



Univerzitet u Beogradu – Građevinski  
fakultet [www.grf.bg.ac.rs](http://www.grf.bg.ac.rs)

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Studijski program:

**GRAĐEVINARSTVO**

Modul:

**MASTER STUDIJE**

Godina/Semestar:

**1 godina / 1 semestar**

Naziv predmeta (šifra):

**Geoinformacioni sistemi u  
saobraćajnicama (M2S1GI)**

Nastavnik:

**Aleksandar Sekulić**

Naslov predavanja:

**Daljinska detekcija**

Datum :

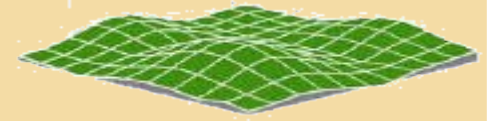
10.11.2021.

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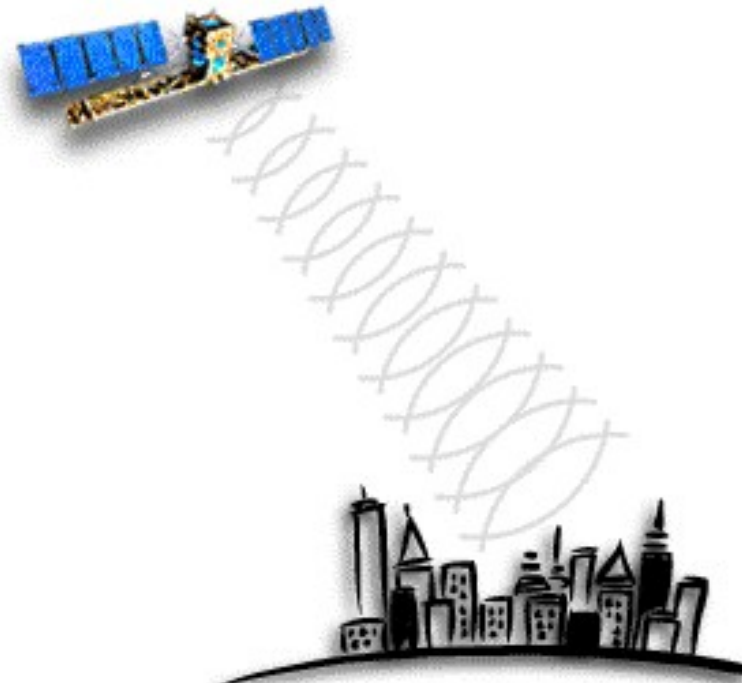
*Beograd, 2021.*

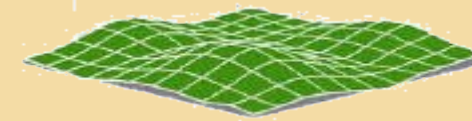
*Sva autorska prava autora prezentacije i/ili video snimaka su zaštićena. Snimak ili prezentacija se mogu koristiti samo za nastavu na daljinu studenta Građevinskog fakulteta Univerziteta u Beogradu u školskoj 2021/2022. i ne mogu se koristiti za druge svrhe bez pismene saglasnosti autora materijala.*

# Definicija daljinske detekcije

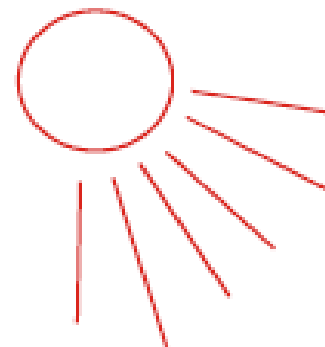
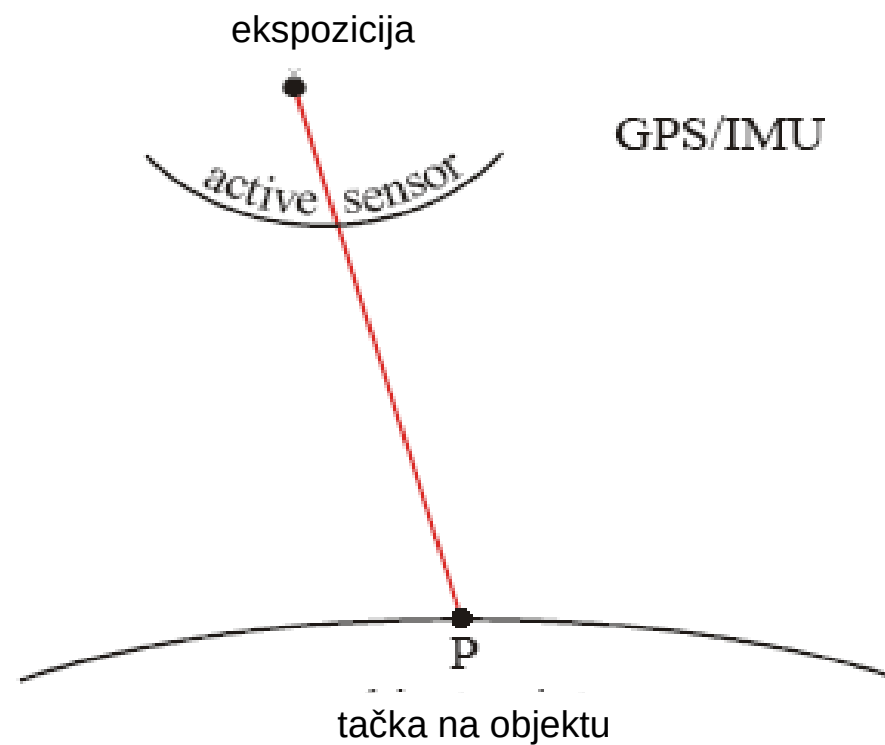


- Daljinska detekcija je nauka (u nekom smislu veština) prikupljanja informacija o Zemljinoj površi i objektima koji se nalaze na njoj, a da se tom prilikom ne dolazi u kontakt sa njima. To se obavlja registrovanjem odbijene ili emitovane energije od površi Zemlje i objekata uz naknadno obrade i analize i kasniju primenu takvih informacija.

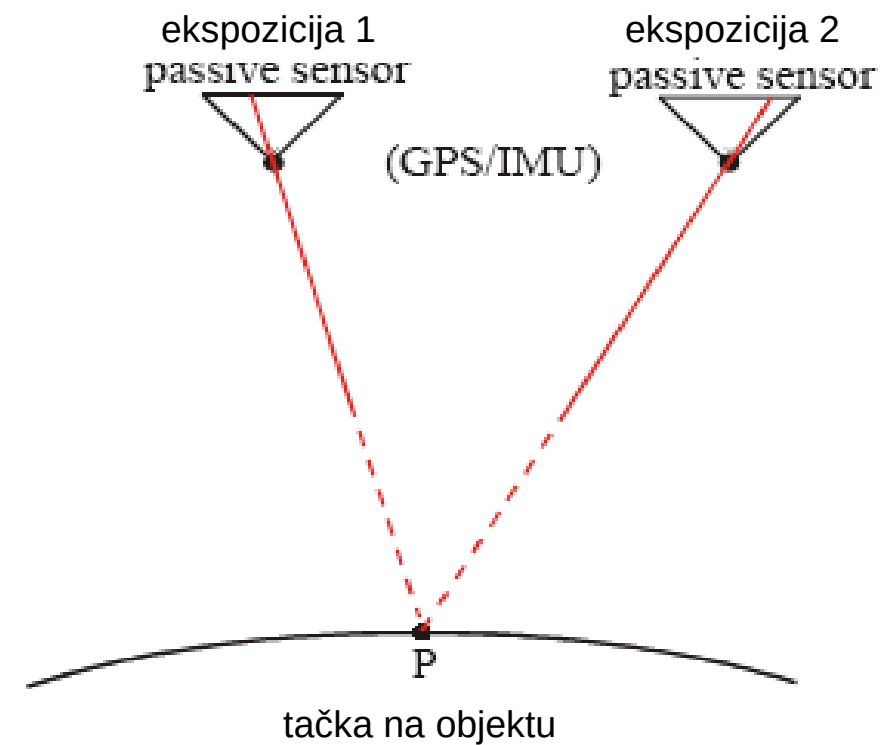




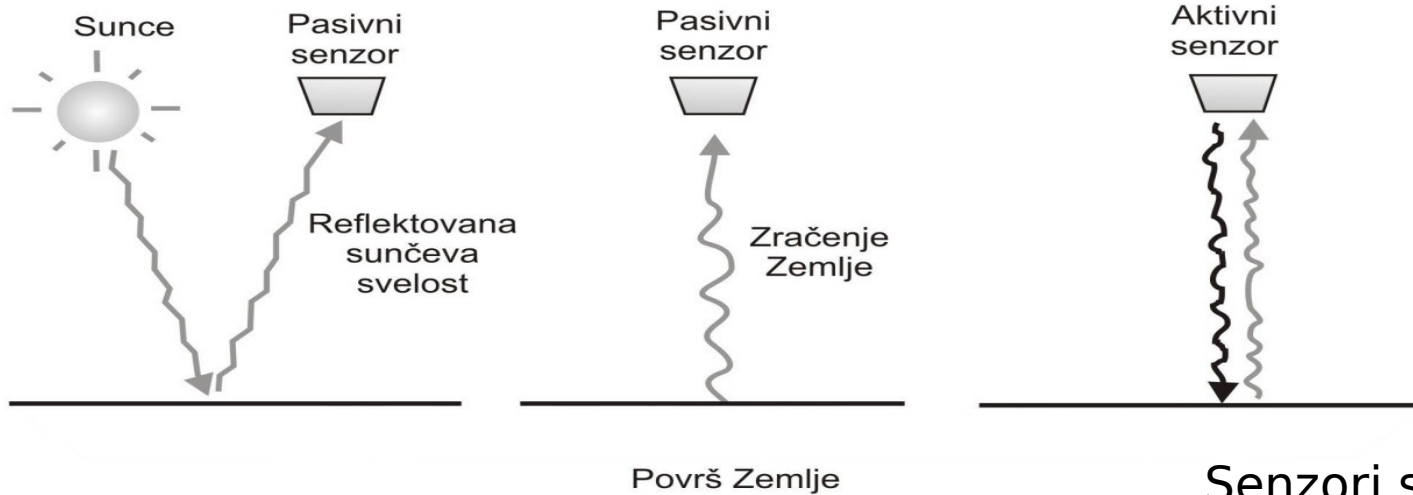
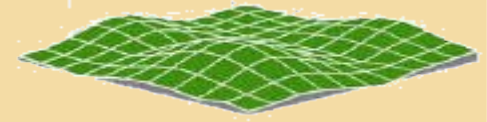
## LASERSKO I RADASKO SNIMANJE



