University of Sarajevu
Mechanical Engineering Faculty
Defense Technologies Department
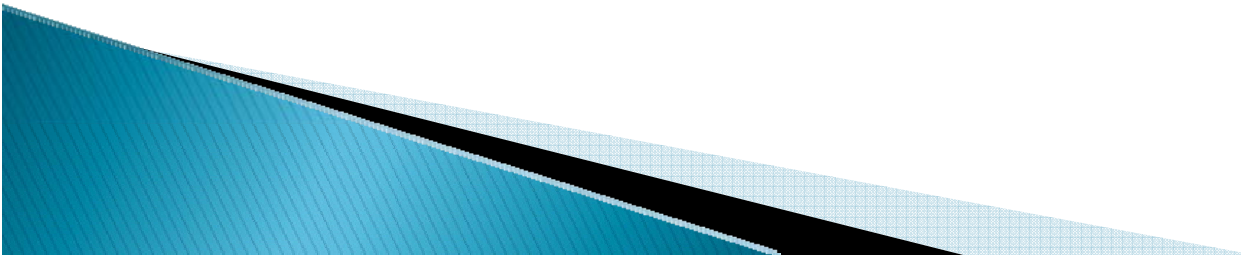
Case:
Tuzla square "Kapija"
Massacre of young people

Tuzla, 25.05.1995.

Berko Zečević
Jasmin Terzić
Alan Ćatovič

www.dtd.ba

Prossecutor demands

- Identification of projectile that hit town Tuzla, place called Kapija on 25.05.1995. at 20^{55}.
- Identification of projectile flight direction.
- Assessment of possible gun fire positions, their minimal distance from the place of projectile impact.
- Determination of lethal zone for projectile HE 130 mm M79 during the proces of natural fragmentation in conditions of high human concentration in small space, with known characteristics of ground.
- External-ballistics analysis of hitting urban part of Tuzla, analysis of dispersion and defining projectile launching zone from gun 130mm M46.
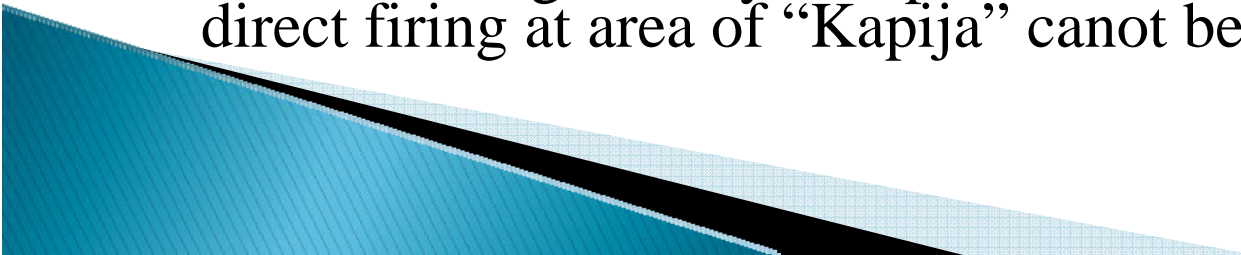
Available data about massacre of young people on 25. 05. 1995. at 20^{55}.
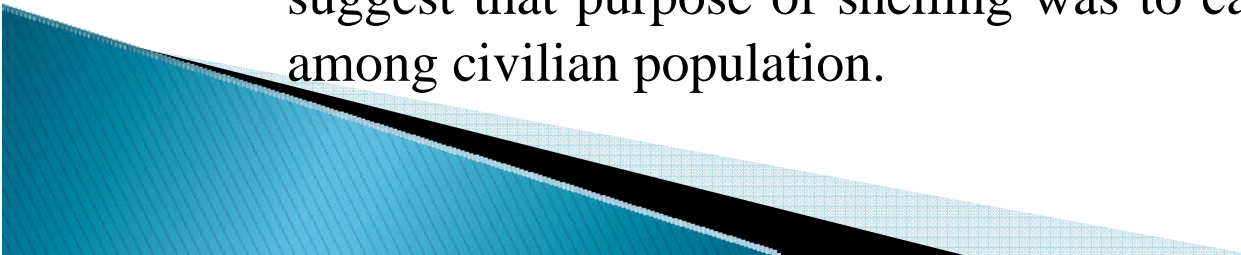
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Available data about massacre of young people on 25. 05. 1995. at 20^{55}

- Brantz C. L.: UNPROFOR Investigation Report: „Tuzla incident" 25 may 1995, Airport Tuzla 270595, Command of Sector North North-East.
  - Tuzla is declared safety zone by UN and as such it was an object of artillery atack on 25. may 1995.
  - In period from 19.03 to 20.46 hours, airport Tuzla and surrounding area were hit with 13 projectiles, of which 4 direct hit on airport.
  - In period from 20.55 to 21.00 hours, city of Tuzla was hit with another 2 projectiles, of which one exploded (second one) in old part of town.
  - In moment when projectile exploded, around 800 people were in viscinity, of whivh 400 in immediate viscinity, on the market where impact occured.
  - Number of casualties after the explosion was 66 dead, and 240 wounded. Most of dead people were between 16 and 27 years.
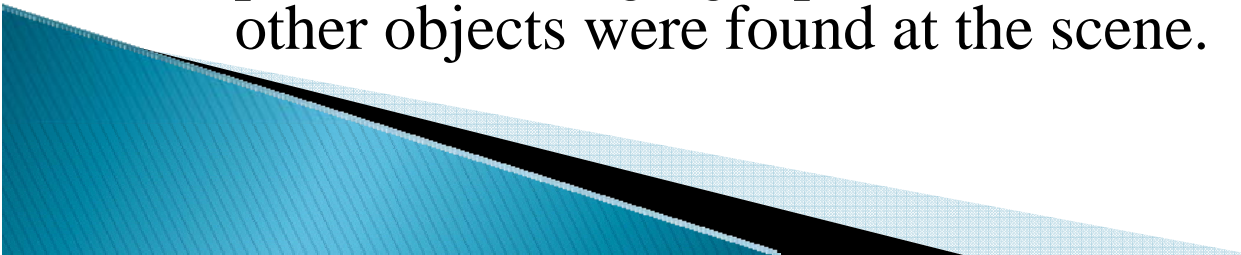
Available data about massacre of young people on 25. 05. 1995. at 20⁵⁵

- Conclusions of Report made by investigation judge of Higher Court in Tuzla and Report made by joint effort of UNPROFOR (UN military observers and Command of Sector Nort North-East) and Bosnian civil and military authorithies:
  1. Projectile 130 mm wth point detonating fuze (contact detonator)
  2. Weapon system "M46 Artillery system",
  3. Bearing: $270° \pm 10°$,
  4. Gun location: 20 km to 27 km,
  5. Facts confirm that artillery projectile 130mm was fired from weapon system from minimal distance of 20 km at urban part of Tuzla.
  6. M46 weapon system was located west of confrontation line at mountain Ozren.
  7. Observing the quality of M46, 130mm projectile and parameters, it can be said that, generally, old part of town was precise target. That is why direct firing at area of "Kapija" canot be ruled out.

Available data about massacre of young people on 25. 05. 1995. at 20^{55}

- In report of IUP HAUKLAND brigadier General, commander, Sector North East, directed to General major Rupert Smith, Commander of UNPROFOR in Sarajevo, on 28.05 1995., it is said:
  1. At least 195 casualties was directly caused by firing, of which at least 72 lost their lifes.
  2. Deaths and wounds were directly caused by one 130mm HE artillery projectile with contact detonator, fired from M46 artillery system, that hit in the middle of several hundred military unactive civilians, around 20:55, on 25. may 1995.
  3. Weapon system was located west of confrontation line in area known as Ozren front, at least 20km away from impact location, with 270° (± 10 °) azimuth.
  4. Location of projectile impact, time of firing and type of projectile used, suggest that purpose of shelling was to cause maximal number of casualties among civilian population.
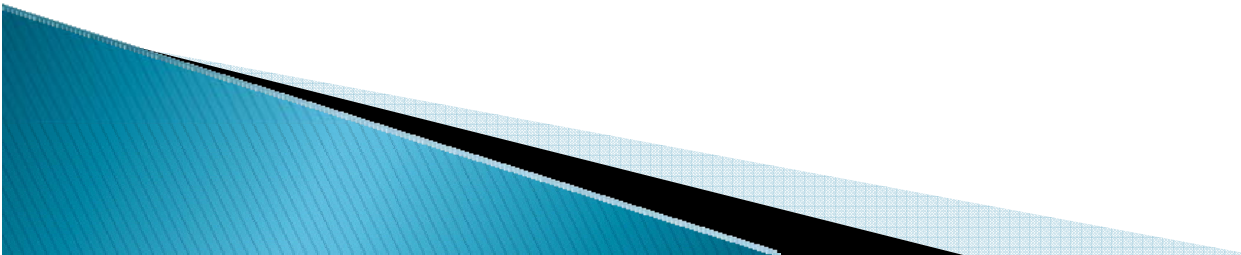
Available data about massacre of young people on 25. 05. 1995. at 20^{55}

▸ In Report made by investigation judge of Higher Court in Tuzla together with investigation authorities from Ministry of Internal Affairs and Center of Public Safety Tuzla, it is said:

1. In the evening hours Tuzla was hit by two projectiles, of which one hit narrow central part of town, locality Kapija, at 20^{55}.

2. In that moment around 1000 – 1500 people were present at that location.

3. After examination of impact location, investigating judge together with investigating team, determined signifficant objects and other important details, after which they conducted measuring, sketching, and photographing the scene.

4. In diameter of 30m around explosion location, numerous proofs about large number of casualties were found. Parts of bodies, foots, palms, parts of head, hair, brain, intestines, fasades of near buildings, personal belongings, parts of shoes, broken glass, wrecked cars, and other objects were found at the scene.

Available data about massacre of young people on 25. 05. 1995. at 20^{55}

6. Projectile hit the pavement – street covered with stone cubes, 2.65m from edge of the building where "NIK" store was located, watched in direction of city market, near first right tire of car "Golf", with reg. Mark TZ 110-777, and exploded.

7. On the pavement significant damage can be seen – crater with diameter of 50cm.

8. In the crater several metal fargments were recovered.

9. Near the crater trails of burning can be seen.

10. Car "Golf", specially his front part where the motor is, was covered with wholes made by fragmentation debris of different size and irregular shape.

Available data about massacre of young people on 25. 05. 1995. at 20^{55}

11. Member of investigation team, experts for ballistics, artillery and pyrotechnics, after examination of metal fragments and projectile crater, degree of damage on near objects, trails of fragments on walls, cars, etc, concluded that it was projectile 130mm with high explosive main charge.

12. Projectile was fired from gun M-46, and bearing was 270°, related to north.

13. On the location of impact, between 1000-1500 young people were present.

View of explosion site and shop "Seljanka"

Explosion site

Damage

View of explosion site and square "Kapija"

Part of square "Kapija"

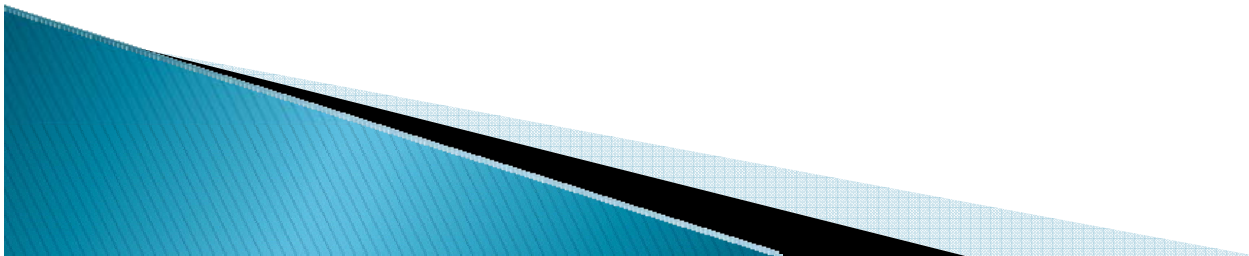# View at square "Kapija" from explosion site
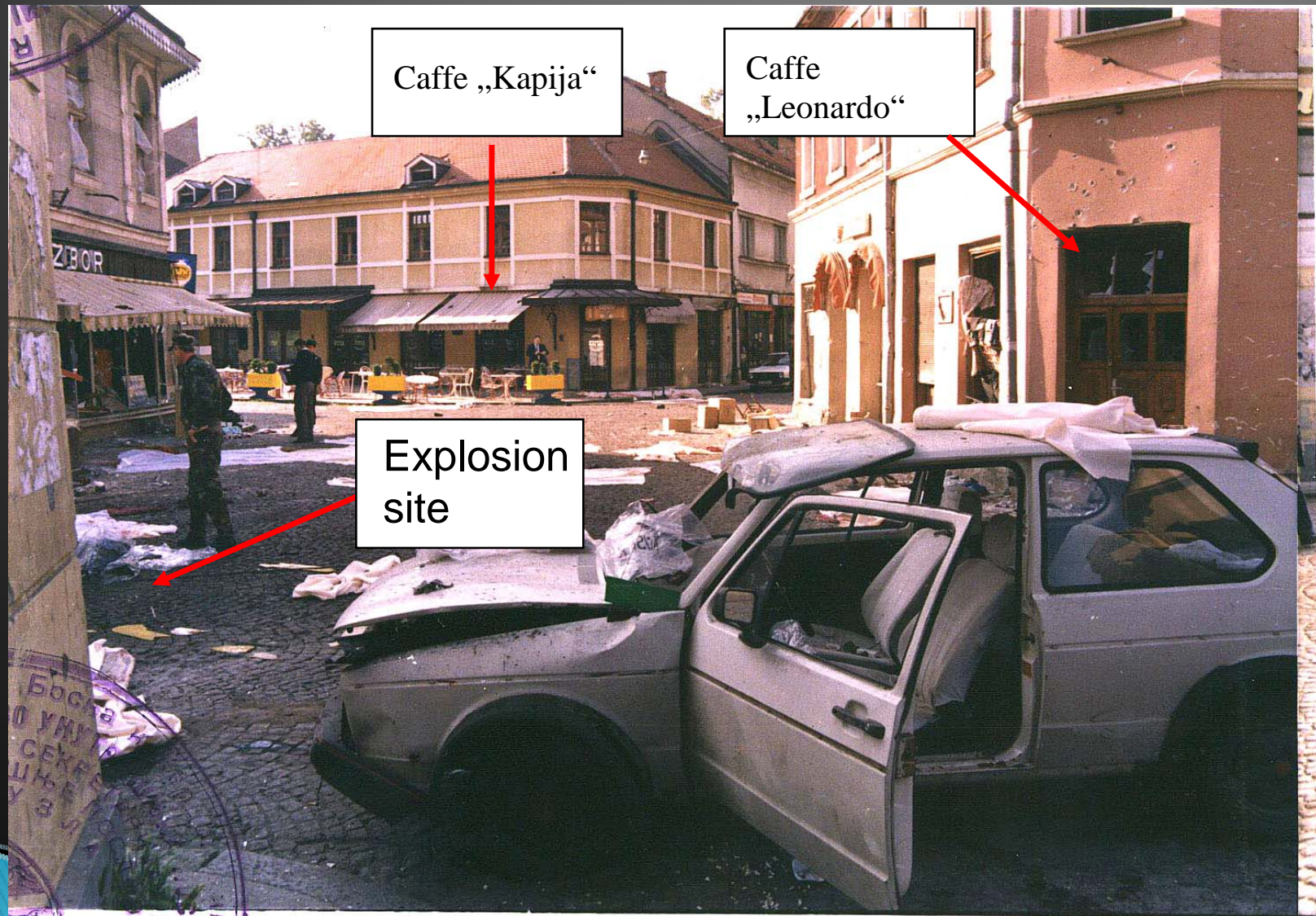
Artillery system, towed gun 130mm M-46 with ammunition

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Towed gun 130mm M-46

- Gun 130mm M-46 is weapon for indirect firing.
- Projectile has high muzzle velocity and relatively large range (27 490 m).
- Country of origin: Russia

Towed gun 130mm M-46

Karakteristike artiljerijskog oružja 130 mm M46

Crew	8
Dimension and mass	
Mass in combat	7700 kg
Mass in march	8450 kg
Length of rifled part	30 cal.
Total length	11730 m
Height to gas brake	2550 m
Width of trail	2060 m
Weapon	
Horizontal oper. field	50°
Elevation range	− 2.5° to 45°
Rate of fire (per min.)	5 – 6 projectiles

Towed gun 130mm M-46

Ammunition for gun 130mm M-46

- From gun 130 mm M-46 ammo with ful and variable charge can be used, which helps in aquiring larger operating zone and on small ranges, or HE (high explosive) ammo, armour-piercing ammo, smoke, illuminating, chemical, and lately ammunition with increased range with base bleed generator (type 130mm frag-HE, ERFB-BB).

- High explosive ammo was produced in factory "TITO" Vogošća (known as PRETIS), under designation TF 130 mm M79.

- Russian ammo acording to nomenclature up to 1990. had desgination 130 mm OF-482, and according to new nomenclature 130-mm Frag-HE, OF-43.

Ammunition for gun 130mm M-46

Ammunition for gun 130mm M-46

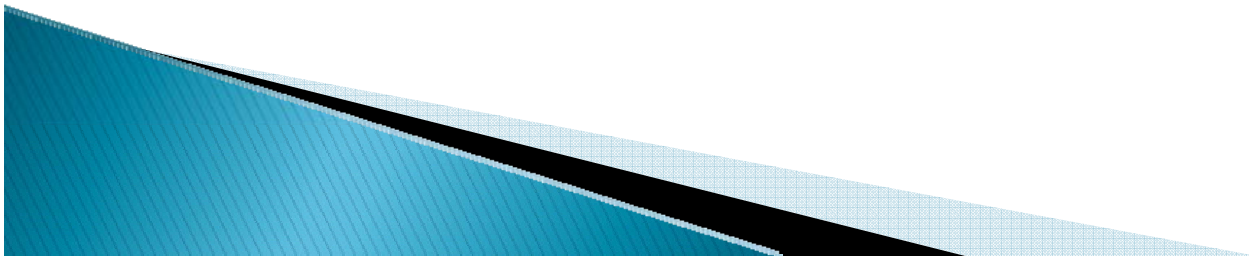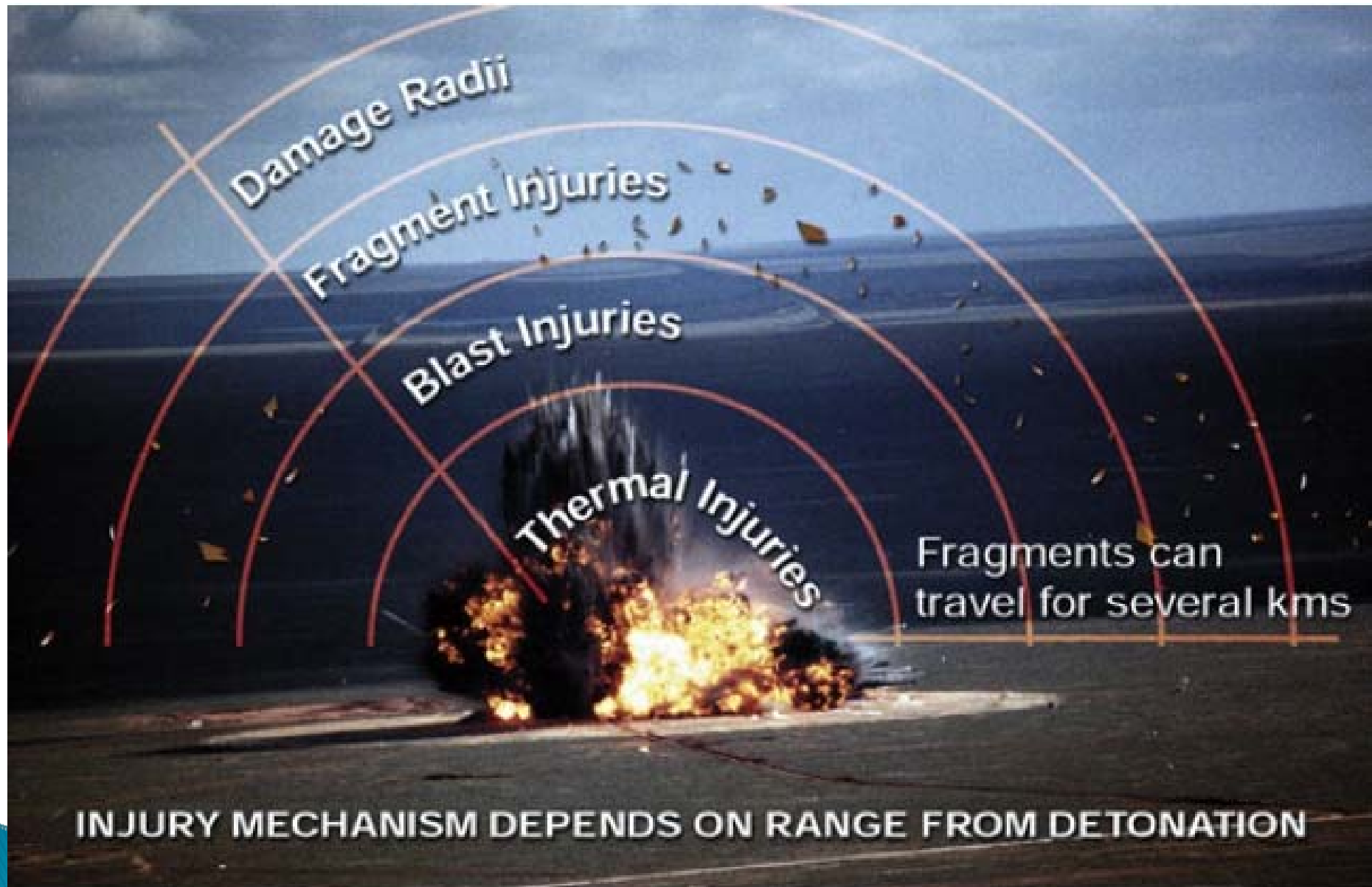| Projectile parameters	
Designation	M-79 or OF-482M or OF-43
Mass of projectile	33.4 kg
Mass of TNT charge	3.64 kg
Muzzle velocity	930 m/s
Maximal range	27.4 km
Fuze	Point detonating (more types) or proximity

Ammunition for gun 130mm M-46
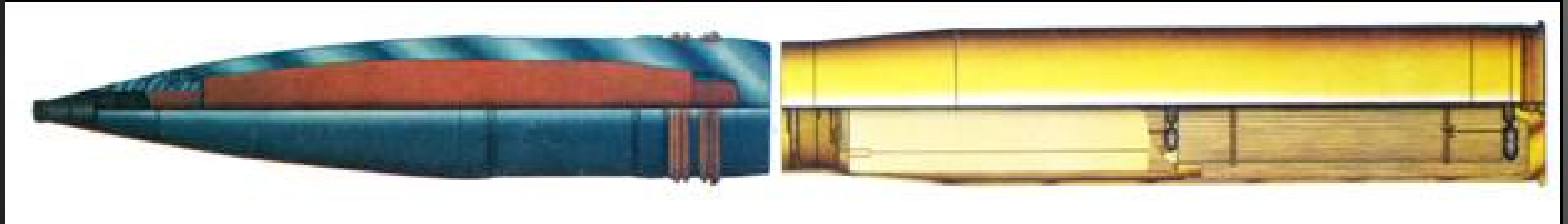
HE projectile effects on target

HE projectile effects on target

▸ HE projectiles are intended for destroying enemy soldiers and materials by means of kinetic energy of fragments made by natural fragmentation process.

