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Applied Science

Homeland Security and Counter-Terrorism Research

The Daniel Rose Yale University - Technion Initiative

Modeling Suicide Bombings[*1] and Qassam Rockets[2]

Edward H. Kaplan

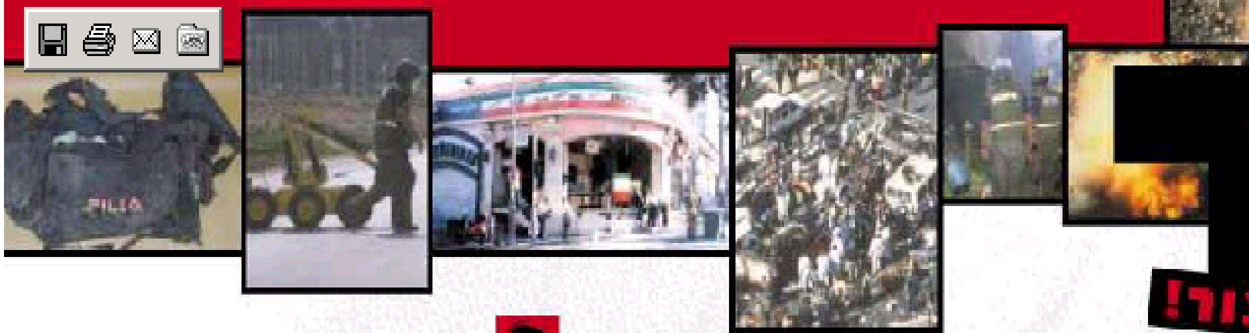
Yale School of Management

Yale School of Public Health

Yale School of Engineering

With [1]Moshe Kress, Naval Postgraduate School (SB) and [2]Lian Zucker, Yale College (Applied Mathematics) (Qassams)

[*]Supported by Defense Advanced Research Project Agency (DARPA) via award 04-S625



טרור
רק ביחד נעצור!

כיצד תנהג אם תקלע לפיגוע התאבדות או לפיגוע ירי ?

גלה ערנות בעיקר במקומות שבהם מתרכז קהל.

אם נתקלת באדם חשוד, ברכב חשוד או בחפץ חשוד - דווח מיד לשוטר או התקשר למוקד

100

חבלן משטרה בפעולה

מה הם הסימנים המחשידים למחבל מתאבד ?

צורה חיצונית

- לבוש שאינו תואם את עונת השנה (כמו מעיל בקיץ)
- צעיר או צעירה (בדרך כלל רווקים) המשתדלים להיטמע בלבושם ובהתנהגותם בקרב אוכלוסיה (בתחבורה ציבורית, במקומות בילוי, בין חיילים, בקרב אוכלוסיה דתית/חרדית) לסביבה שאינם שייכים אליה.
- בליטות יוצאות דופן מתחת ללבוש.

התנהגות מחשידה

- מתח, עצבנות, הזעה מוגברת
- הליכה איטית תוך כדי התבוננות לצדדים או ריצה מחשידה.
- ניסיונות חוזרים להתרחק מכוחות הביטחון.
- מישוש חוזר ועצבני מתחת ללבוש.
- מלמול עצבני והיסוס.

ציוד נלווה

- מזוודה, תיק יד, תרמיל גב.
- חוטי חשמל, מפסקים או ציוד אלקטרוני המתבצבצים מתוך התיק או מתוך הכיס.

כיצד תזהה רכב חשוד ?

- לוחית הזיהוי של הרכב מאולתרת או אינן תואמות (קדמית לאחורית).
- רכב החונה זמן רב במקום מרכזי בצורה מחשידה או במקום אסור.
- חלקו האחורי של הרכב שקוע בצורה בולטת.

מטען חגורת נפץ

כיצד תנהג במקרה של חשד?

- התקשר ללא דיחוי למוקד 100, והעבר למוקדן פרטים רבים ככל האפשר על החשוד או על הרכב.
- נסה לשמור עם החשוד או עם הרכב על קשר עין מטווח בטוח, במשך כל זמן השיחה עם המוקדן.
- המתן לכוחות המשטרה שיגיעו אליך.

TERROR
let's stop it together!

How to behave if you find yourself around a suicide-bombing or shooting?

Stay alert, especially in crowded places.

If you've come across a suspicious person, suspicious object or suspicious vehicle- alert a police officer or call 100.

100

A police bomb-disposal expert at work.

What are suspicious signs that can give away a suicide-terrorist?

External appearance

- Clothes unsuitable for the time of year (e.g., a coat in summer).
- A youngster (usually) who is trying to blend, by dress and behavior, with the surrounding population (on public transport, at entertainment places, amongst soldiers, or religious/Orthodox groups), even though he or she doesn't belong to that group.
- Anything protruding in an unusual way under the person's clothing.

Suspicious behavior

- Nervousness, tension, profuse perspiration.
- Walking slowly while glancing right and left, or running in a suspicious manner.
- Repeated attempts to steer clear of security forces.
- Repeated nervous feeling for something under one's clothing.
- Nervous, hesitant mumbling.

Suspect equipment

- A suitcase, shoulder/hand-bag, backpack.
- Electrical wires, switches or electronic devices sticking out of the bag or pocket.

How to identify a suspicious vehicle?

- License-plate looks "improvised" or mismatched (different front and back plates).
- A vehicle parked suspiciously for a prolonged time in a central place or in a no-parking area.
- The vehicle's rear part sags noticeably (loaded down).

Type of explosive belt

What to do in case you suspect something?

- Call 100 at once, and give the switchboard operator as many details as possible about the suspect or the vehicle.
- While speaking to the operator, try to keep an eye on the suspect or vehicle from a safe distance.
- Wait for the arrival of the police forces.

israel.jpost.com

Jan. 29, 2007 10:13 | Updated Jan. 29, 2007 15:01

Eilat suicide bomber may not have meant to target bakery

By YAAKOV KATZ AND JPOST STAFF

Investigations into Monday morning's suicide bombing in Eilat, the first to strike Israel's southernmost city, indicated that the 21-year-old bomber (Muhammed Faisal al-Saksak, a resident of the Gaza Strip and member of the Fatah-affiliated Aksa Martyrs Brigades) may not have intended to detonate his explosives pack in a bakery, but planned to execute the attack in a more crowded area.

According to reports by security sources, at least two local residents had spotted Saksak, whose heavy coat and large bag aroused their suspicions, and called the police. Channel 2 reported that one of the people who alerted local police was the taxi driver who took Saksak into town.

Saksak, who appeared to have stopped at the bakery for coffee before reaching his final destination, blew himself up after he saw the police cars approaching.

The scene of Eilat's first suicide bombing. Al Aksa Martyrs Brigades and the Islamic Jihad claimed joint reponsibility. Photo: **Channel 2**

http://players.mediazone.co.il/media/authors/34/playlists/14526/14526_static.asx

1/29/2007 Eilat Attack
(Source: *Jerusalem Post*)

- Al-Arabiya television reported on Monday that the bomber was Muhammad Faisal al-Saksak, a 21-year-old Gaza resident and member of Al Aksa Martyrs Brigades. *According to reports by security sources, at least two local residents had spotted al-Saksak, whose heavy coat and large bag aroused their suspicions, and called the police.*
- When al-Saksak - who, according to security forces, appeared to have stopped for coffee on his way to execute the bombing in a more crowded area - saw police cars approaching the bakery, he blew himself up.