## FOTOGRAMETRIJA I SATELITSKI SNIMCI

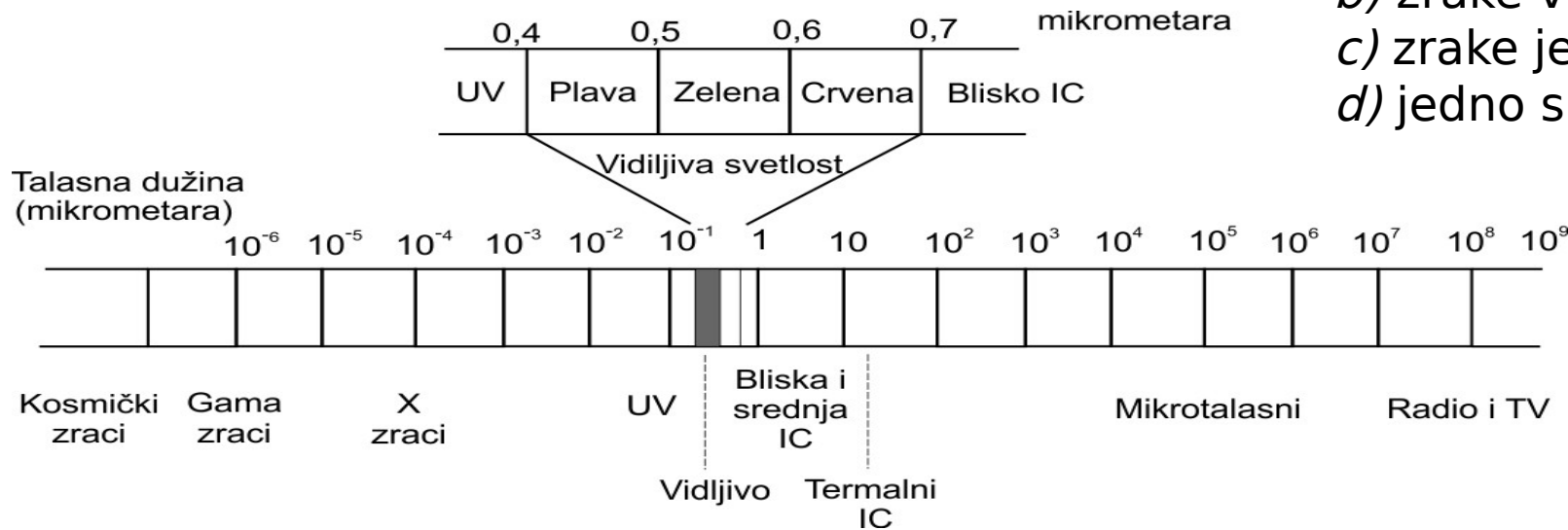


# Aktivni i pasivni senzori

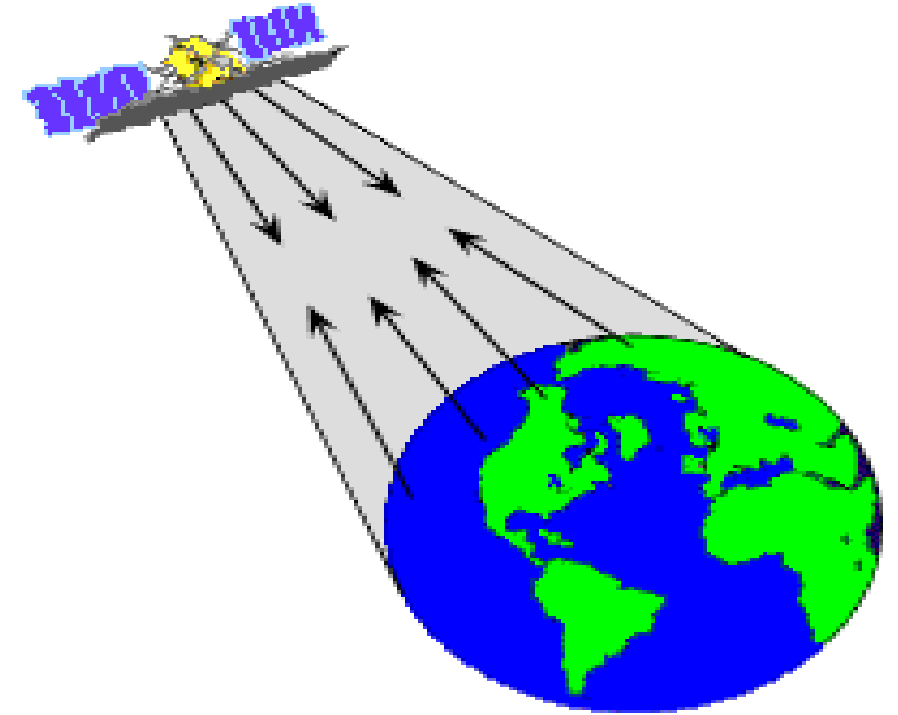
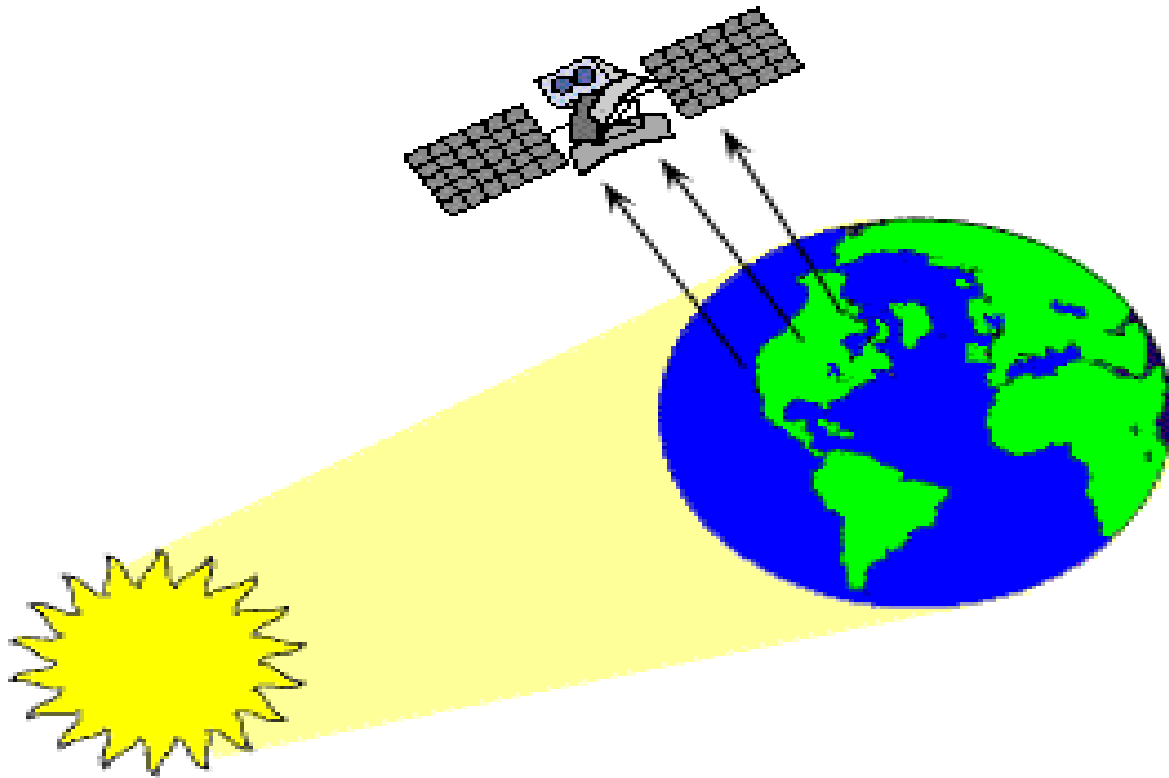
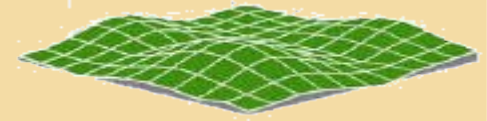


Senzori su konstruisani tako da registruju:

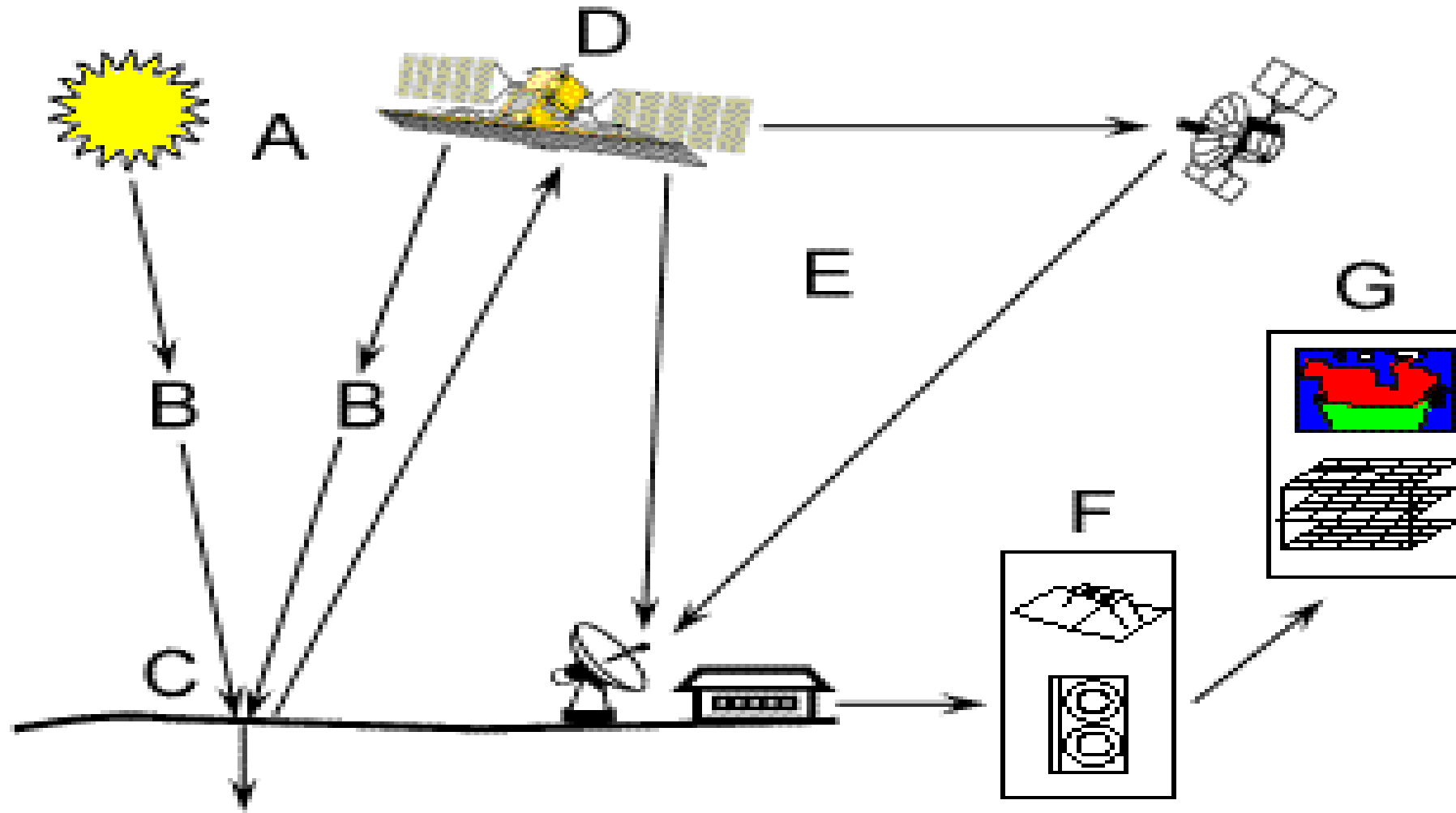
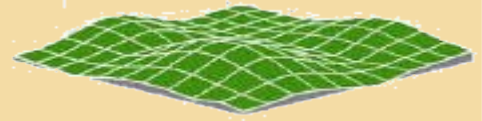
- a) šire ili uže spektralno područje,
- b) zrake više različitih talasnih dužina u celini,
- c) zrake jedne talasne dužine,
- d) jedno spektralno područje.



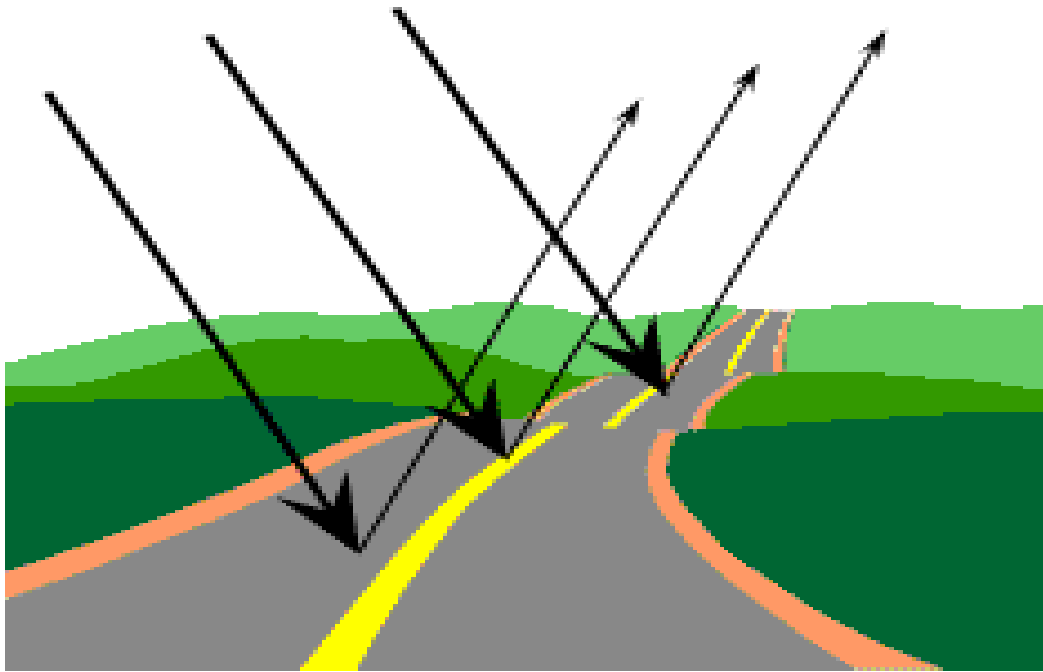
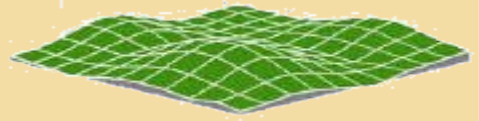
# Pasivni vs aktivni senzori



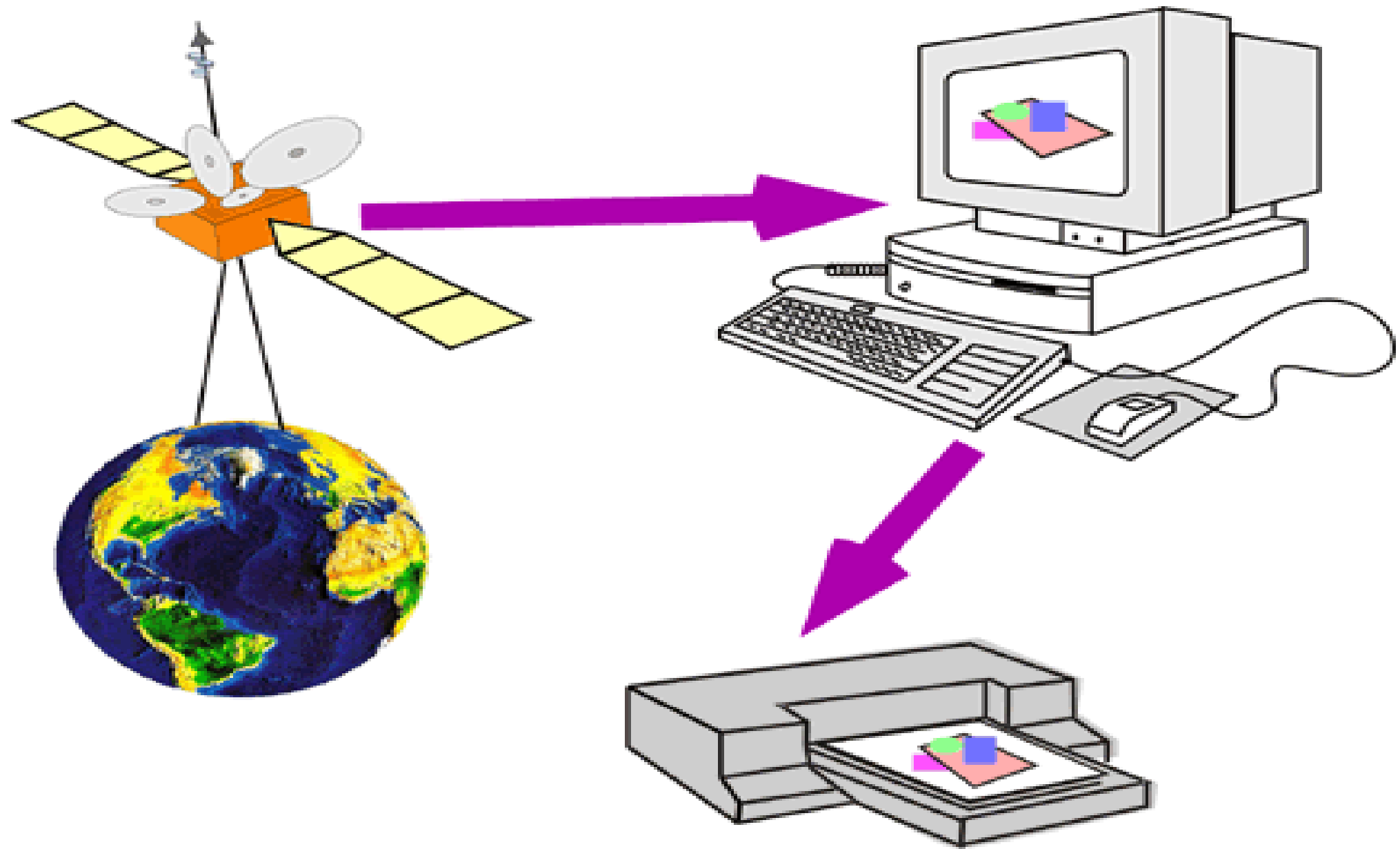
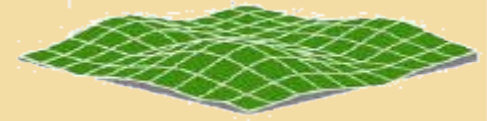
# Daljinska detekcija