▸ Generally, following mechanisms of wounding exist:
  ◦ Wounding due to thermic effects,
  ◦ Wounding due to shock waves (blast efect),
 ◦ Wounding due to fragmentation effects (kinetic energy of fragments).

HE projectile effects on target

Damage Radii
Fragment Injuries
Blast Injuries
Thermal Injuries
Fragments can travel for several kms

INJURY MECHANISM DEPENDS ON RANGE FROM DETONATION

HE projectile effects

▸ During detonation high pressure is generated (200.000-400.000 bar), which acts on projectile body in microseconds.

▸ This pressure is higher than projectile body tensile strength.

▸ In several microseconds, one kg of explosive produces around 1000 liters of extremelly compressed detonation products.

▸ As a consequence of this energy transformation, projectile body is expanding and fragmenting.

▸ According to experiments, initial diameter of projectile can be increase up to 3 times, before natural fragmentation takes place.

▸ Part of energy is absorbed, part is lost in decompression, and only 30% of total energy is transformed in fragment kinetic energy.
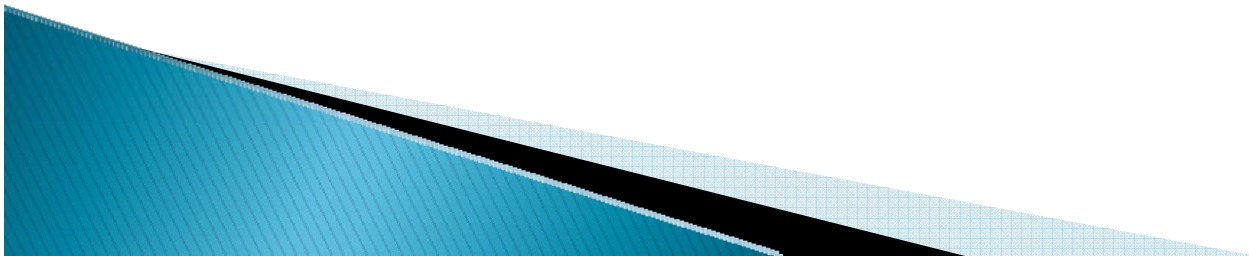
HE projectile effects
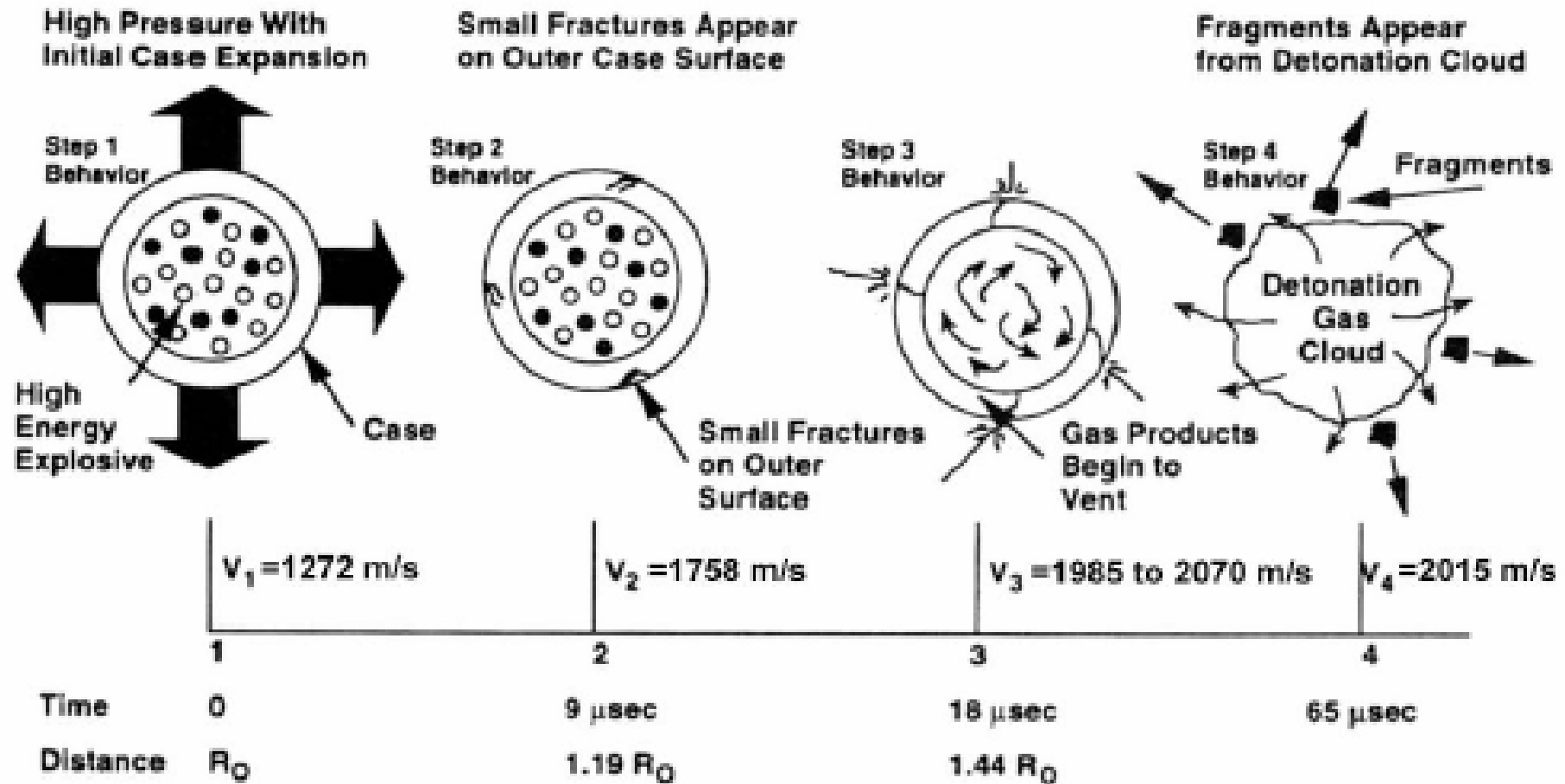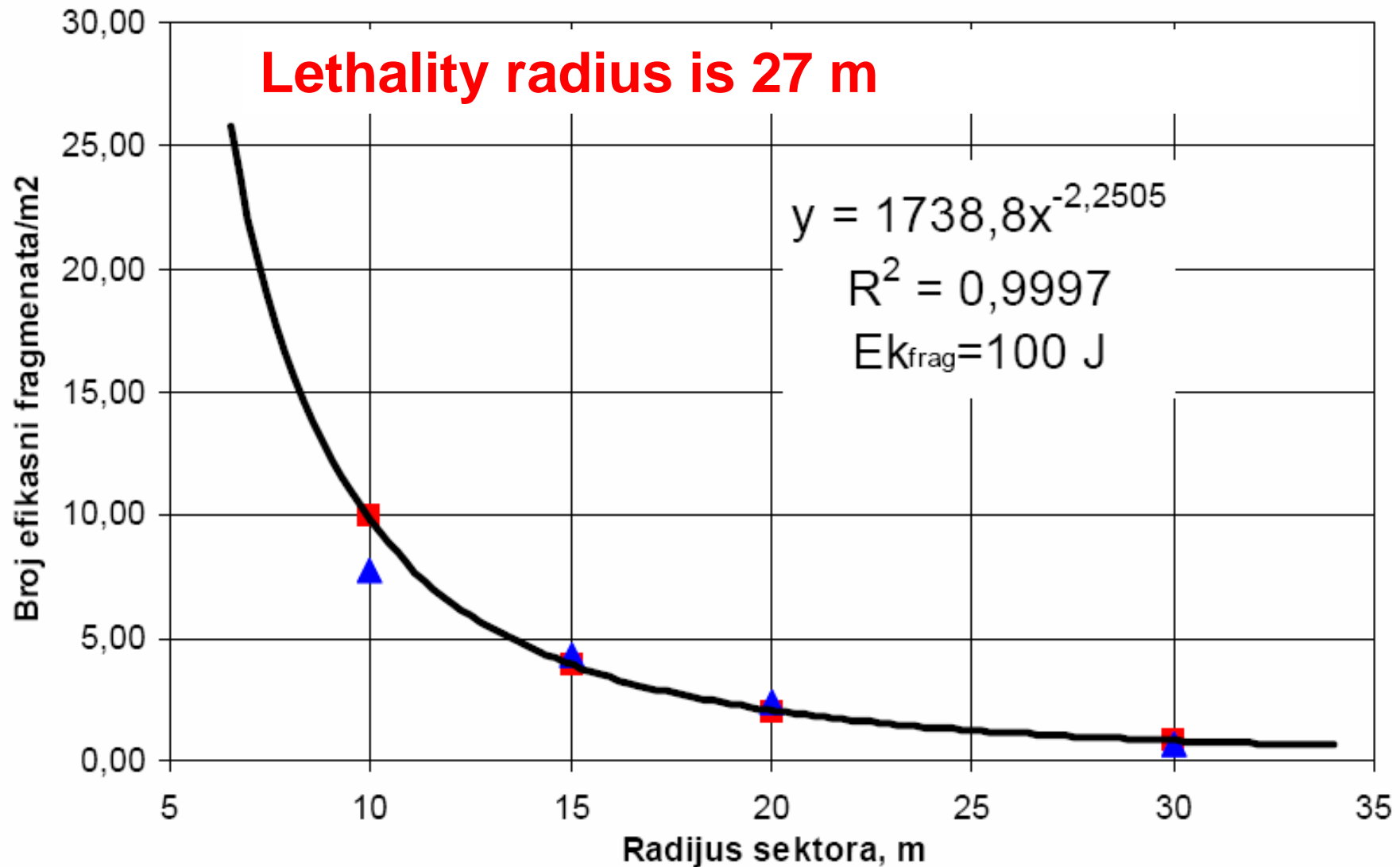
X-Ray shot of natural fragmentation process

Expanding of projectile body
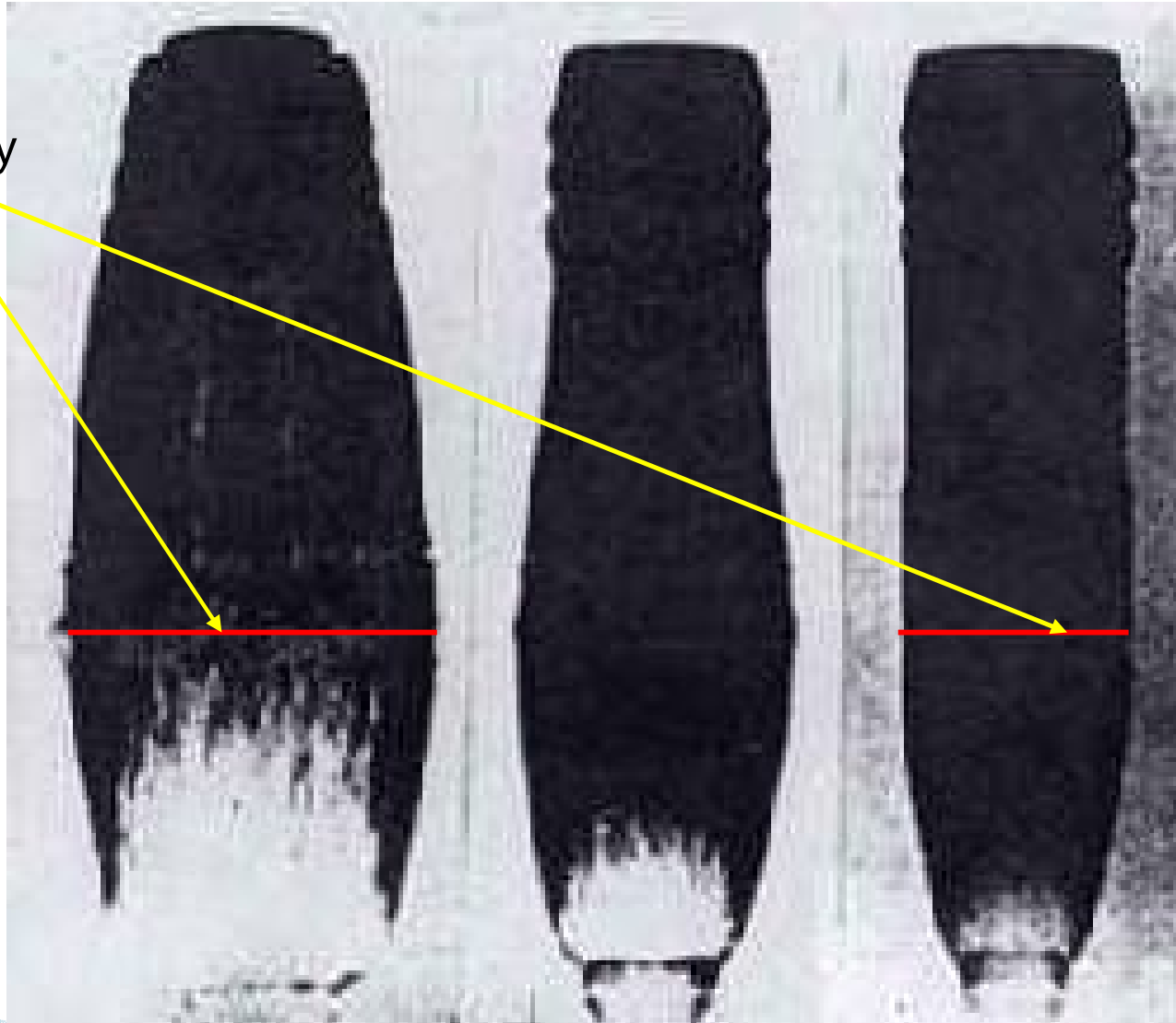
Process of body expansion

$V_i/V_0=1$

$V_i/V_0=1,21$

$V_i/V_0=1,5$

$V_i/V_0=3,0$

Lethality radius for 130mm M79

Lethality radius is 27 m

$y = 1738,8x^{-2,2505}$

$R^2 = 0,9997$

$Ek_{frag} = 100\ J$

(y-axis) Broj efikasni fragmenata/m2

(x-axis) Radijus sektora, m

Lethality radius for 130mm M79

- At distance of 27 m from center of explosion, every person was hit by at least one deadly fragment (it is adopted that area of human figure is in that case 1 m^2)
- Average fragment velocity in moment of explosion is 850 m/s, so it is obvious that large number of fragments can simply penetrate through human body and incapacitate next person, standing behind.
- That means that number of targets that were hit by lethal fragments is multiplied since human figure is not homogenous target.

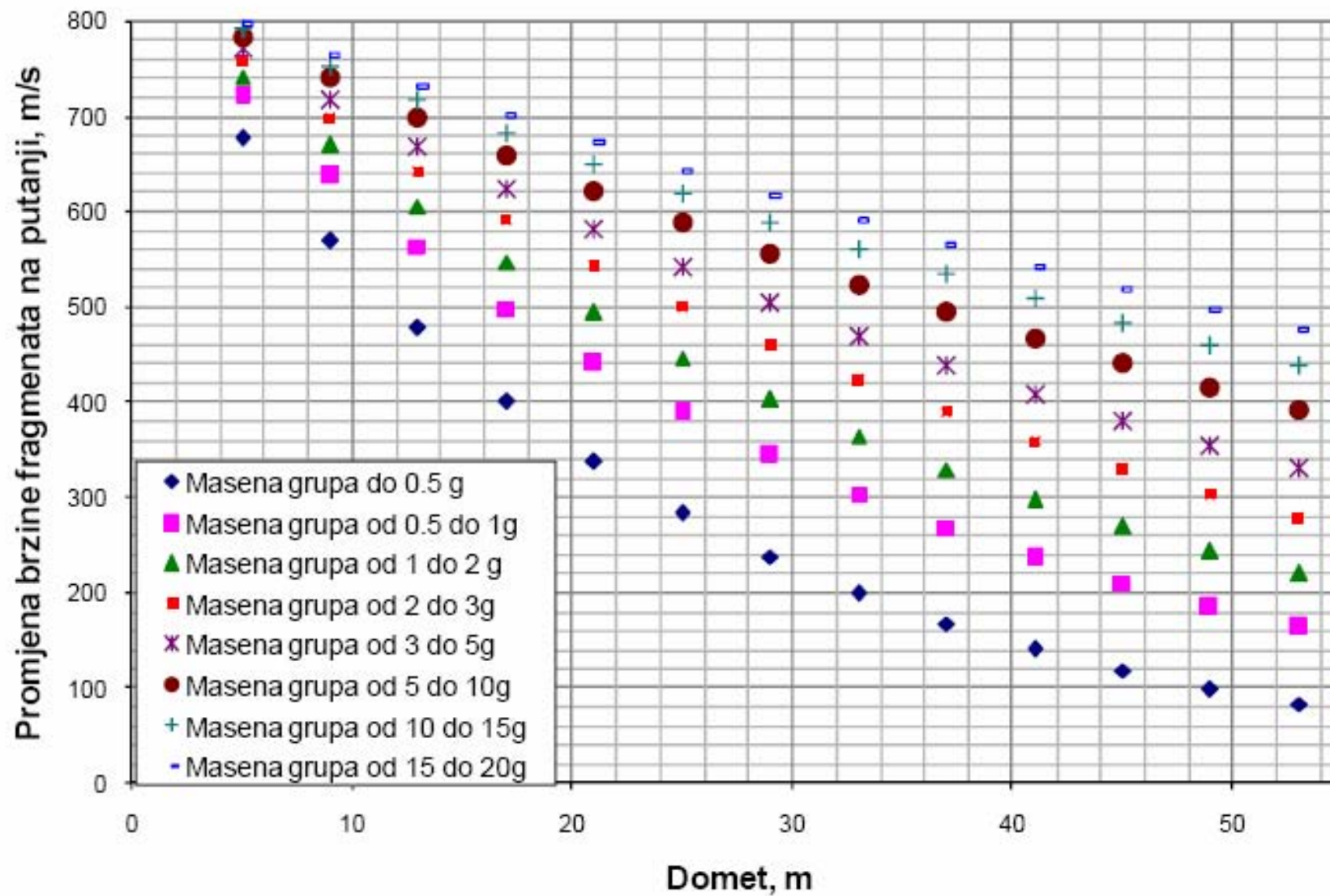# Effects of natural fragmentation for 130mm M79
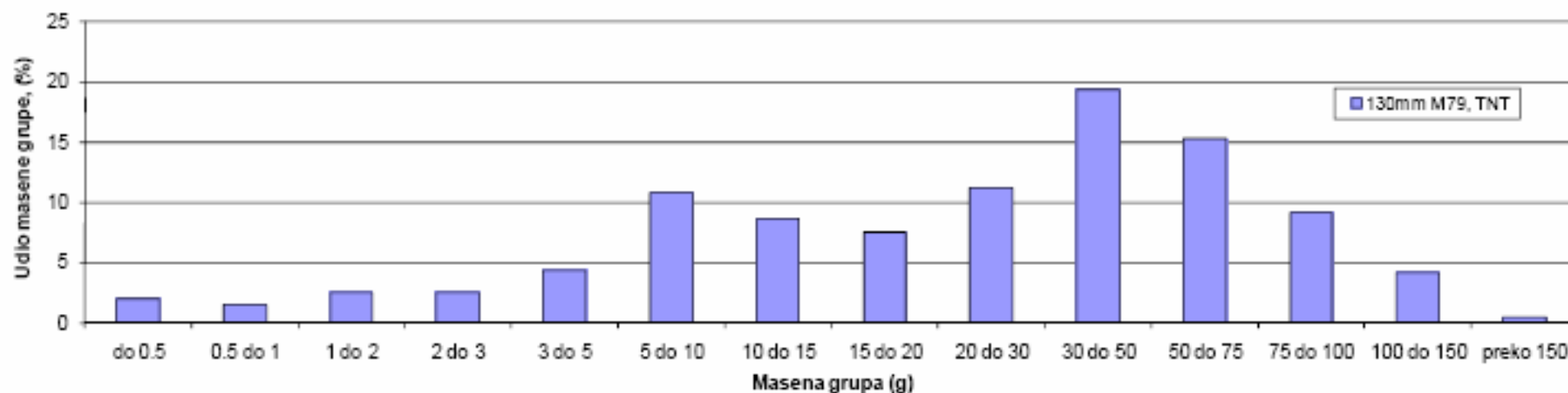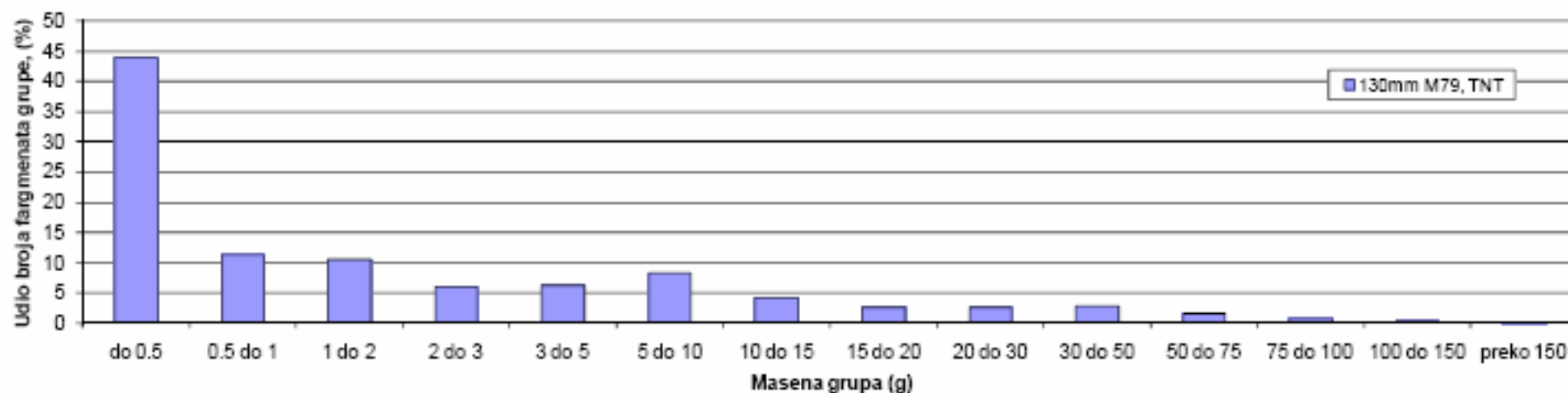
Largest number of fragments is up to mass group of 2 g and during natural fragmentation of projectile 130 mm M79, some 4.000 to 6.800 fragments are formed.
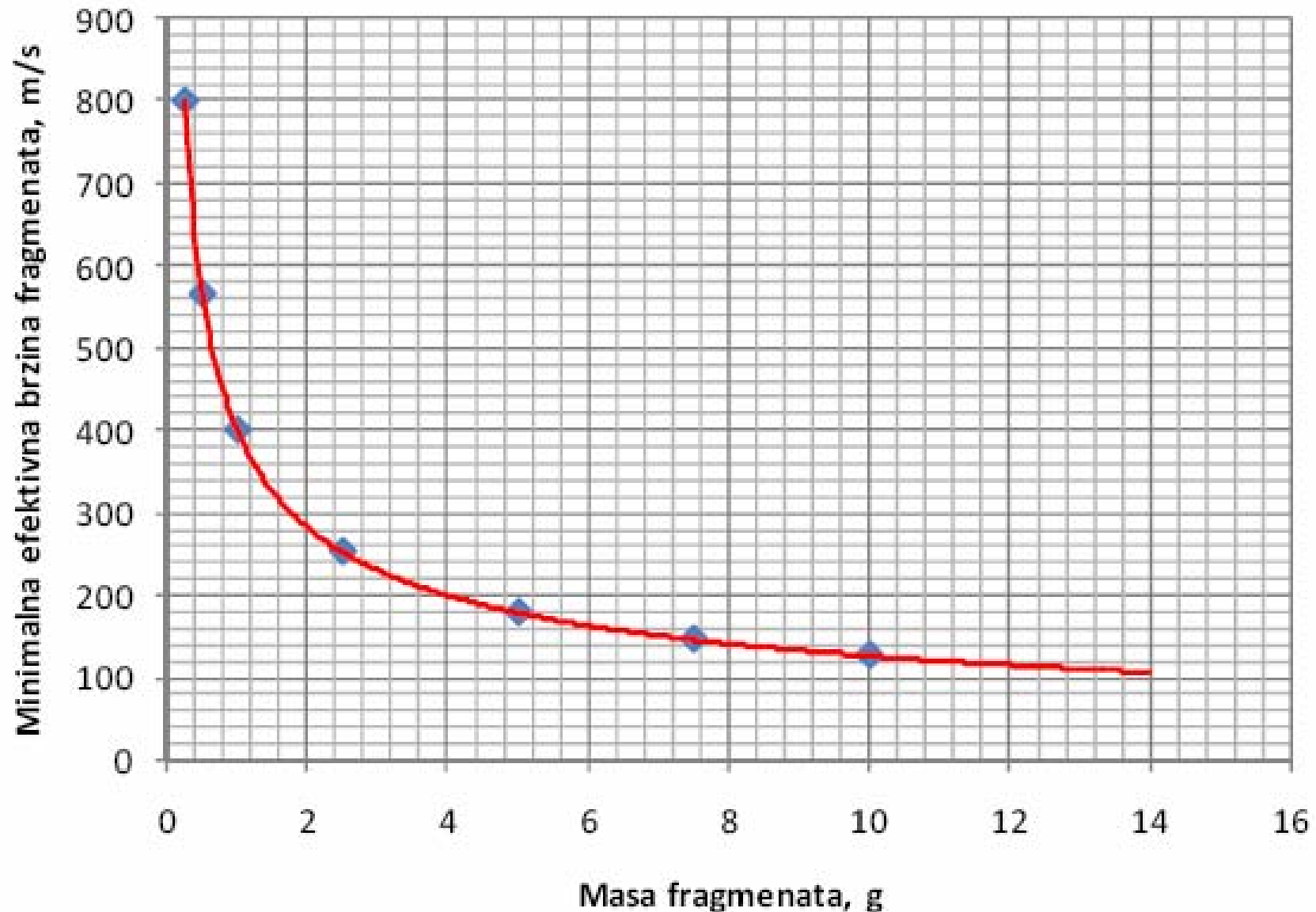
Fragment velocity
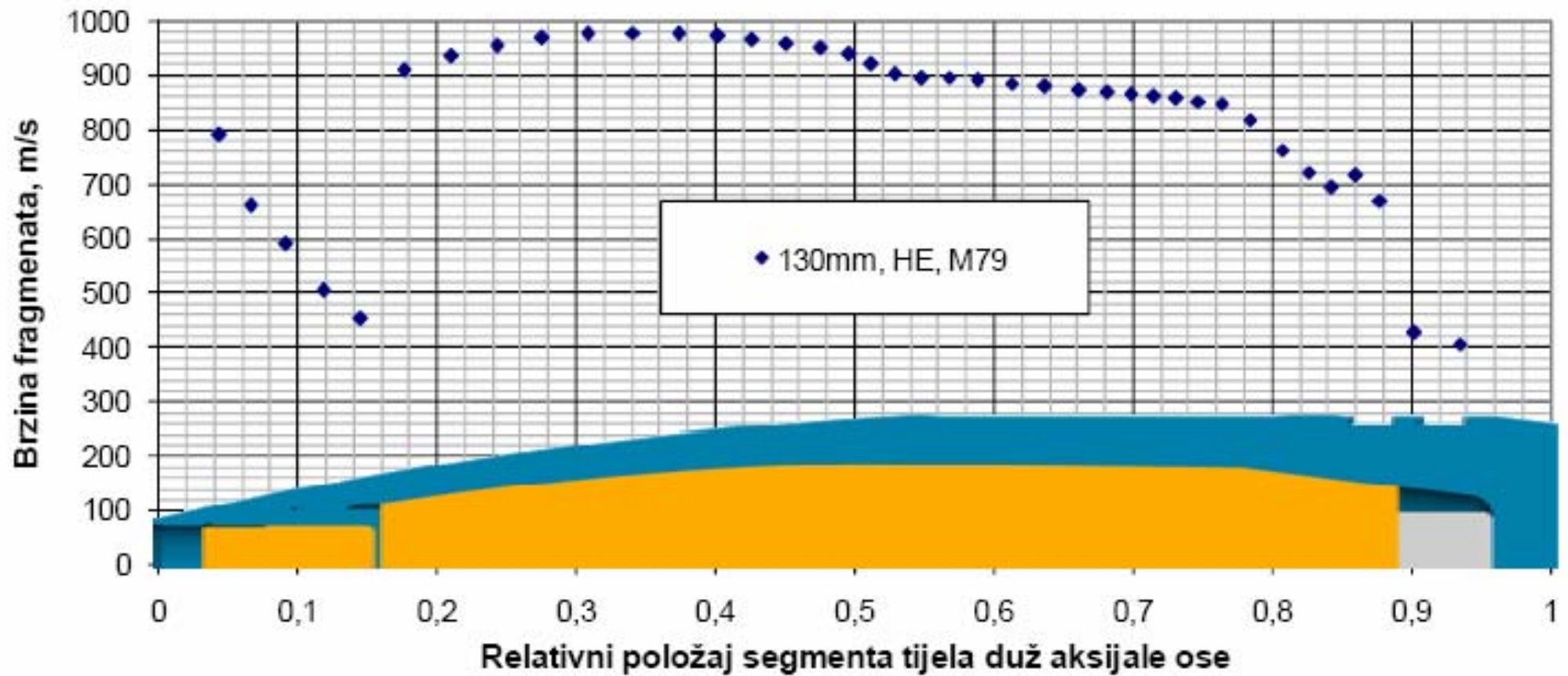
Fragment flight dynamics

