21 JANUARY 2026

Beirut Port Explosion: Comparison of Field Damage to Explosive Safety Standards

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ACKNOWLEDGEMENTS

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AGENDA

1. Beirut Port Explosion
2. TNT Equivalency
3. Explosives Safety Siting
4. Summary and Conclusions

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BEIRUT PORT EXPLOSION

- Port of Beirut opened in 1887
- Over time, port officials seized and stored hazardous materials in Hangar 12
  - Ammonium Nitrate (2000+ tons)
  - Fuel
  - Acid
  - Fuse Spools
  - Fireworks (~15 tons)

BEIRUT PORT EXPLOSION

- 4 August 2020
- Sequence of events:
  - Fire started in Hangar 12
  - Fireworks ignited
  - Ammonium Nitrate detonated
- Societal Impact
  - ~200 deaths
  - 6000+ injuries
  - 300,000+ homeless
  - USD$10-15 billion damage

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TNT EQUIVALENCY

- Based on eyewitness video and estimated shock wave velocity, researchers initially estimated that 200-1000 tons of ammonium nitrate contributed to the event (approximately 150-700 tons of TNT, median = 500 tons of TNT)
- But…we are going to see if that is indeed the case…

Event	Year	Approx. TNT Equiv. (tons)	Magnitude with respect to Beirut
Oklahoma City Bombing, Oklahoma	1995	2.5	0.5%
Chernobyl Reactor Meltdown	1986	10	2.0%
West, Texas Fertilizer Plant	2013	12.5	2.5%
Tianjin, China Warehouse	2015	21	4.2%
Toulouse, France Storage	2001	40	8.0%
Port of Beirut, Lebanon Hangar 12	2020	500	--
Oppau, Germany Fertilizer Plant	1921	1000	200%
Texas City, Texas SS Grandcamp	1947	2100	420%
Halifax, Canada Freighter Collision	1917	2900	580%

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EXPLOSIVE SAFETY STANDARDS

- United States Department of Defense Explosive Safety Board (DDESB)
  - Air Force: AFMAN 91-201
  - Navy: NAVSEA OP 5, Volume 1
- United Kingdom Ministry of Defence
  - DSA 03.OME Part 2 / formerly JSP 482
- North Atlantic Treaty Organization (NATO)
  - NATO AASTP-1

QUANTITY DISTANCE ARCS

EXPLOSIVE SITE

QUANTITY DISTANCE ARCS

INTERMAGAZINE DISTANCE (IMD)

Intermagazine Distance (IMD)

Distance to an Ammunition & Explosive Storage Facility.

