 MANPADS missile, and resulted in a wing fuel tank fire, loss of all three hydraulic systems, and a crash landing with no injuries at the Baghdad International Airport. The Mombasa attack was directed at an Israeli Arkia charter jet, but the missile(s) did not hit the target.

[3] See, for instance United States Department of State Fact Sheet, "The MANPADS Menace: Combating the Threat to Global Aviation from Man-Portable Air Defense Systems." http://www.state.gov/t/pm/rls/fs/53558.htm.

MANPADS Model – User Interface

Inputs and Ranges of the Manpads Model

Probabilities	**Base**	**Case**	**Min**	**Max**
Attempted Attack in 10 years	0.50	0.50	0.00	1.00
Interdiction|Attempt	0.00	0.00	0.00	0.10
Hit|Attack	0.80	0.80	0.50	1.00
Crash|Hit	0.25	0.25	0.00	0.50
Effectiveness of Countermeasures				
Deterrence Effectiveness	0.50	0.50	0.00	1.00
Interdiction Effectiveness	0.00	0.00	0.00	1.00
Diversion/Destruction Effectiveness	0.80	0.80	0.00	1.00
Crash Reduction Effectiveness	0.00	0.00	0.00	1.00
Consequences				
Fatalities|crash	200	200	0	400
Cost of the Plane (millions)	200	200	0	500
Economic Loss|Fatal Crash (billions)	100	100	0	500
Percent of Loss|Hit and Safe Landing	25%	25%	0%	50%
Percent of Loss|Miss	10%	10%	0%	25%
Number of False Alarms/Year	10	10	0	20
Cost of Countermeasures (billions)	10	10	5	50
Tradeoffs				
Value of Life (millions)	5	5	0	10
Cost of a False Alarm (millions)	10	10	0	100

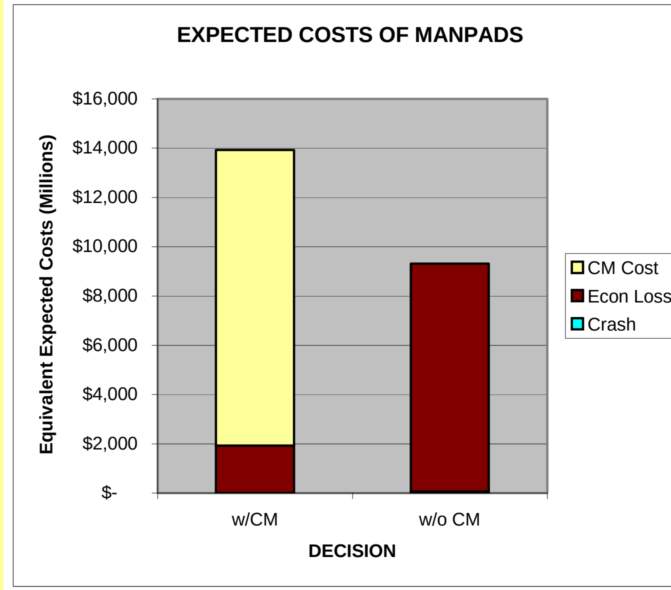


Outputs of Manpads Model

		Total	Crash	Econ Loss	CM Cost
Expected Costs w/ Countermeasures (millions)	**w/CM**	**$ 14,864**	$ 14	$ 3,850	$ 11,000
Expected Costs w/o Countermeasures (millions)	**w/o CM**	**$ 18,635**	$ 135	$ 18,500	$ -