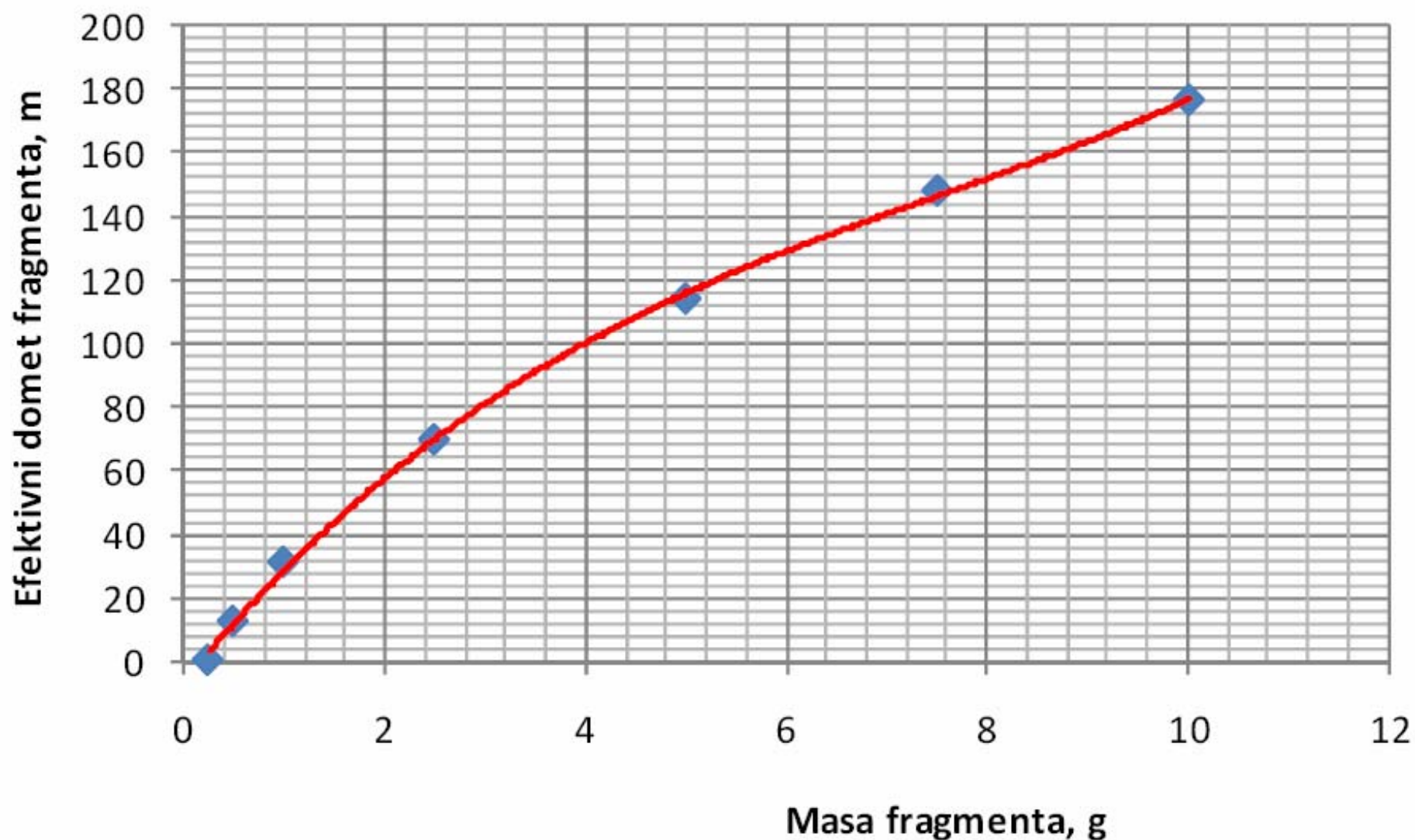# Maximal effective velocity of fragment

Fragments with masses larger than 2g should have velocity 300 m/s or less to cause deaths and heavy wounds.

Effective fragment range

Effective fragment range with mass larger than 5g for projectile 130mm M79 is 115m and more, measuring from the center of explosion, and there are more than 2200 such fragments for 130mm M79.

Determination of projectile caliber
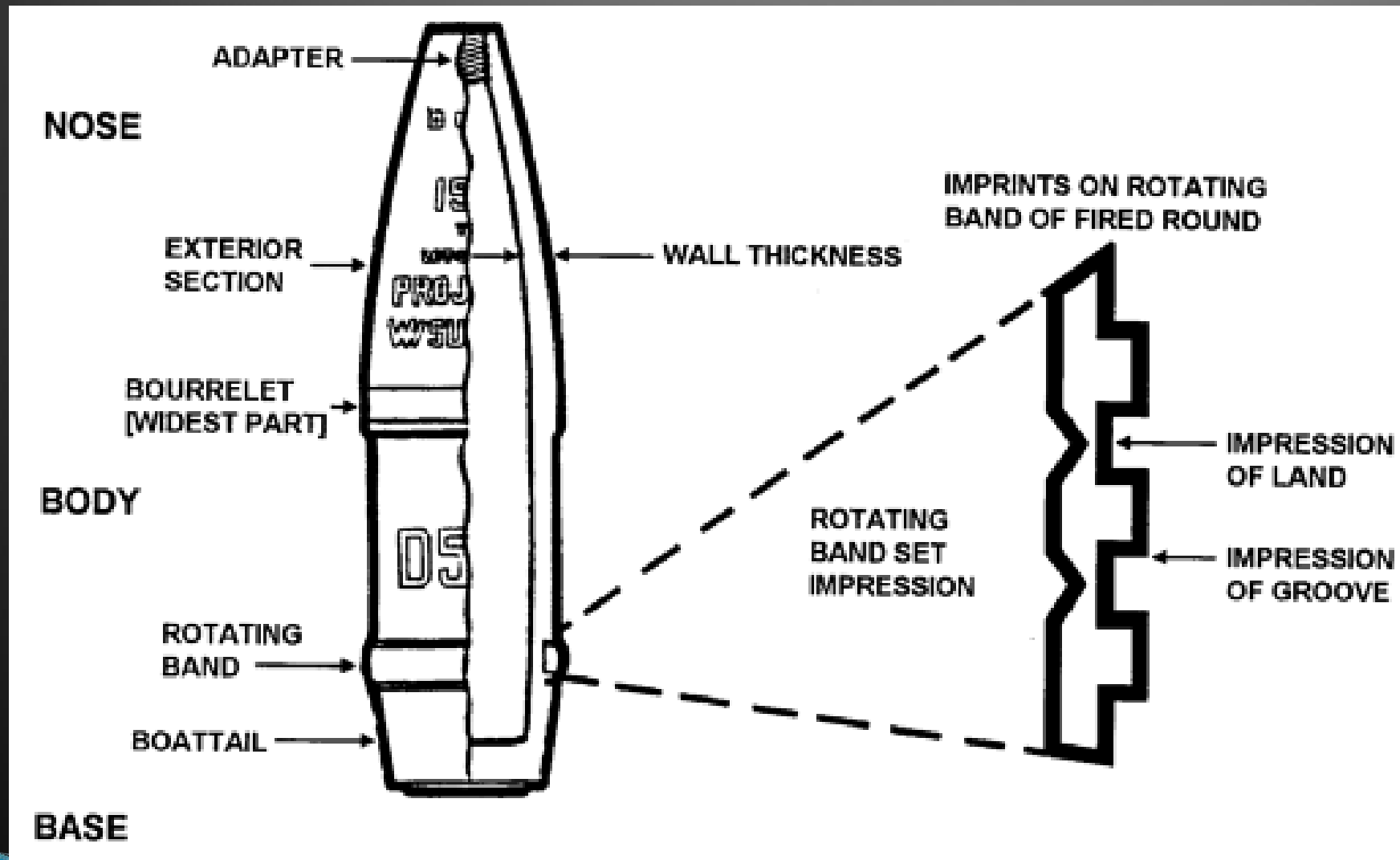
Rotating band and its bearing

- In order to identify projectile by caliber, type, origin, following is necessary:
  - Apperance of rotating band grooves,
  - Width of rotating band, number, width and depth of grooves,
  - Dimensions and apperance of rifling on rotating band bearing.
- Database is needed with detailed dimensions of projectiles, fuze types, material types, technologies for development, colours and surface protection, markings, etc.

# Rotating band and its bearing
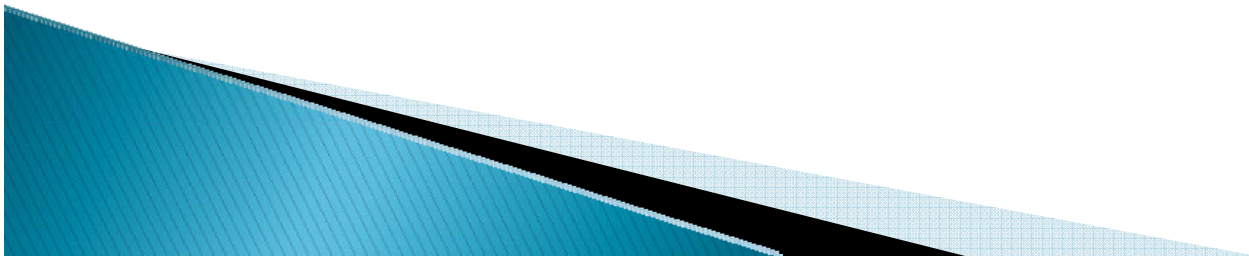

ST-CW-07-29-71
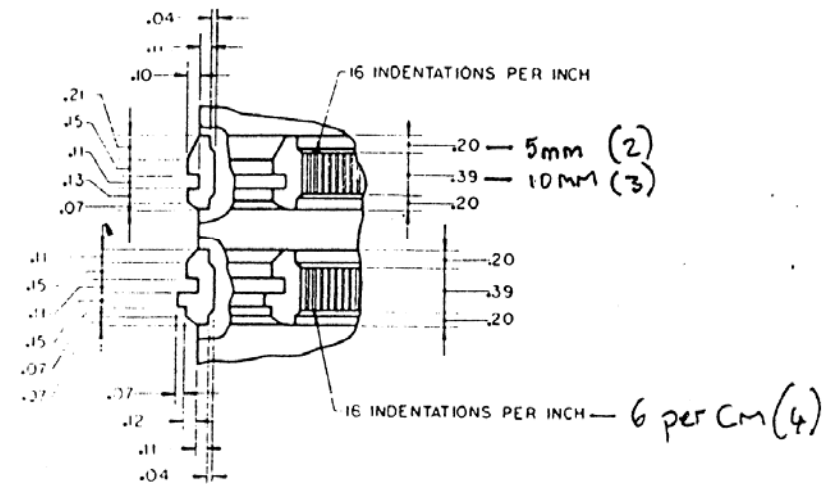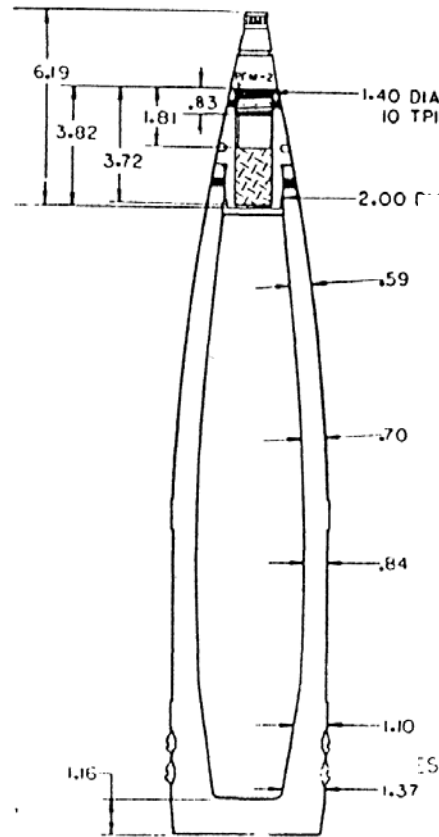
Analysis of massacre

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Identification of crater and explosion site

- Drawing of square "Kapija" was made based on urbanistic plab of city Tuzla from 1964. On it, only the explosion site is marked, and the car is inserted in proportion to other dimensions.
- Explosion site was thoroughly photographed and these photos are shown bellow:
  ◦ Centar f explosion is determined as intersection of arcs whose origins are at the ends of building, in front of which explosion took place, or R1=2,65 m and R2=5,6 m.
  ◦ Distance between building ends is 6,5 m.