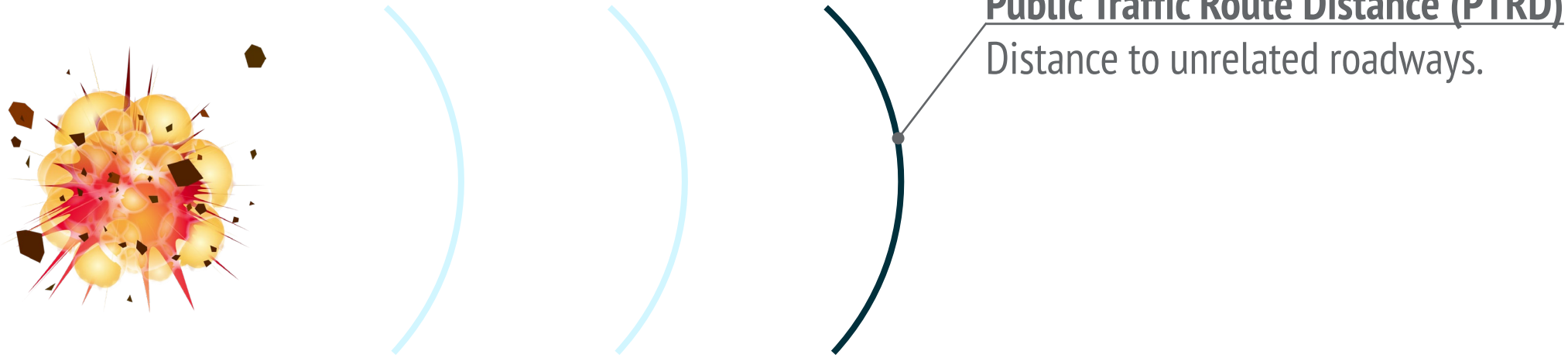
QUANTITY DISTANCE ARCS

INTRALINE DISTANCE (ILD)

Intraline Distance (ILD)
Distance between Ammunition & Explosive-related Facilities.

QUANTITY DISTANCE ARCS

PUBLIC TRAFFIC ROUTE DISTANCE (PTRD)

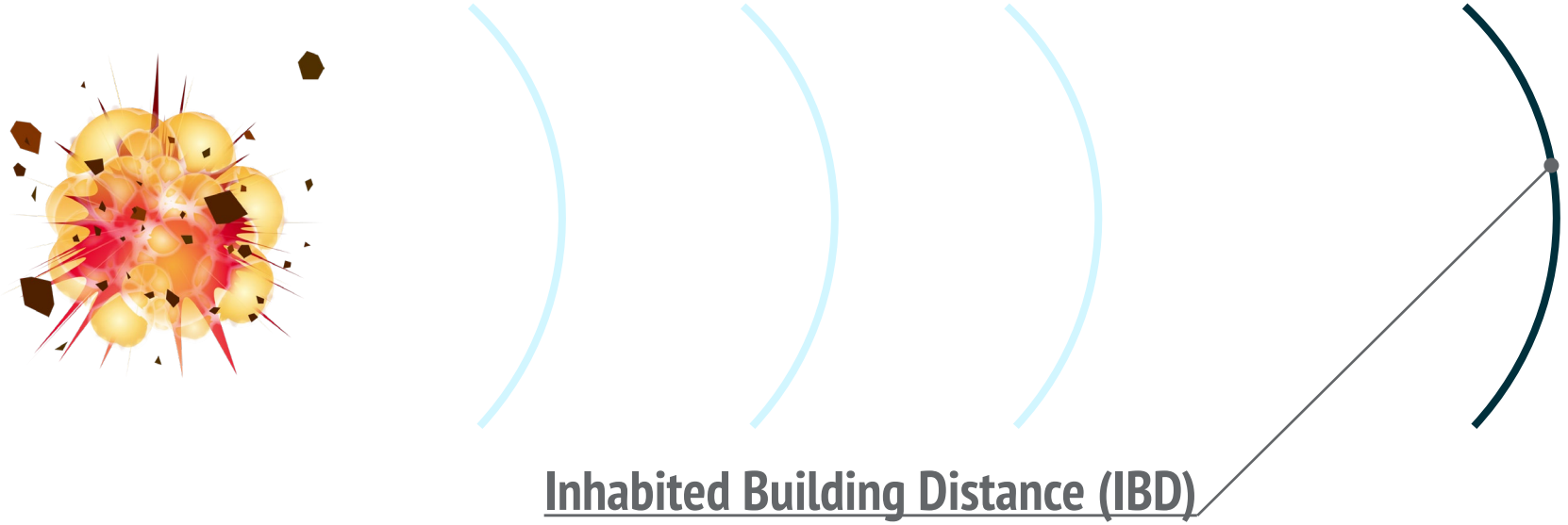


Public Traffic Route Distance (PTRD)

Distance to unrelated roadways.