- Editorial, May 9, 2003:
  - **"...despite nearly a decade of suicide bombing attacks on Israel's citizens, its weapons manufacturing industry, led by Rafael, the Armaments Development Authority, has not come forth with a technological reply to that weapon. This failure to invent an early detection device ... is even more mind-boggling if reports that such an effort has not even been ordered are true."**

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Four Killed In Sri Lanka Suicide Bombing

Wednesday, July 7, 2004

A suspected member of Sri Lanka's Liberation Tigers of Tamil Eelam blew herself up today, killing four police officers and injuring 13 people in the first suicide attack in the capital, Colombo, since a cease-fire was signed in 2002, Agence France-Presse reports.

CBSNEWS.com

Feb. 15, 2005 3:32pm ET ▸ The Early Show ▸ CBS Evening News ▸ 48 Hours

WORLD ▪ Section Front

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Deadly Blast Hits Moscow

MOSCOW, Aug. 31, 2004

FREE VIDEO

8 Dead In Moscow Blast

(AP) A woman strapped with explosives blew herself up outside a busy Moscow subway station Tuesday night, killing at least 10 people and wounding more than 50 — the second terrorist attack to hit Russia in a week.

News

Afghan election count nears end as suicide bombing emphasises dangers

An American woman and an Afghan girl who was selling books were killed in Saturday afternoon's attack on the famous "Chicken Street" shopping strip, which is popular with foreigners.

Three Icelandic peacekeepers from the NATO-led International Security Assistance Force and five Afghans were injured in the bombing.

Asian Developing

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Breaking news International

21 Dead, 27 Hurt in Iraq Suicide Bombing

Tuesday February 8, 2005 2:46 PM

AP Photo BAG103

Quake Hits Tokyo; No Injuries Reported
8:31 pm

By JASON KEYSER

Associated Press Writer

Ex-GOP Candidate Bauer to Pay FEC Fine
8:31 pm

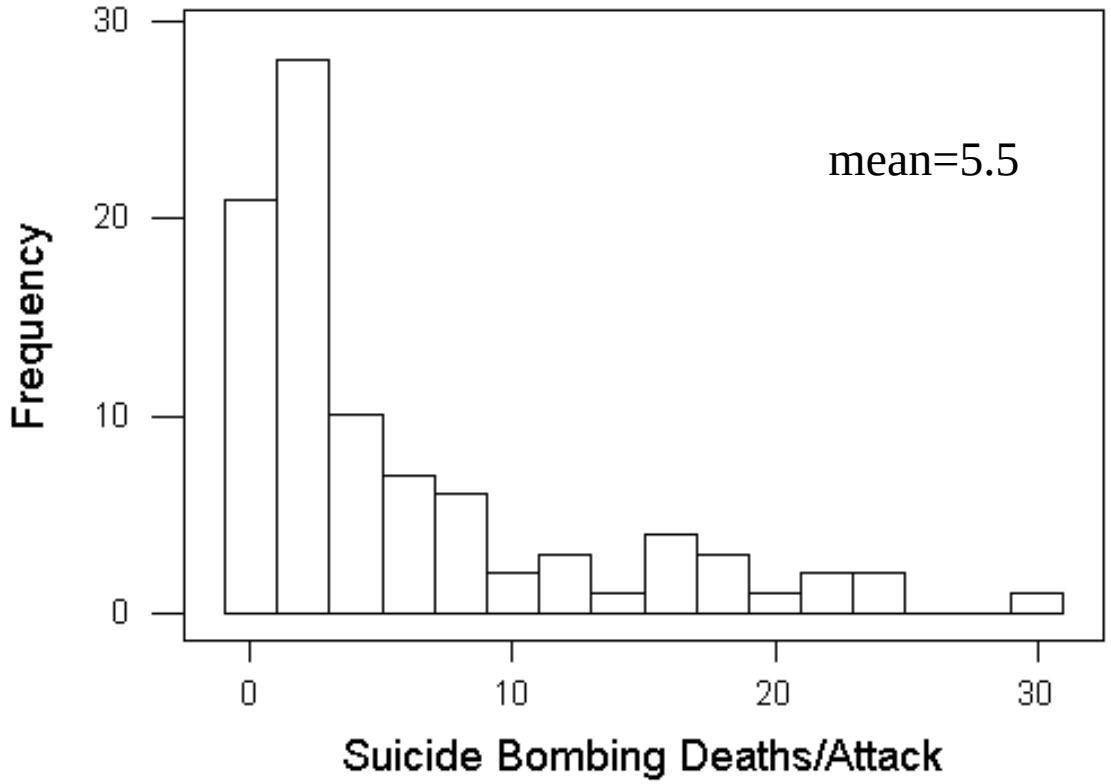
BAGHDAD, Iraq (AP) - A suicide bomber blew himself up in a crowd of Iraqis outside an army recruitment center Tuesday, killing 21 other people and injuring 27 more, the U.S. military said. It was the deadliest attack in the Iraqi capital since last week's election.

Modeling Suicide Bombing Casualties

- Focus on the expected number of individuals in a target area struck by *effective fragments* from the bomb

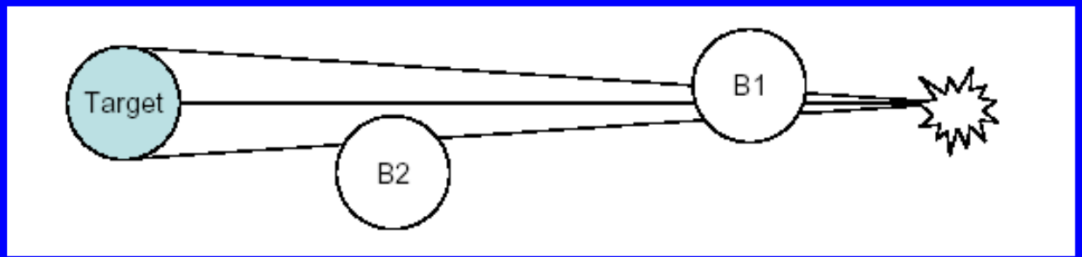
Shrapnel Injury From Suicide Bomb

Distribution of Deaths per Suicide Bomb in Israel (2001-2003)



Modeling Suicide Bombing Casualties: Assumptions

- SB at center of circular target of radius τ
- Individuals distributed over target via spatial Poisson process with density λ
- Bomb releases n expected harmful fragments
- Fragments are dispersed in beam spray at angle $\beta/2$ from the horizontal at height h_0 as spatial Poisson
- Individuals are modeled as cylinders with base width b and height $h = 2h_0$
- Also assume *complete blocking*



