New advanced technologies in 3D mapping using laser scanning devices and photogrammetric techniques

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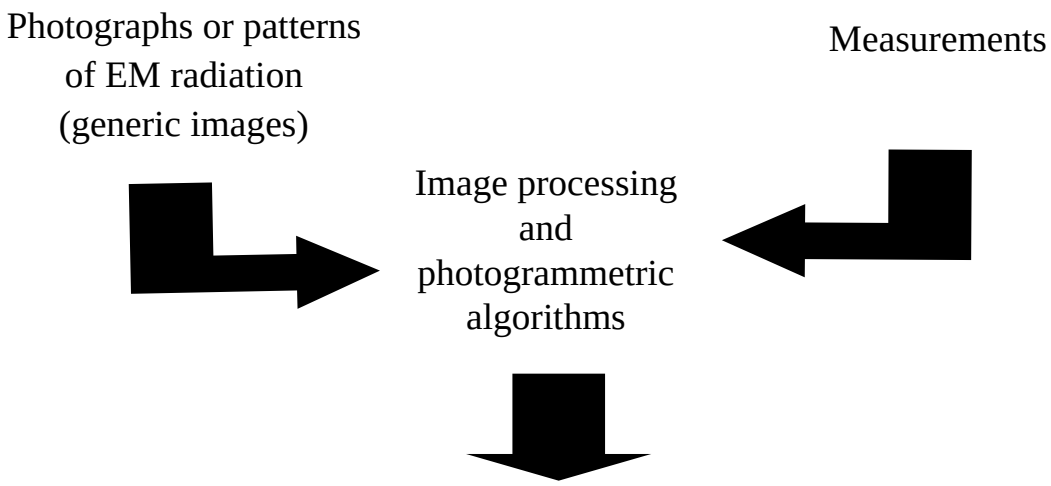
Outline

- Introduction
- State of the Art
- Applications
- Conclusions

Introduction

- Photogrammetry
  - Is the art, science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena" (American Society of Photogrammetry 1980).
- Laser scanning (LIDAR)
  - A procedure to measure and analyze the real world and record the shape (or even the colour) of manmade object and the natural environment

Principles of Photogrammetric procsessing

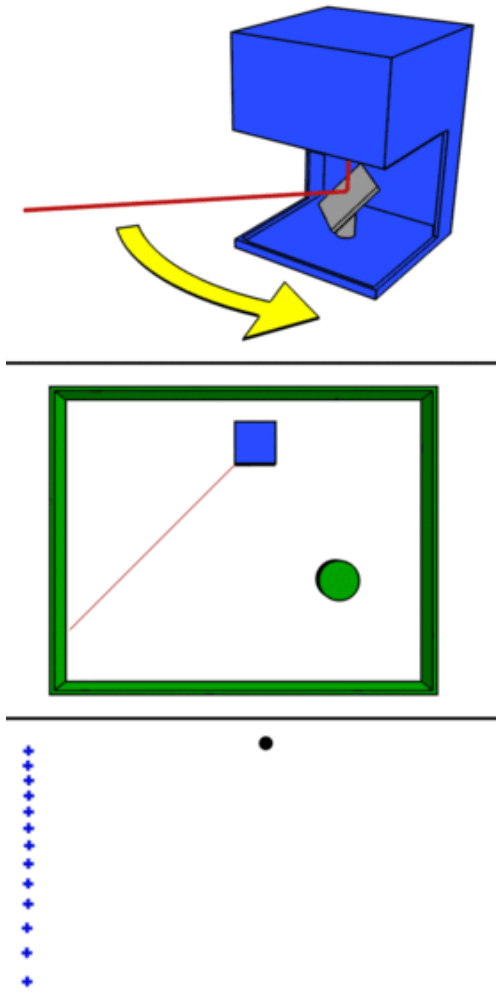


Topographic data

i.e 2D maps, 3D maps, DEM, ortho images, contour line maps, 3D models of objects, etc

Principles of Laser Scanning (LIDAR)

- Laser beam
- Rotating mirror
- Variable resolution
- No color (if not equipped with imaging sensor)



From wikipedia

Conventional approaches

- Aerial Photogrammetry (manned and unmanned Aerial Vehicles)
- Terrestrial Photogrammetry (mostly Manned Vehicles or remotely controlled)
- Satellite (remote sensing) techniques (Unmanned satellite platforms)