QUANTITY DISTANCE ARCS

INHABITED BUILDING DISTANCE (IBD)

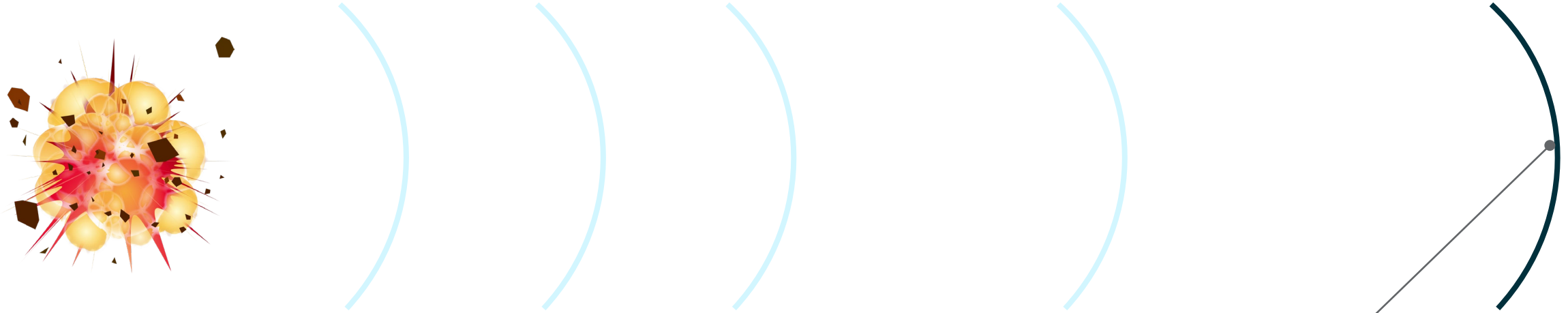


Inhabited Building Distance (IBD)

Distance to unrelated inhabited buildings, on-base or off-base.

QUANTITY DISTANCE ARCS

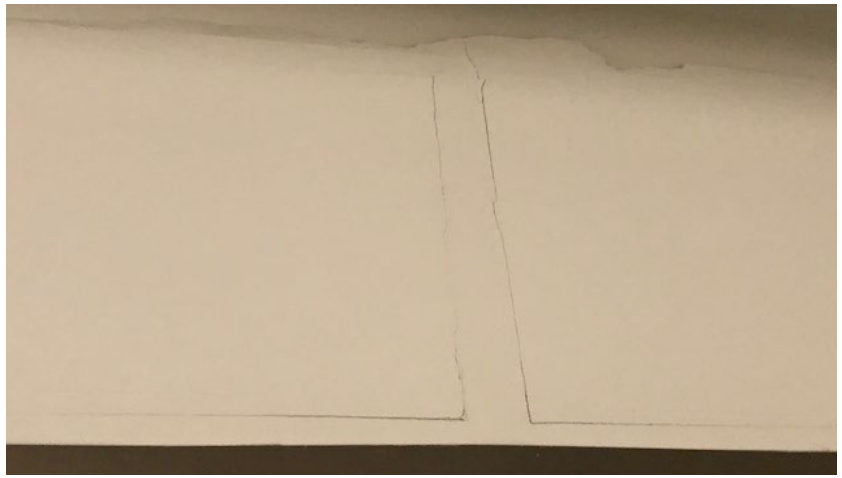
VULNERABLE BUILDING DISTANCE (VBD)

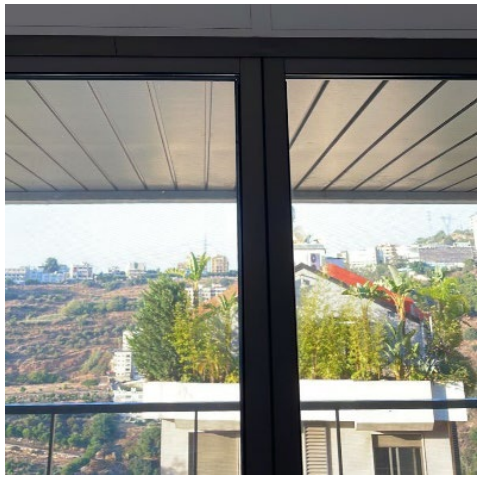


Vulnerable Building Distance (VBD)
Distance to unrelated, vulnerable facilities based on their construction type. (not recognized by DDESB)