MANPADS Model – User Interface

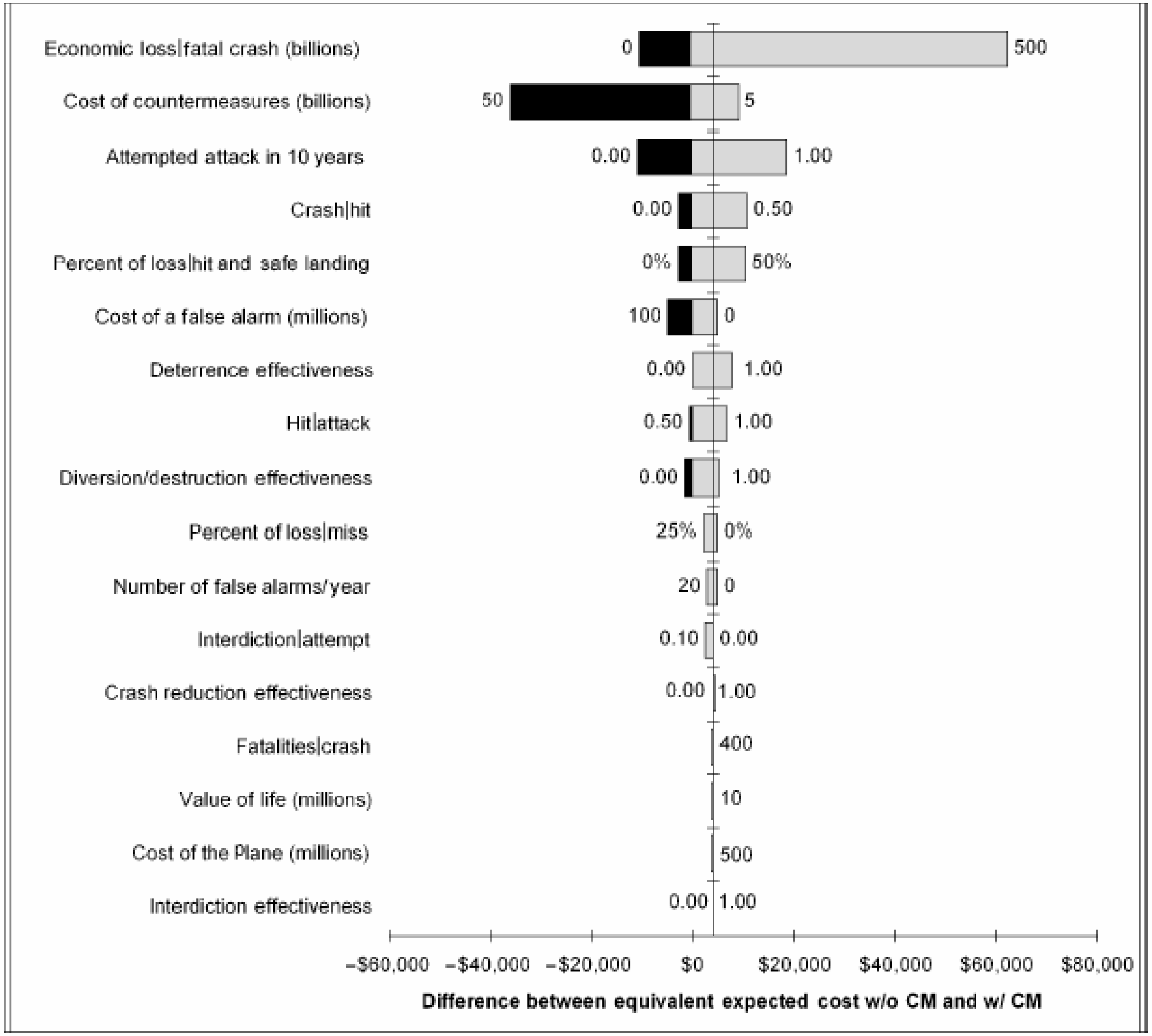
Probabilities	Base	Case	Min	Max
Attempted Attack in 10 years	0.50	0.25	0.00	1.00
Interdiction|Attempt	0.00	0.00	0.00	0.10
Hit|Attack	0.80	0.80	0.00	1.00
Crash|Hit	0.25	0.25	0.00	1.00
Effectiveness of Countermeasures				
Deterrence Effectiveness	0.50	0.50	0.00	1.00
Interdiction Effectiveness	0.00	0.00	0.00	1.00
Diversion/Destruction Effectiveness	0.80	0.80	0.00	1.00
Crash Reduction Effectiveness	0.00	0.00	0.00	1.00
Consequences				
Fatalities|crash	200	200	0	400
Cost of the Plane (millions)	200	200	0	500
Loss to Economy|Fatal Crash (billions)	100	100	0	500
Percent of Loss|Hit and Safe Landing	25%	25%	0%	50%
Percent of Loss|Miss	10%	10%	0%	25%
Number of False Alarms/Year	10	10	0	20
Cost of Countermeasures (billions)	10	10	5	50
Tradeoffs				
Value of Life (millions)	5	5	0	10
Cost of a False Alarm (millions)	10	20	0	100