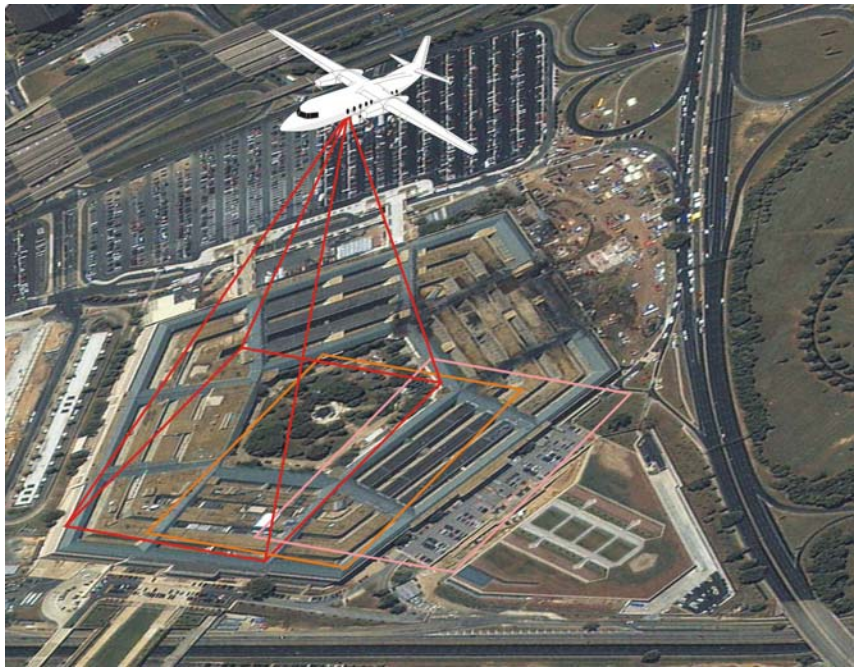
Photogrammetry Vs Laser Scanning

- High accuracy when sophisticated algorithms are combined
- Multi image configuration
- Fast but not for real time applications
- Needs further digitization process

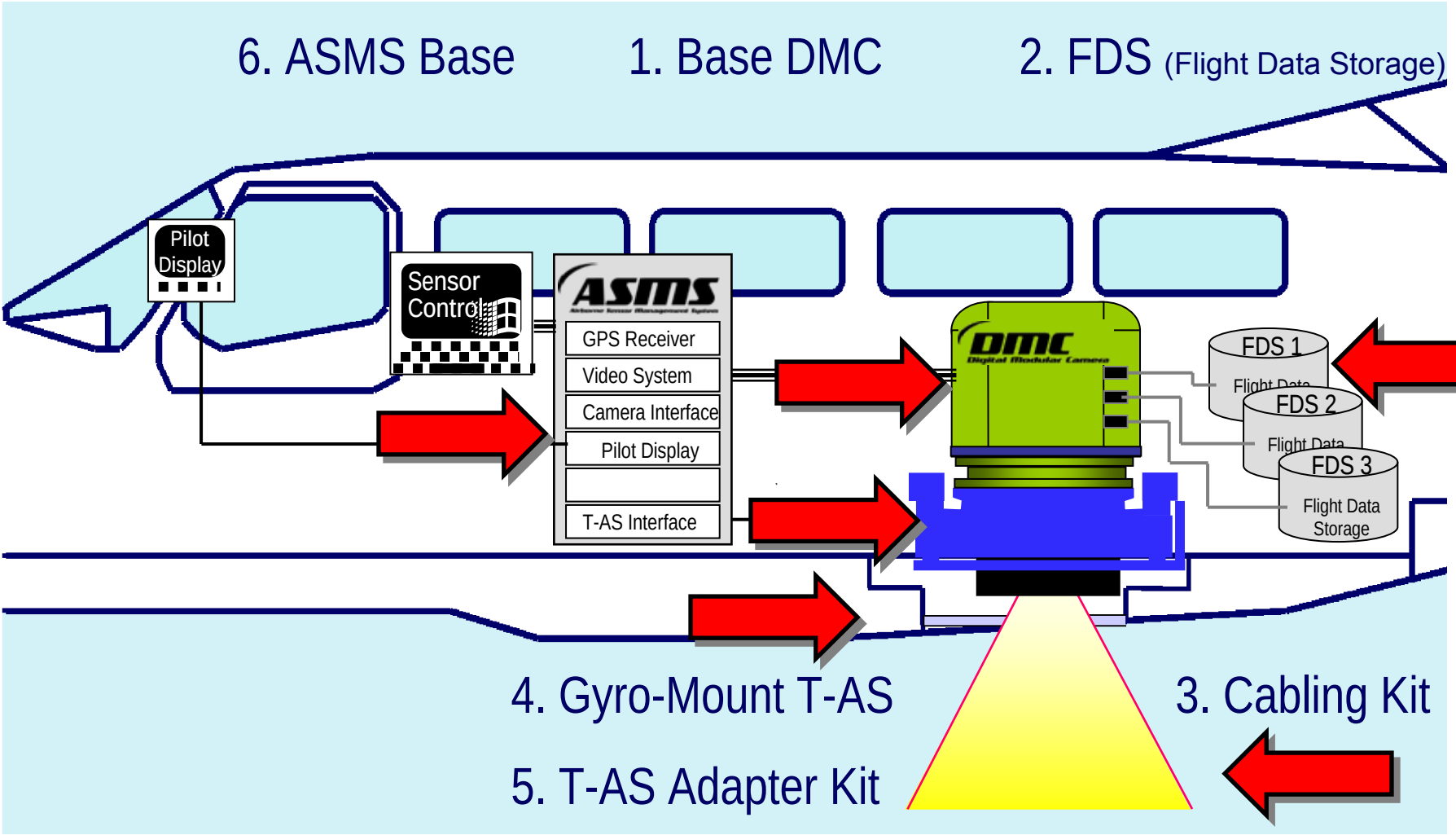
- Faster (real time)
- Possible data loses when the resolution is low
- Not applicable at high altitudes
- Huge amount of information
- Needs further digitization process