EXPECTED DAMAGE

QD	Blast Pressure (kPa)	Structural Damage	Façade Damage	Injuries	Fatalities
VBD	< 6.9	Superficial	Very Minor	Very Few	None
IBD					
PTRD					
ILD					
IMD					





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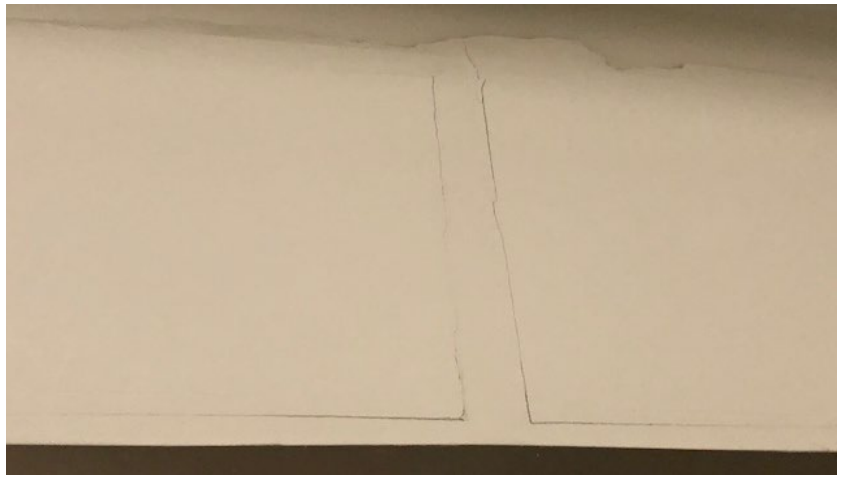
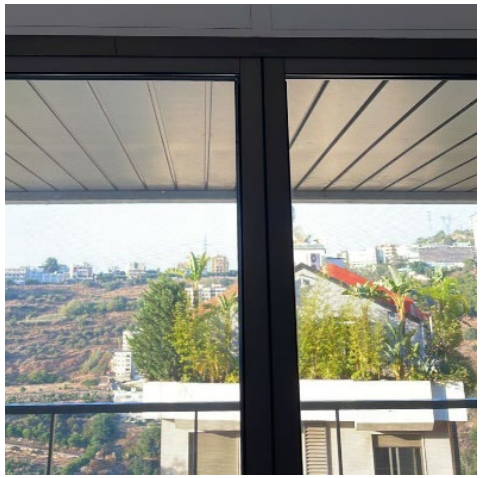
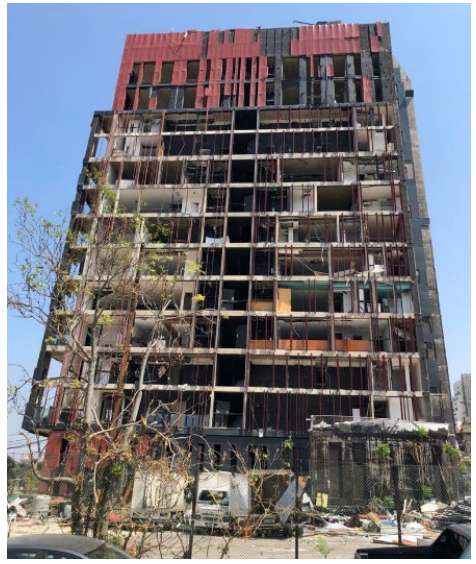