# Rasipanje signala

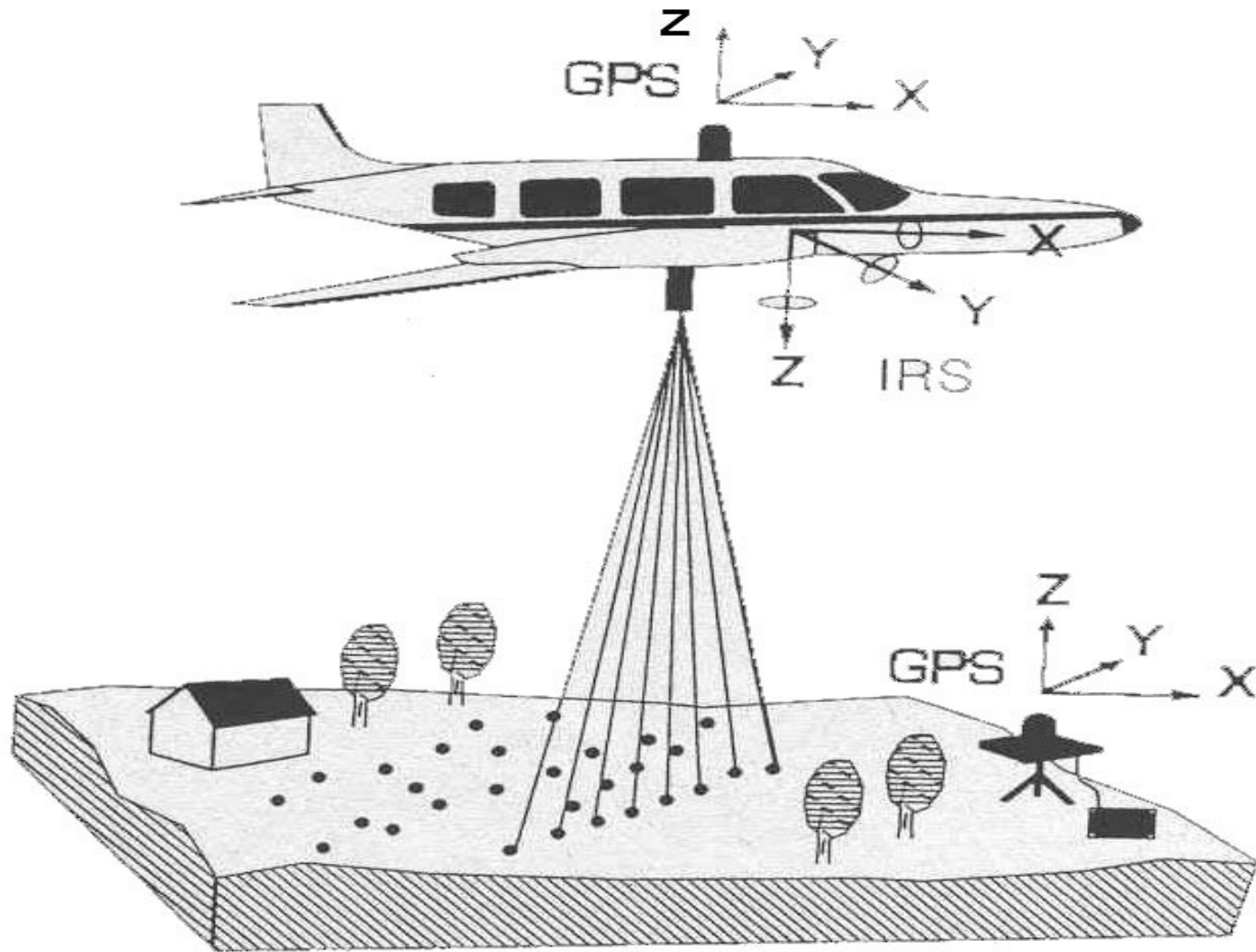
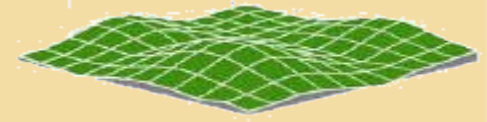


# Metode daljinske detekcije

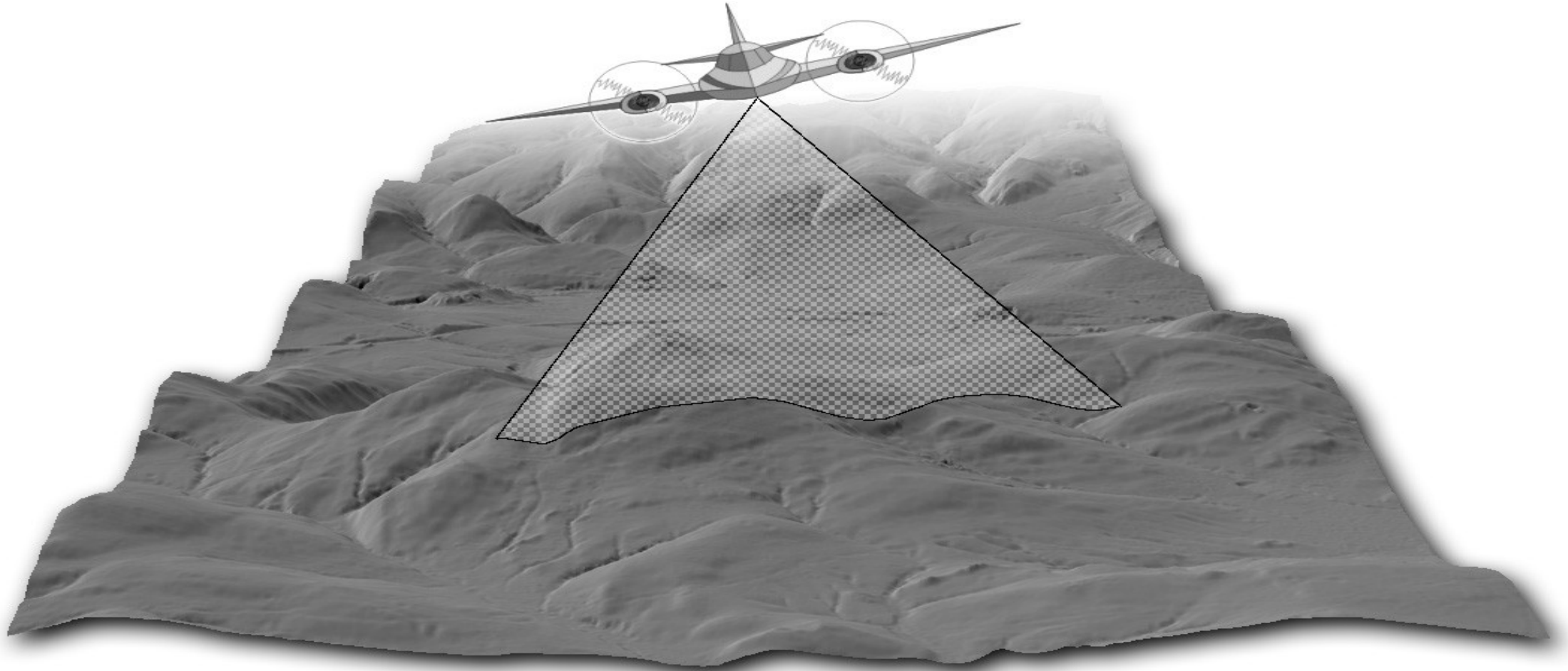
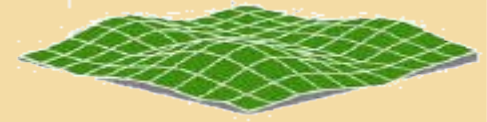


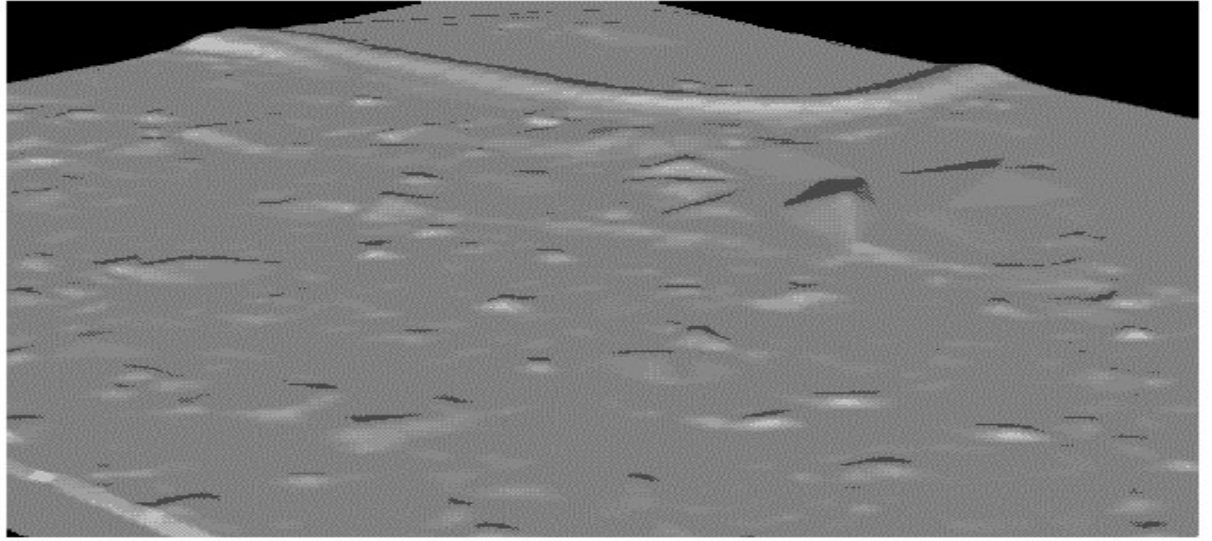
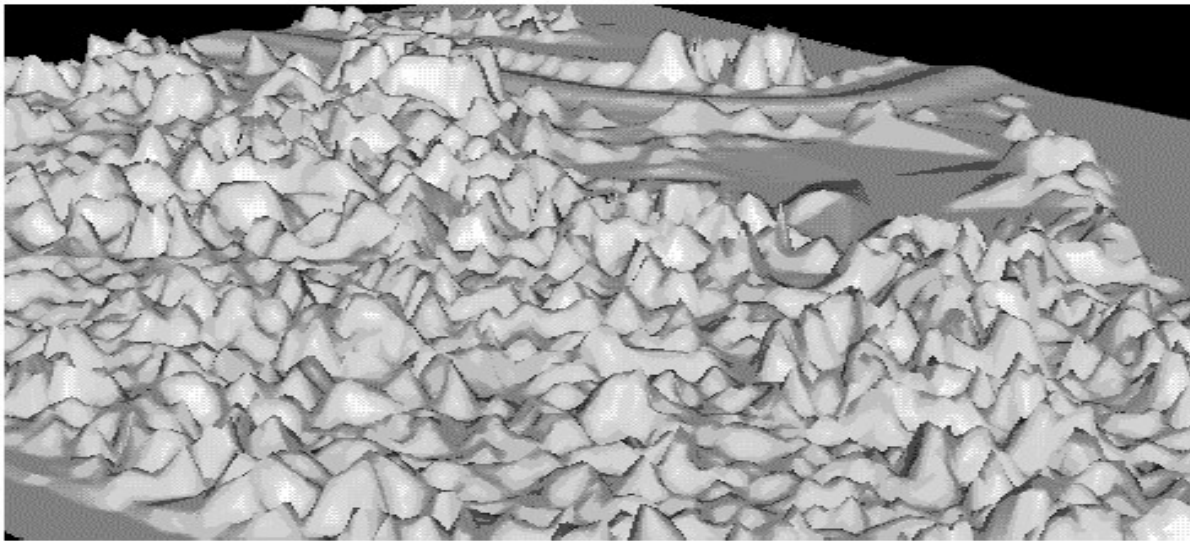
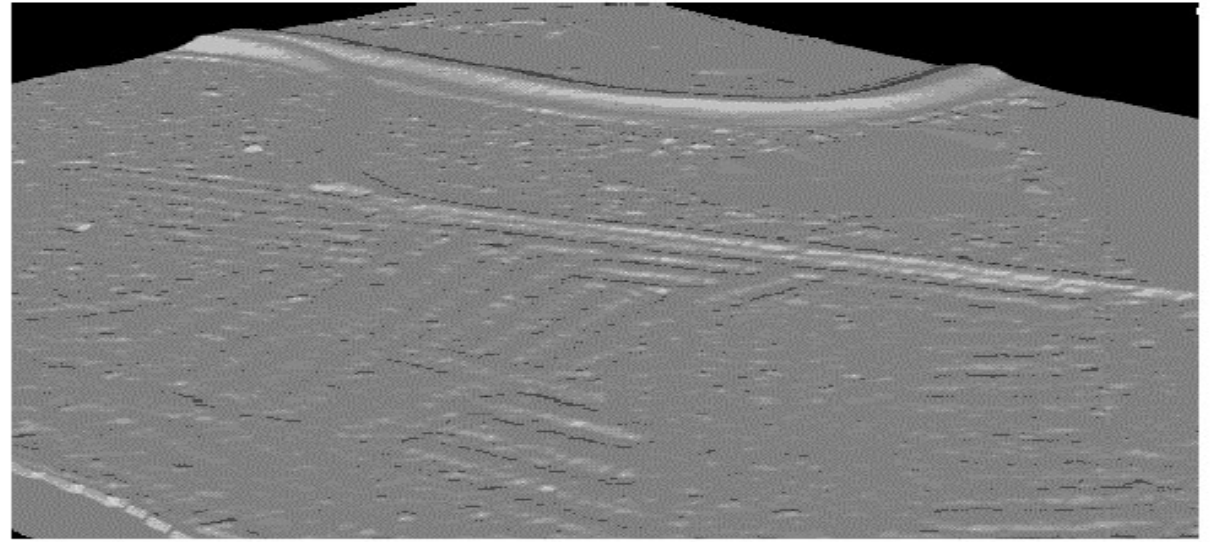
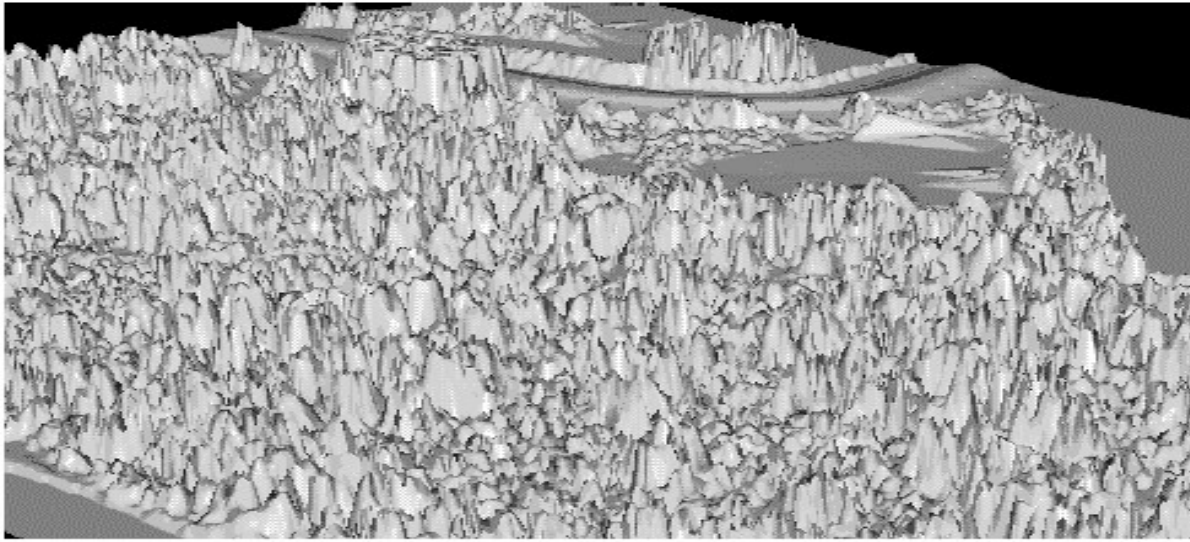
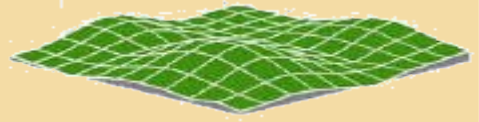