Aerial Photogrammetry

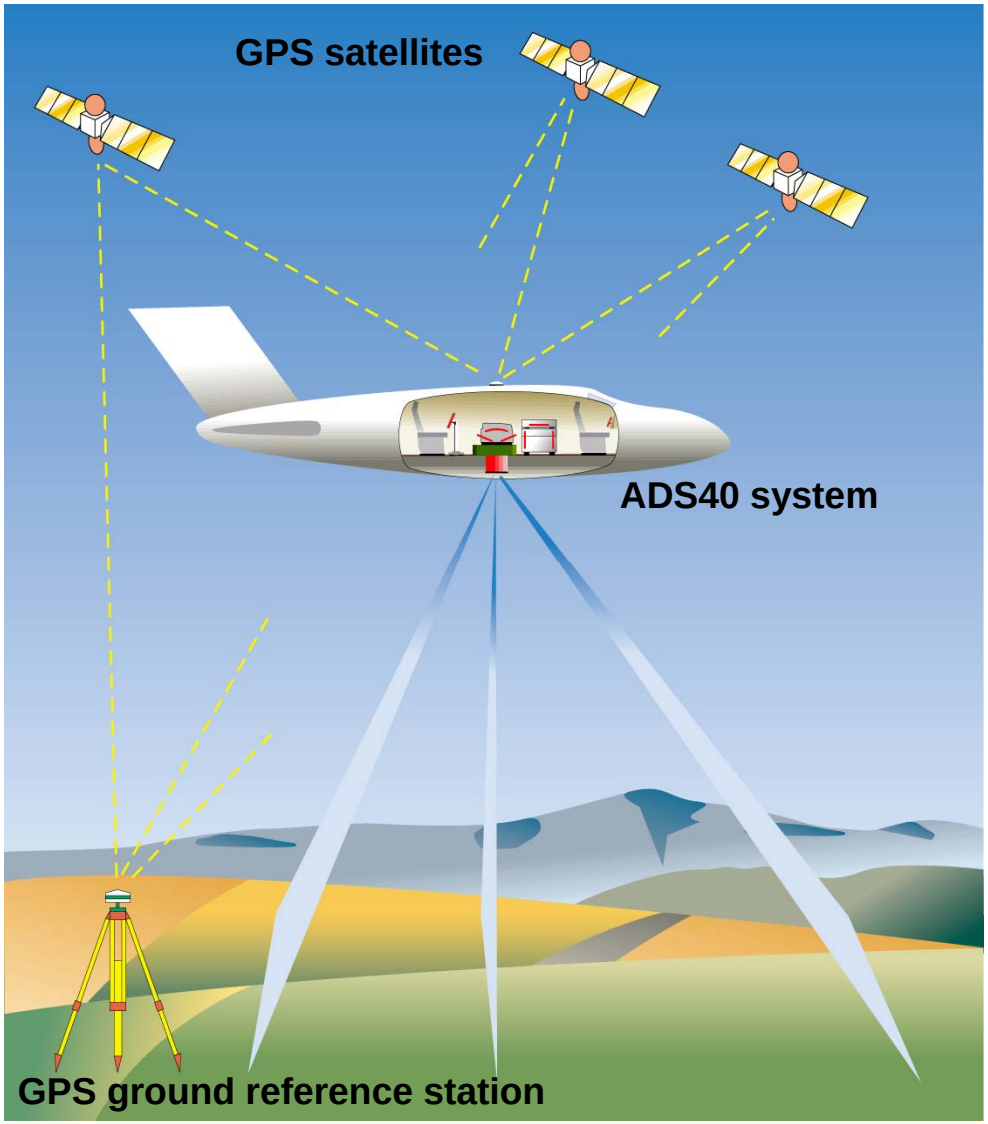
- Standard configuration of (Digital) Metric Cameras
- Special equipment
  - Radiometry (e.g. panchromatic /multispectral)
  - Geometry (linear/ matrix)
  - GPS/INS
  - LIDAR