Identification of crater and explosion site

Space filled with young people

Projectile flight direction

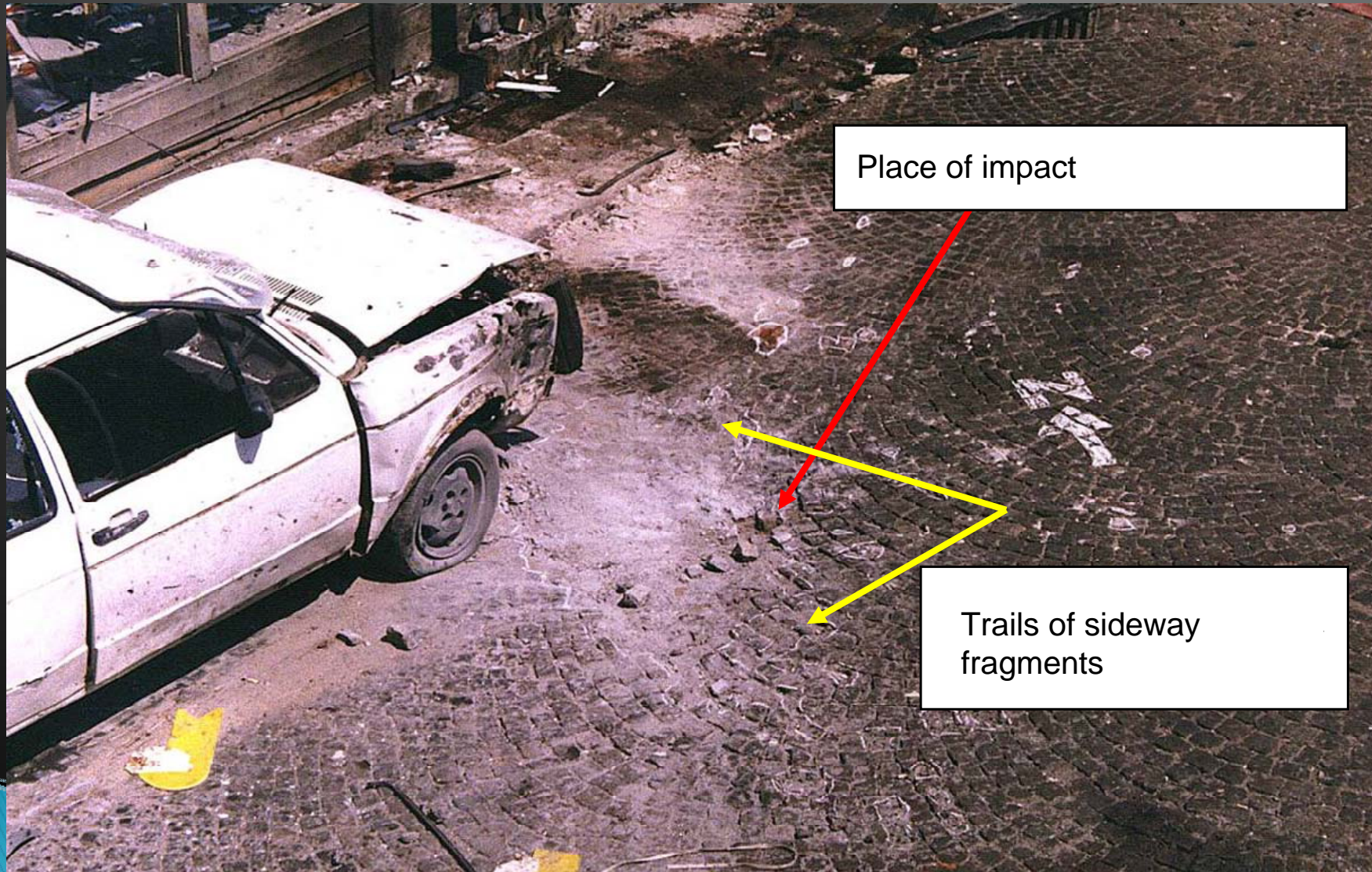1 : 300
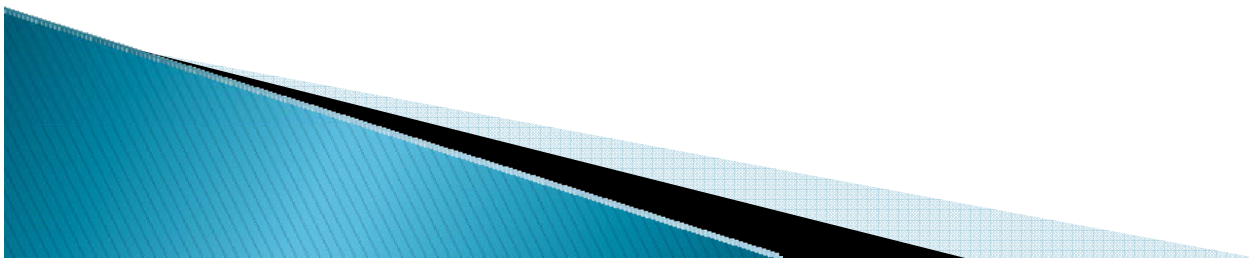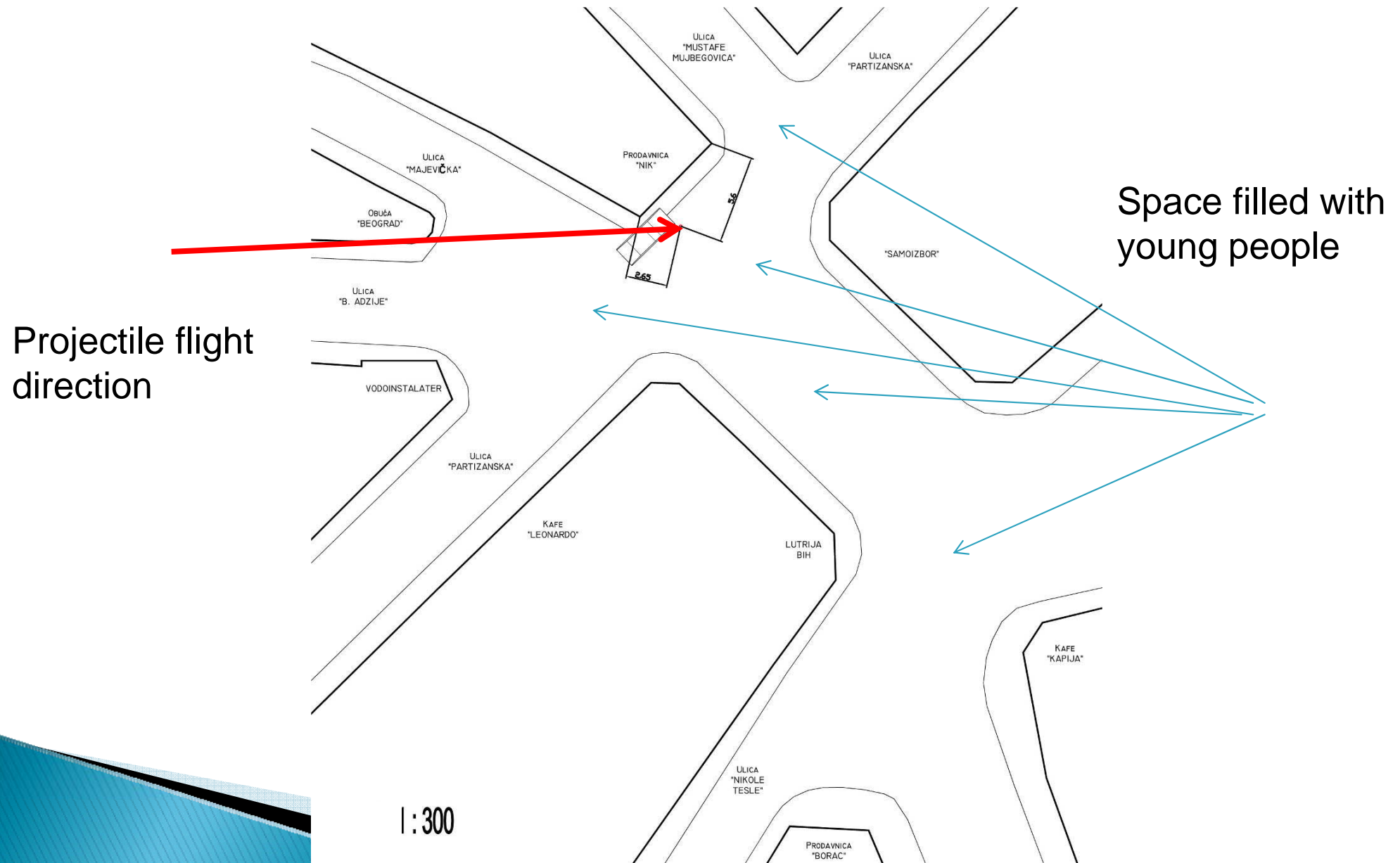
Explosion site

Explosion site and trails of fragments on granite surface and car

Position of car regarding the building and explosion site

APOTEKA

"N" stands for North

Position of car regarding the building and explosion site

Place of impact

Trails of sideway fragments

View of explosion site from first floor of the building

Projectile flight direction

Trails of sideway fragments on granite surface

Crater from explosion
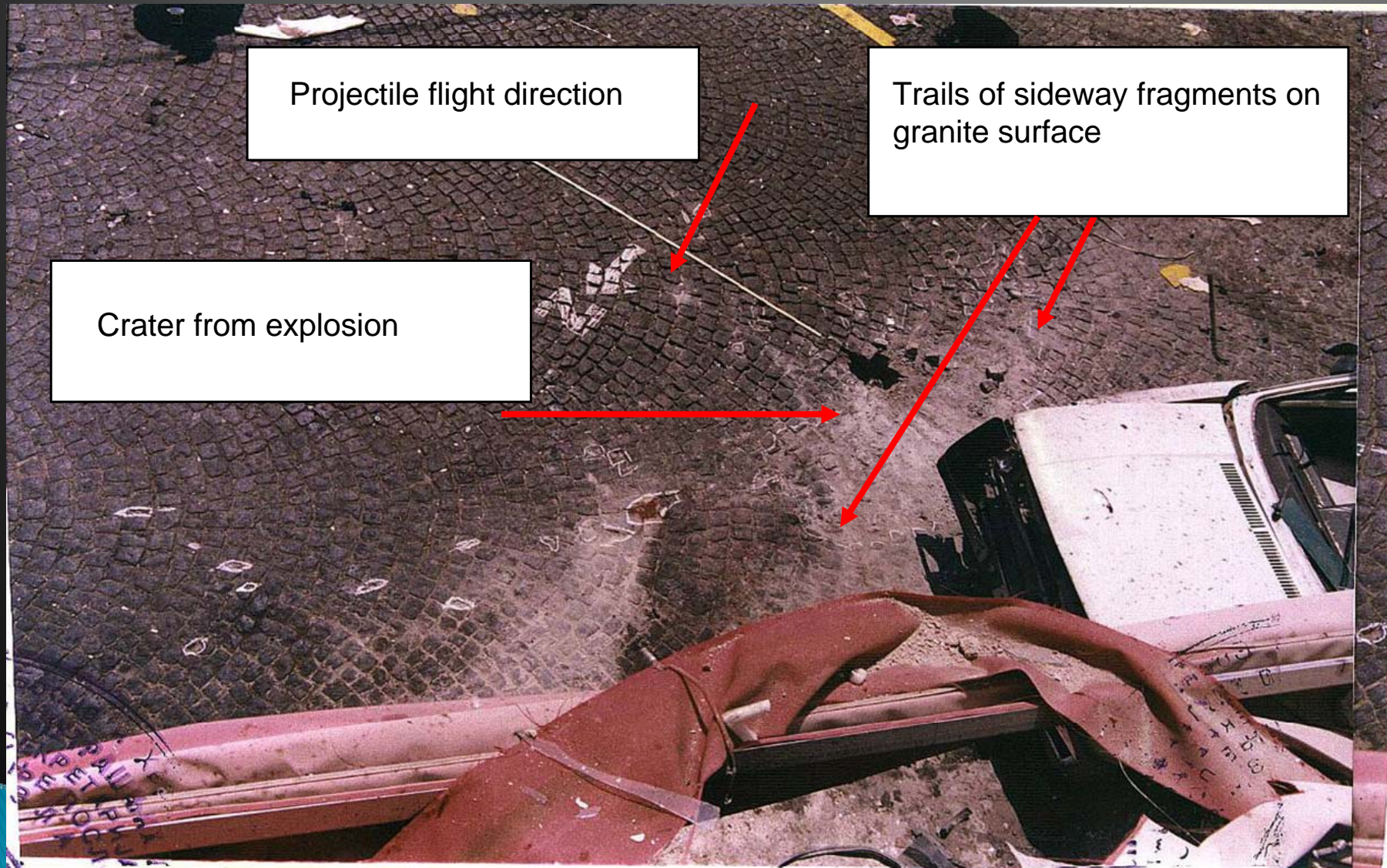
Clear trail of damage, and specialy furrows of sideway fragments

Left arrow shows furrow made by fragments impact in granite cubes, and right arrow direction of flight
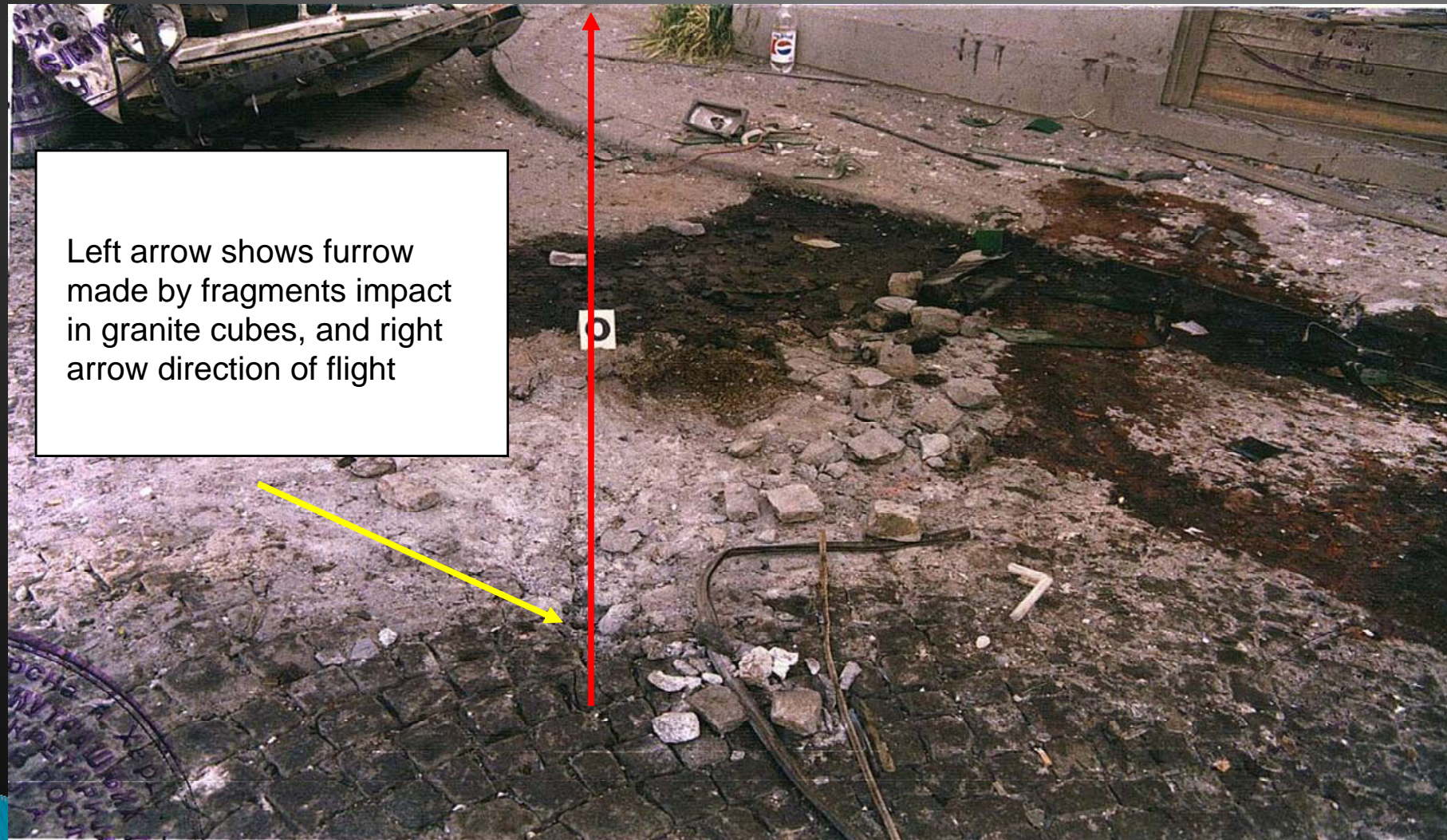
Clear trail of furrow on granite cubes

Clear trail of furrow made by fragments impact in granite cubes allows precise determination of direction of flight
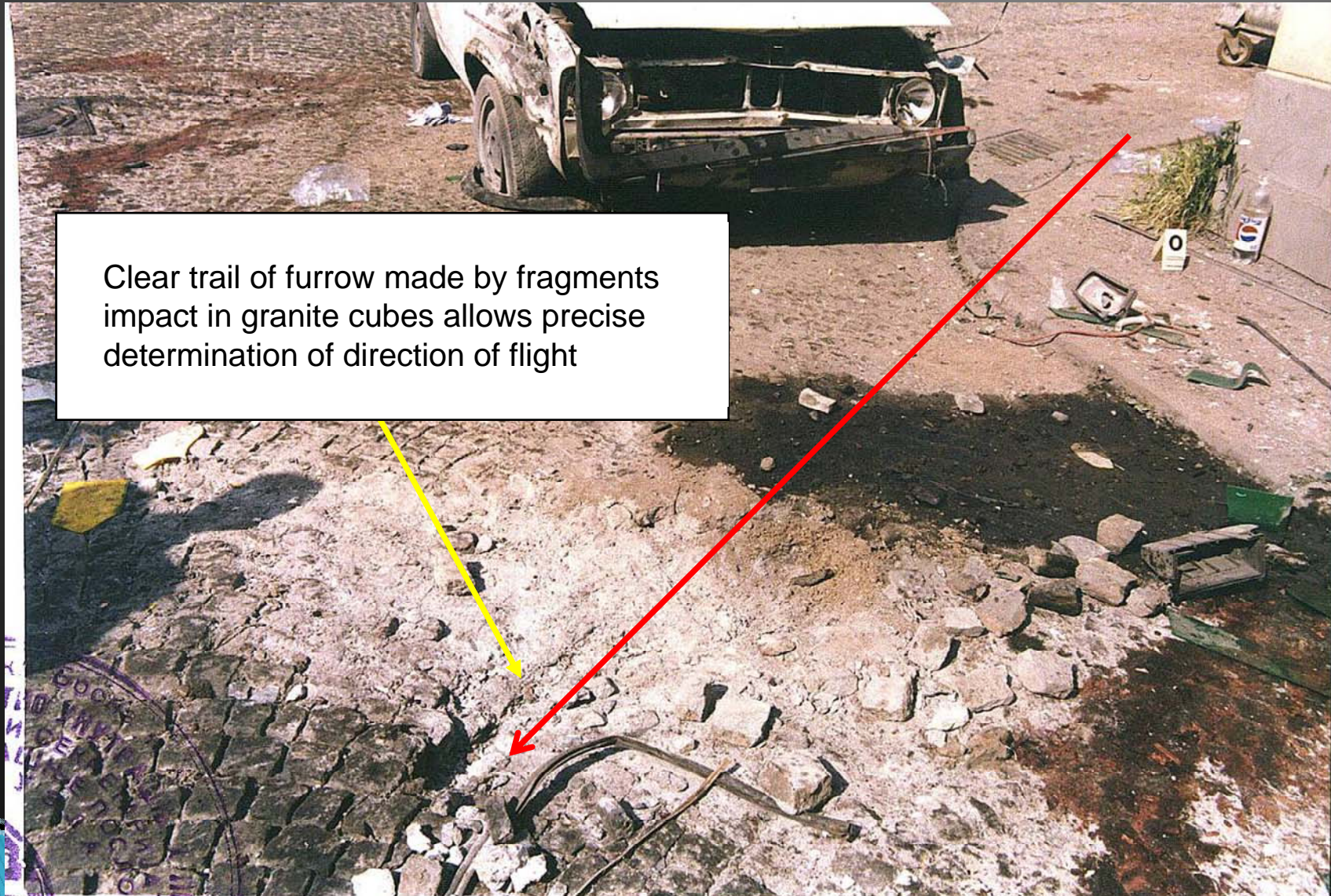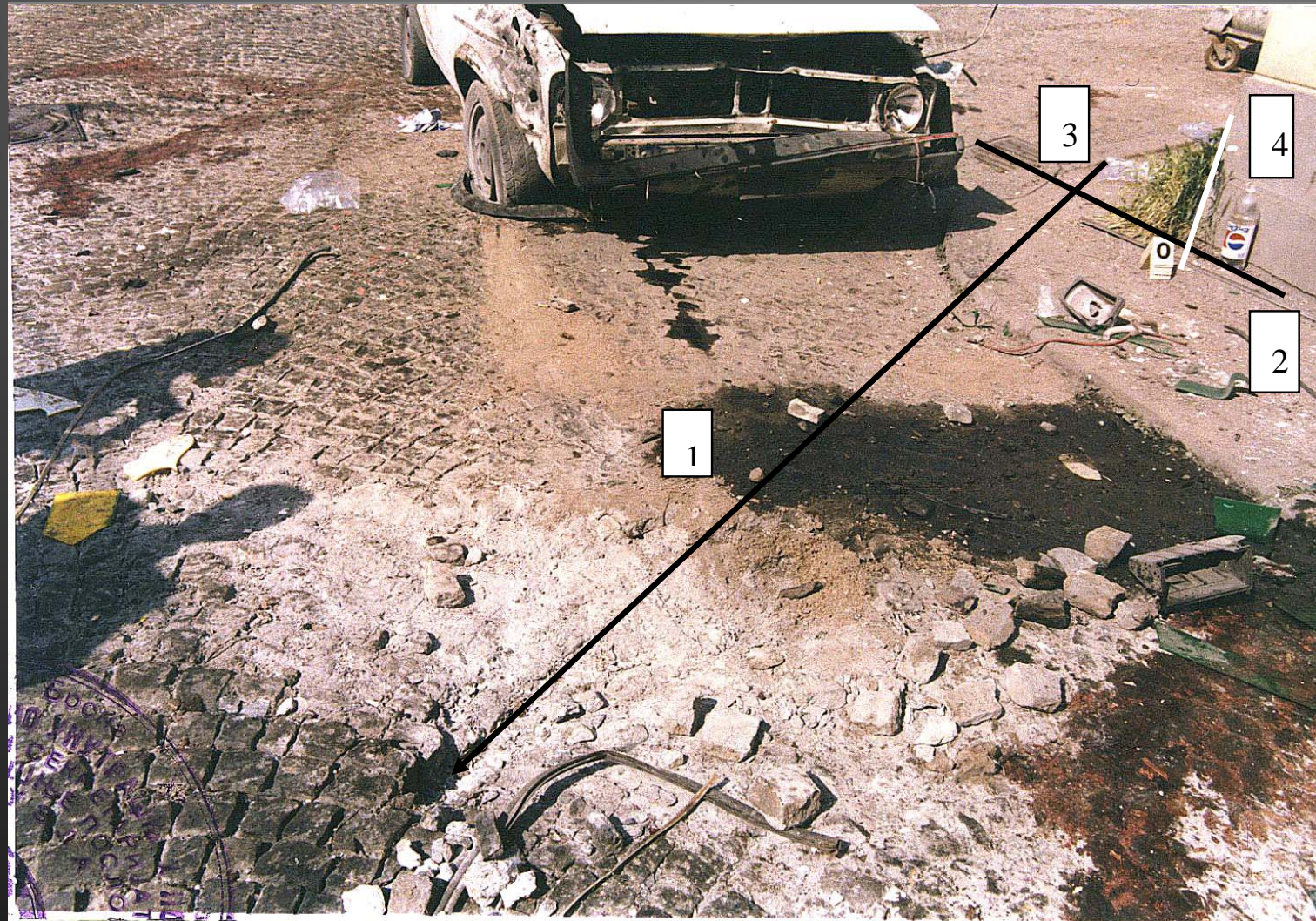
Wider plan of square "Kapija"
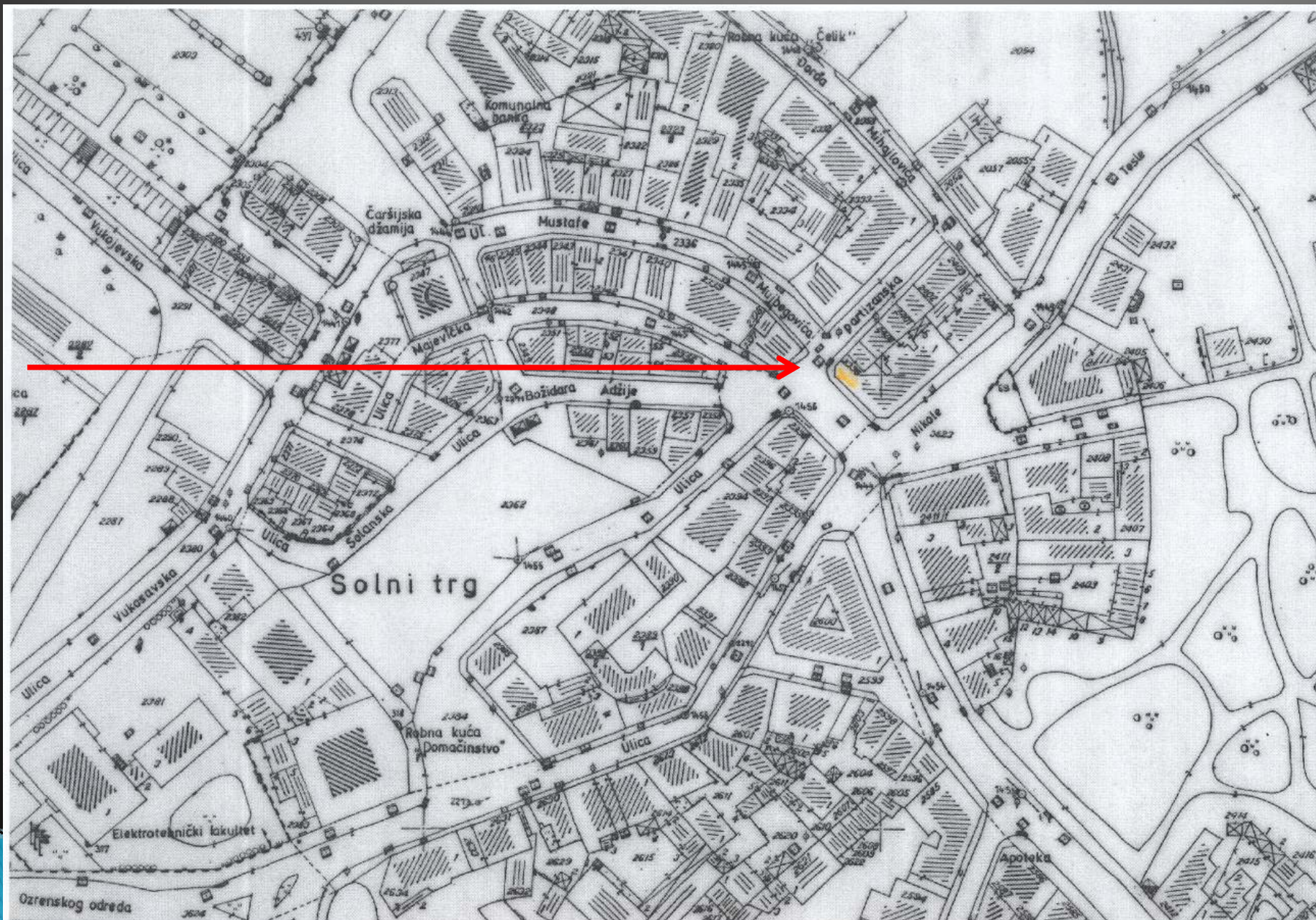
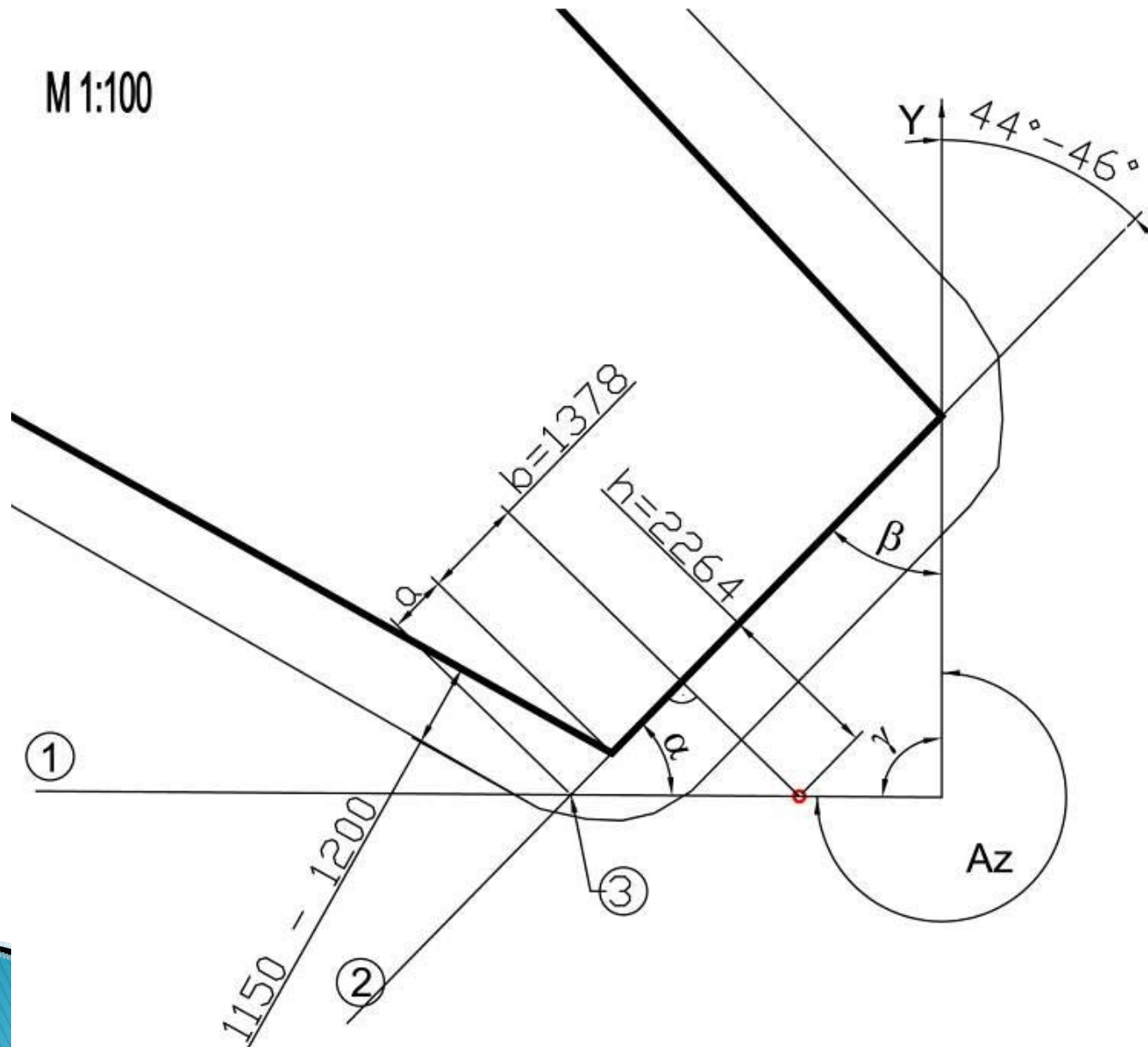# Identification of flight direction for projectile