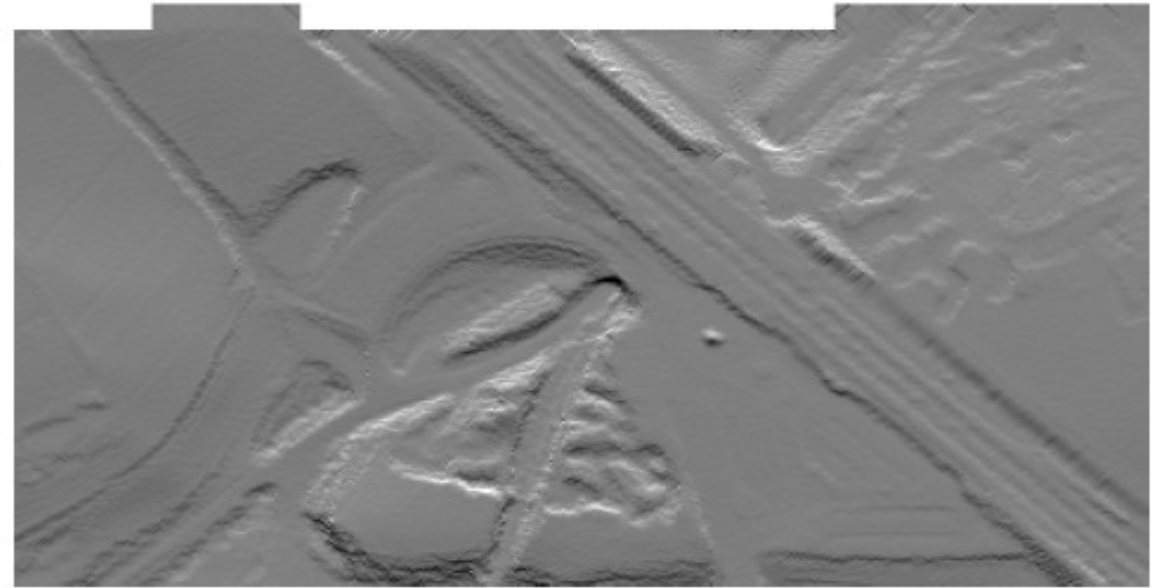
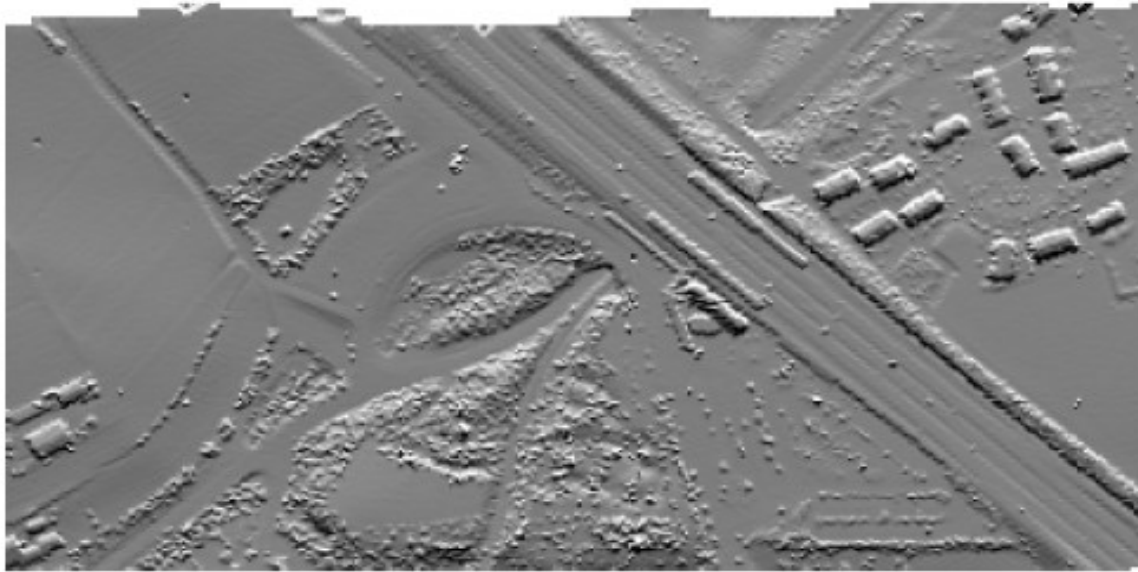
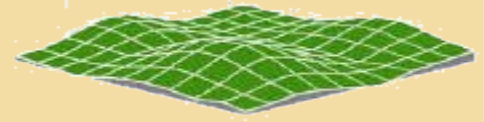
# Light Detection And Ranging (LIDAR) or Airborne Laser Scanning (ALS)

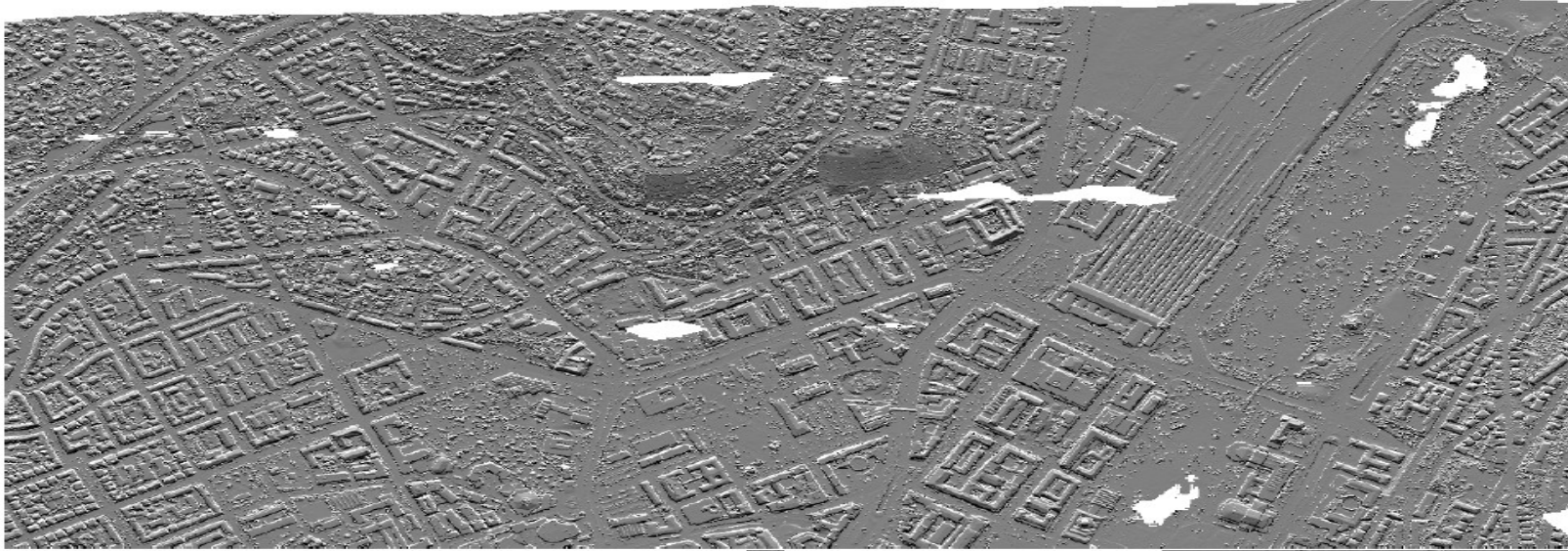
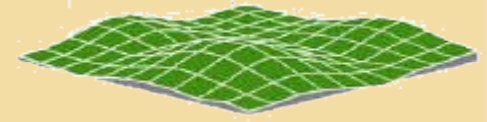


# LIDAR (*L*ight *D*etection *A*nd *R*anging)

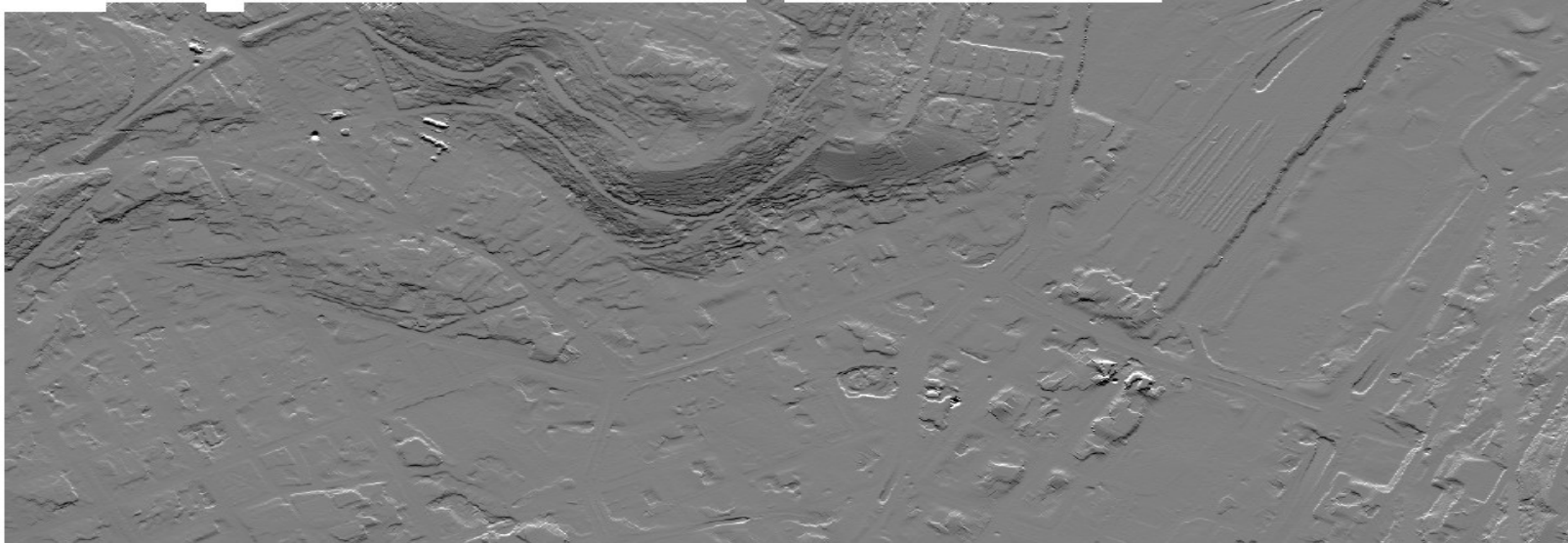






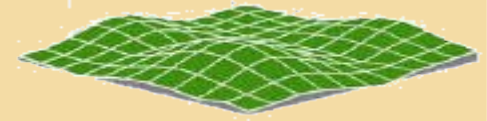


Ne filtrirani  
DMP

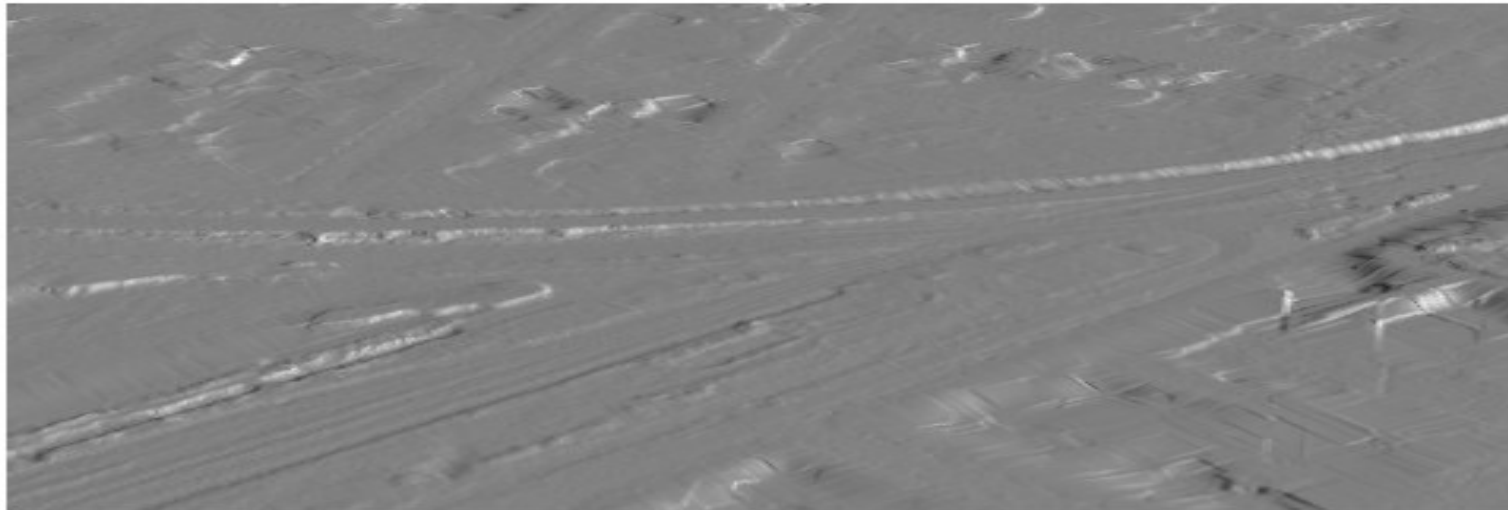


**Štutgrat**

Filtrirani  
DMT

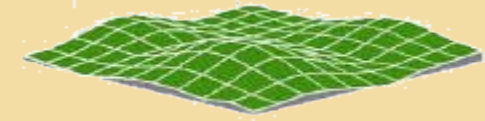


Ne filtrirani  
DMP



Beč

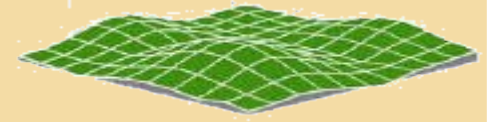
Filtrirani  
DMT



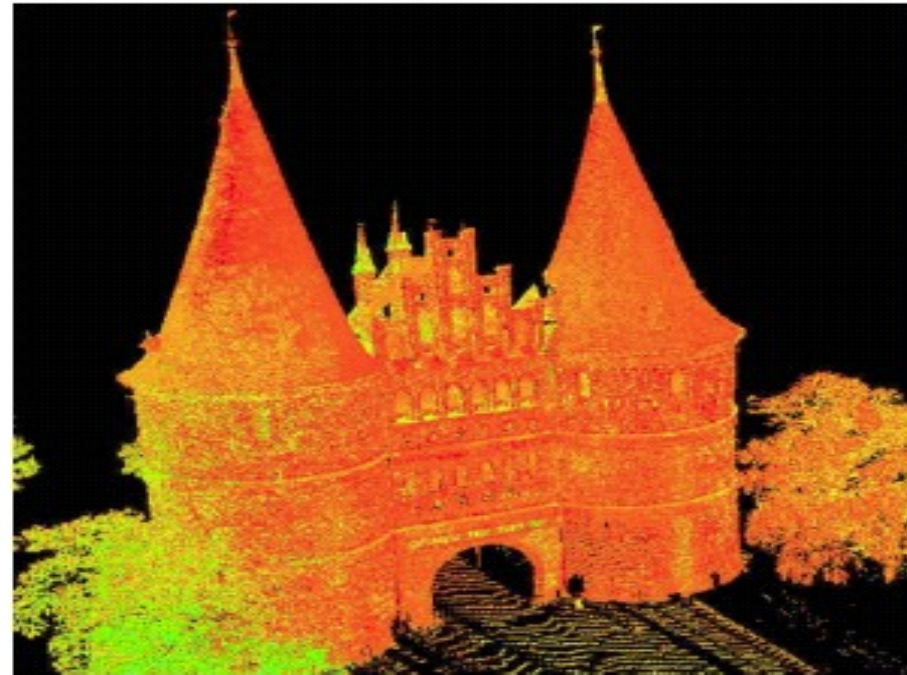
- *Light Detection And Ranging (LIDAR) ili Airborne Laser Scanning (ALS)*