Modeling Suicide Bombing Casualties

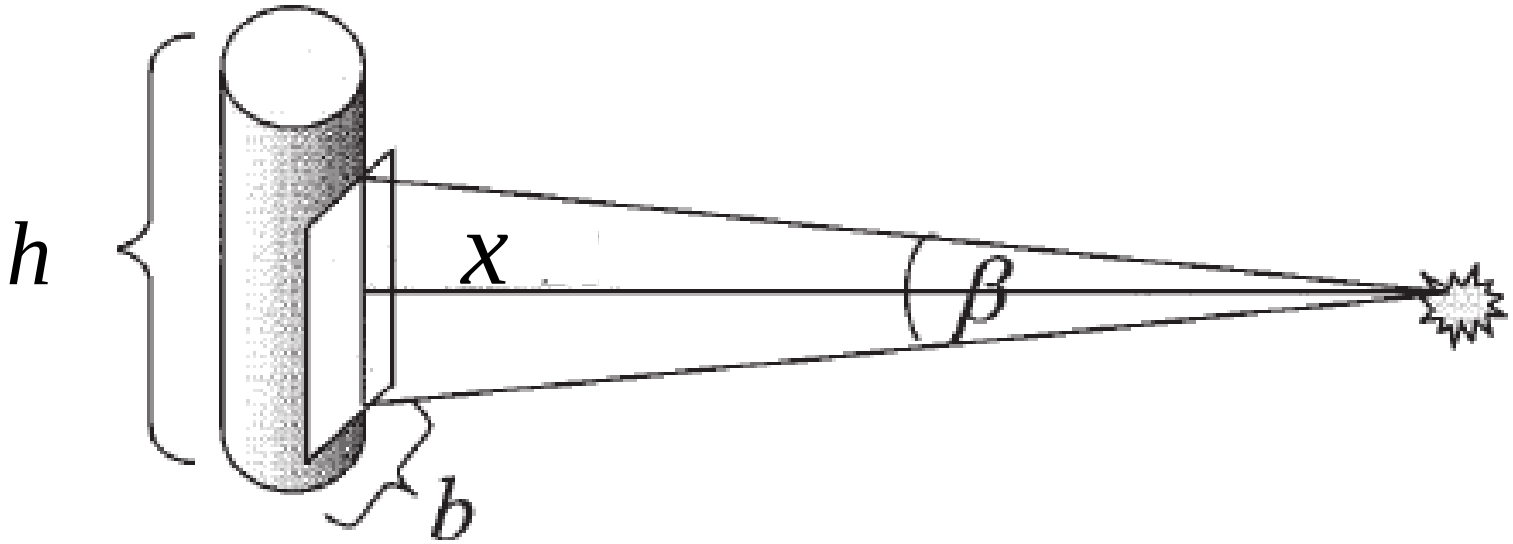
- Let $c(x)\,dx$ = expected casualties between distances x and $x+dx$ from bomber
- Total expected casualties then equal $\int_0^{\tau} c(x)dx$

- $c(x)\,dx$ = expected # persons in $(x, x+dx)$
  - x probability of exposure to fragments
  - x conditional probability of being hit

Modeling Suicide Bombing Casualties

- Expected # persons in $(x, x+dx) = \lambda\, 2\pi x\, dx$
  (from the spatial Poisson assumption)
- Probability of exposure = $\exp(-\lambda b x)$
  (probability that nobody is in corridor of length x and width b; spatial Poisson)
- Hit probability = $1 - \exp(-\sigma(x) b h(x))$
  where $h(x)$ is the exposed height at distance x and $\sigma(x)$ is the density of bomb fragments in the beam spray at distance x from the explosion (so $bh(x)$ is the area exposed to fragments at distance x, and $\sigma(x)bh(x)$ is the expected number of fragments that strike an exposed individual at distance x)

Modeling $h(x)$ and $\sigma(x)$



$h(x) = \min [h, 2x \tan(\beta/2)]$

$\sigma(x)$ = E[bomb fragments] / [dispersion area (x)]

$= n / [4\pi x^2 \sin(\beta/2)]$

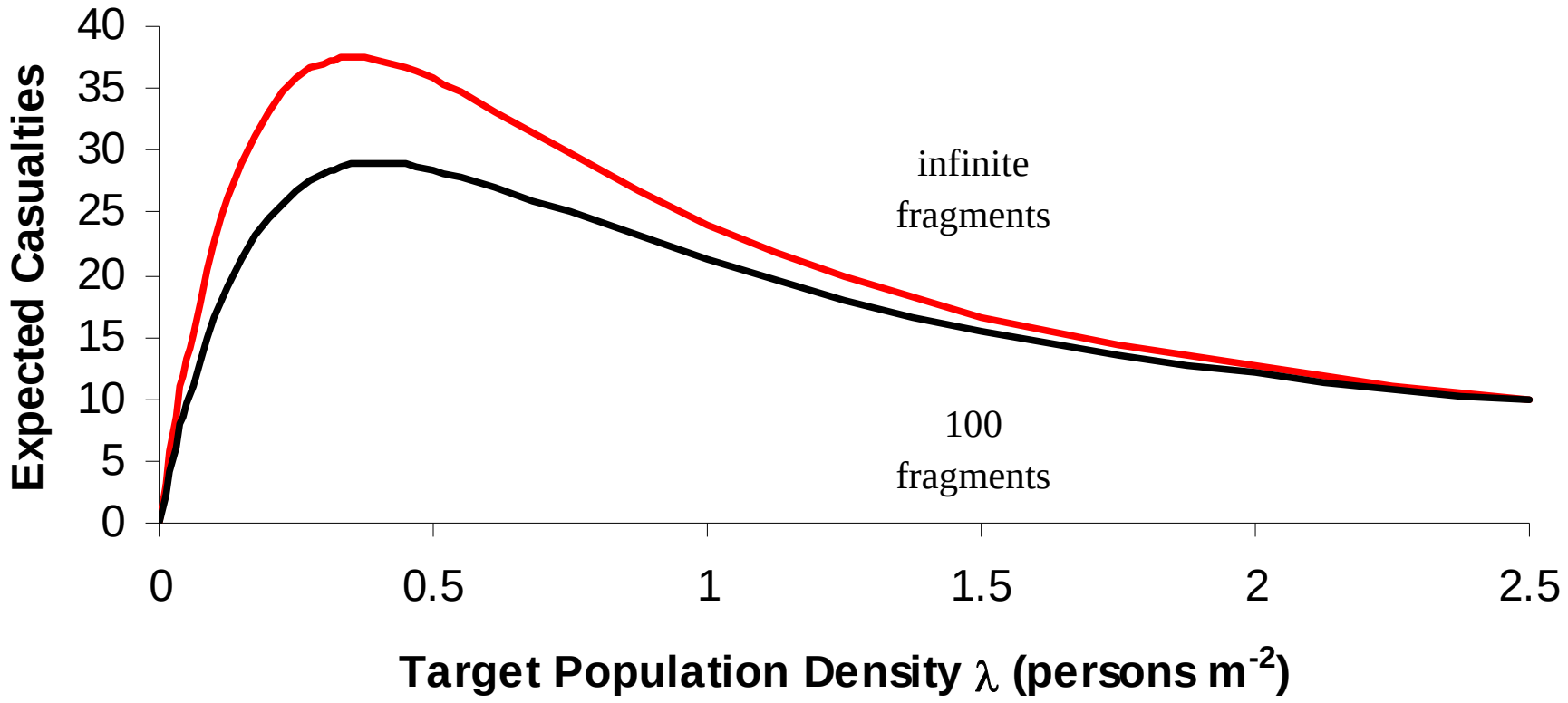
Summary: Modeling Suicide Bombing Casualties

$$\overline{c} = \int_0^{\tau} \lambda 2\pi x \times e^{-\lambda b x} \times \left(1 - e^{-\sigma(x) b h(x)}\right) dx.$$

Base Case Parameter Values

Parameter	Description	Value
τ	Target area radius	10 m
λ	Target area population density	π^{-1} persons m^{-2}
b	Individual base width	0.5 m
h	Individual height	1.75 m
h_0	Suicide bomb belt height	$h/2 = 0.875$ m
h'	Post hit-the-deck height	0.5 m
n	Expected harmful bomb fragments	100
β	Beam spray dispersion angle	10°