Determination of distance of intersection point from building edges and angle between two directions (direction through furrow and direction through bottom of vertical building wall)

Identification of flight direction for projectile

▸ Since width of roadside is 180mm, with method of similarity, it can be determined that wanted distance is around 800mm.

▸ In calculation system, measurement error is included, and in order to find this error influence, average point on distance 800 ± 100 mm from building edge will be considered.

▸ For additional check, calculation of pavement width is made and determined value is around1150 mm.

▸ From urbanistic drawing of wider area of square "kapija", obtained from Service for geodetic and Legal affairs of municipality Tuzla, it can be determined that width of pavement on this place is between1150-1200 mm.
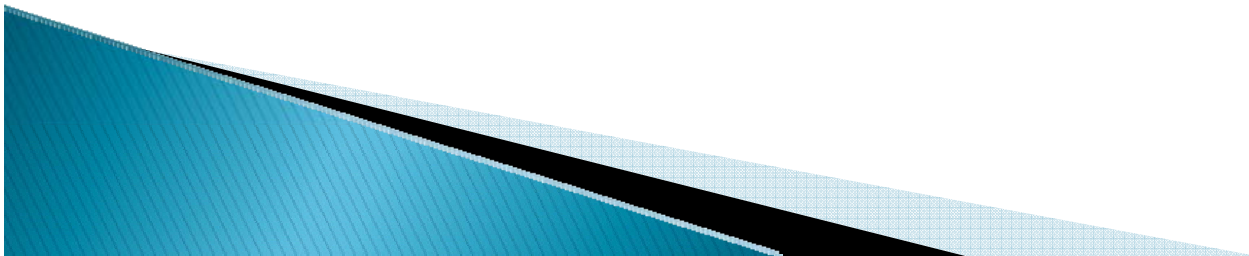
# Identification of flight direction for projectile

Identification of flight direction for projectile

	Determination og angle (α) between flight direction (mark 1) and direction of builidng wall bottom (mark 2), angle γ and azimuth of flight direction		
	Distance a=700mm	Distance a=800mm	Distance a=900mm
$tg\,\alpha = \dfrac{a+b}{h}$	1,0895091	1,0394857	0,0038545
Angle α	47,45°	46,11°	44,82°
Angle γ (β=44°)	88,55°	89,89°	91,18°
Angle γ (β=46°)	86,55°	87,89°	89,18°
Azimuth Az (°)	271,45°–273,45 °	270,11°–272,11 °	268,82°–270,825 °
Azimuth Az range (°)	268,82°–273,45°		

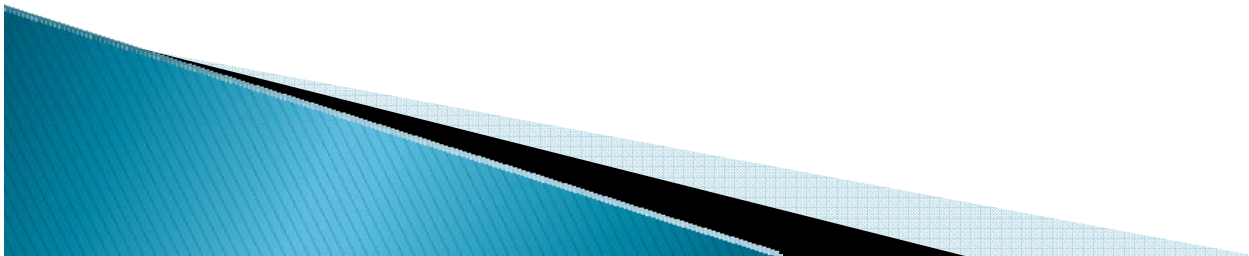# Angle of impact of projectile

- Based on analysis it can be concluded that probable direction of projectile flight was Az$= 271^0 \pm 2,5^0$.

- Determined angle corresponds with results ($270^0 \pm 10$) obtained by joint comission UNPROFOR and Interior Affairs Ministry in Tuzla. Difference is only in signifficant reduction of projectile impact zone width.
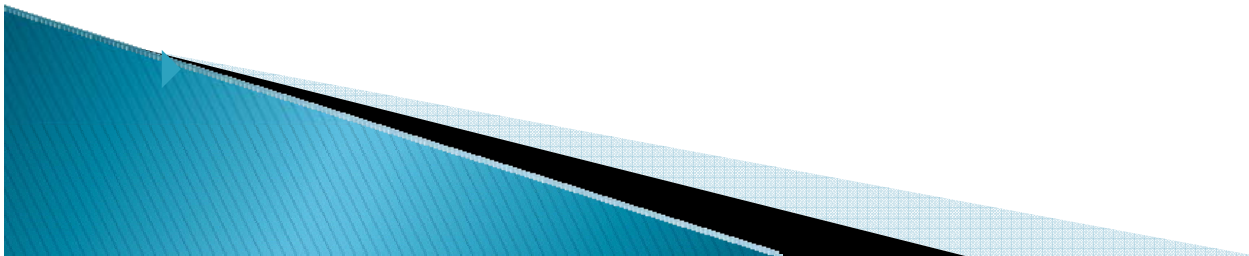
Determination of angle of projectile impact

- Analysing photos from explosion site, it can be seen that projectile went over the building "Obuća" and hit the ground made of granite cubes, near the car "Golf", which was parked close to building "Nik".
- When geometrical parameters of building "obuća" are observed (distance from explosion site, height) then it is possoble to assess minimal angle of impact in zone between building and car.

Determination of angle of projectile impact

- Mr. Mirsad Đedović, dipl. ing. geod. filmed macro location of crime scene, from geodetic point of view.

- It can be seen that impact angle in zone above the building and up to impact point is larger than **31⁰**, because path of projectile followed projection A–A.
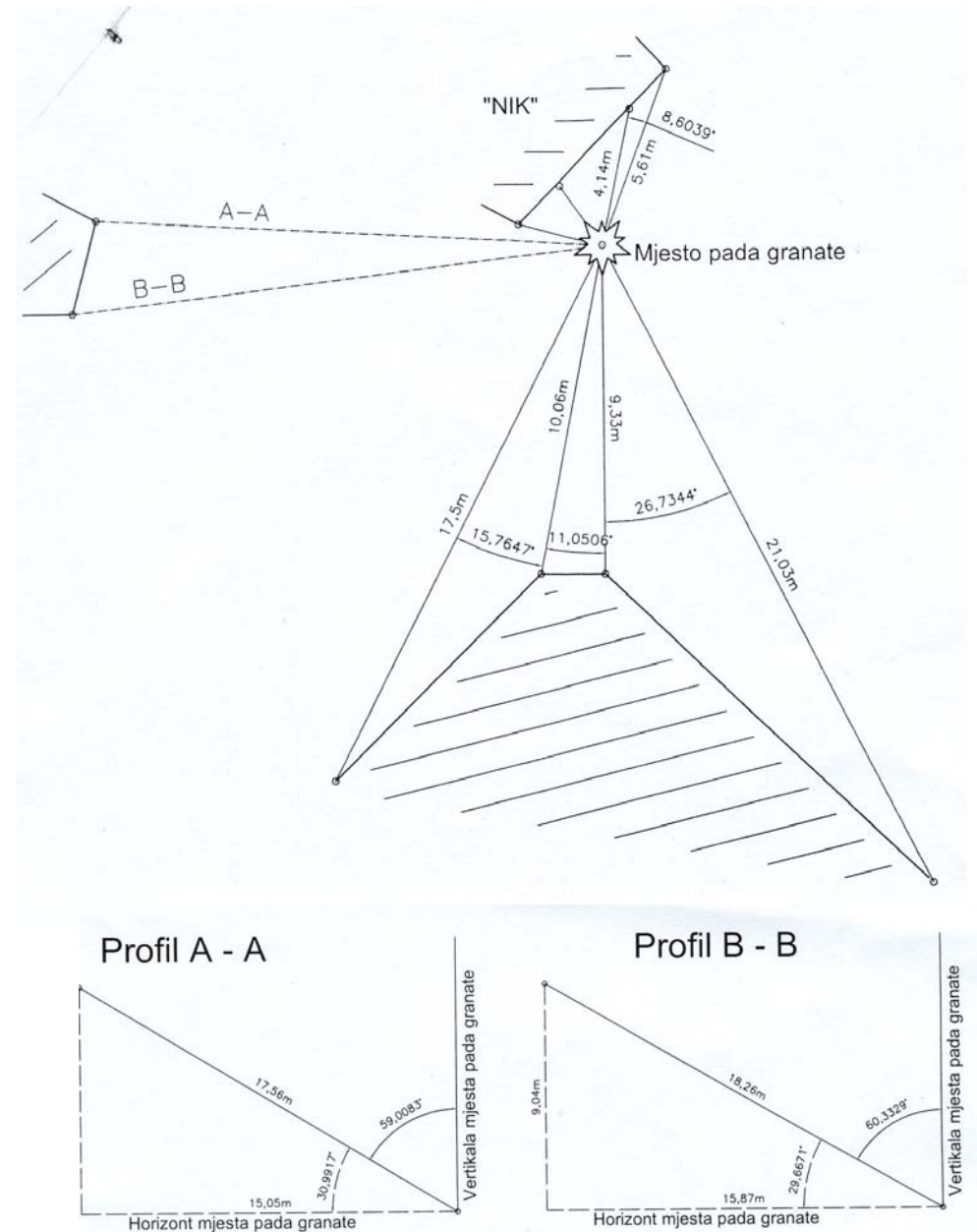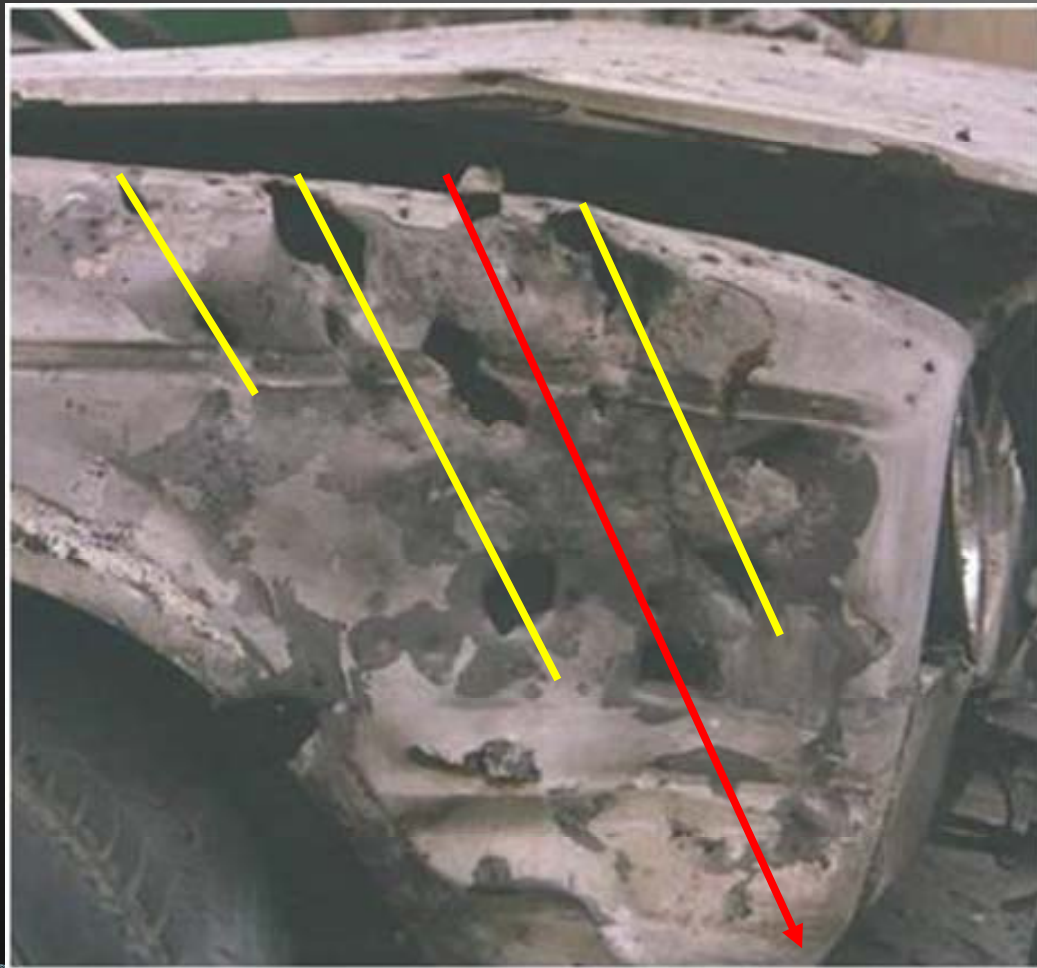
Shot of square part in zone of descending path flight of projectile

Trails of penetration in right car bumper made by projectile fragments

Main lines of projectile fragments

Main lines of fragments on front right bumper are relatively parallel.

It can be seen that angle of inclination of fragments is larger than 60°

Reconstruction of crime scene

Reconstruction of crime scene

Reconstruction of projectile impact conditions

Minimal projectile impact angle for which projectile can go over the right front side of the car is 62⁰.

# Projectile impact angle

Two positions of projectile without contact with car, left is impact angle 68⁰ (maximal range), and right is impact angle 73⁰

Projectile impact angle

- **Based on reconstruction and data from firing tables for gun 130 mm M46, impact angle of HE projectile 130 mm is in interval:**
  - $62^0 \leq \theta \leq 67^041'$
- **From firing tables for gun 130 mm M46 now it is possible to determine firing position for table conditions and for given impact angles:**
  - $26.500 \text{ m} \leq X_{VP} \leq 27.480 \text{ m}$

# Identification of caliber and projectile type

- It can be very precisely identifed caliber and projectile type based on found parts of rotating band bearing and rotating band iteslg or larger parts of projectile body.
- After examination of explosion site, Investigating comission found 178 fragments of different shape and mass, and from the dead bodies – 25 fragments were recovered.
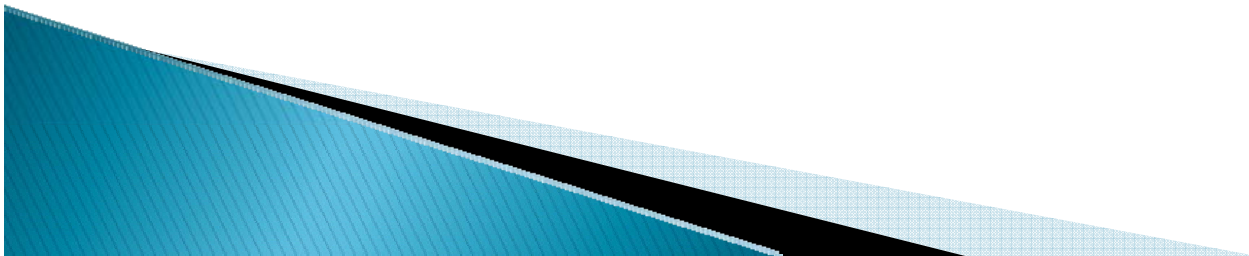
Identification of caliber and projectile type