Naziv sistema	Horizontalna tačnost (m)	Visinska tačnost (cm)
ALTM 1020 Aero Asahi	1‰ hl	<15
TopoSys	0.5‰ hl	<15
Nakanihon	1 (na visini leta 200m)	10-25 (hl = 200m)
FLI-MAP II	<0.10	<10
ScaLARS	1 (na visini leta 700m)	<20 (hl = 700m)
AeroScan	0.30	20
RAMS	0.30	30
DATIS	1	15
HawkEye	3	30

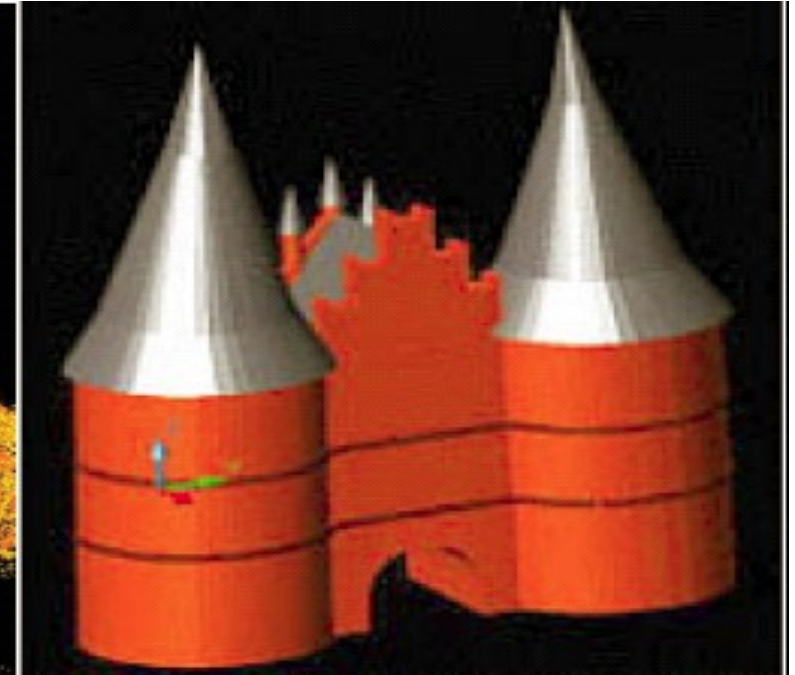
# HDS (High definition surveying) koncept



Zamak u Luebeck-u;



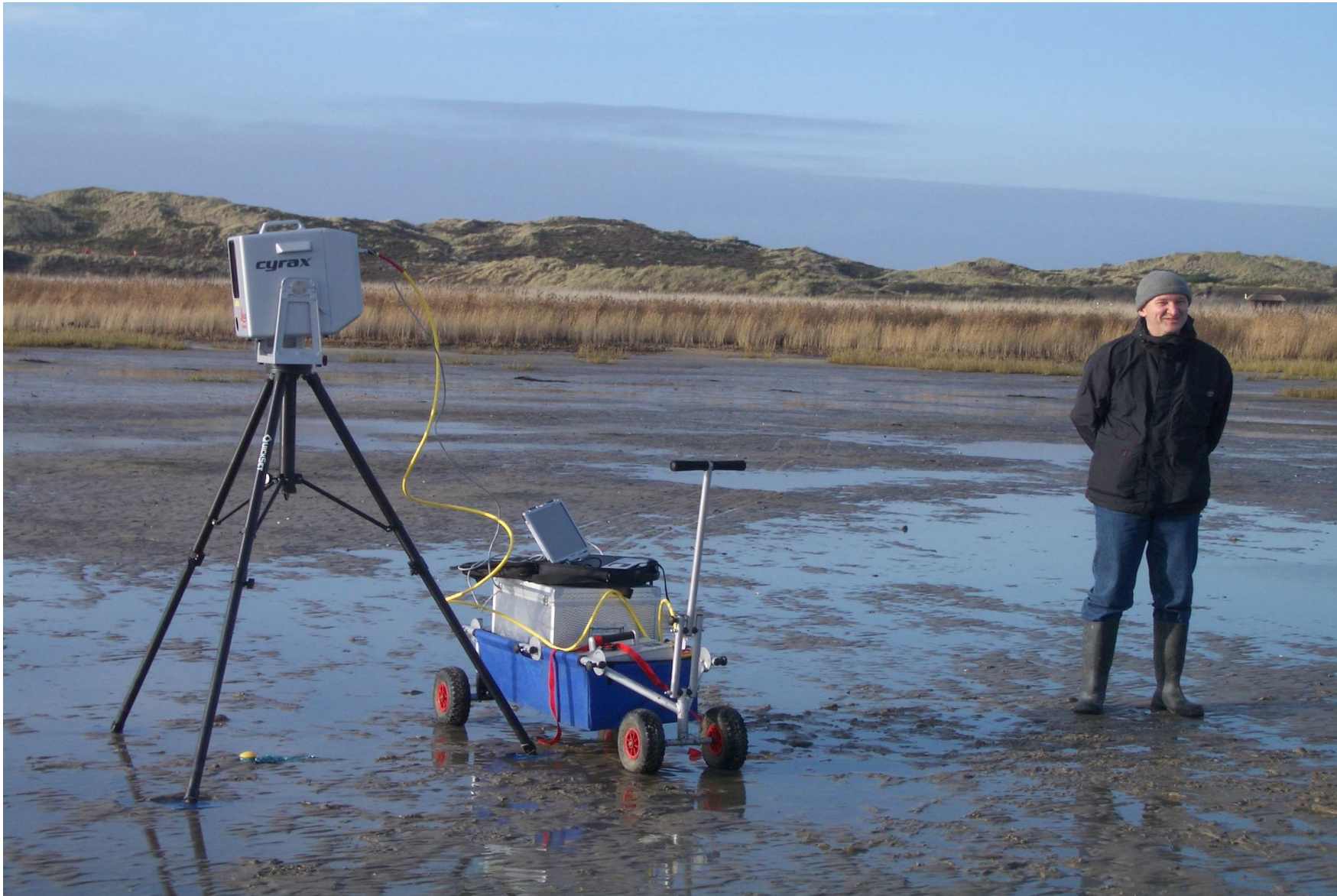
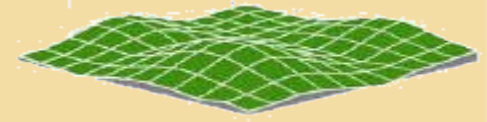
3D mereni oblak tačaka;



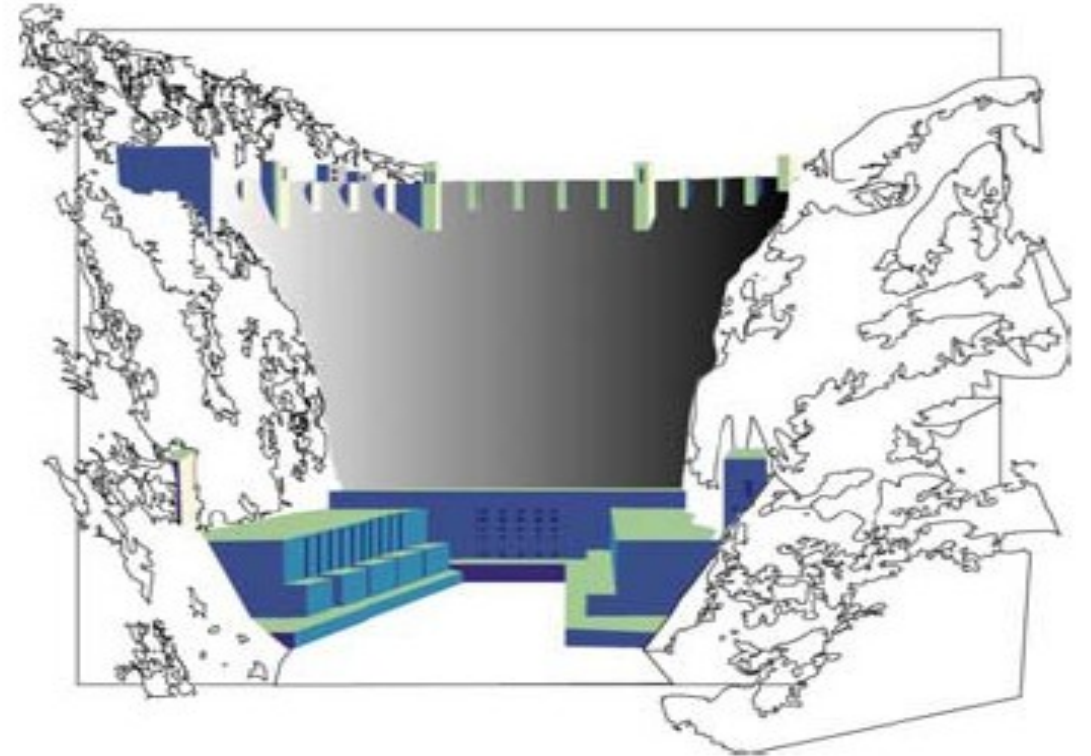
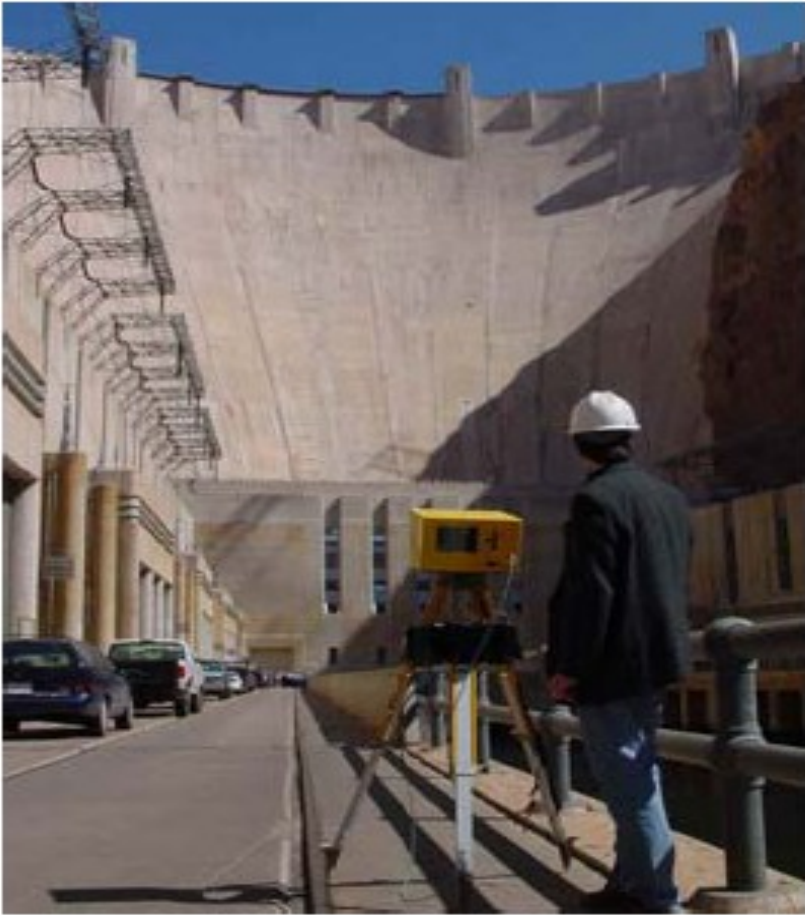
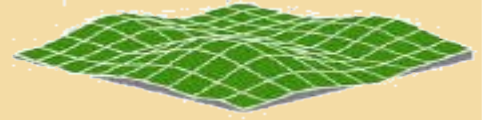
3D model u ACAD-u