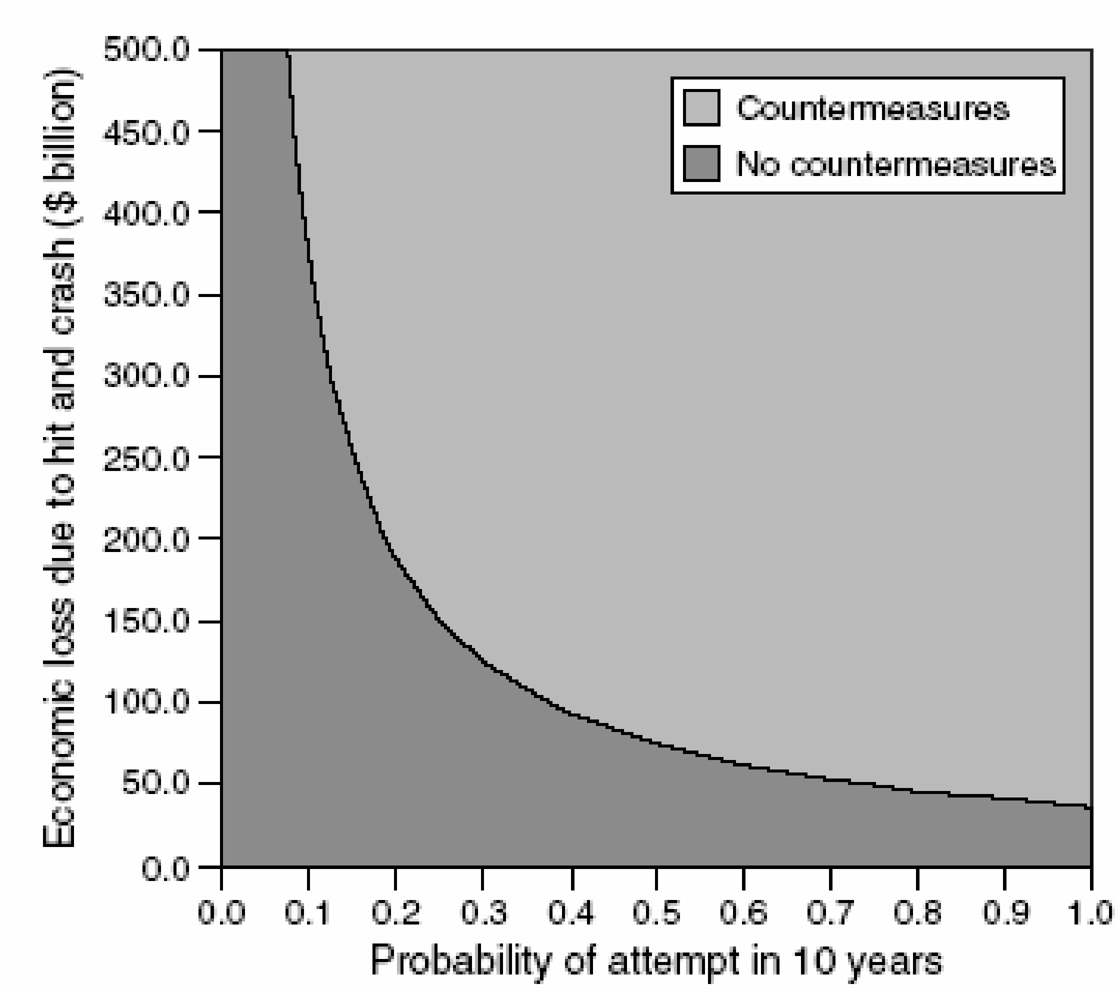
Outputs of Manpads Model

		Total	Crash	Econ Loss	CM Cost
Expected Costs w/ Countermeasures (millions)	**w/CM**	**$ 13,932**	$ 7	$ 1,925	$ 12,000
Expected Costs w/o Countermeasures (millions)	**w/o CM**	**$ 9,318**	$ 68	$ 9,250	$ -