Detail of rotating band bearing for projectile 130 mm M79 and photos of fragment parts from the zone of rotating band bearing
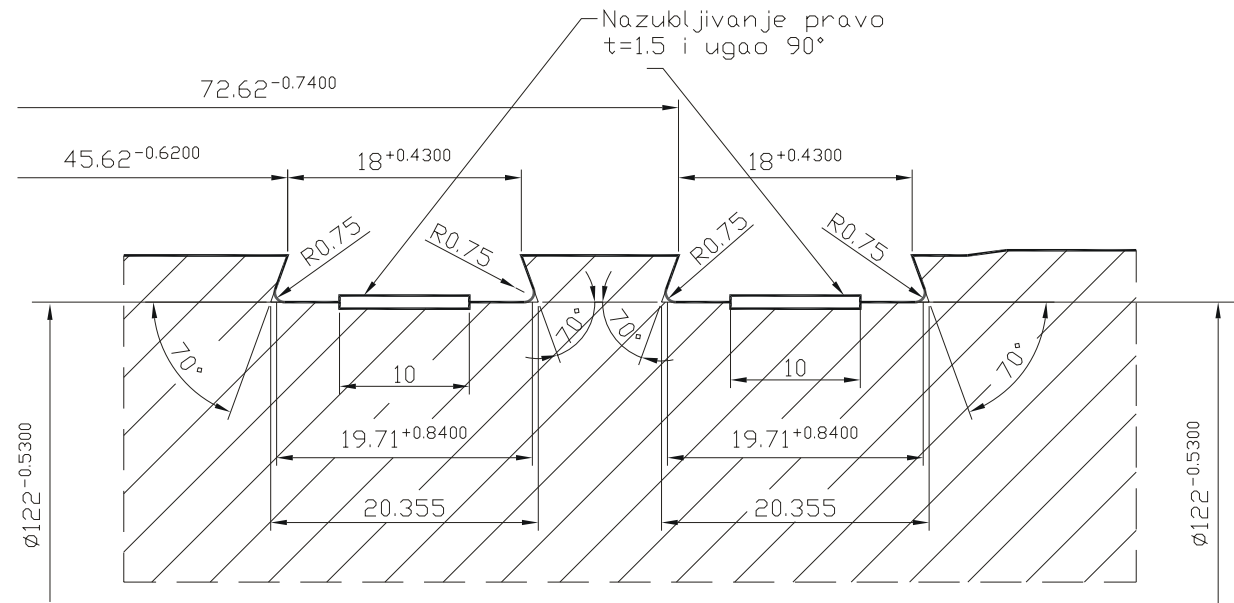
Recovered fragments from projectile 130mm M79
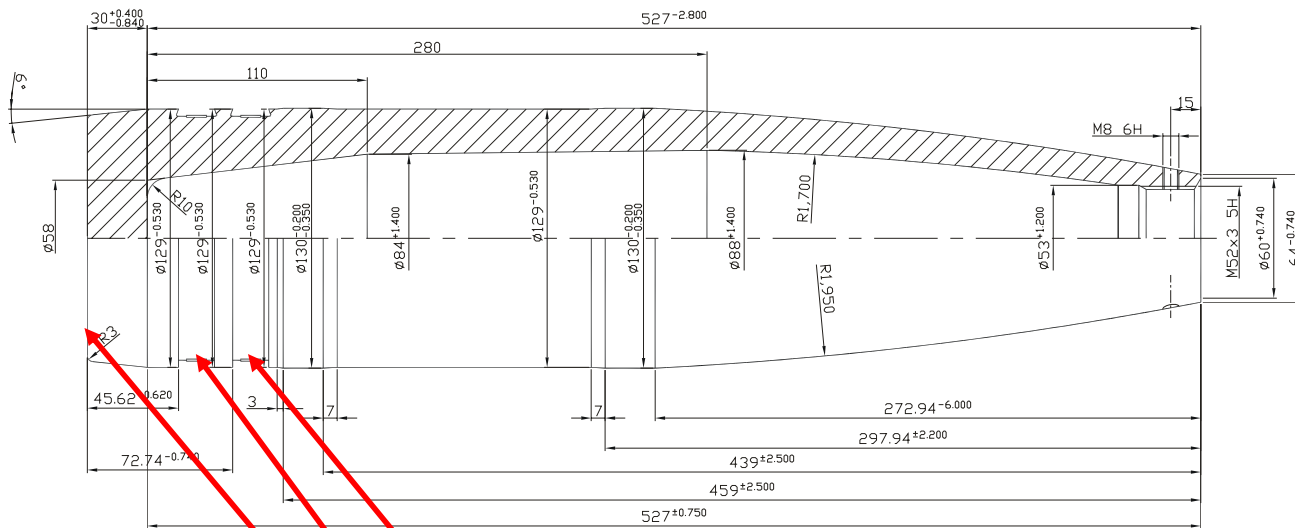
Recovered fragments from projectile 130mm M79

Parts of projectile 130mm M79
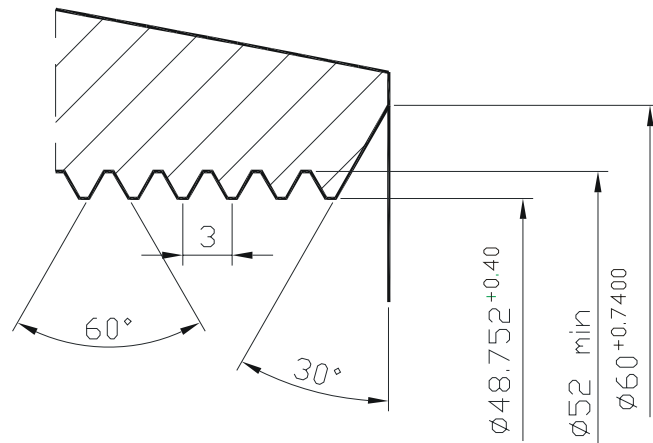

rotating band bearing

Place where found fragments originates. It is clearly seen that diamater of bottom is around 120mm

Parts of projectile 130mm M79

Detalj navoja M52x3 5H JUS.M.B0.013.
M 2:1

Detail of screw on top part of projectile

Details of fuze UTIU M72
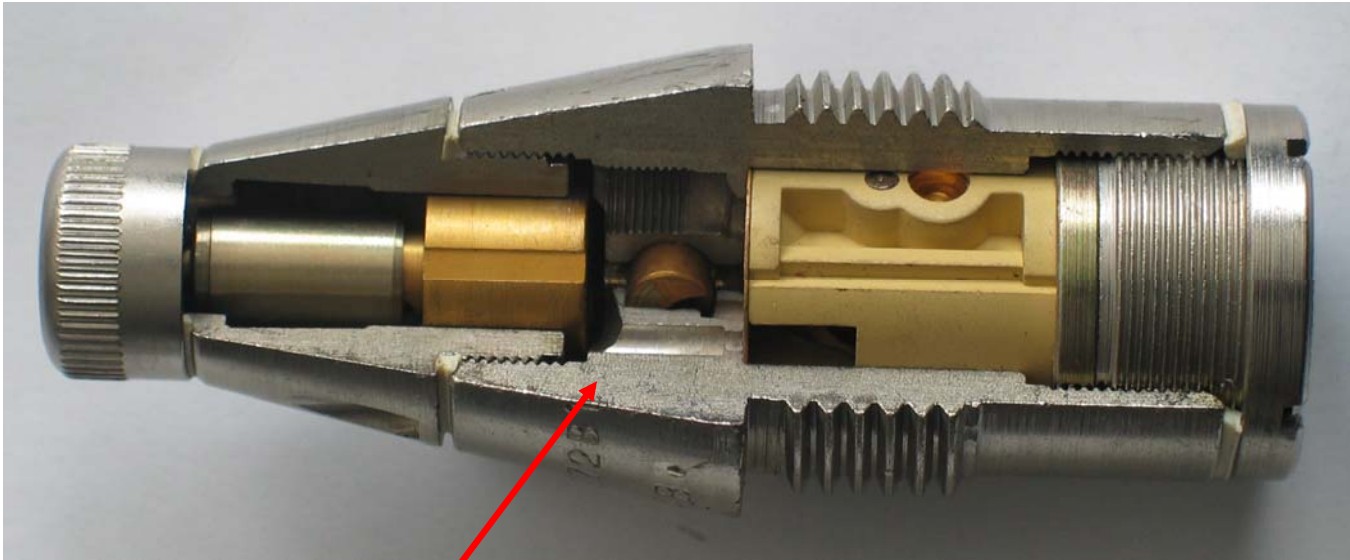
Adapter

3D intersection of projectile 130mm M79

Rotating band bearing
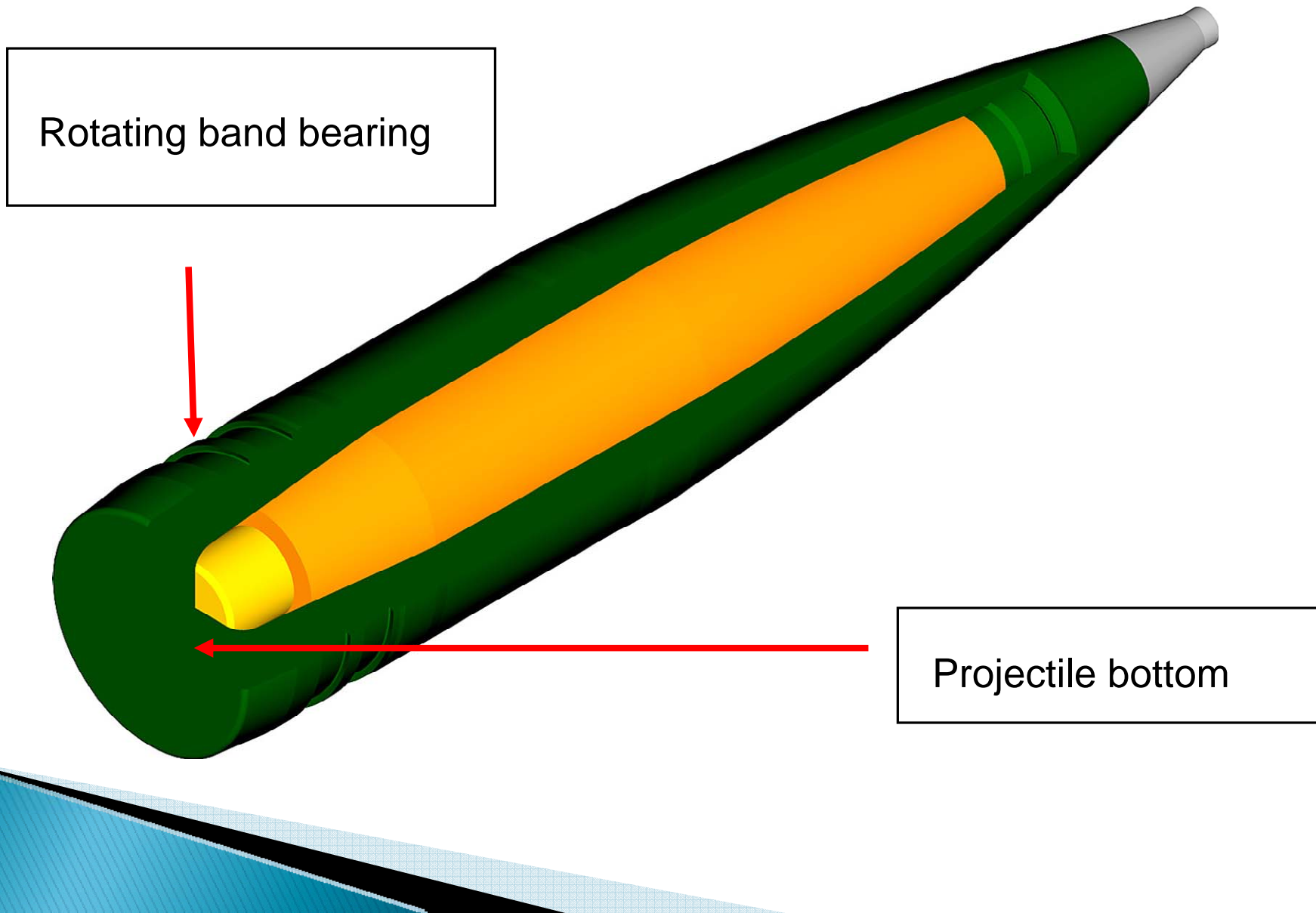
Projectile bottom

Projectile 130mm M79 identification

- Based on analysis of fragments from two independent regions of projectile body it is undoubtly determined that fragments found on explosion site originate from HE projectile 130 mm M79, which is launched from gun 130 mm M46.

- On square "Kapija" on 25.05.1995 at 20^{55} hours artillery projectile 130 mm M79 exploded, killed 71 person and wounded another 124.
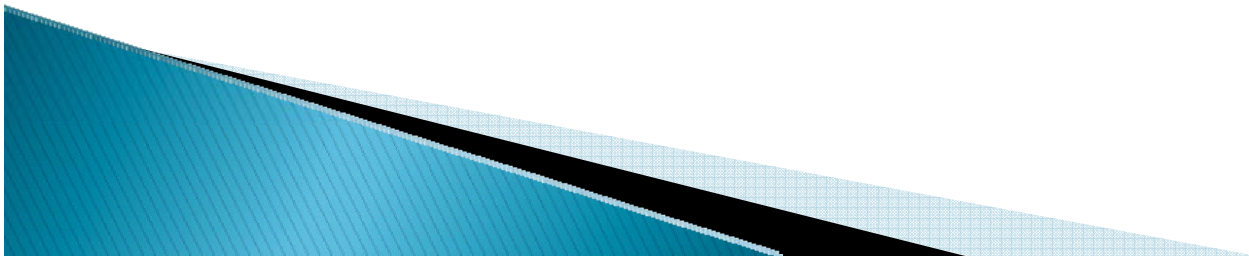
Terminal effects of projectile 130mm M79

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Terminal effects of projectile 130mm M79

- In standard artillery projectiles during detonation, primary effects are kinetic energy of fragments, and secondary effects are blast effects (overpressure)
- Effective force of shock wave is limited to small area – for projectile 130mm this area has diameter of 2,8m with its center in explosion center.
- According to US studies, overpressure for wich substantial human tissue damaged can occur are defined.
- At overpressure of 1,4 to 2 bar aspersion of lungs occurs, and at 7 to 15 bar death is imminent.
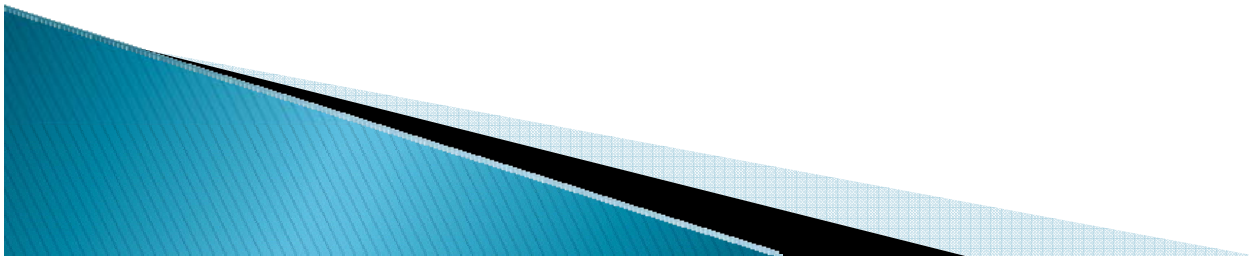
Terminal effects of projectile 130mm M79

‣ During natural fragmentation of projectile130 mm M79 4.000 zo 6.800 fragments are formed.

‣ Fragments with mass up to 10 g occupies 87% of total fragment number, while it is only 28% of total projectile body mass.

‣ 56% of fragments have mass larger than 1 gram.

‣ Kinetic energy of fragments, which is around 850m/s in initial moment, is dominant cause of hard injuries in wide open spaces.

‣ Radius of lethality for 130mm M79 is 27m from explosion center
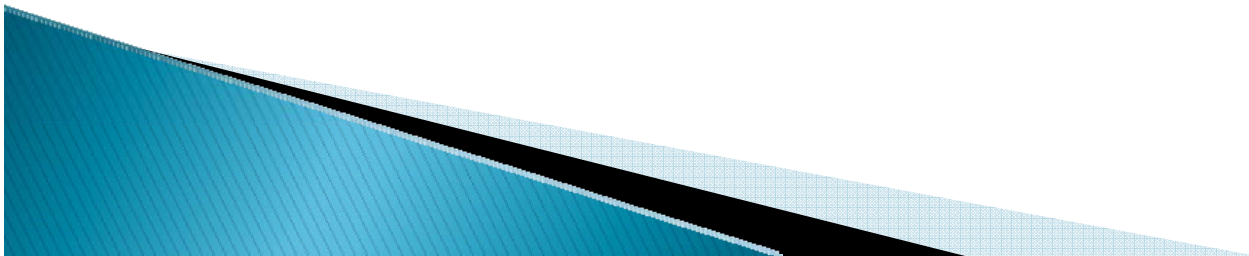
Terminal effects of projectile 130mm M79

- Hipoticaly, under conditions of constant fragment density, every person facing fragments would be hit with one lethal fragment.
- On distance 10m from explosion center, eery person could take in average 8,08 lethal fragments or 23,3 fragment with different impact energy in its body.
- On distance 5m from explosion center, eery person could take in average 14,9 lethal fragments or 23,3 fragment with different impact energy in its body.
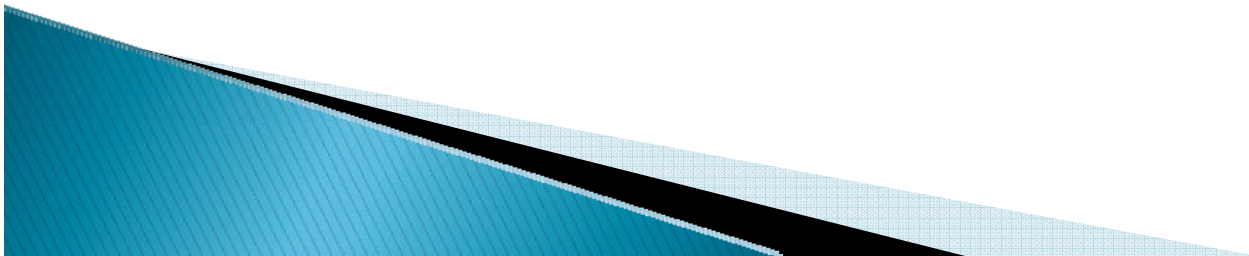
Terminal effects of projectile 130mm M79

▸ This is statistical analysis of real experimental data for 130 mm M79, and they clearly indicate that this projectile is very efficient against human targets, specialy if their density in terrain is large.

▸ If in the space between explosion center and defined point in space are people or other obstacles, so it is clear that obstacles and humans will absorb part of fragments and statistical analysis will have different character.
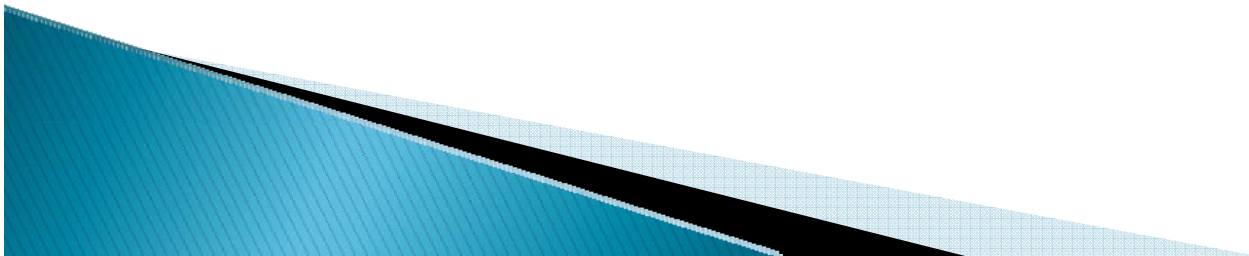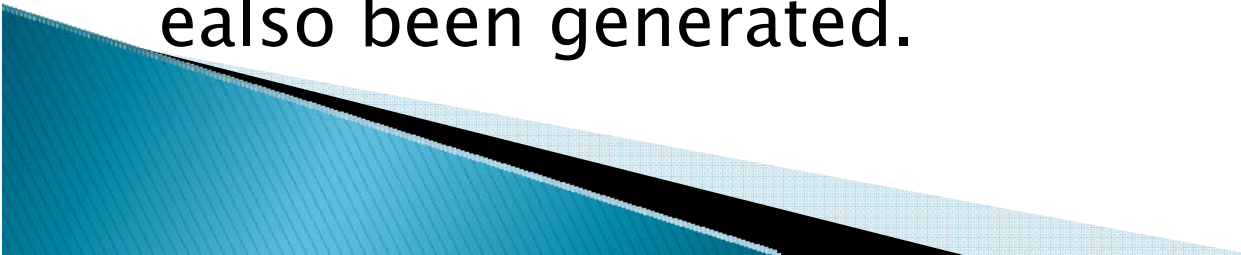
Terminal effects of projectile 130mm M79

- If we assume that people on distance 5m were faced to the center of explosion and that average width of human figure is 0,6m, than in this circle 52 people could statistically absorb around 15 lethal fragments.
- Assuming that all people were faced sideways toward the center of explosion, and if their width is 0,3m, than statisticaly 105 people could absorb 15 lethal fragments.
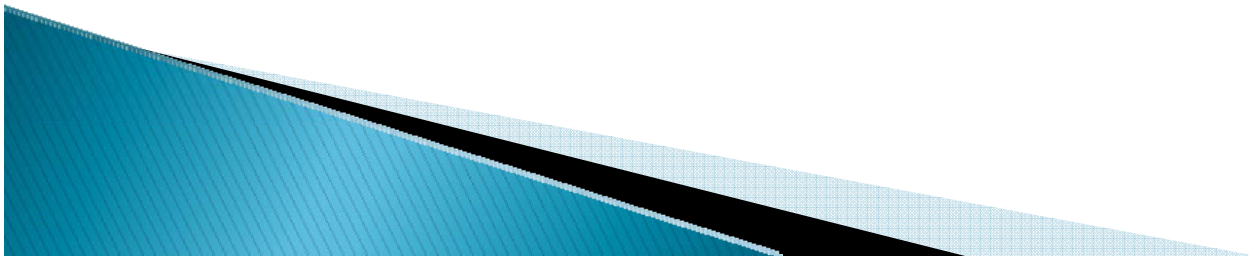
Terminal effects of projectile 130mm M79

- Fragment velocvity in explosion moment was in average larger than 850 m/s, so it is obvious that large number of fragments penetrated human body and exit and hit other people standing in its path.
- That means that number of person hit with lethal fragments would signifficantly increase, since human tissue is not homogenous target.
- In this case granite cubes ground played signifficant role.
- When fragment hits granite surface, some erosion of stone could occur, so secondary fragments could have ealso been generated.

Terminal effects of projectile 130mm M79

- Based on avalibale data on testing of 130 mm M79 and similar projectiles, it is possible to make simulation of spatial distribution of efficient fragments (with kinetic energy larger than 80J) in condition of impact angle of 60° and assess the influence of lateral fragment sprays on square "Kapija".
- On following picture lateral fragment sprays can be seen. Limit of lethal zone is on distance of 27m from explosion center and lateral spray is tilted around 30^0.
- Largest lethal zone is achived when impact angle of projectile is 90^0.