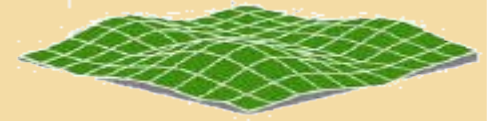
# Terestički laserski skener



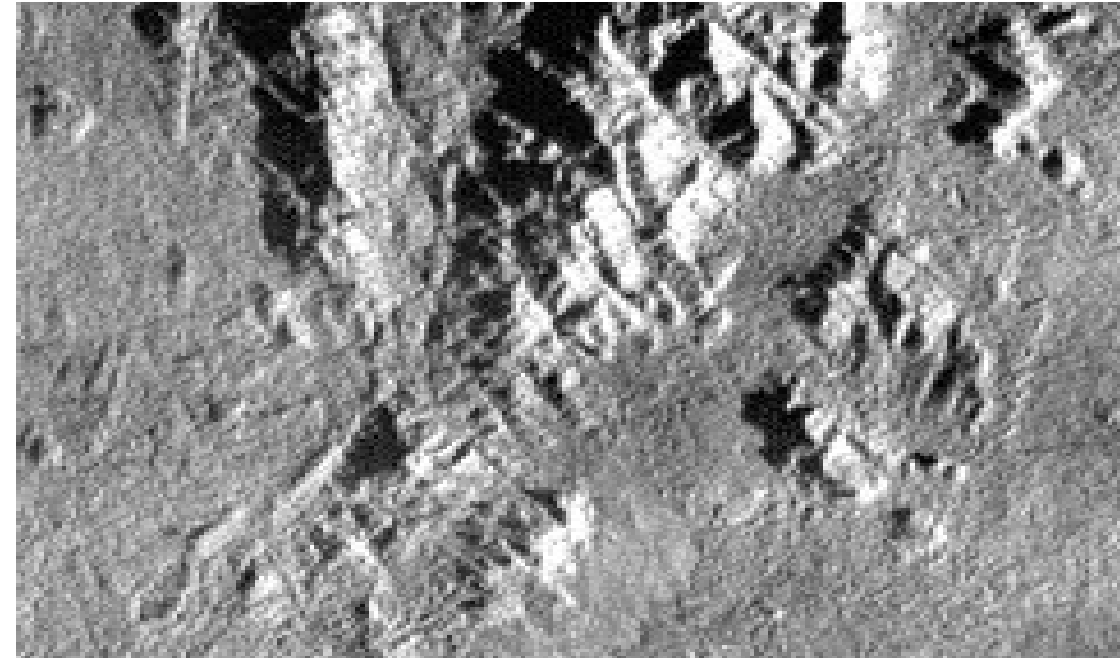
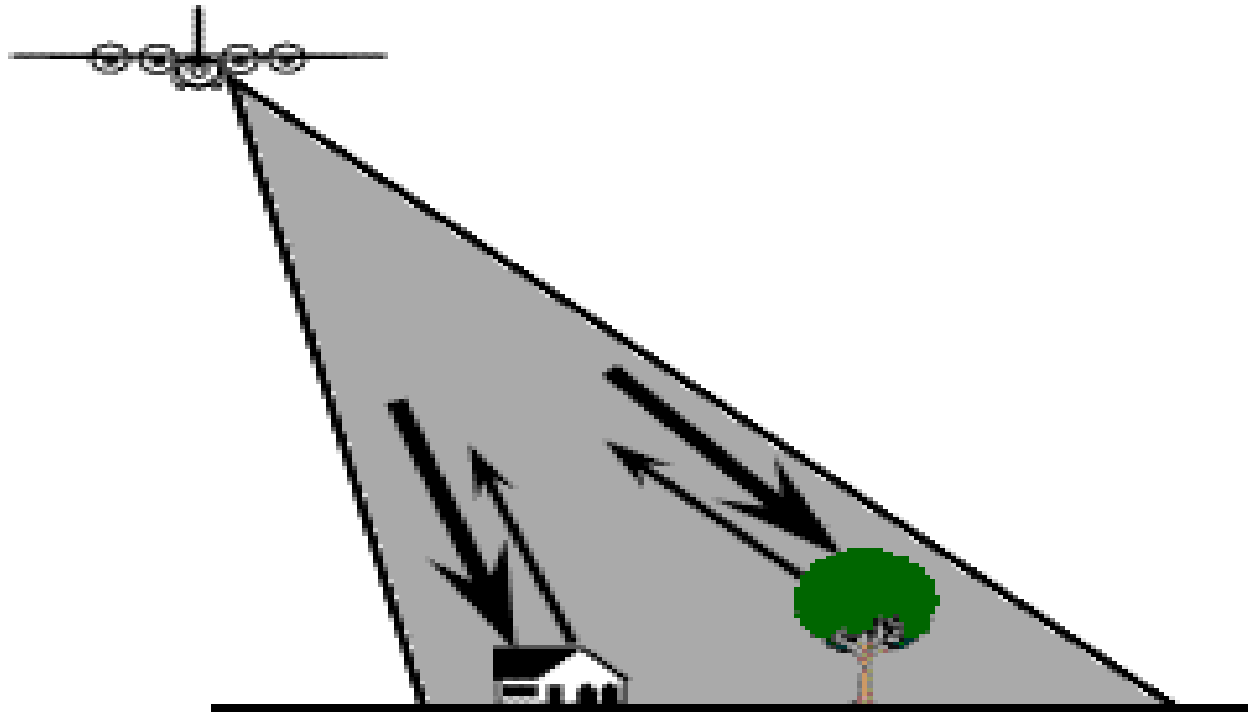
# Deformaciona merenja

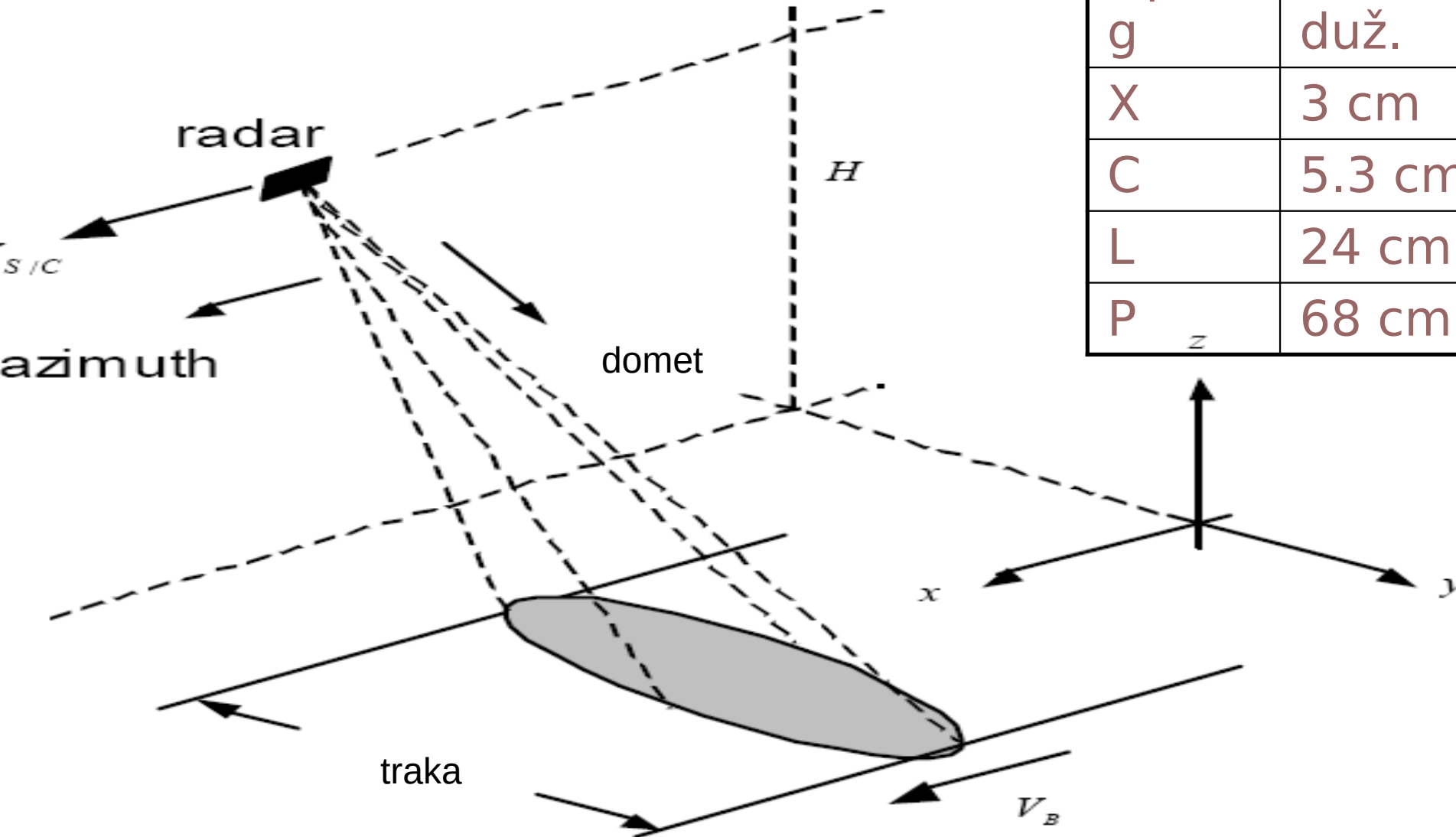
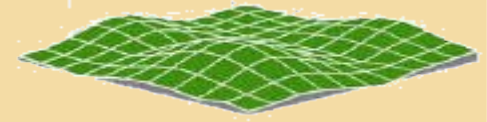


# SAR i InSAR

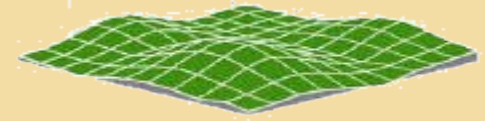


- SAR (Syntetic Aperture Radar)
- InSAR (Interferometric Syntetic Aperture Radar)

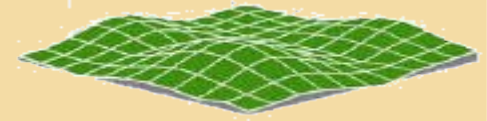




Opse g	Talasma duž.	Frekvencija
X	3 cm	9.6 GHz
C	5.3 cm	5.6 GHz
L	24 cm	1.3 GHz
P	68 cm	0.3 GHz

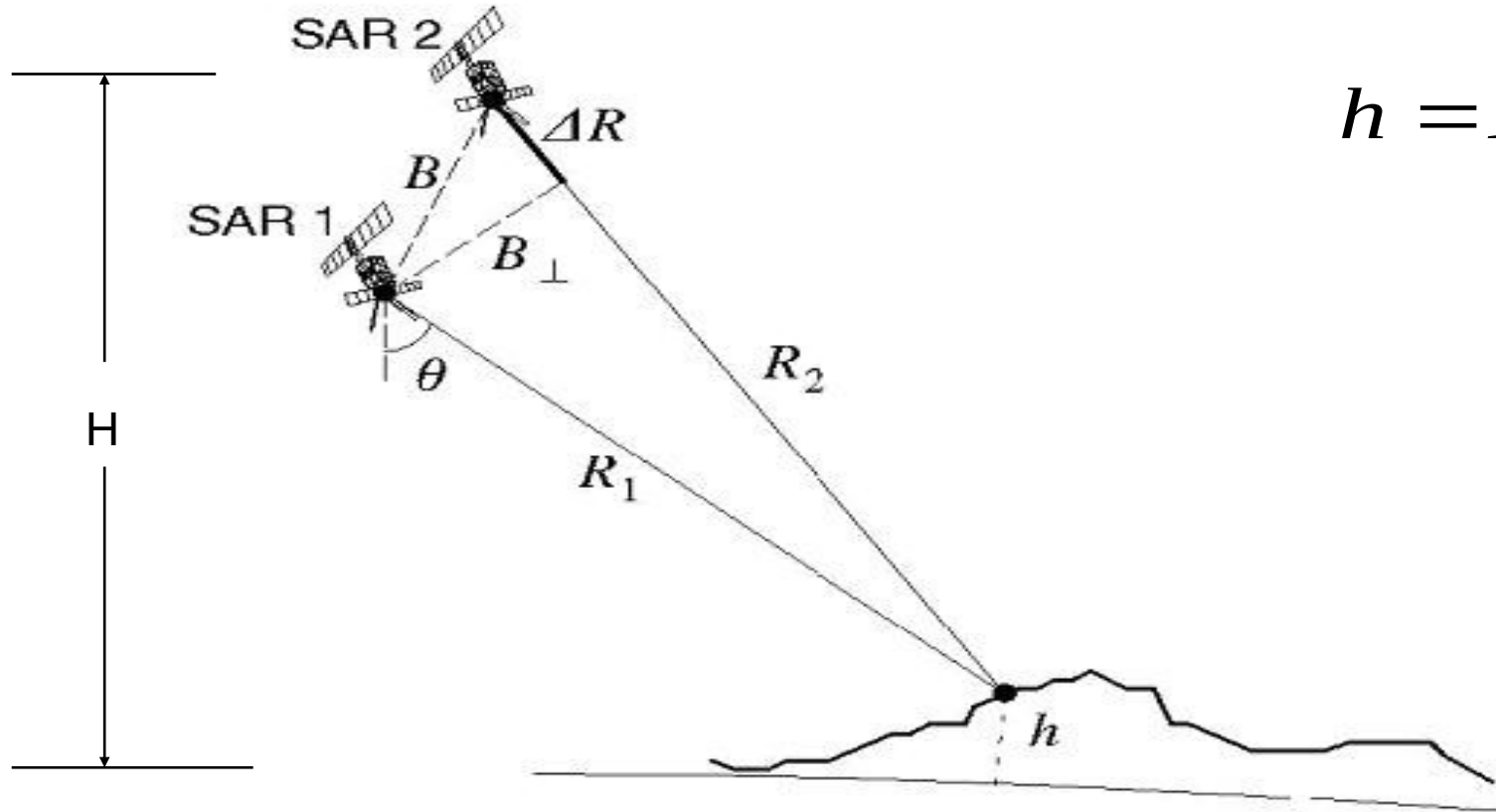


- Rezolucija SAR slike je nezavisna od rastojanja do terena,
- Tačnost koordinata SAR piksela ne zavisi od tačnosti platforme sa senzorom,
- Geometrijska tačnost SAR slike ne zavisi od rastojanja,
- SAR prikupljanja podataka ne zavisi od doba dana,
- Oblaci ne ometaju SAR prikupljanje podataka

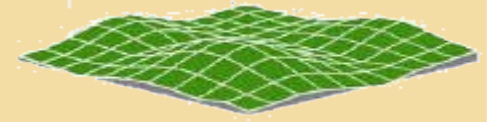


°R-fazna razlika

$$h = H - (R_1 + \Delta R) \cos \Theta_2$$



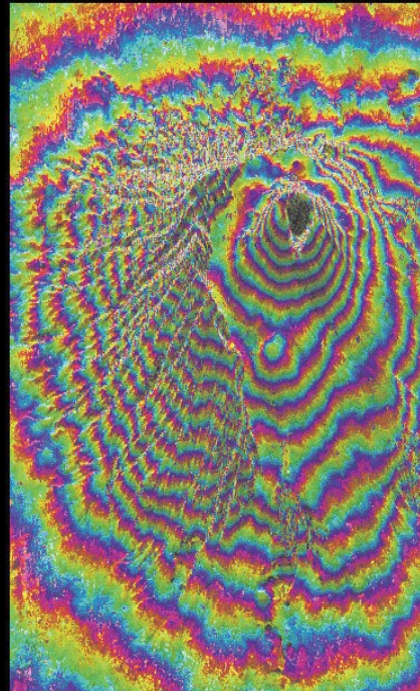
# SAR snimak



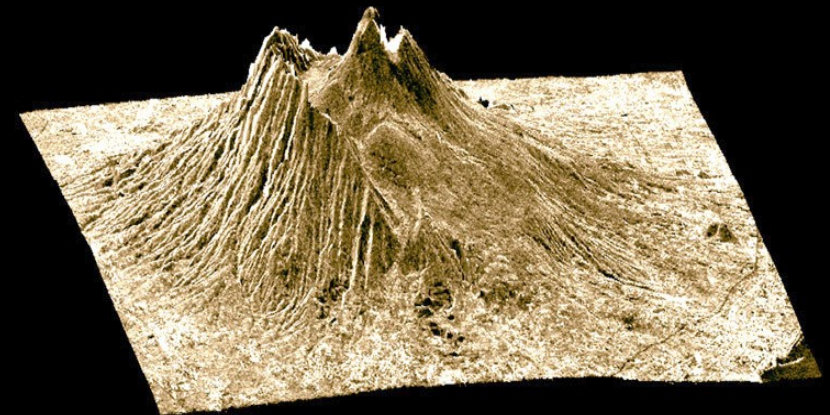
ERS-1 SAR, Vesuvius, Italy



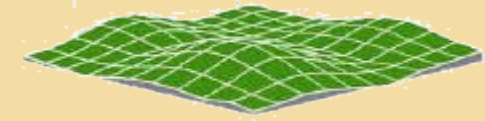
ERS-1 SAR, Vesuvius, Italy – Interferogram