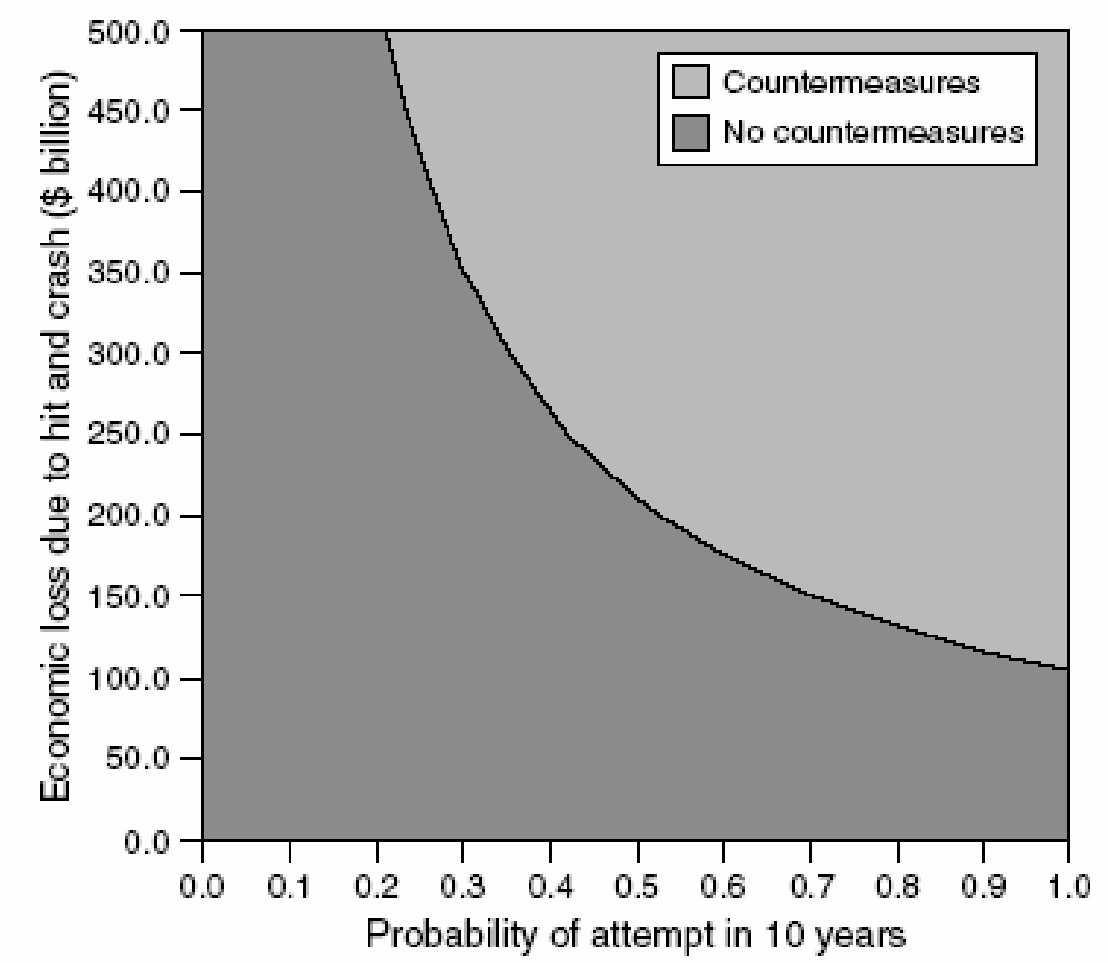
Tornado Diagram



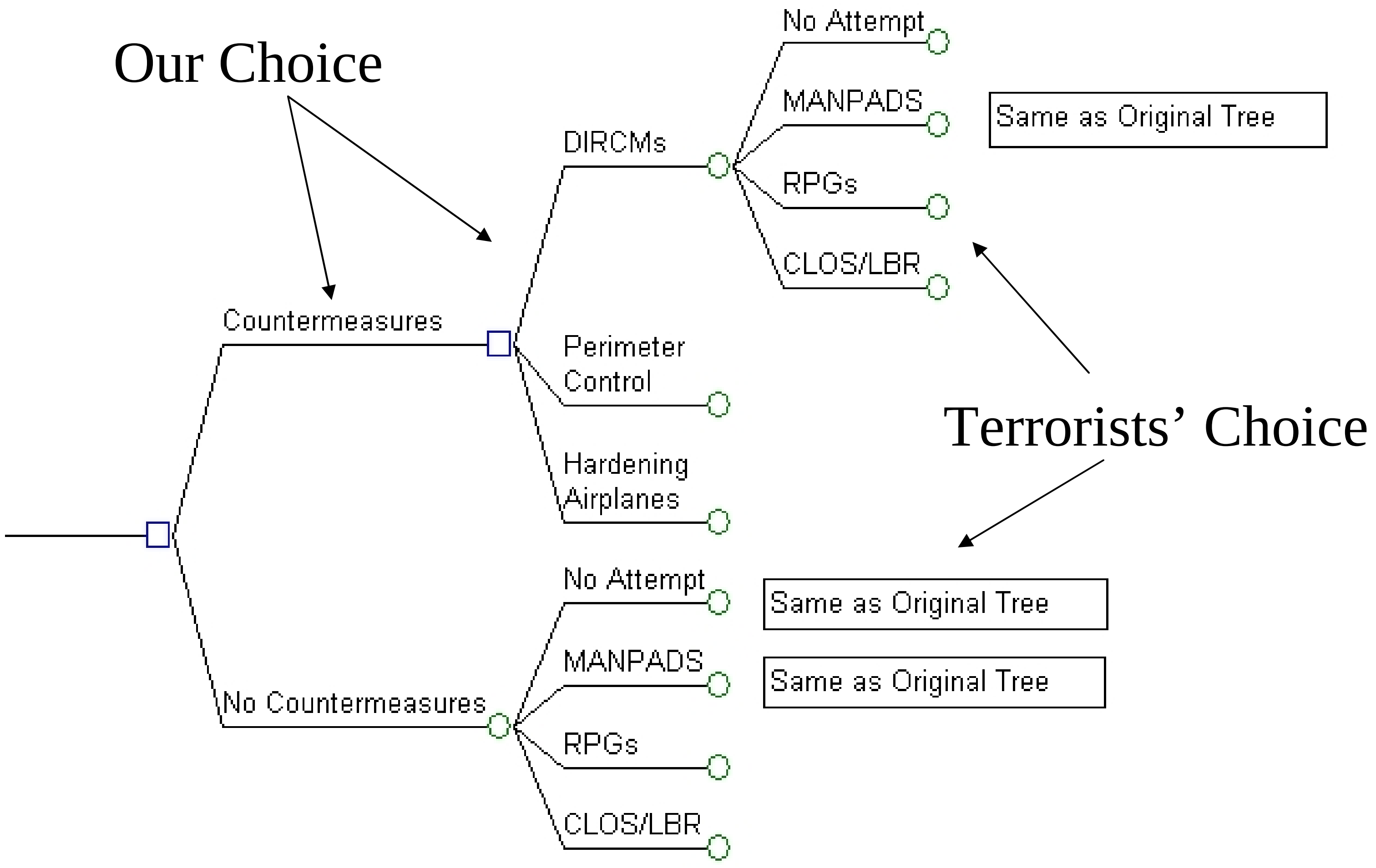
Two Way Sensitivity Analysis on Economic Losses and Probability (Cost=$10b)



Two Way Sensitivity Analysis on Economic Losses and Probability (Cost=$30b)



What About Shifting Terrorist Tactics?



MANPADS Conclusions

- MANPADS countermeasures can be cost-effective if
  - the probability of a major attack is above 40%
  - the cost of countermeasures is less than $15 billion
  - the economic costs are more than $75 billion
- Considering shifting tactics of terrorists
  - this conclusion still holds
  - but: we should also add perimeter controls (RPGs)
- MANPADS is a national issue, not an airline issue
- Consider policies to mitigate the economic impacts