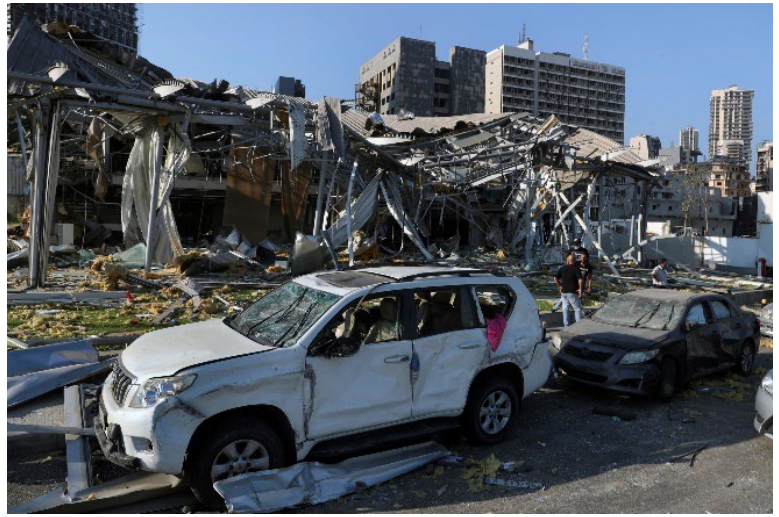
EXPECTED DAMAGE

QD	Blast Pressure (kPa)	Structural Damage	Façade Damage	Injuries	Fatalities
VBD	< 6.9	Superficial	Very Minor	Very Few	None
IBD	8.3	Very Minor	Minor	Very Few	Very Few
PTRD					
ILD					
IMD					



EXPECTED DAMAGE

QD	Blast Pressure (kPa)	Structural Damage	Façade Damage	Injuries	Fatalities
VBD	< 6.9	Superficial	Very Minor	Very Few	None
IBD	8.3	Very Minor	Minor	Very Few	Very Few
PTRD	11.7	Minor	Moderate	Few	Very Few
ILD					
IMD					



EXPECTED DAMAGE

QD	Blast Pressure (kPa)	Structural Damage	Façade Damage	Injuries	Fatalities
VBD	< 6.9	Superficial	Very Minor	Very Few	None
IBD	8.3	Very Minor	Minor	Very Few	Very Few
PTRD	11.7	Minor	Moderate	Few	Very Few
ILD	24.0	Major	Major	Moderate	Few
IMD					

PRE-EXPLOSION
JULY 2020

Façade Damage	Injuries	Fatalities
Very Minor	Very Few	None
Minor	Very Few	Very Few