DMC Intergraph Airborne System

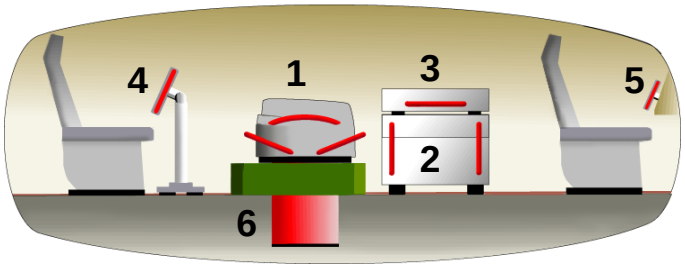


Airborne ADS40 system



ADS40 System

1 Sensor head SH40 with:
- Digital optics DO64
- IMU



2 Control unit CU40 with:
- position & attitude computer POS

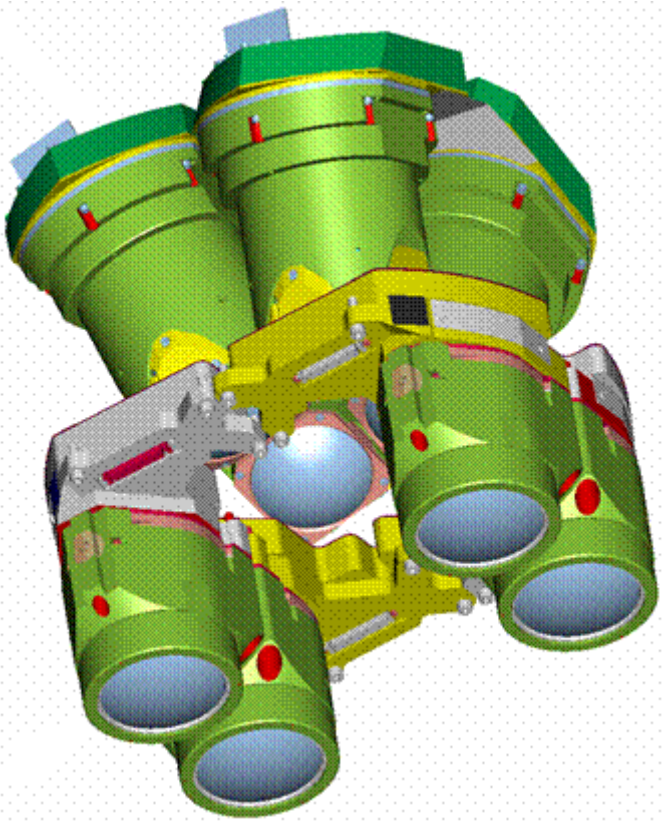
3 Mass Memory MM40

4 Operator interface OI40

5 Guidance Indicator GI40

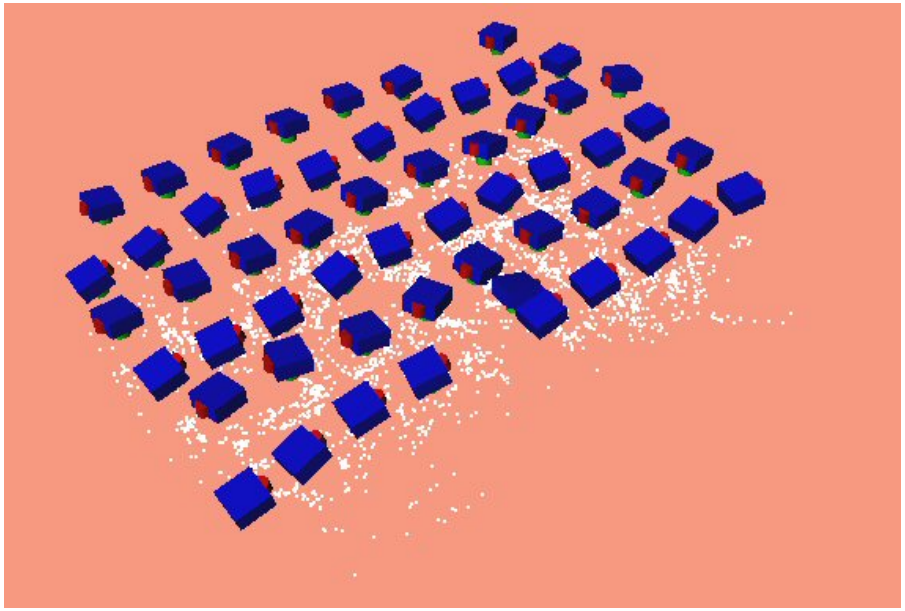
6 Mount PAV30

Matrix Vs Linear



Unmanned Aerial Vehicles

- Not dedicated for Photogrammetric applications
- Equipped with conventional GPS sensors
- Low altitude – small resolution
- Sophisticated image processing to avoid blunders



Type of UAVs

Κατηγορία		Βάρος (kgr)	Ακτίνα Δράσης (Km)	Επιχειρησιακή Οροφή (m)	Διάρκεια Πτήσης (h)
Nano	η	<0.025	<1	≤100	<1
Micro	μ	<5	<10	≤250	<1
Mini	Mini	<25/ 30 / 150	<10	150 / 250 / 300	<2
Close Range	CR	25-150	10-30	3000	2-4
Short Range	SR	50-250	30-70	3000	3-6
Medium Range	MR	150-500	70-200	5000	6-10
Medium Range Endurance	MRE	500-1500	>500	8000	10-18