Terminal effects of projectile 130mm M79

Tlo

16 m

1,8 m

Lethal zone (human height is 1,8 m)
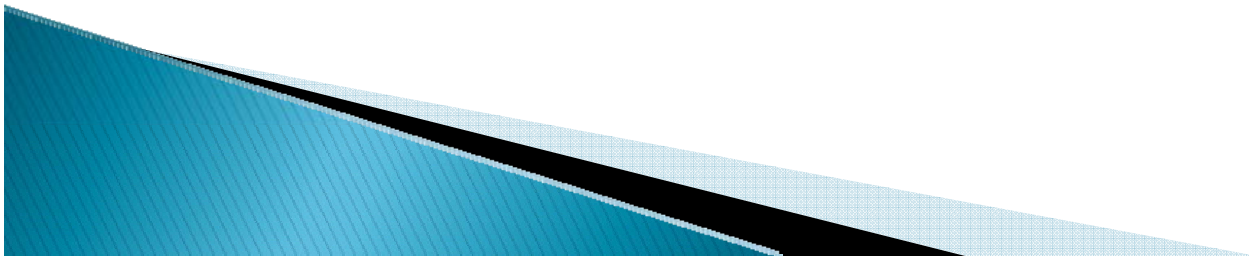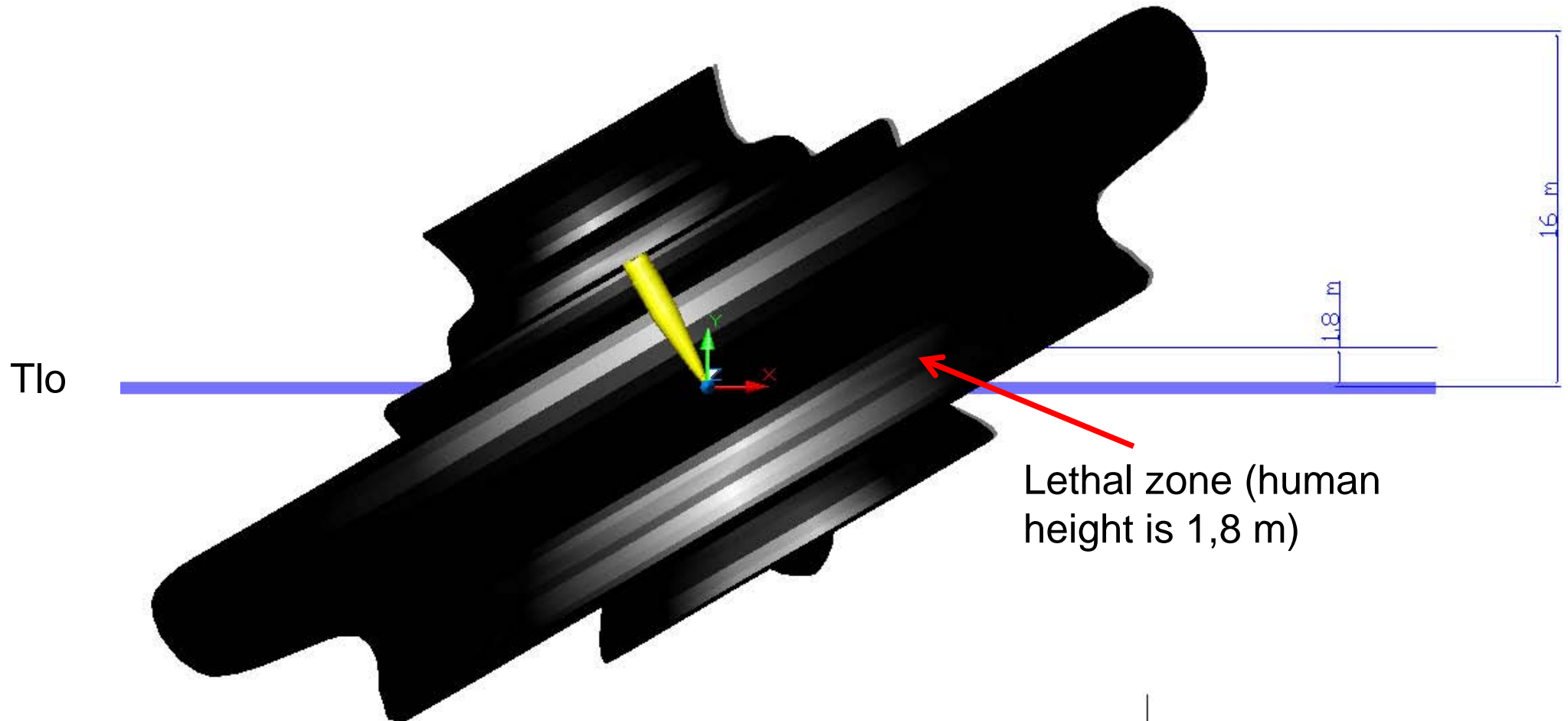
Results of investigation are fully compatible with findings of Investigation comission about casualty number (dead and wounded) and damage on object in square "Kapija". Total number of casualties is 195, where 71 persons were killed

Total lethal zone

Effective lethal zone
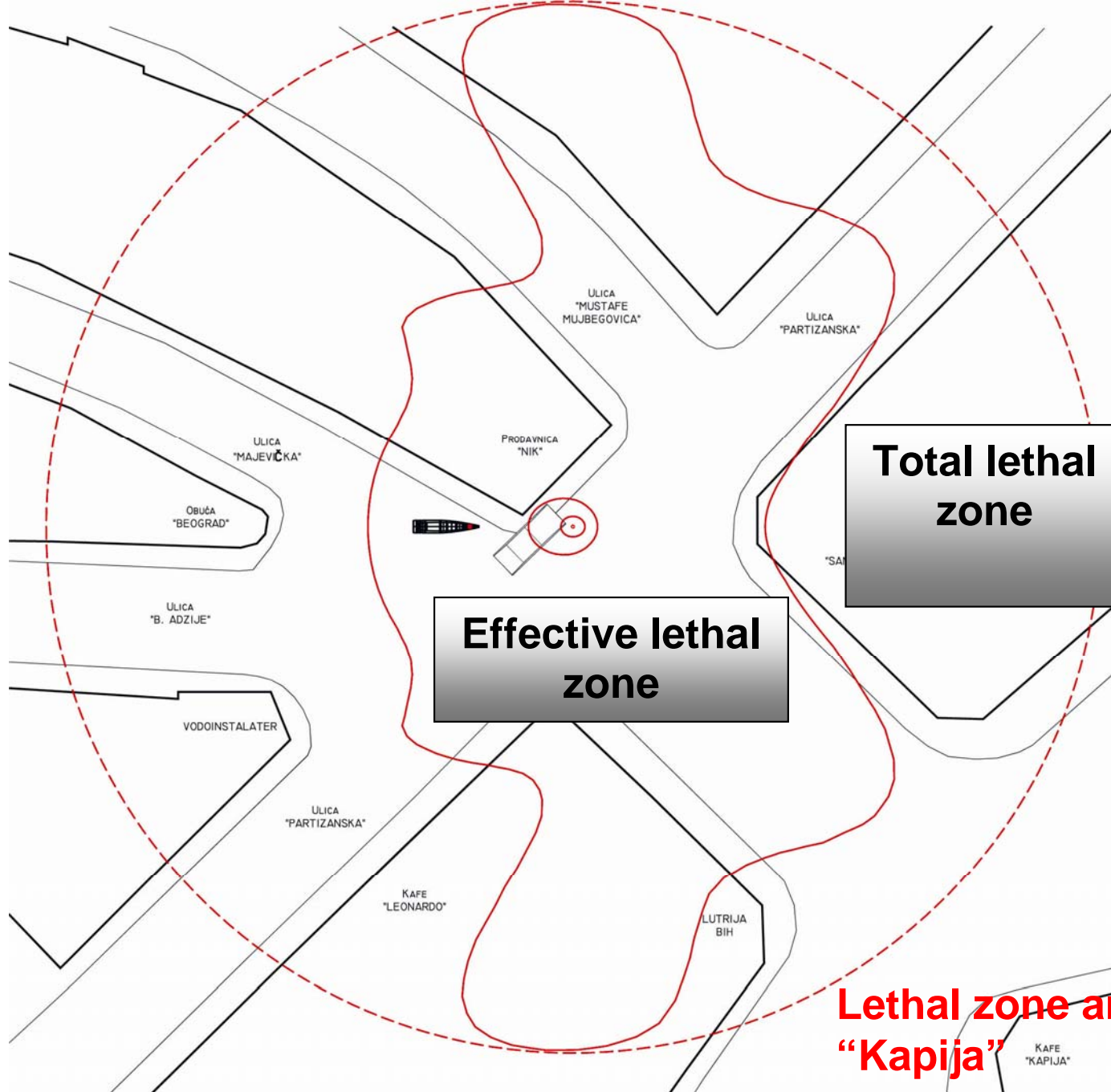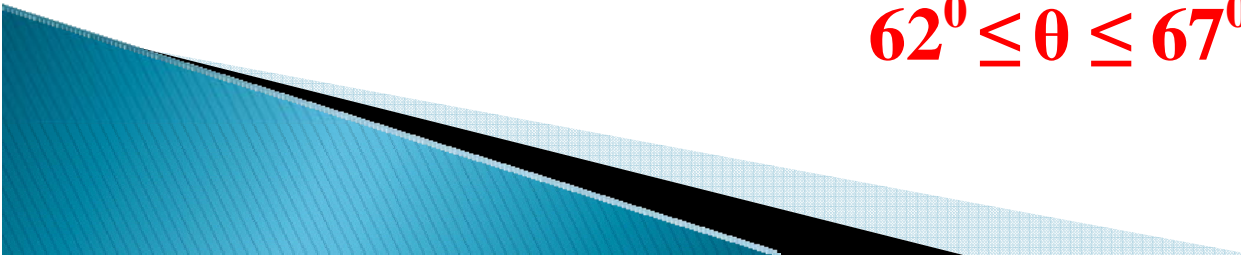
Lethal zone and damage zone in square "Kapija"

Probable launching zone

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Probable launching zone for projectile 130mm M79

Analysis of masacre location square „Kapija" concluded undoubtly following facts necessary for external-ballistic analysis, based on which probable launching zone is determined:

1. **Caliber and type of projectile is identified. Projectile exploded on 25.05.1995 at 20^{55} and caused human casualties. This projectile is HE projectile 130 mm M79 or OF-482 (russian designation)**

2. **Launching weapon was gun 130 mm M46.**

3. **Probable projectile flight direction was Az= $271^{0\ \pm 2,5}$.**

4. **Impact angle of projectile 130mm M79 was in interval:**

$$62^{0} \leq \theta \leq 67^{0}41'$$

Probable launching zone for projectile 130mm M79

▸ From firing tables for gun 130 mm M46 for given impact angles and table conditions, distance was:

$$26.500 \text{ m} \leq X_{VP} \leq 27.480 \text{ m}$$

▸ Gunsi 130 mm M76 are weapons which are towed by truck or wcaterpillar vehicles. Mass of weapon is over 8t, so they can be transported only over hard ground and fire position must be close to road.

▸ When we look topographic map on distance 26.500 m from impact point and azimuth of $271^{0 \pm 2,5}$, then it canbe seen that there is one road and village Panjik.

▸ In front of Panjik are villages Nešići and Blagojevići.

Probable launching zone for projectile 130mm M79
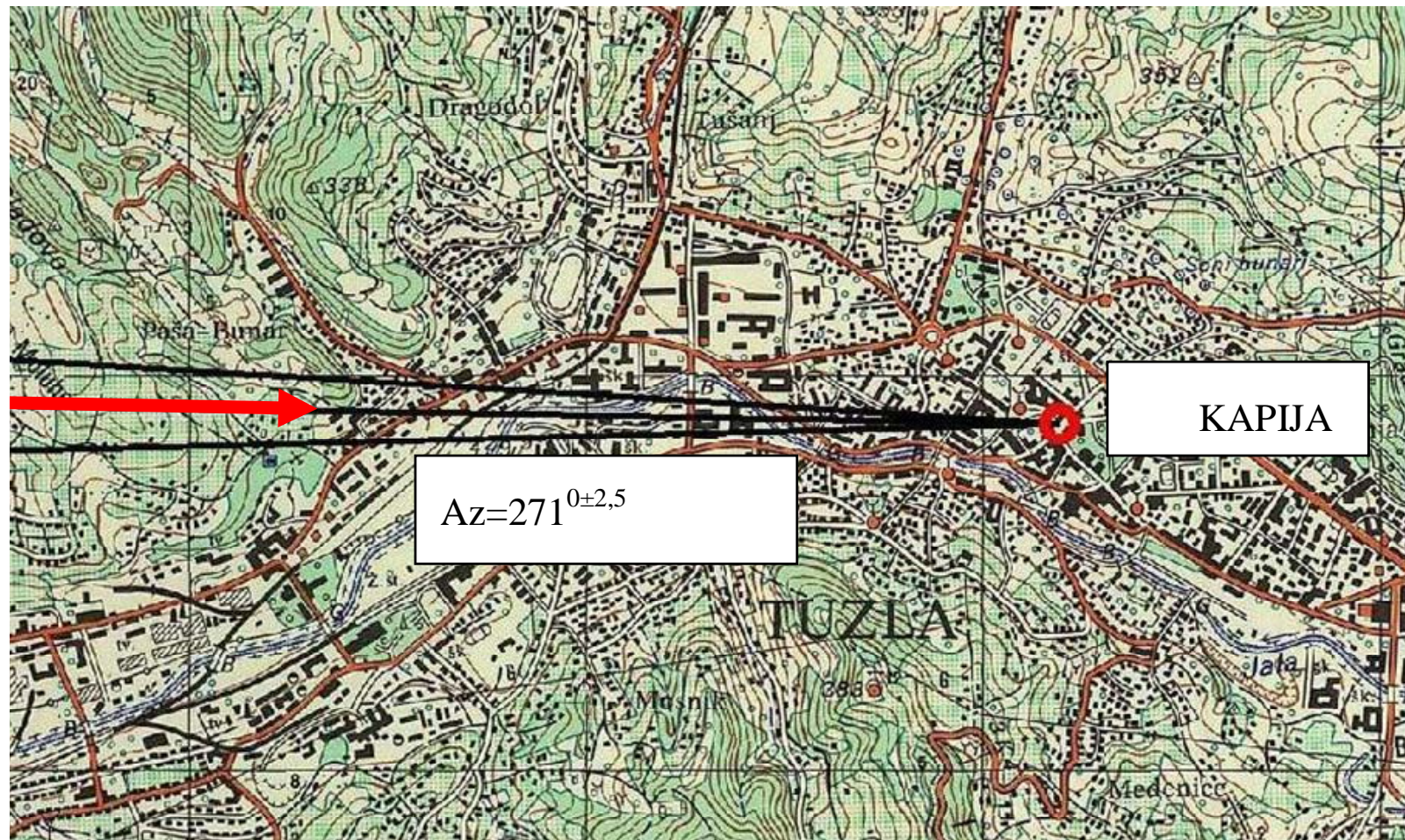
Map of wide location of explosion site with marked direction of flight

Probable launching zone for projectile 130mm M79

- Simulation are conducted for possible trajectories of projectile 130 mm M79 for full charge and data for meteo conditions were available (atmosphere).

- For simulation of trajectories for full charge ($V_0=930$ m/s) softver 3-DOF is used with original ballistic coefficients according to firing tables for gun 130 mm M46. Normal table conditions are adopted.

- Distance from gun 130 mm M46 is determined. It was range of 26.500 m (on map marked as minimal range) where condition of minimal impact angle (62°) is fullfilled.

Probable launching zone for projectile 130mm M79
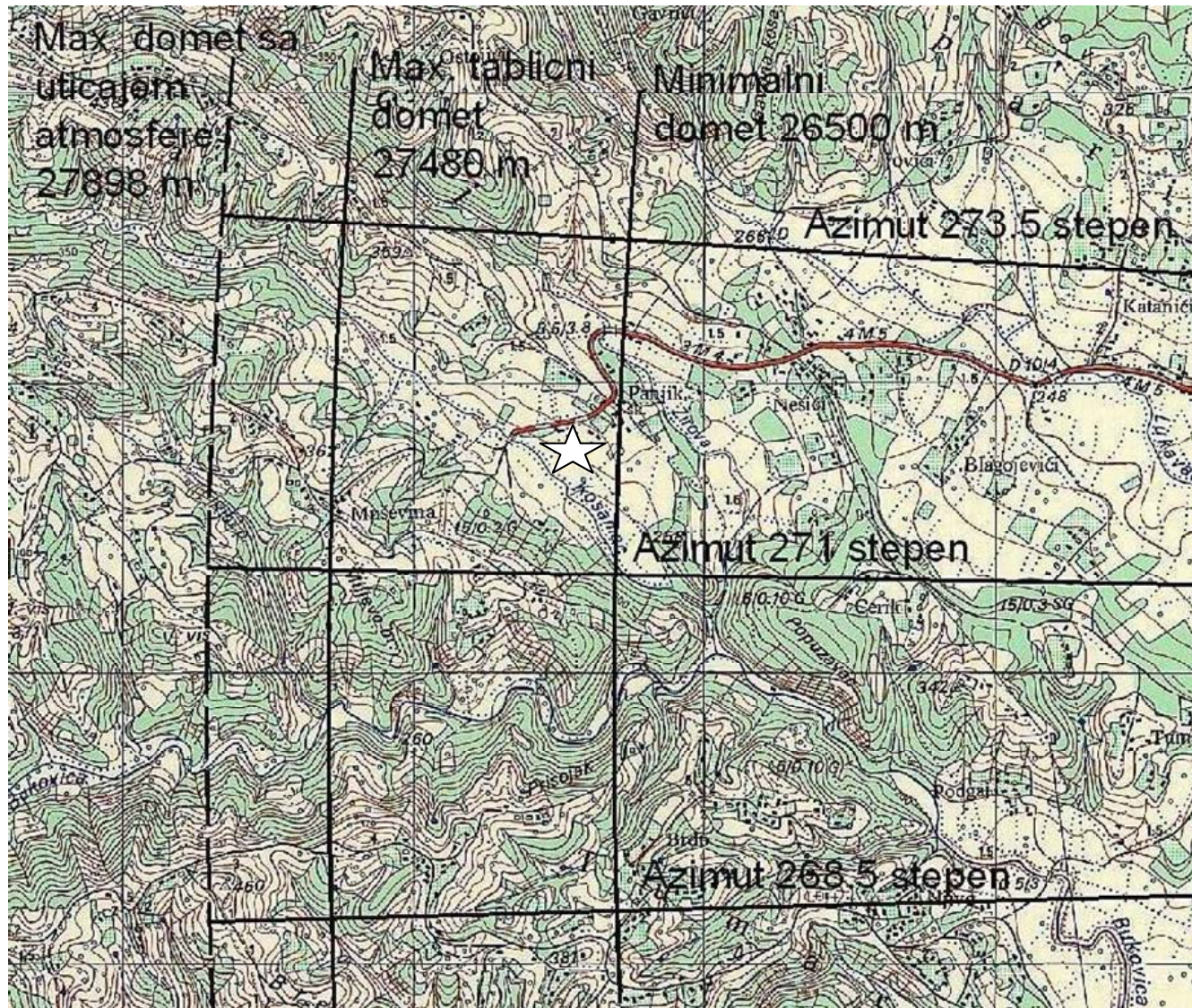
Caculated zone of position of firing post for gun 130 mm M46 (Probable zone is village Panjik, near the road and this location is marked with star)

Probable launching zone for projectile 130mm M79

	Launch angle	Flight time	Impact velocity	Impact angle	Range	Vertex
	38	76,941	341,32	-59,8205	26071,4	7476,4
	39	78,599	342,73	-60,608	26286,5	7779,4
	40	80,252	344,15	-61,3662	26487,9	8086,2
	41	81,889	345,58	-62,0935	26671,4	8395,2
	42	83,517	347,01	-62,7937	26838,7	8706,9
	43	85,132	348,47	-63,467	26989,1	9021,3
	44	86,734	349,93	-64,1121	27122,6	9337,4
	45	88,324	351,41	-64,7339	27237,7	9656,3

Basic table data for projectile 130 mm M79 with condition of height difference between fire position and explosion site
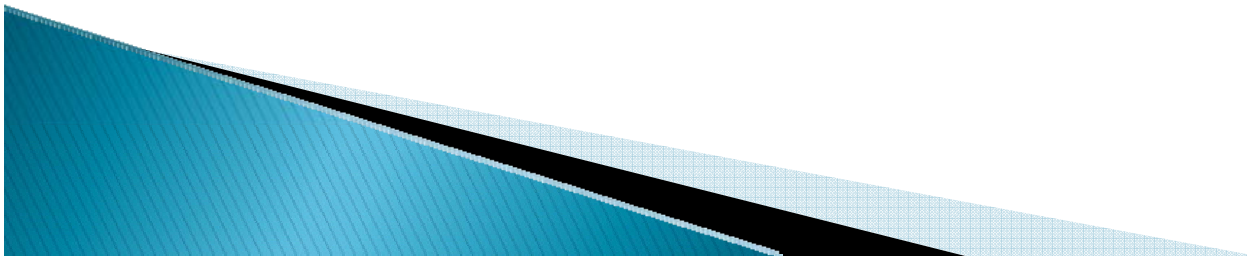
Probable launching zone for projectile 130mm M79
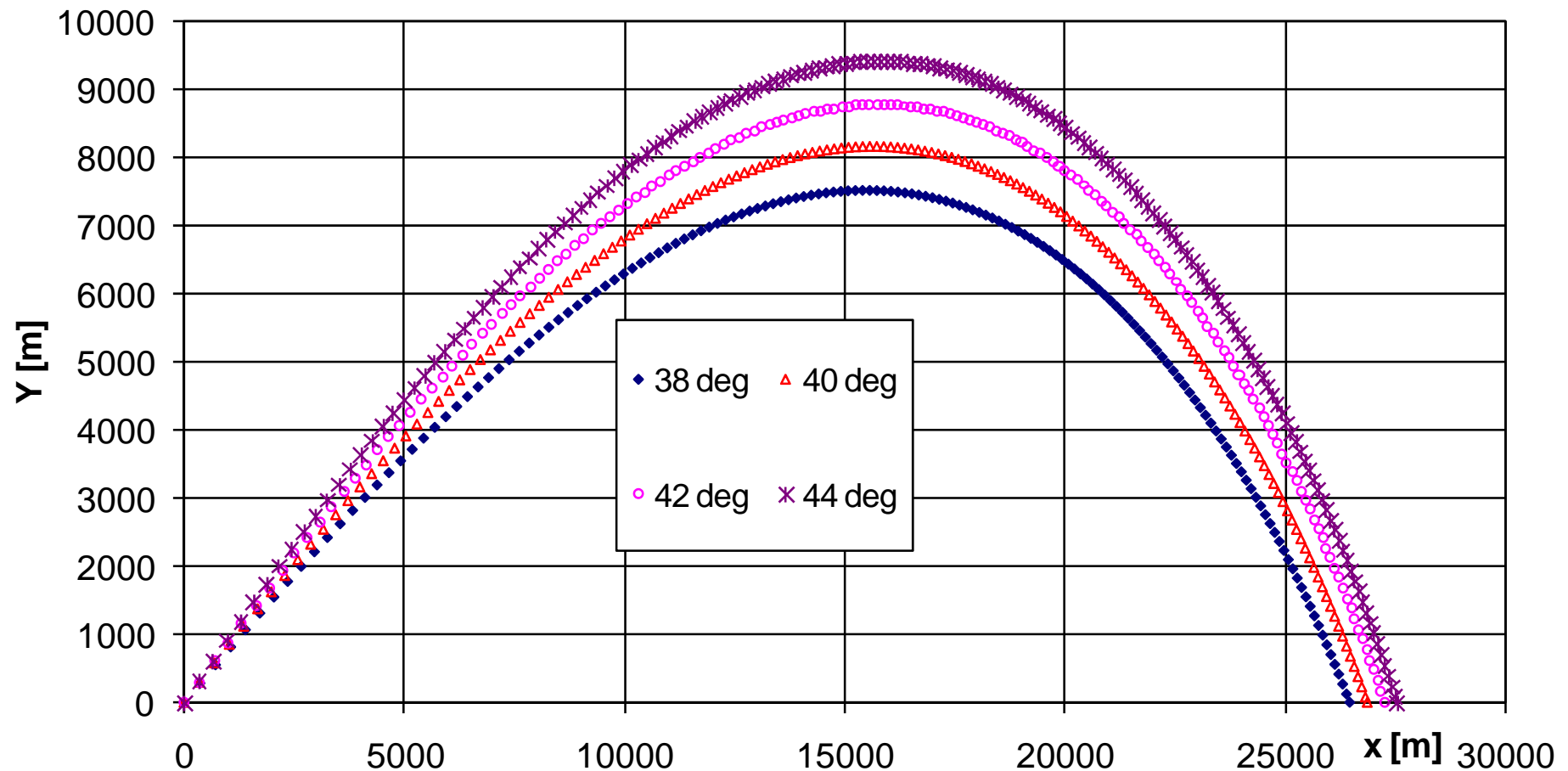
Trajectory of projectile 130 mm M79 with calculated atmospheric parameters on 25.05.1995.