IMD	55.3	Destruction

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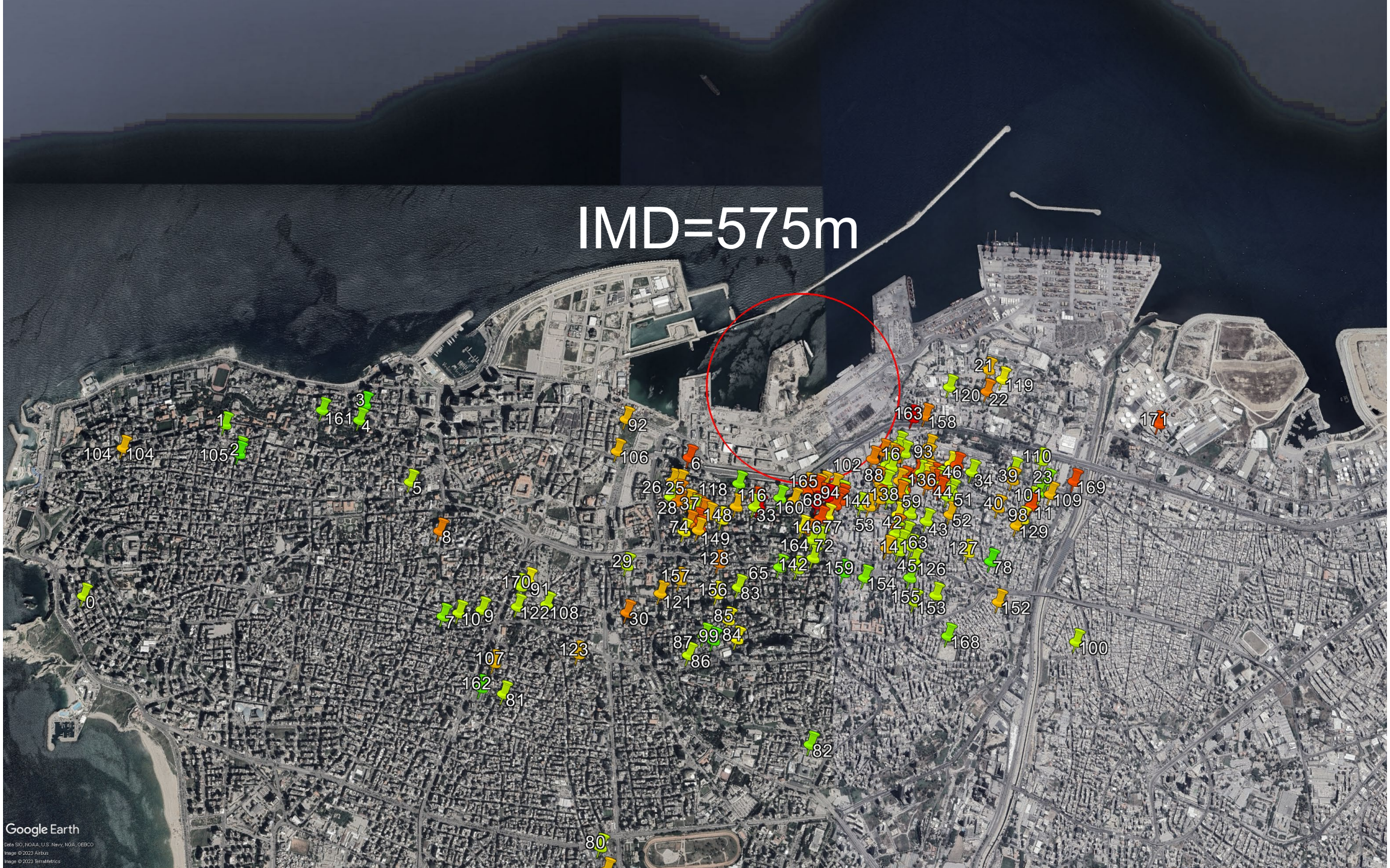
POST-EXPLOSION
AUGUST 2020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Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2023 Airbus
Image © 2023 TerraMetrics