Numerical Example



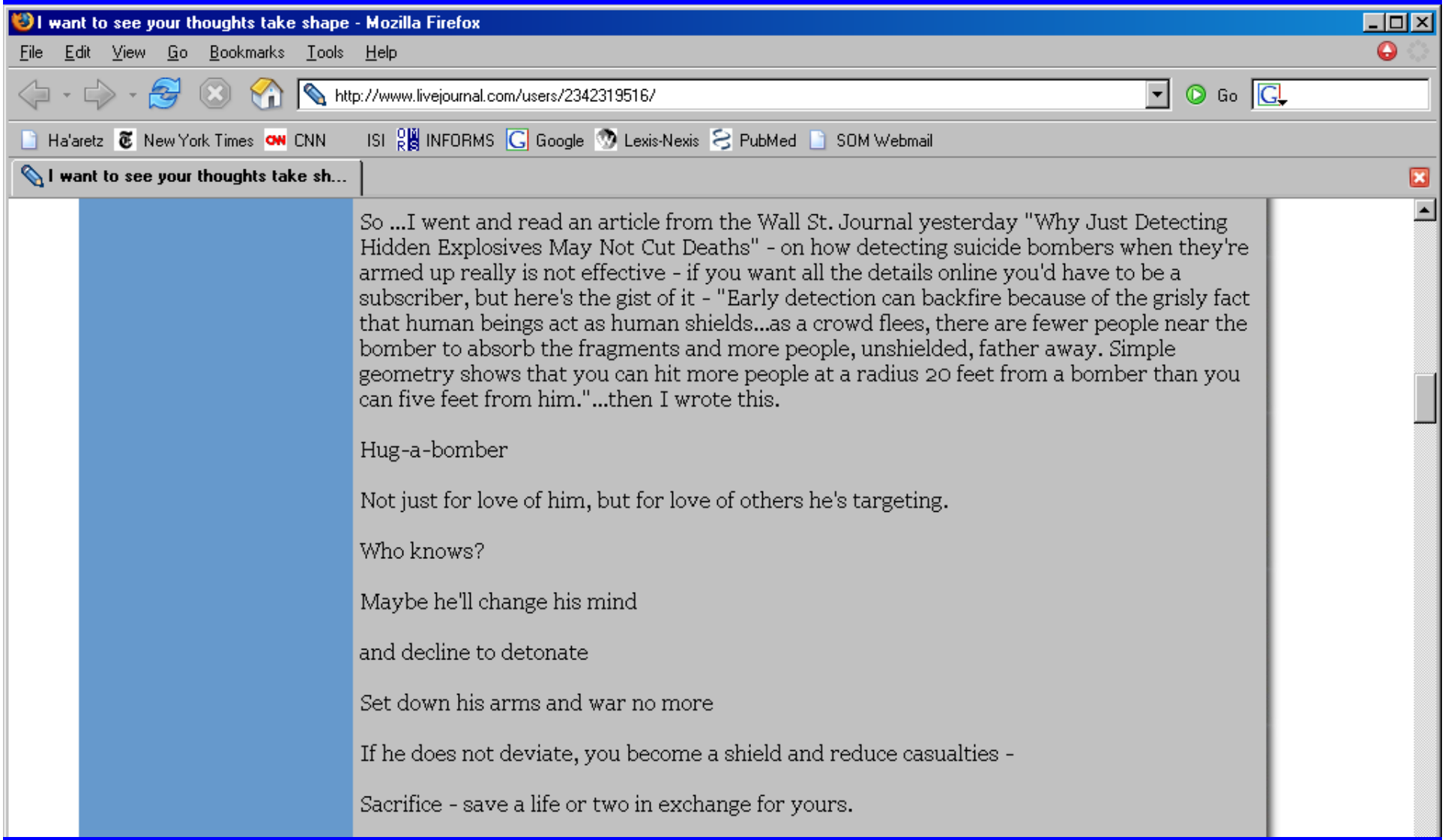
SCIENCE JOURNAL

By SHARON BEGLEY

Why Just Detecting Hidden Explosives May Not Cut Deaths

Early detection can backfire because of the grisly fact that human beings act as human shields. "There is a trade-off between crowd size and crowd blocking," says Prof. Kaplan. A large, dense crowd puts more people in harm's way, but "the probability of being exposed to a bomb fragment declines exponentially with the size of the crowd." As a crowd flees, there are fewer people near the bomber to absorb the fragments (as when a soldier falls on a grenade) and more people, unshielded, farther away. Simple geometry shows that you can hit more people at a radius 20 feet from a bomber than you can five feet from him.

"If the first ring of unshielded people is at a greater radius, there are more of them, and more will be hit," says Prof. Kaplan.


I want to see your thoughts take shape - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://www.livejournal.com/users/2342319516/
Go
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I want to see your thoughts take sh...
So ...I went and read an article from the Wall St. Journal yesterday "Why Just Detecting Hidden Explosives May Not Cut Deaths" - on how detecting suicide bombers when they're armed up really is not effective - if you want all the details online you'd have to be a subscriber, but here's the gist of it - "Early detection can backfire because of the grisly fact that human beings act as human shields...as a crowd flees, there are fewer people near the bomber to absorb the fragments and more people, unshielded, father away. Simple geometry shows that you can hit more people at a radius 20 feet from a bomber than you can five feet from him."...then I wrote this.
Hug-a-bomber
Not just for love of him, but for love of others he's targeting.
Who knows?
Maybe he'll change his mind
and decline to detonate
Set down his arms and war no more
If he does not deviate, you become a shield and reduce casualties -
Sacrifice - save a life or two in exchange for yours.


iskonportal
tražilica:
Internet
start
Google
naslovnica
vijesti
sport
film/tv
glazba
crna kronika
novac
kultura
znanost
tehnoklik
fotografija
auti
lijepi i zdravi
bebe
web kuhinja
iz drugih medija
webcafe
infocentar
ticket shop
iskon &
UJ FUJ!!!
Posao u Iskonu
Voditelj/ica izgradnje pristupne
Kupite ulaznice online
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Detektori ne otkrivaju bombaše samoubojice
Uvođenje opreme koja se sastoji od osjetljivih senzora koji bi trebali detektirati bombaše samoubojice neće spasiti mnogo života, pokazuju rezultati nove studije.
"Pješaci samoubojice mogu biti spriječeni na bolji način i to investiranjem u razumijevanje razloga koji dovode do akcija koje pak odvraćaju teroriste od poduzimanja takvih napada", objavili su sveučilišni profesori Edward H. Kaplan i Moshe Kress u najnovijem broju časopisa Proceedings of the National
anketa
Koristite li neki od file-sharing programa?
da
ne
rezultati
glasaj
.old
BBC-jevi programi će se moći downloadati
Uhvaćeni pisci virusa Zotob
Paul Allen u Dubrovniku
Crv poliglot napada MSN korisnike
Telekomi pred novim izazovima
Ništa od
JEDINSTVENA PRILIKA!
60 dana surfanja
FLAT RATE samo za 1kn
+ poklon
XXL adsl naruči ovdje
glasaj i osvoji nagrade
želim BESPLATNI on-line tečaj
Cisco Systems NETWORKING ACADEMY
wireless
Antene nebu pod oblake
Izbacivanje kablova na osobnoj razini
Rječnik bežičnih pojmova
SVE NA JEDNOM MJESTU
webcafe
WEB TJEDNA
Paragliding
IGRICA TJEDNA