Probable launching zone for projectile 130mm M79

	Launch angle,	Flight time	Impact velocity	Impact angle	Range	Vertex	Deviation
	38	77,599	343,77	-59,8412	26507,0	7583,1	41,3
	39	79,274	345,27	-60,6238	26729,4	7892,0	42,2
	40	80,942	346,79	-61,3761	26937,8	8203,9	43,0
	41	82,594	348,31	-62,0980	27128,2	8518,9	43,8
	42	84,236	349,85	-62,7924	27301,8	8836,2	44,6
	43	85,865	351,40	-63,4611	27458,0	9156,5	45,3
	44	87,482	352,97	-64,1013	27597,1	9478,8	46,0
	45	89,084	354,55	-64,7195	27717,4	9803,4	46,7

Basic table data for projectile 130 mm M79 with condition of height difference between fire position and explosion site, and parameters of atmosphere, determined using 3DOF software
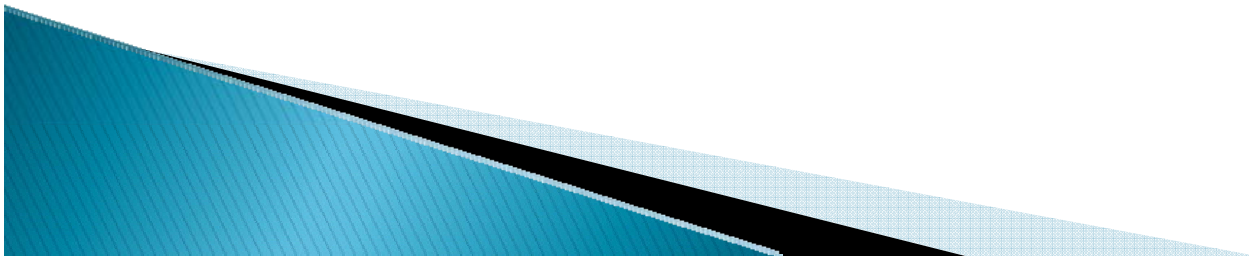
Probable launching zone for projectile 130mm M79

▸ Considering the influence of atmosphere and other parameters and that posistion of fire post was 30m above altitude of explosion site, minimal distance of fire post (position behind village Panjik iz marked with star) is:

$$X_{VP}= 27.100\pm380 \text{ m}$$

Probable launching zone for projectile 130mm M79

- According to available map with displacement of artillery command of Second Ozren Light Infantry Brigade, from 29.04.1994, it is clearly seen – in that moment two artillery guns 130 mm M46 were in village Blagojevići.
- On this map, targets were designated, and these corresponds with zone where projectile detonated.
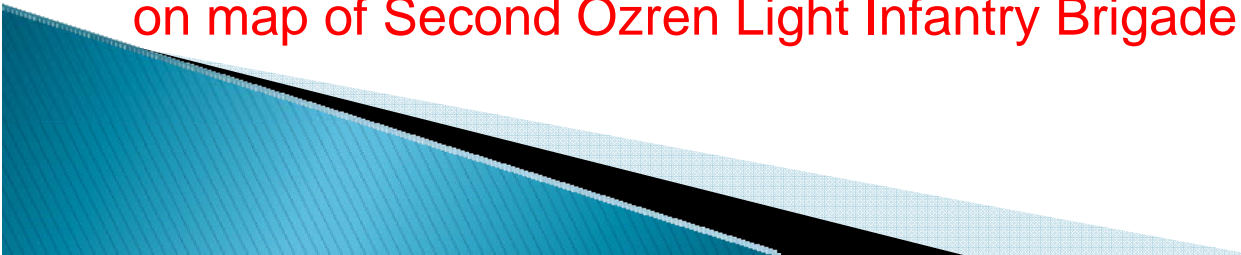
Probable launching zone for projectile 130mm M79

VP Panjik

VP Blagojević

Trg Kapija

Displacement of artillery posts of guns 130 mm M46 and targets in city of Tuzla on map of Second Ozren Light Infantry Brigade, dated from 29.04.1994.

Probable launching zone for projectile 130mm M79
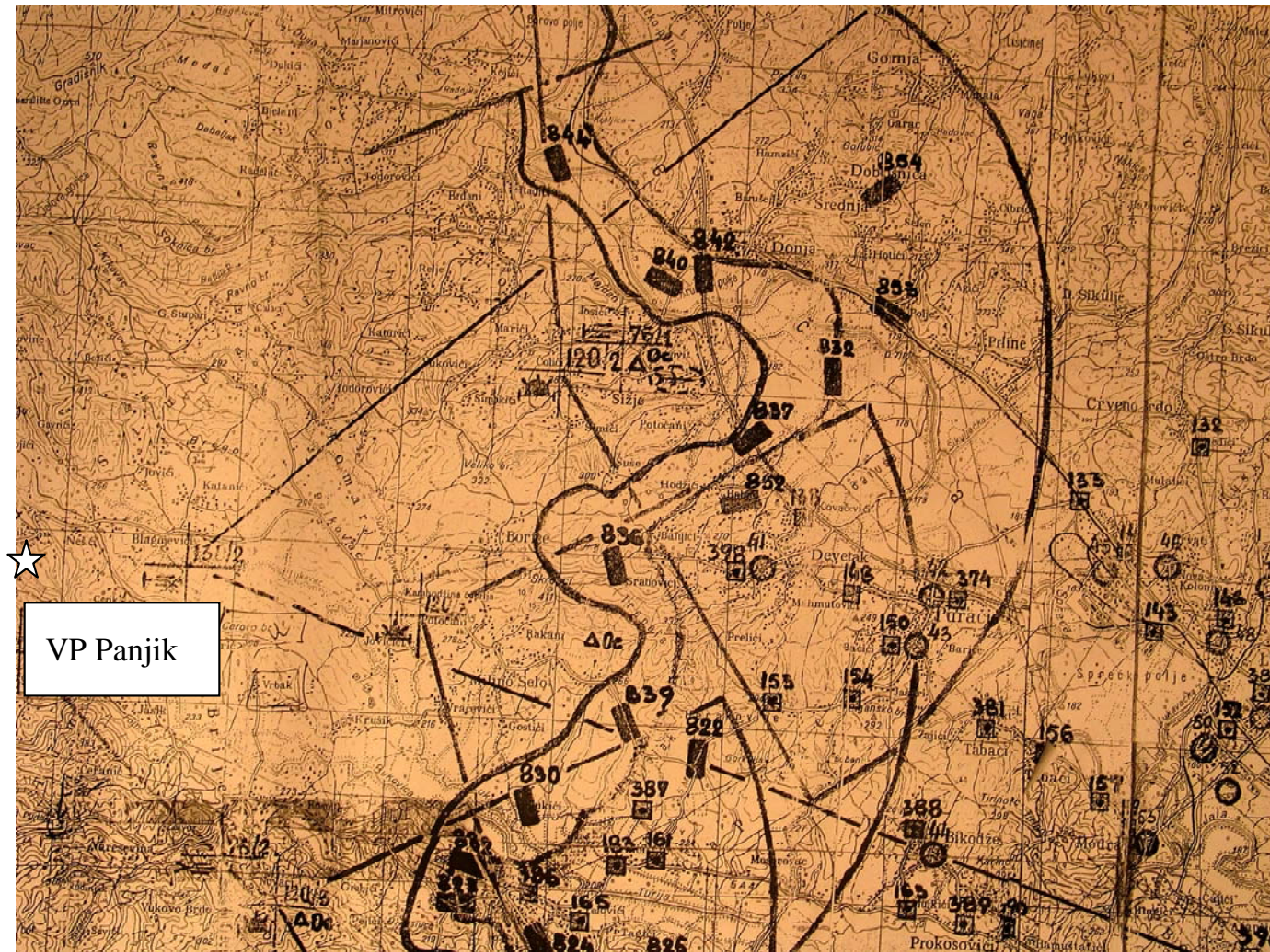
VP Panjik

Distance of fire post Blagojevići from fire post Panjik is only 2km and along both posts roads are present

Probable launching zone for projectile 130mm M79
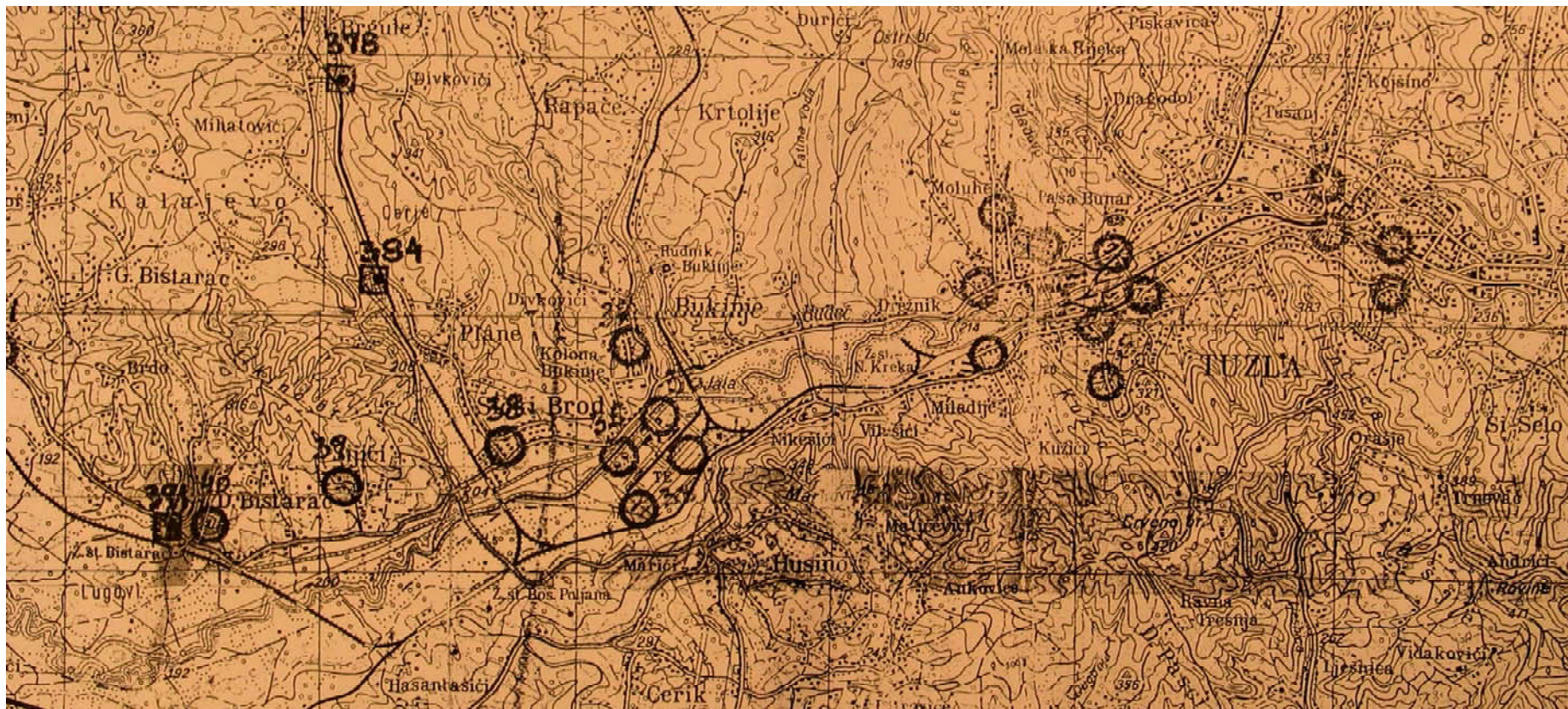
Defined targets in Tuzla for guns 130 mm M46, according to artillery command of Second Ozren Light Infantry Brigade, from 29.04.1994.

Probable launching zone for projectile 130mm M79
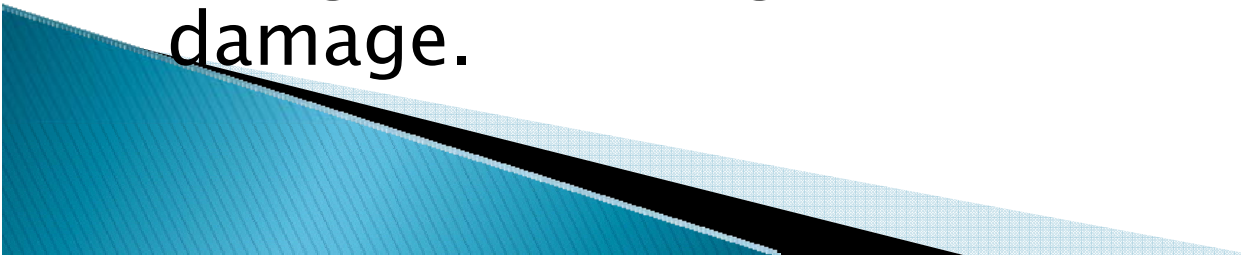
Location of projectile explosions, launched from zone on distance of 26km and more

Probable deviation and dispersion for projectile 130mm M79

Probable deviation and dispersion for projectile 130mm M79

- In firing tables for gun130 mm M46 and for HE projectile 130 mm M79 probable deviation and dispersion asre given.
- Values of deviation and dispersion are changed with increase of range (and by changing angle of launch.
- From definition of probable circular error it is clear that some projectiles will have larger deviation regarding the target.
- This shows that there is no possibility that unguided artillery or rocket projectiles can hit designated target, without causing collateral damage.

Probable deviation and dispersion for projectile 130mm M79
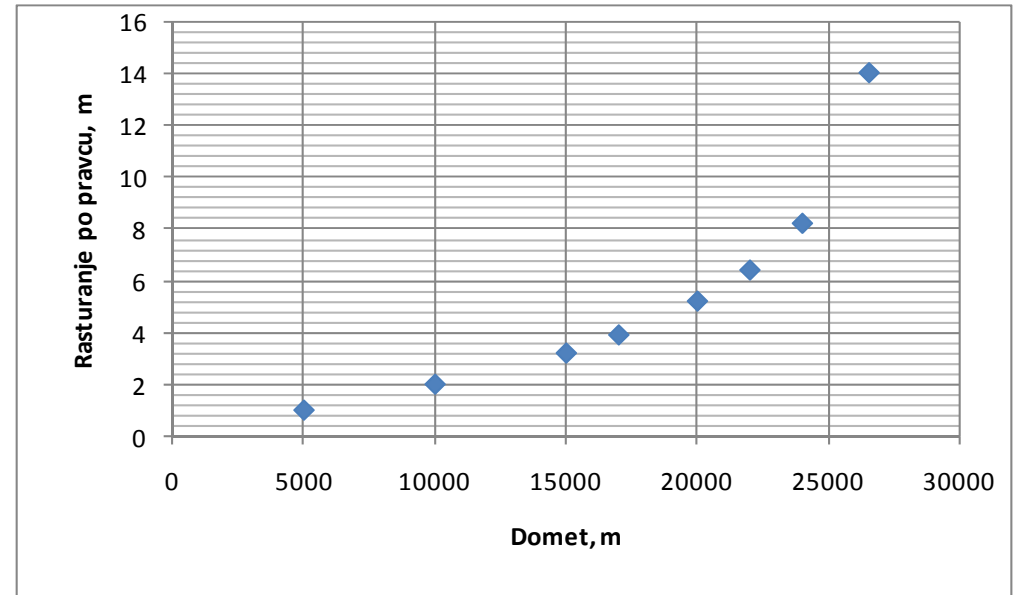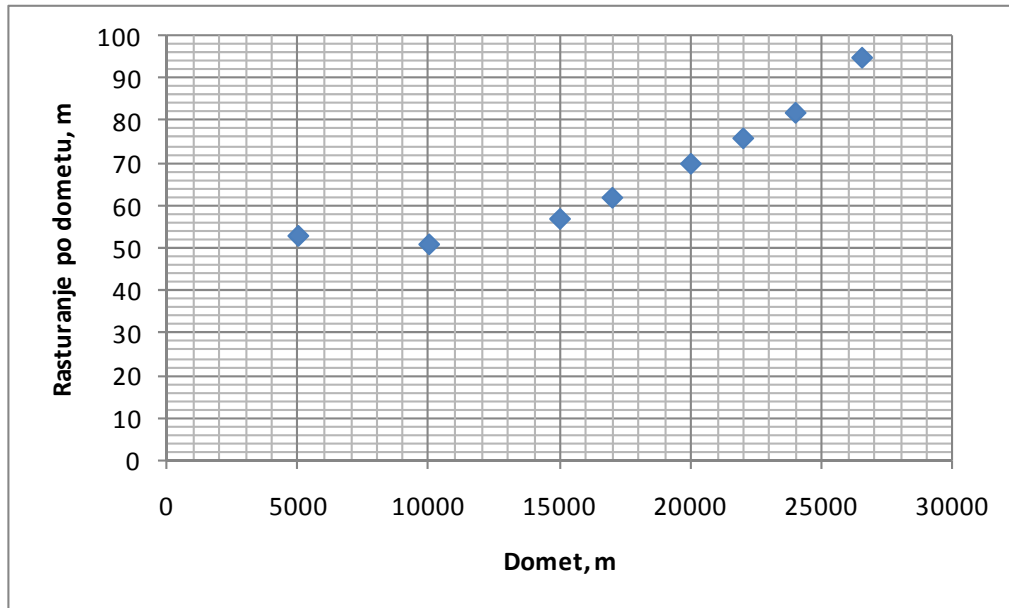
Table deviation and dispersion for projectile 130 mm M79
launched from gun 130 mm M46

Probable deviation and dispersion for projectile 130mm M79

▸ For gun 130mm M46 and projectile 130 mm M79 this means that in conditions when we know atmospheric parameters (temp., pressure, humidity, wind speed), projectile mass, wearness of gun tube, it is possible that impact point of projectile is located up to $\pm 4Vd$ regarding designated target point (380 m in range of 27.450 m), and $\pm 4Vp$ (left or right frm firing direction 56 m).

▸ System is complicated if there is no control over parameters of atmosphere or control ow gun tubes.

Probable deviation and dispersion for projectile 130mm M79

| Deviation because of change of:						
Range	Air temperature for 10°	Air pressure for 10 mbar	Propellant temperature for 10°	Axial wind for 10 m/s	Initial velocity for 10 m/s	Possible extreme deviation of range
15000	200	79	238	175	197	889
18000	259	105	268	270	222	1124
20000	292	121	291	343	241	1288
24000	330	154	352	517	291	1644
26542	273	193	450	703	372	1991

Table values of deviation because of change of parameters which ifluence the range of projectile for 130 mm M79 launched from gun 130 mm M46.

Data show that it is not possible to fire at individual targets, without causing signifficant collateral damage.
Term Collateral Damage which describes unexpected destruction on military and civilian targets, clearly indicates awareness of military commanders that their "sofisticated" weapons in real combat conditions have expected errors when hitting the target.

Conclusions
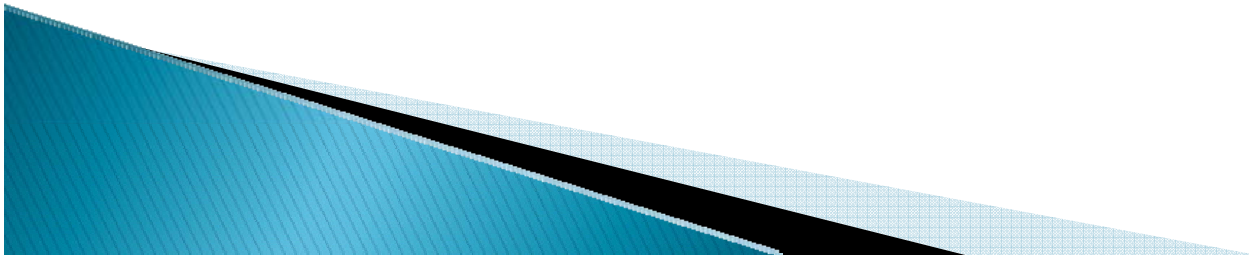
Conclusions

Projectile that hit town Tuzla, locality called "Kapija" on 25.05.1995 at 20:55 hours was fired from artillery weapon for indirect firing, **gun 130 mm M46**.

Projectile caliber is 130 mm, type **HE projectile 130 mm M79** or OF-482 (russian designation).

Probable flight direction was $\mathbf{A_z = 271^{0 \pm 2,5}}$.

Interval of impact angle for projectile 130mm in moment of explosion was:

$$62^0 \leq \theta \leq 67^0 \text{ i } 41'$$

Based on impact angle, possible fire positions were determined – minimal distance from impact point. From firing tables for gun 130 mm M46 for given impact angles and table conditions, **distance** was:

$$26.500 \text{ m} \leq X_{VP} \leq 27.480 \text{ m}$$

Conclusions

- Guns 130mm M46 are heavy weapons towed with trucks or wheeled cars. Weapon mass is around 8T, so transport can be dane only across solid ground and fire position must stay close to roads.

- Considering known data on projectile, impact angle, atmospheric parameters on day 25.05.1995, and considering that fire post was around 30m above explosion site, calculation of projectile trajectories was made using software 3-DOF with ballistic coefficient from firing tables for gun 130 mm M46 and **minimal distance from firing post** was determined:

$$X_{VP} = 27.100 \pm 380 \text{ m}$$

- From topographic ground map in given zone and with azimuth interval $271^0 \pm 2,5^0$, it can be clearly seen that in this area there is only one road and village – **Panjik**.

Conclusions

- HE projectile 130mm M79 during natural fragmentation process forms
- from **4000-6800 fragments** of different mass and shape.
- Average fragment velocity was 850 m/s.
- Equivalent lethality radius for HE projectile 130 mm M79 is around **27 m**, where every target with area of $1m^2$ on given distance takes impact of minimum one lethal fragment (with kinetic energy minimal 80J).
- In analysis it is clearly indicated that efficient lethal zone completely corresponds to destruction effect of human target, that took place on 25.05.1995 at 20:55 hours on square „Kapija".
- For gun 130mm M46 and projectile 130mm M79 in conditions of complete knowledge of atmospehric parameters (temp., presssure, humidity, wind speed), projectile mass, gun tube damage, etc, it is possible to fire at target which is located up to $\pm4V_d$ related to target location (±380 m for range of 27.450 m), and also $\pm4V_p$ (left or right of firing direction 56 m).
- **With gun 130 mm M46 and projectiles 130 mm M79 it is not possible to fire at individual targets in urban areas, without inflicting considering collateral damage to local population.**