ERS-1 SAR, Vesuvius, Italy – DEM

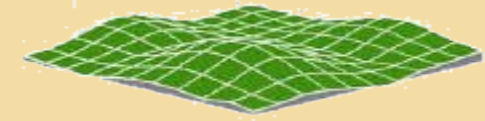


# SAR misije



SAR på satellitt	resolution x,y	Life span	Repeat period	Scene size
ERS-1/ERS-2	50 m	1992 - 2001	35 days	100 x 100 km
Envisat	50 m	2003 - 2010	35 days	100 x 100 km
Radarsat-1	25 m	1995 -	24 days	50 x 50 km
Radarsat-2	Ultrafine: 2.1-4.6 x 2.8 m Fine: 7-10 x 8 m Standard: 17-27 x 25 m	2007 -	24 days	Ultrafine: 20 x 20 km Fine: 50 x 50 km Standard: 100 x 100 km
TerraSAR-X	1.2 x 1-4 m 3 x 3-6 m 16 x 16 m	2007 -	11 days	5-10 x 10 km 30 x 30-50 km 100 x 100 km
CosmoSkyMed - 4 satellitter	1 m 3-15 m 100 m	2007 -	1-7 days *	10 x 10 km 40 x 40 km 200 x 200 km
Sentinel-1A/1B	IW: 5 x 20 m	2014 – 2015 -	12 days 6 days **	IW: 250 x 250 km
TerraSAR-X NG	1.2 x 1-4 m 3 x 3-6 m 16 x 16 m	2016 -	6 days**	5-10 x 10 km 30 x 30-50 km 100 x 100 km
Radarsat CM – 3 satellitter	3 m 5 m 30 m 50 m 100 m	2018 -	4 days ***	20 x 20 km 30 x 30 km 125 x 125 km 350 x 350 km 500 x 500 km
Cosmo-Skymed SG – CSG 2 satellitter	1 m 3 m 20 m 40 m	2015 -	8 days **	10 x 10 km 40 x 40 km 100 x 100 km 200 x 200 km

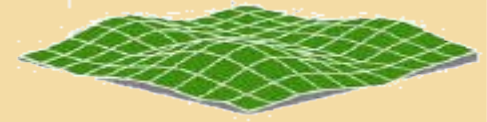




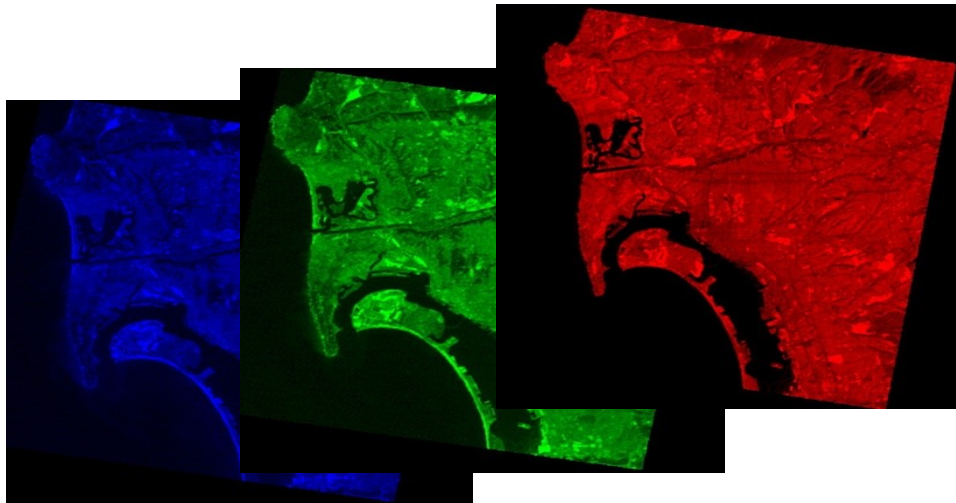
- *Interferometric Synthetic Aperture Radar (InSAR)*

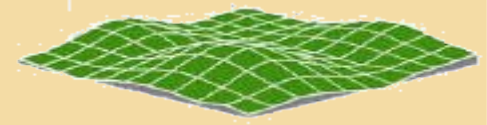
Parametar	INSAR (Star-3i)	LIDAR
Visina leta	6000m - 9000m	300m – 1800m
Brzina leta	750km/čas	~200km/čas
Ugao zahvatanja	30°-60°	+/- 20° (35°max)
Širina zahvata (na tlu)	5 – 8km	0.7 – 1 km
Rezolucija ortorektifikovane slike	2.5m	/
Rezolucija merenja terena	2.5m, 5m, 10m	3 – 5m (0.5min)
Vertikalna tačnost DTM-a		
Apsolutna	1.0m	15-35cm
Relativna (1 $\sigma$ )	~30cm	/
Horizontalna tačnost DTM-a	2.5m	0.5-1.0m
Brzina akvizicije podataka		
Maksimalna (km <sup>2</sup> /čas)	4 000	~200
Prosečna (km <sup>2</sup> /čas)	1 000	?

# Kolor kompozit RGB (321) model

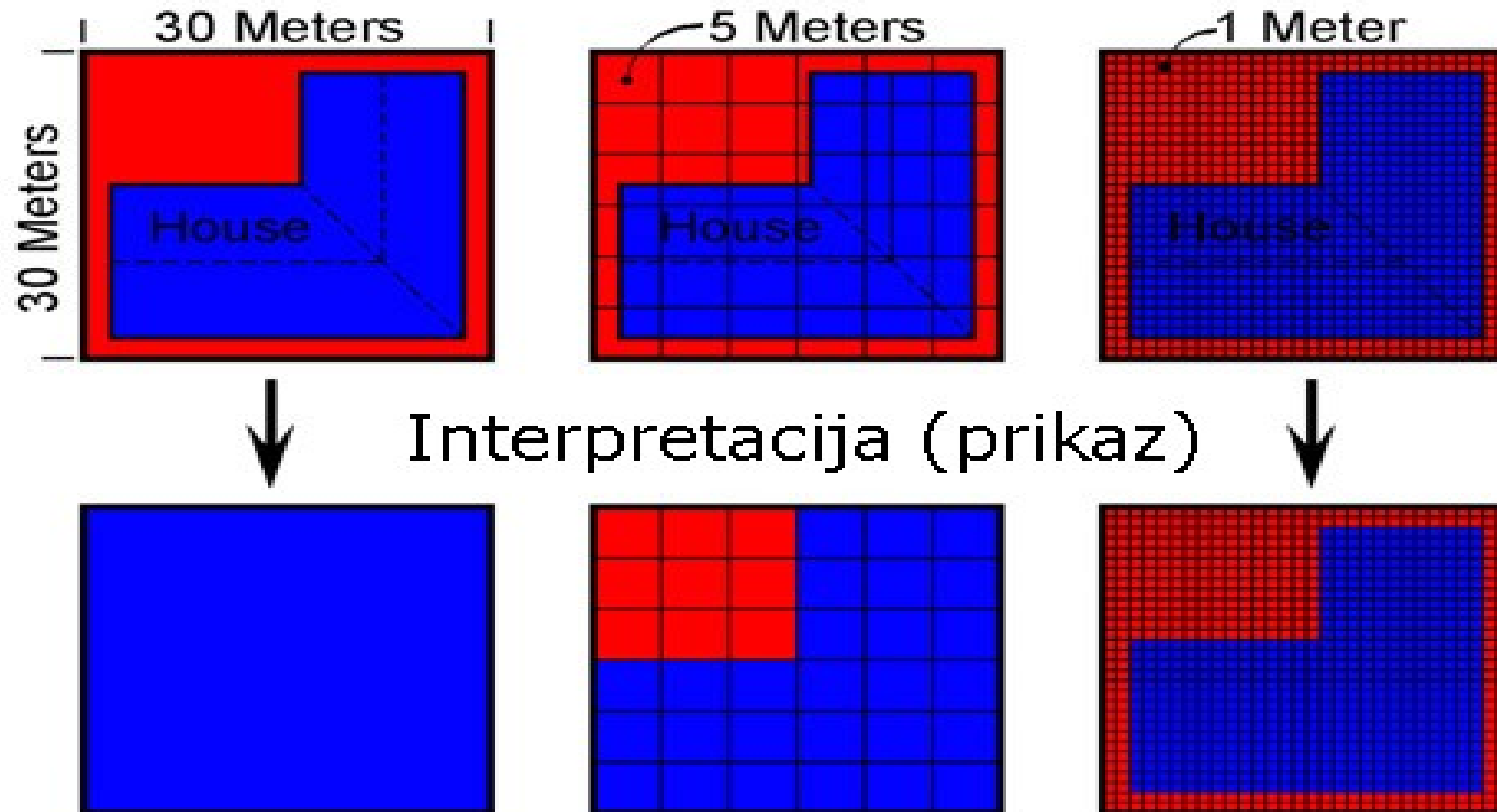


Kombinacija kanala 3+2+1

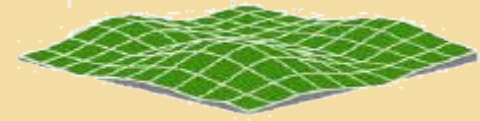




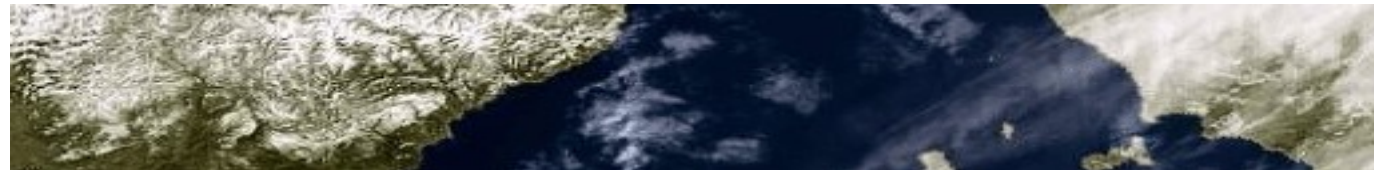
## Veličina piksela (Rezolucija)



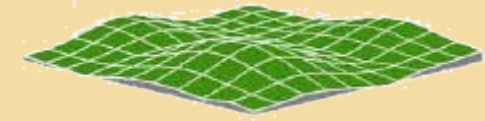
# Satelitski snimci niske rezolucije



- Satelitske podatke sa niskom rezolucije odlikuje prostorna rezolucijom od oko 1 km ili nekoliko stotina metara.
- Ovi podaci su dobijeni isključivo u Multispektralnom režimu, uključujući vidljivi i infracrveni deo optičkog spektra.
- Pogodni za kartiranje u razmerama oko 1:1,000,000.
  
- Tipične aplikacije uključuju:
  - Globalno i kontinentalno kartiranje
  - Monitoring vegetacije
  - Modelovanje prinosa useva
  - Praćenje katastrofa
  - Snežni pokrivač i praćenje glečera

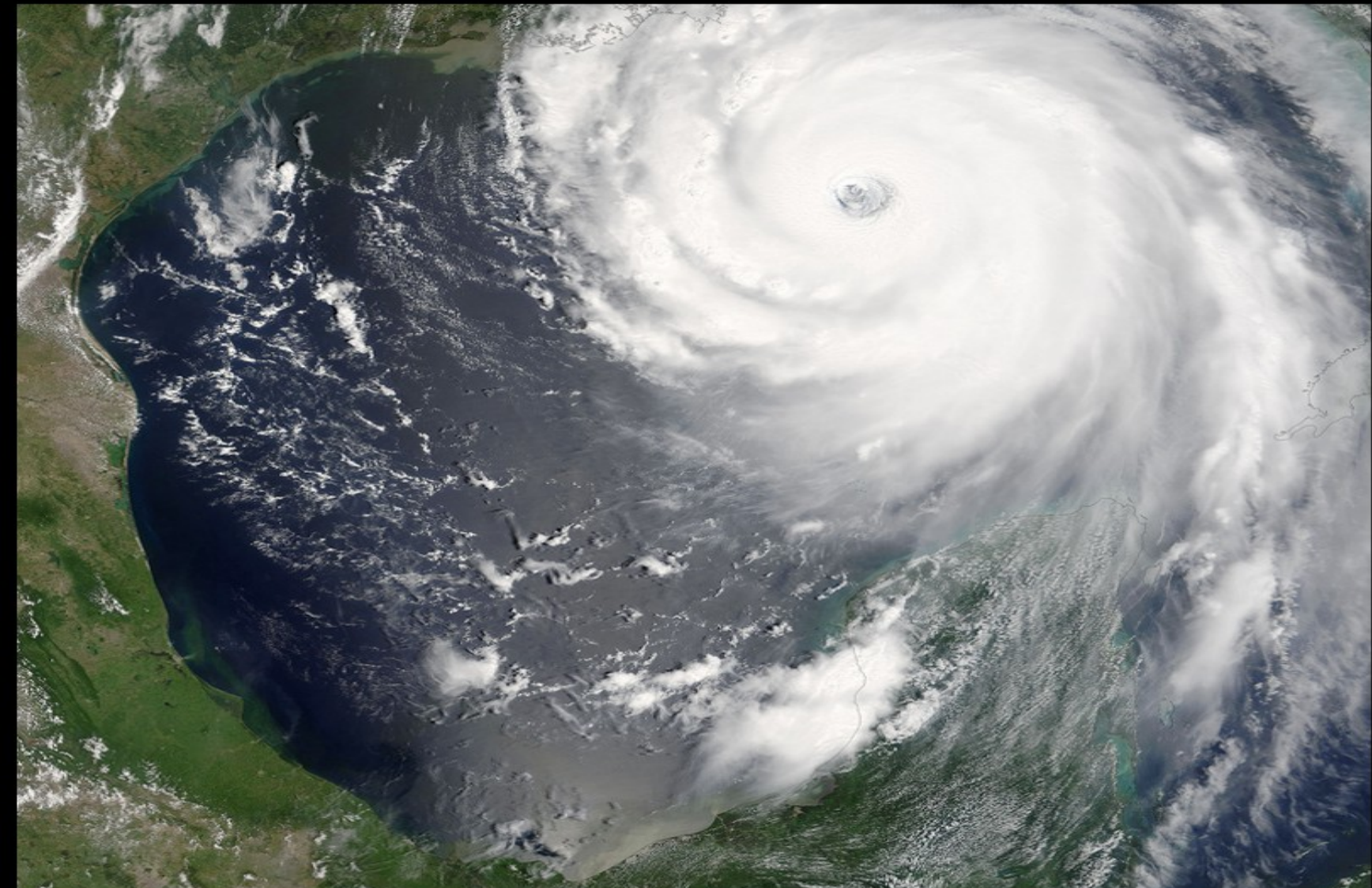
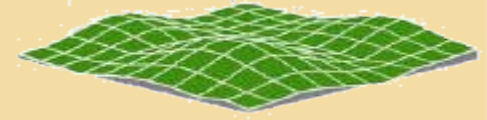