Rough Calibration

- Base case: 28.5 individuals struck by bomb fragments
- In Israel: average of 5.5 deaths and 40 injuries per bomb
- Our base case is equivalent to deaths plus 60% of injuries in average Israeli attack
  - reasonable as injuries also result from broken glass or other debris not included in the beam spray

Interventions Given Timely Detection

- Three plausible interventions are:
  - neutralize the bomber (success with prob θ)
  - run away (can be thought of as lowering λ)
  - hit the deck! (can be thought of as lowering h)
- Lowering λ could make things worse due to loss of crowd blocking
- Lowering h could make things worse as well due to loss of crowd blocking (those falling under the beam spray no longer protect those further out in the target area), though number of harmful fragments becomes more crucial

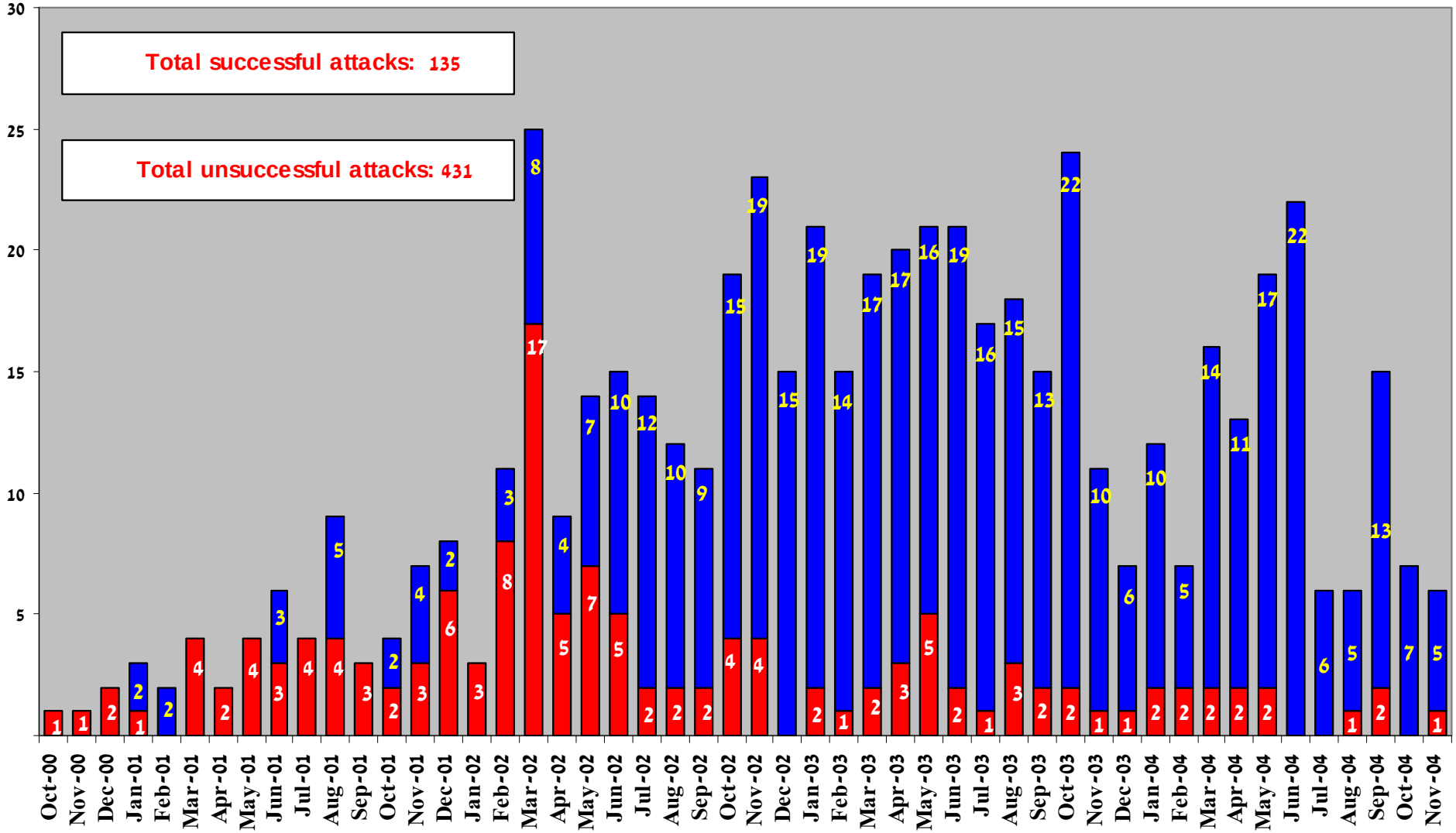
Implications

- Even if a suicide bomber is detected in time to intervene, the intervention might not succeed, and in some circumstances could make matters worse
  - e.g. lowering λ would make things better in our base case ($\lambda = 1/\pi$), but worse if $\lambda > .4$
- If "hit-the-deck" is followed, people really need to "get down!" (to about 0.2 meters) to minimize casualties

A Different Approach

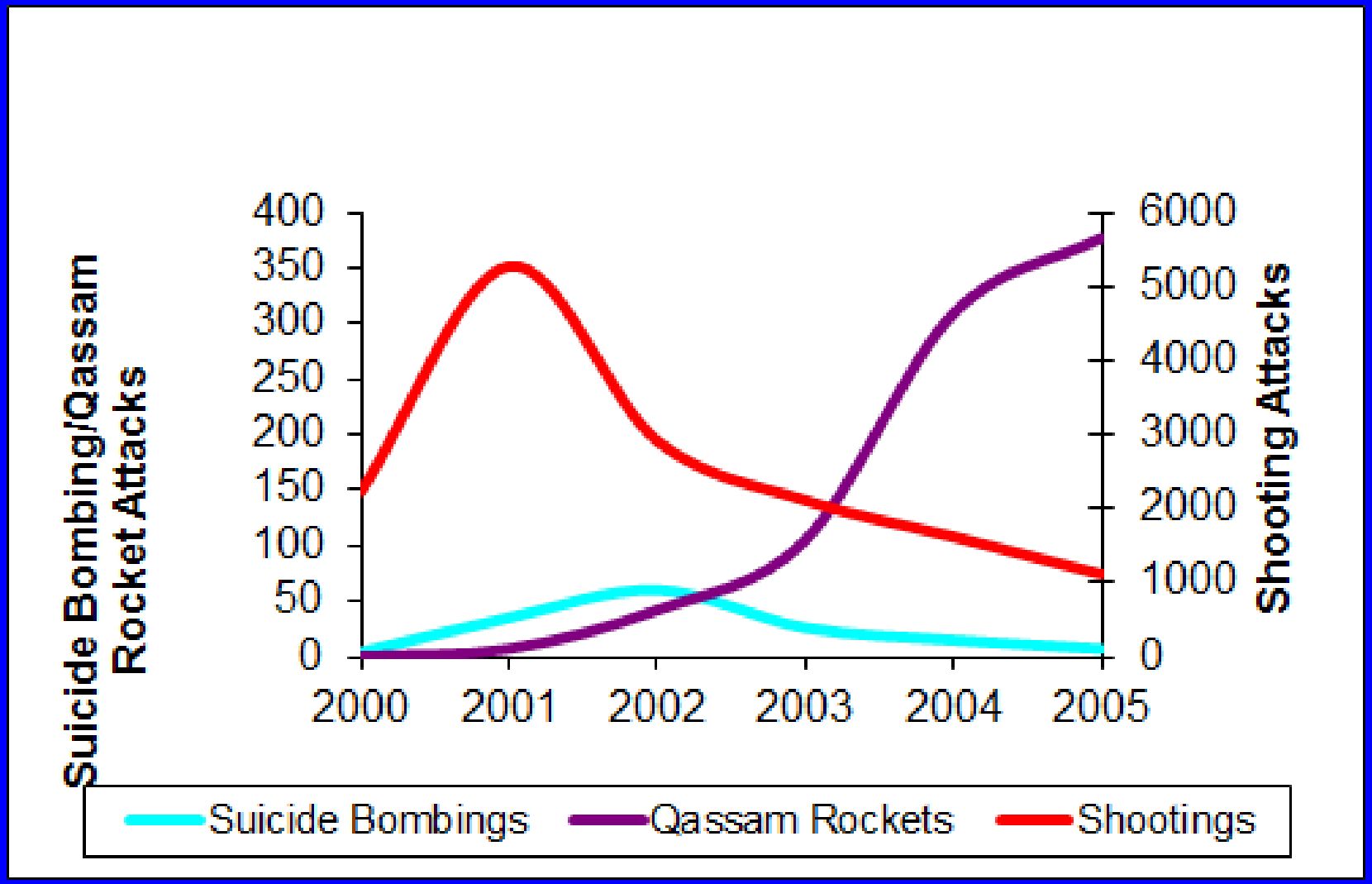
- Instead of focus on last-minute detection, think about investing in intelligence to prevent attacks in the first place??