ILD=800m
IMD
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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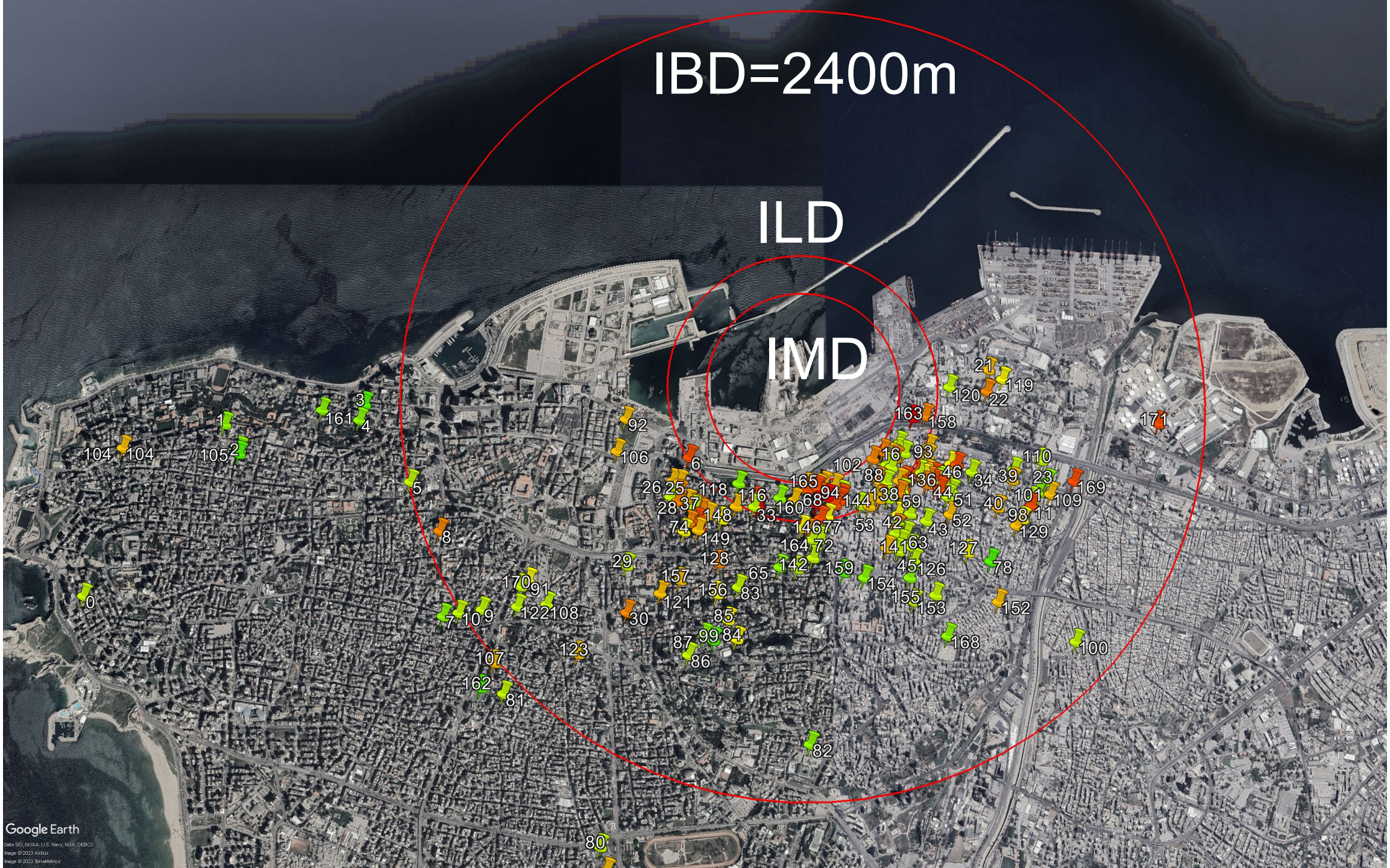
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ILD
IMD
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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NET EXPLOSIVE WEIGHT – FIELD SURVEY

QD	Survey Distance (m)	TNT (tons)	ANFO (tons)
IBD	2400	1772	2097
ILD	800	1406	1664
IMD	575	2288	2708
	AVERAGE	1822	2156

- Reports suggest that approximately 2750 tons of ammonium nitrate was stored in Hangar 12
- Field survey estimated that approximately 2150 tons of ammonium nitrate contributed to the explosion
- 78% of stored explosives contributed to the explosion

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EXPLOSIVE SAFETY STANDARDS

- The field assessment showed wide variability in damage, even for buildings nearly adjacent to each other. The construction type and age of the building is a factor that is not considered explicitly in the standards.

- The Intermagazine Distance accurately captured the significant destruction within the Port of Beirut. Once the blast wave moved past Charles Helou Highway, the damage was more sporadic, with several buildings suffering substantial façade failure but minor structural damage.

- Buildings over 6 kilometres from Hangar 12 experienced minor, non-structural damage which would not have been considered in the explosive safety standards.

FIELD OBSERVATIONS

- Field observations and structural assessment are important to help provide engineering solutions for the historical, heritage, and ancient religious buildings in Beirut.

- The structural design (i.e. seismic resistance) and construction quality varies throughout the infrastructure in Beirut, which has a major influence on the building's response during an explosion.

THANK YOU

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