# Satelitski snimci niske rezolucije



Satelit	Senzor	Broj kanala	Prostorna rezolucija [m]	Postojeća arhiva	Satelit	Senzor	Broj kanala	Prostorna rezolucija [m]	Postojeća arhiva
Landsat 8	<a href="#">TIRS</a>	2	100.0	2013	TERRA	<a href="#">MODIS</a>	36	250.0, 500.0, 1000.0	2000
NPP	<a href="#">VIIRS</a>	22	375.0, 750.0	2012	SPOT 4	<a href="#">VEGETATION 1</a>	4	1000.0	1998
Envisat	<a href="#">MERIS</a>	15	300.0	2002	IRS-1D	<a href="#">WiFS</a>	2	188.0	1997
Meteosat MSG	<a href="#">GERB</a>	7	40000.0	2002	OrbView-2	<a href="#">SeaWiFS</a>	8	1130.0	1997
Meteosat MSG	<a href="#">SEVIRI</a>	12	1000.0, 3000.0	2002	IRS-1C	<a href="#">WiFS</a>	2	188.0	1996
SPOT 5	<a href="#">VEGETATION 2</a>	4	1000.0	2002	RESURS-01-1	<a href="#">MSU-S</a>	2	240.0	1985
RESURS-01-1	<a href="#">MSU-SK</a>	5	170.0, 600.0	1985					

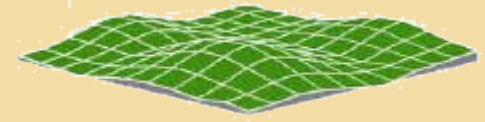
# Niska rezolucija satelitskih snimaka



Envisat MERIS  
(USA/Canada)

ENVISAT / MERIS image (resolution 300 m, 09  
9 / 10

TERRA / MODIS image (500 m resolution, 28.08.2005), Gulf of Mexico, Hurricane Katrina © 2010  
NASA



Satelitski snimci sa srednjom i visokom rezolucijom se odnose na prostorne rezolucije od nekoliko desetina metara.

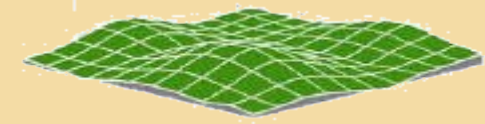
Ovi podaci dobijeni su često istovremeno u panhromatskom i mulitspektralnom režimu sa značajnim učešćem spektralnih kanala koji pokrivaju infracrveni optički spektar. Neki sateliti prikupljaju podatke isključivo u redovnim misijama, obično nekoliko nedeljenih ciklusa. Ostali sateliti su u stanju da se podatke prikupljaju prema zahtevu kupca. U oba slučaja obimne arhive podataka su dostupne i sadrže sve snimke prikupljene od lansiranja satelita.

Podaci su pogodni za kartiranje ili ažuriranje karata u opsegu razmere 1:100,000 – 1:25,000.

Standardna primena obuhvata:

- Regionalno kartiranje za potrebe regionalnog planiranja
- Praćenje Urbanog razvoja
- Kartiranje zemljišnog pokrivača / korišćenja zemljišta
- Promene i monitoring vegetacije
- Kartiranje poljoprivrednih područja i klasifikaciju poljoprivrednih useva
- Kartiranje šumskih područja i klasifikacija šumskih ekosistema
- Geološko i geomorfološko kartiranje

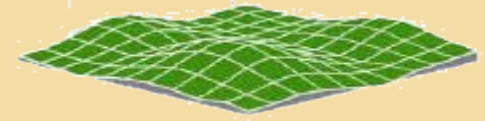
# Satelitski snimci srednje i visoke rezolucije



NAZIV SENZORA	DATUM LANSIRANJA	SPEKTRALNI KANALI	REZOLUCIJA	POKRIVENOST
<b>SPOT 1-7</b>	1986-2014	Pan, MS + short-wave IR	Do 1.5-m	Globalna
<b>FORMOSAT-2</b>	May 21, 2004	4-band Pan MS	2-m 8-m	fiksiranoj putanji
<b>EROS A</b>	December 5, 2000	Pan	2-m	Globalna
<b>RapidEye</b>	August 29, 2008	5-band MS	5-m	Globalna
<b>DEIMOS-1</b>	July 29, 2009	3-band MS	22-m	Globalna



# Satelitski snimci vrlo visoke rezolucije

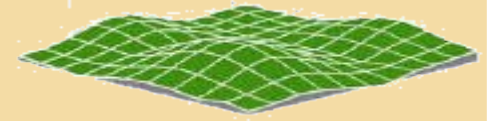


- Satelitski podaci sa veoma visokom rezolucijom se odnose na prostorne rezolucije na oko 1 m.
- Ovi podaci mogli dobiti samo u panhromatski režimu, češće u kombinaciji panhromatskog i mulitspektralnog opsega. Danas, to je najprogresivniji domen daljinsku detekciju.
- Podaci su pogodni za mapiranje ili ažuriranje karata u opsegu razmere 1:25,000 – 1:5,000

Standardna primena obuhvata:

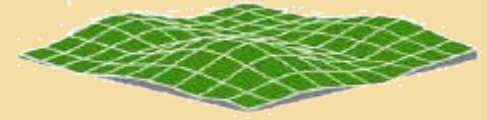
- Detaljni kartiranje
- Urbana studije 3D modela gradova
- Precizna poljoprivreda, kontrola poljoprivrednih aktivnosti
- Planiranje i projektovanje infrastrukture
- Kartiranje transportne infrastrukture šumama inventara
- Kartiranje rasutih vegetacionog
- Monitoring kopova, odlagalištima i aktivnosti rekultivacije zemljišta od erozije
- Izrada Digitalnih modela terena

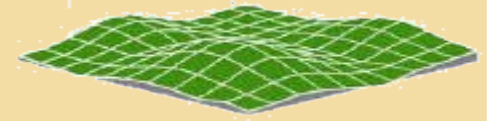
# Satelitski snimci vrlo visoke rezolucije



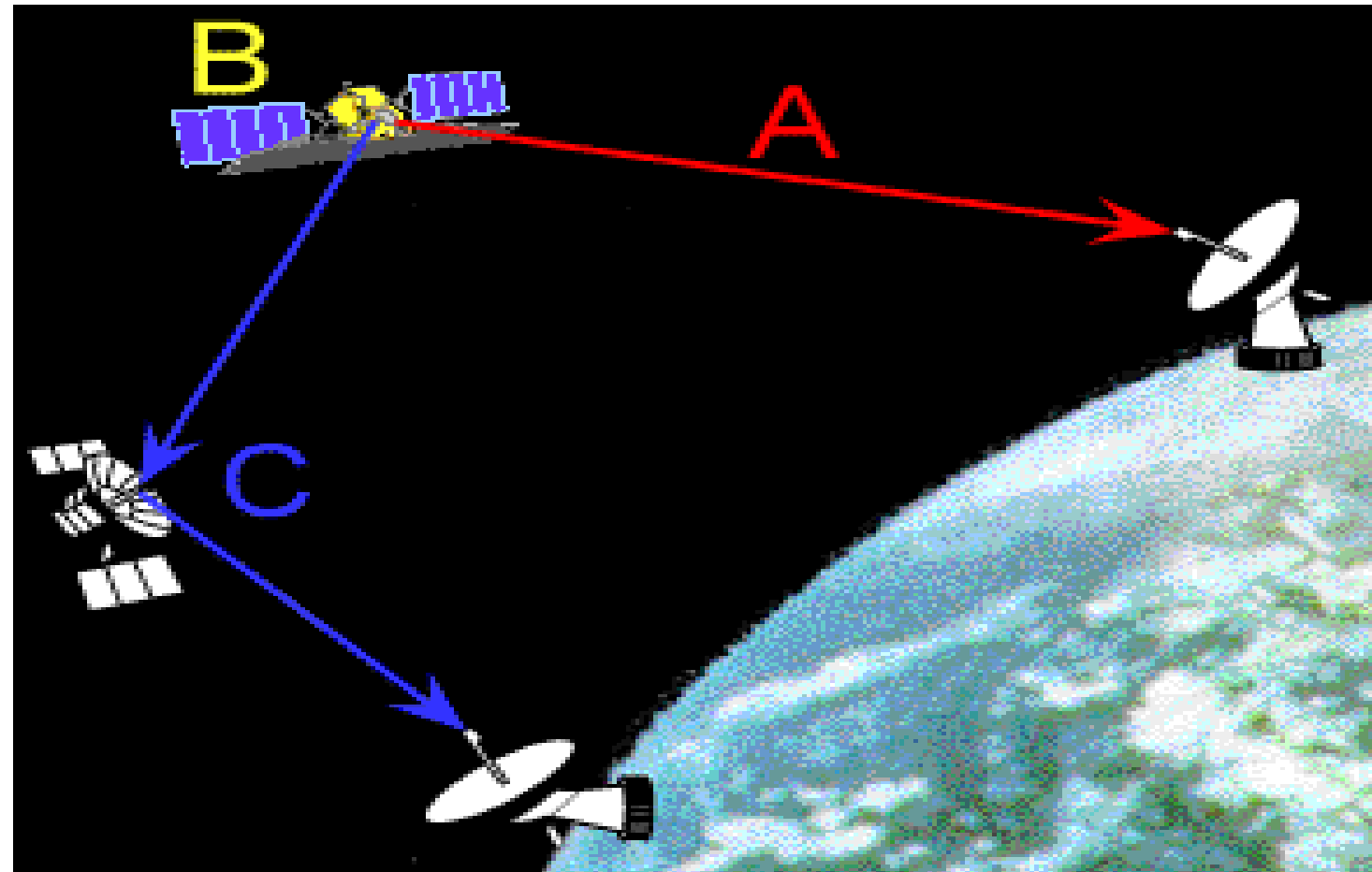
NAZIV SENZORA	DATUM LANSIRANJA	SPEKTRALNI KANALI	REZOLUCIJA	POKRIVENOST
<b>WorldView-1</b>	Septembar 18, 2007	Pan	50-cm	Globalna
<b>WorldView-2</b>	Oktober 8, 2009	Pan 8-band MS	50-cm 2-m	Globalna
<b>Pléiades 1A/1B</b>	Decembar 17, 2011	Pan 4-band MS	50-cm 2-m	Globalna
<b>GeoEye-1</b>	Septembar 6, 2008	Pan 4-band MS	50-cm 2-m	Globalna
<b>Quickbird</b>	Oktober 18, 2001	Pan 4-band MS	60-cm 2.4-m	Globalna
<b>EROS B</b>	April 25, 2006	Pan	70-cm	Globalna
<b>IKONOS</b>	Septembar 24, 1999	Pan 4-band MS	80-cm 3.2-m	Globalna

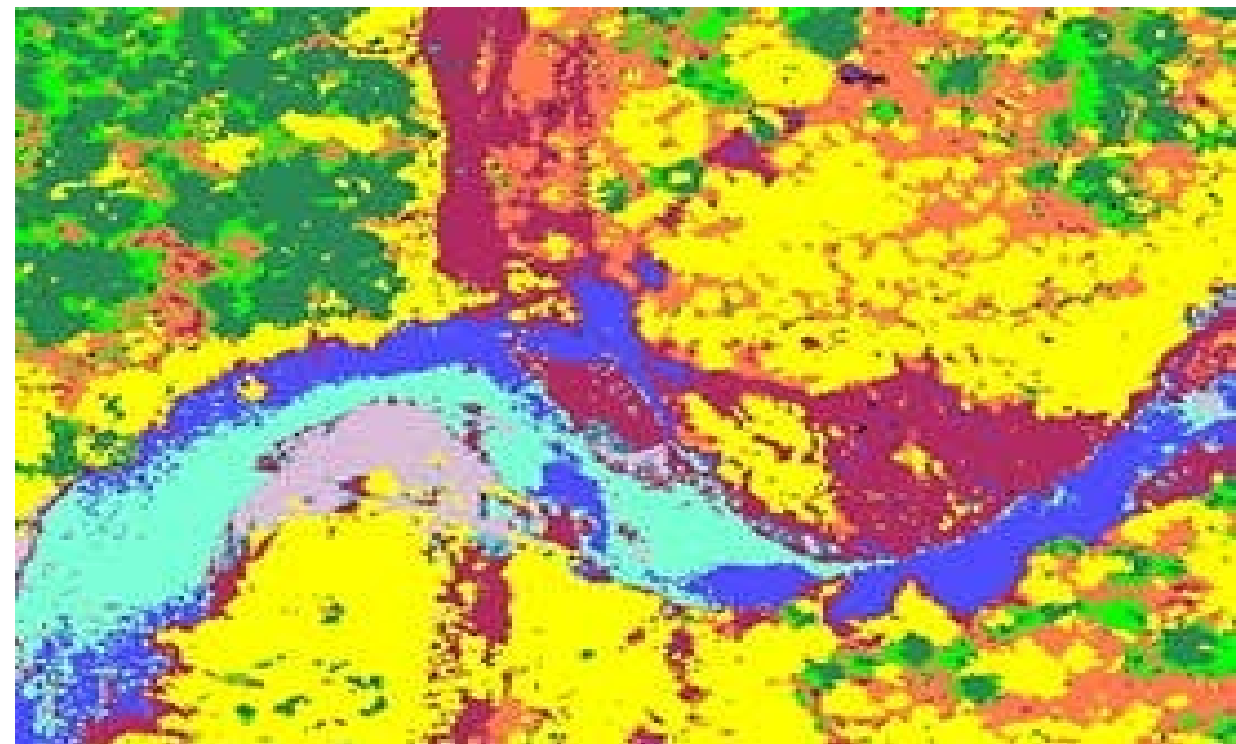
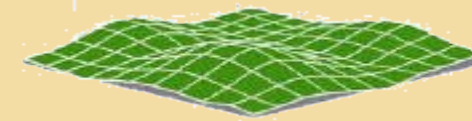
# Visoka rezolucija satelitskih snimaka





- A) direktno prema zemaljskoj satelitskoj stanici
- B) memorisanja podataka za naknadnu transmisiju
- C) sa satelita na satelit i kasnijom transmisijom ka zemaljskoj satelitskoj stanici





**Tamno zelena:** četinari **Zelena:** nisko granje **svetlo ljubičasta:** šljunak  
**Žuta:** listopadna šuma **Narandžasta:** suvo zemljište **Crvena:** vlažno zemljište **Plava (svetlo):** voda **Plava (tamno):** duboka ili čista voda

# Procesiranje snimaka