Successful vs. Unsuccessful (thwarted) Terrorist Attacks

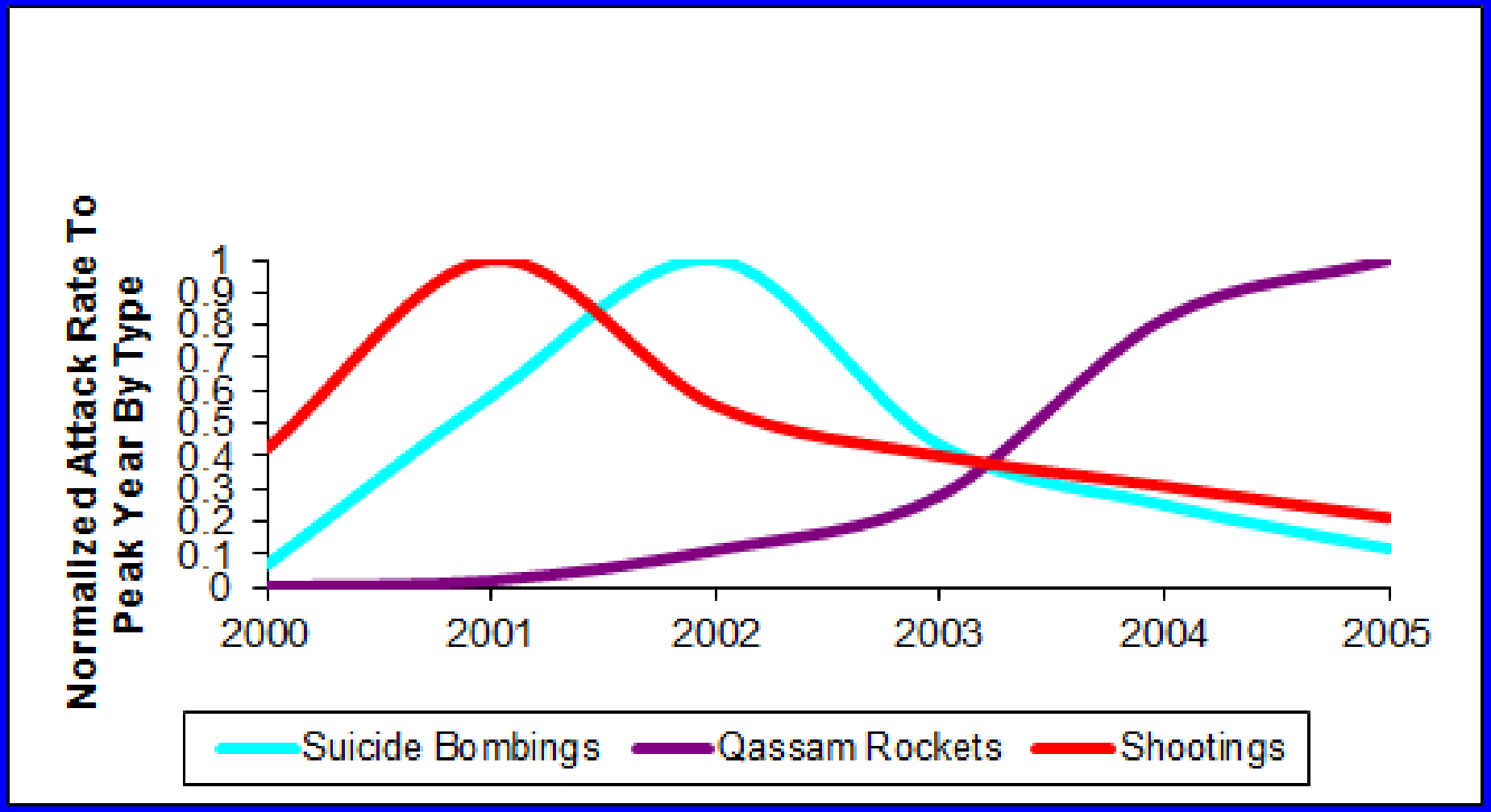


Unsuccessful attacks: IDF and ISA thwarting operations , "work accidents", etc

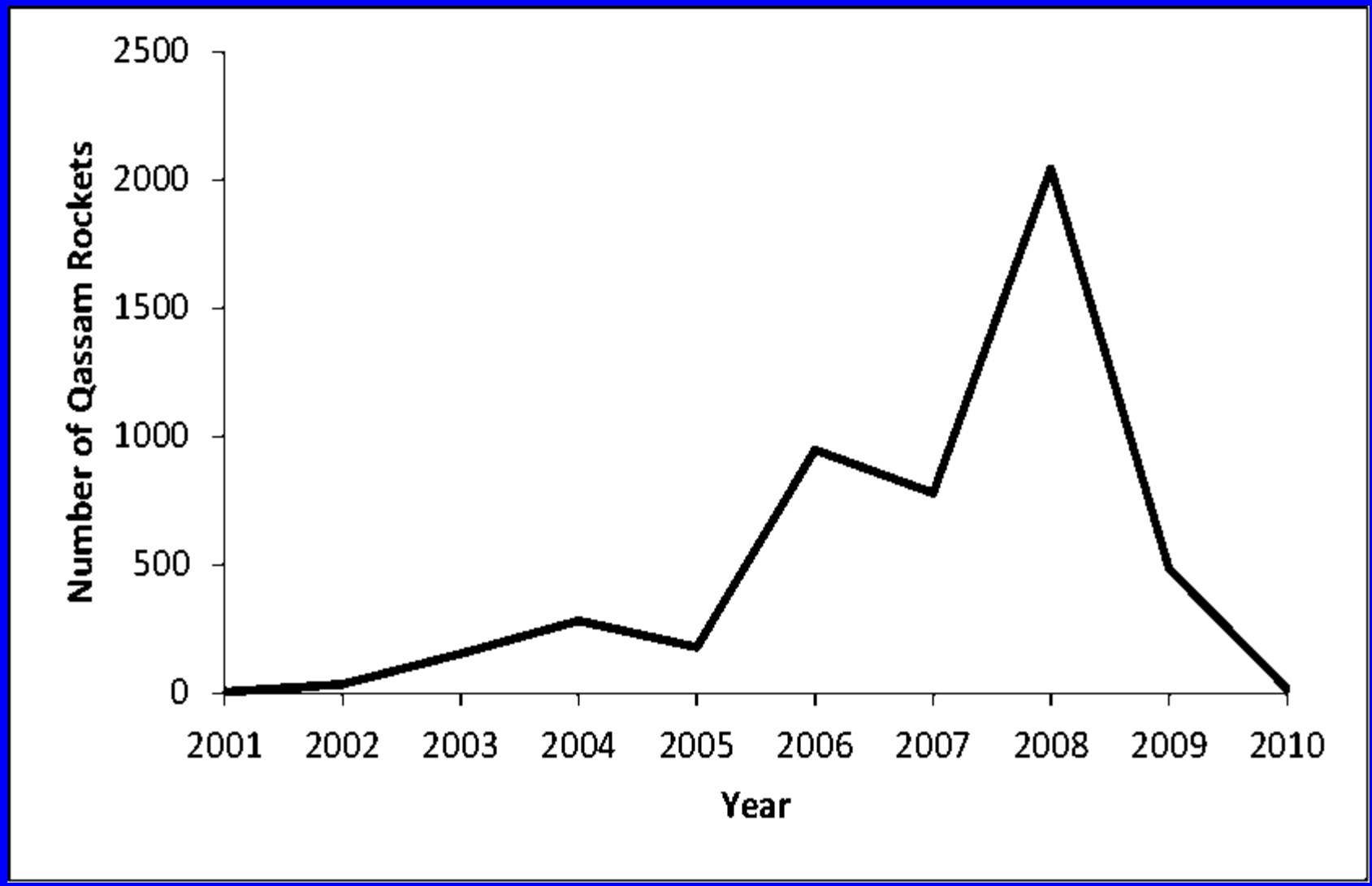
Changing Modes of Terror Attacks



Changing Modes of Terror Attacks



Qassam Rocket Attacks: 2001-10



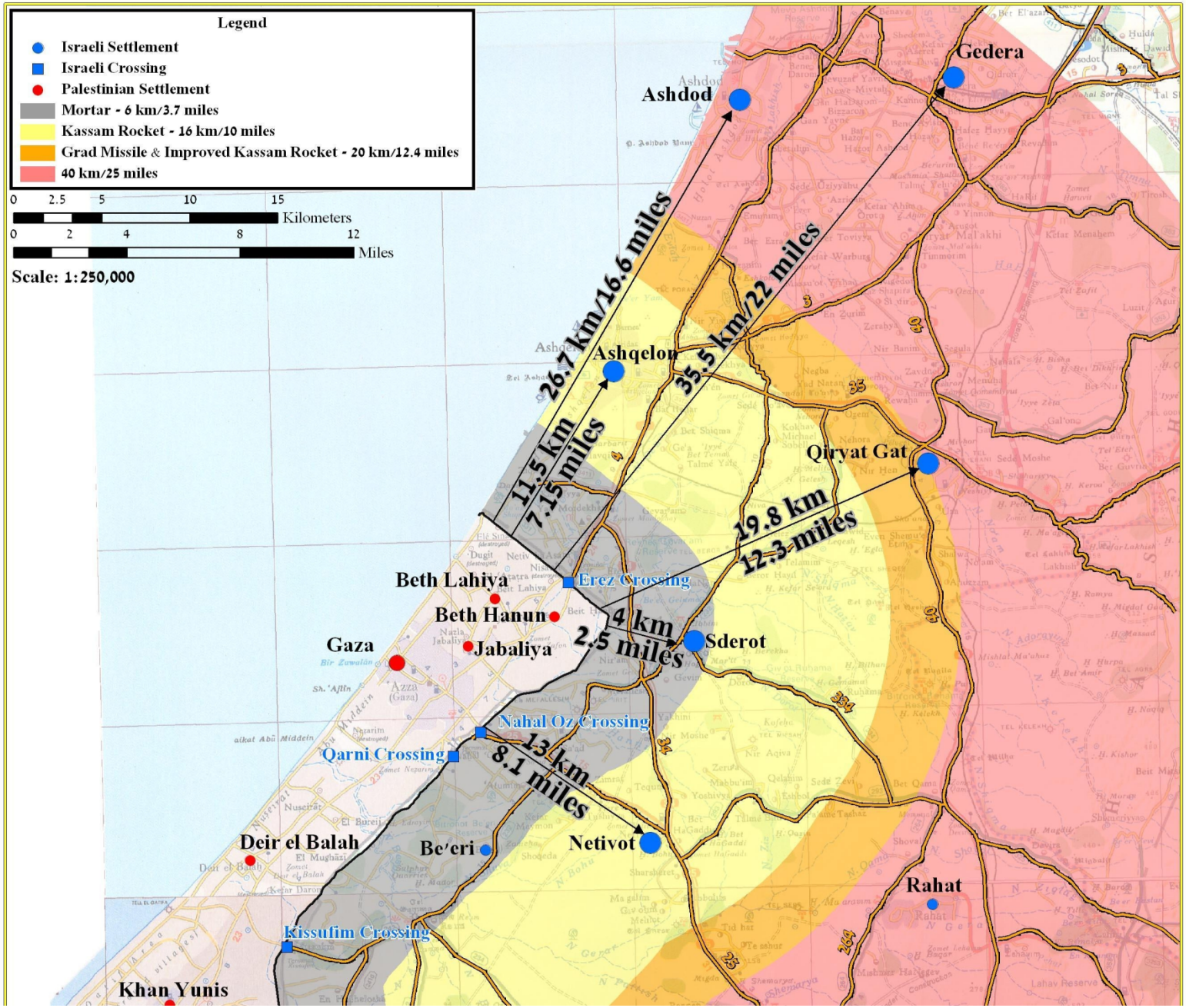
HAMAS Artillery Rockets

Global Security.org

NAME	Qassam-1	Qassam-2	Qassam-3	Grad	WS-1E	Fadjr-5
DIAMETER	60 mm	150 mm	170 mm	122 mm	122 mm	333mm
RANGE	4 km	10 km	12 km	20 km	45 km	75 km
WARHEAD	0.5 kg	5 kg	15 kg	18 kg	22 kg	90 kg
YEAR	2001	2002	2005	2008	2008	2012
SOURCE	Gaza	Gaza	Gaza	Iran	China [via Iran?]	

- Unclassified -

Gaza Strip - Rocket Ranges



Qassam Rockets

Qassam Damage

Qassam Attacks

- Southern Israel has been bombarded with Qassam rockets fired from the Gaza Strip
- 5,000 rockets hit town of Sderot between 2001-2010; 90% of residents experienced rocket landing on their street or adjacent
- Yet only 10 deaths and <500 injuries
- Many observers thus conclude that Qassams are only “symbolic threat”

Qassam Attacks

- While Qassams cause “psychological trauma...the rockets are essentially very ineffective and rarely do damage” (*MSNBC*)
- *BBC News*: since 2,000 rockets did not cause even a single death, the Israeli government must be inflating the dangers the rockets pose
- Qassams, “...with such a low fatality rate and with the characteristic imprecision of the weapons...cannot be expected to inflict a fatality most of the time.” (*Mondoweiss*)

Why So Few Qassam Casualties?

- In Southern Israel:
  - Most homes and public facilities have rocket proof fortified rooms and/or access to nearby bomb shelter
  - Alarm system since 2004, gives 10-45 seconds to seek cover
  - Iron Dome antimissile defense system since, 2011, credited with intercepting Qassams though efficacy questioned

Mass Casualty Potential

- September 11, 2007 Qassam strike on the Zikim training base
  - 1:18 AM, single Qassam rocket exploded next to tents containing sleeping Israeli soldiers
  - No deaths; 70^{+} injured, including 11 urgent casualties of whom "...at least five needed immediate life-saving procedures" (*Emergency Medicine Journal* 26 (2009): pp. 293-298)

What If No Civil Defense???

- Observed casualties in Southern Israel poor guide for what to expect if Qassam-like rockets used in Afghanistan, Iraq, Pakistan, other places with poor civil defense infrastructure
- Build counterfactual model of casualties per rocket in undefended location using Sderot as case study

Model

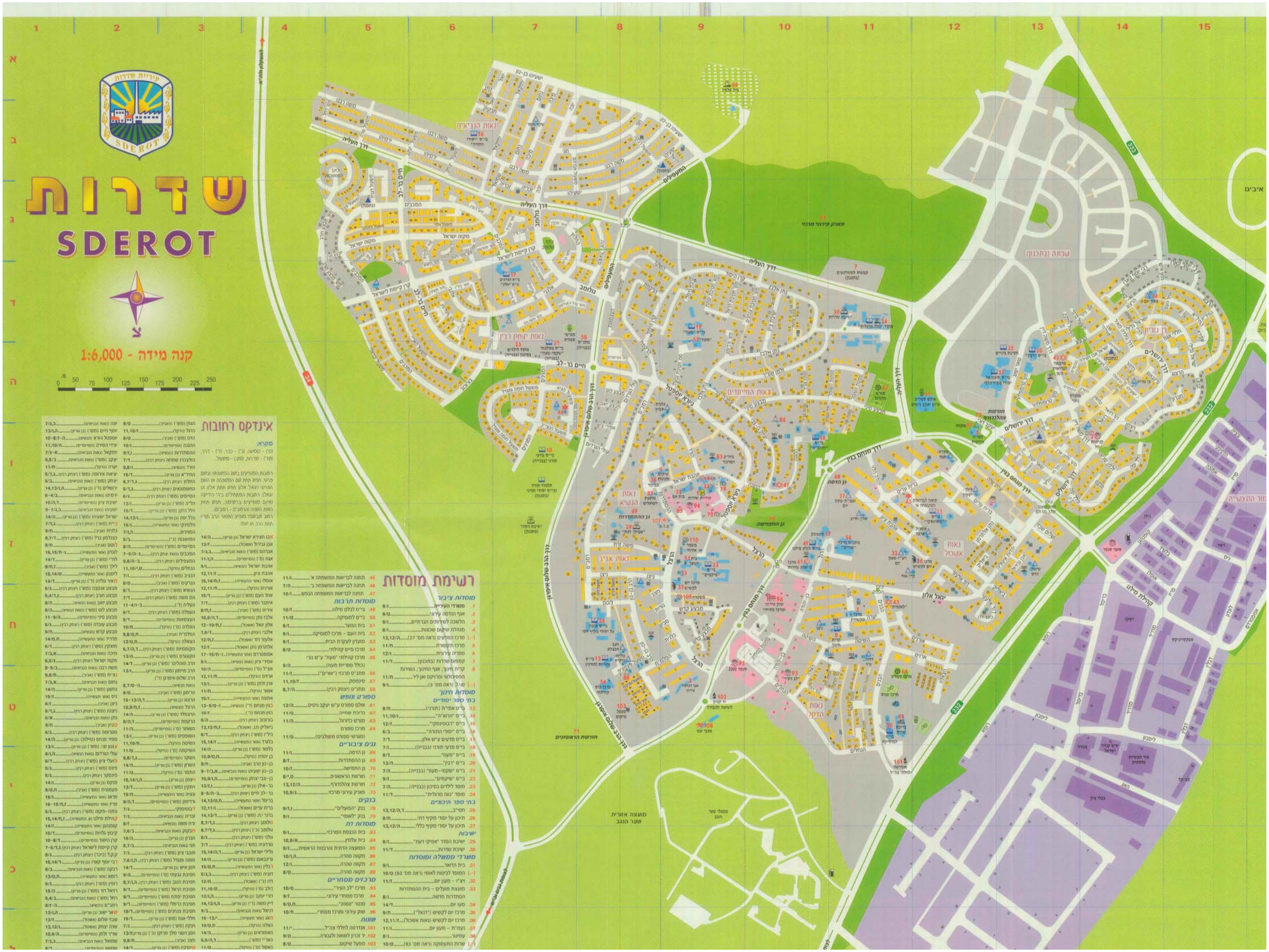
- Majority of Qassam damage from lethal shrapnel (not enough explosives for shock wave casualties)
- Same idea as suicide bombing model

$$c = \int_0^{\tau} \lambda 2\pi r e^{-\lambda b r}\, dr = \frac{2\pi}{\lambda b^2}\left(1 - (1 + \lambda b \tau) e^{-\lambda b \tau}\right)$$

Qassam Guidance Systems

- There aren't any; rockets land spatially at random
- Let a_i (p_i) denote areal fraction occupied by land use *i* (population found in land use *i*)
- Population density $\lambda_i = p_i / (1.9\ a_i) \times 10^{-6}$ persons/square meter

$$Casualties = \sum_i a_i c_i$$



עיריית שדרות
SDEROT
שדרות
SDEROT
קנה מידה - 1:6,000
אינדקס רחובות
רשימת מוסדות
דרך העליה
דרך ירושלים
דרך מנחם בגין
שכונה (בתכנון)

Land Use Category	Map Color/Symbol	Area (km^2)	% of Total Land Area
Residential	Yellow	0.4185	21.9%
Factories in Industrial Zone	Dark purple	0.1069	5.6%
Park	Dark green	0.1069	5.6%
Public Facilities	Blue	0.0698	3.6%
Schools	Blue, book symbol	0.0383	2.0%
Commercial Centers	Red	0.0248	1.3%
Streets / Sidewalk	Gray	0.7268	38.0%
Empty Land	Light green	0.4212	22.0%
TOTAL		1.913	100%

Where Is Everybody?

- Hard to know where everybody is
- Idea: find worst (best) case bounds by allocating population to maximize (minimize) number of casualties

$$\max \sum_i a_i c_i$$

subject to

$$\sum_i p_i = 20,700$$

Results

- Worst case: 0.83 casualties per rocket
- Best case: 0.24 casualties per rocket
- Data from Sderot: 0.09 casualties/rocket
- Implication: Absent civil defence, casualties would be three to nine times higher than observed
- E.g. given 10 observed deaths, absent civil defense would have expected 27 to 92 fatalities in Sderot

Caveats

- Analysis likely underestimates number of casualties per rocket for any scenario:
  - injuries from blast effects completely ignored
  - injuries from falling debris within a structure due to explosion also ignored
  - complete crowd blocking assumed (even partially obscured line-of-sight to explosion leaves person unharmed)
  - rockets fall spatially at random
  - shrapnel injury radius of 5 meters

Conclusion

- That so few casualties have resulted from so much Qassam rocket fire has led to public discussion that downplays Qassams as relatively harmless
- Qassams are *not* harmless; rather, analysis implies that layered civil defense measures have prevented injuries and saved lives
- Analysis highlights risks faced by unprotected populations from terrorist attacks with Qassam or equivalent rockets