Low Altitude-Deep Penetration	LADP	250-2500	>250	50-9000	0.5-1
Low Altitude-Long Endurance	LALE	15-25	>500	3000	>24
Low Altitude-Long Endurance	MALE	1000-1500	>500	5/8000	24-48
High Altitude-Long Endurance	HALE	2500-5000	>2000	20000	24-48
Combat UAV	UCAV	>1000	+/- 1500	12000	+/- 2
Optionally Piloted Aircraft	OPA	2500-5000	>2000	12000	+/- 8

Photogrammetric UAVs evaluation

Type	Range	Flying Duaration	Resistance Weather condition	Manouvre capability
Balloon	-	**	-	-
Airship	**	**	-	**
Paraglider	*	-	-	-
Kite	*	-	-	-
Glider	**	*	*	*
Propeller & Jet engines	**	**	*	*
Single rotor	*	*	*	**
Coaxial	*	**	*	**
Quadrotors	-	-	-	**
Multi-rotors	*	*	*	**

-:NOT AVAILABLE, *: LIMITED AVAILABILITY, **: COMPLETE AVAILABILITY

Laser scanners

- In terms the carrier or installation
  - Terrestrial laser scanners
  - Aerial (LIDAR)
  - Mobile Mapping Systems
- In terms of applications
  - Indoor
  - Outdoor
- In terms of technology used
  - Optical (Triangulation scanners)
  - Range scanners (Time of Flight/Phase scanners)

Terrestrial Scanners

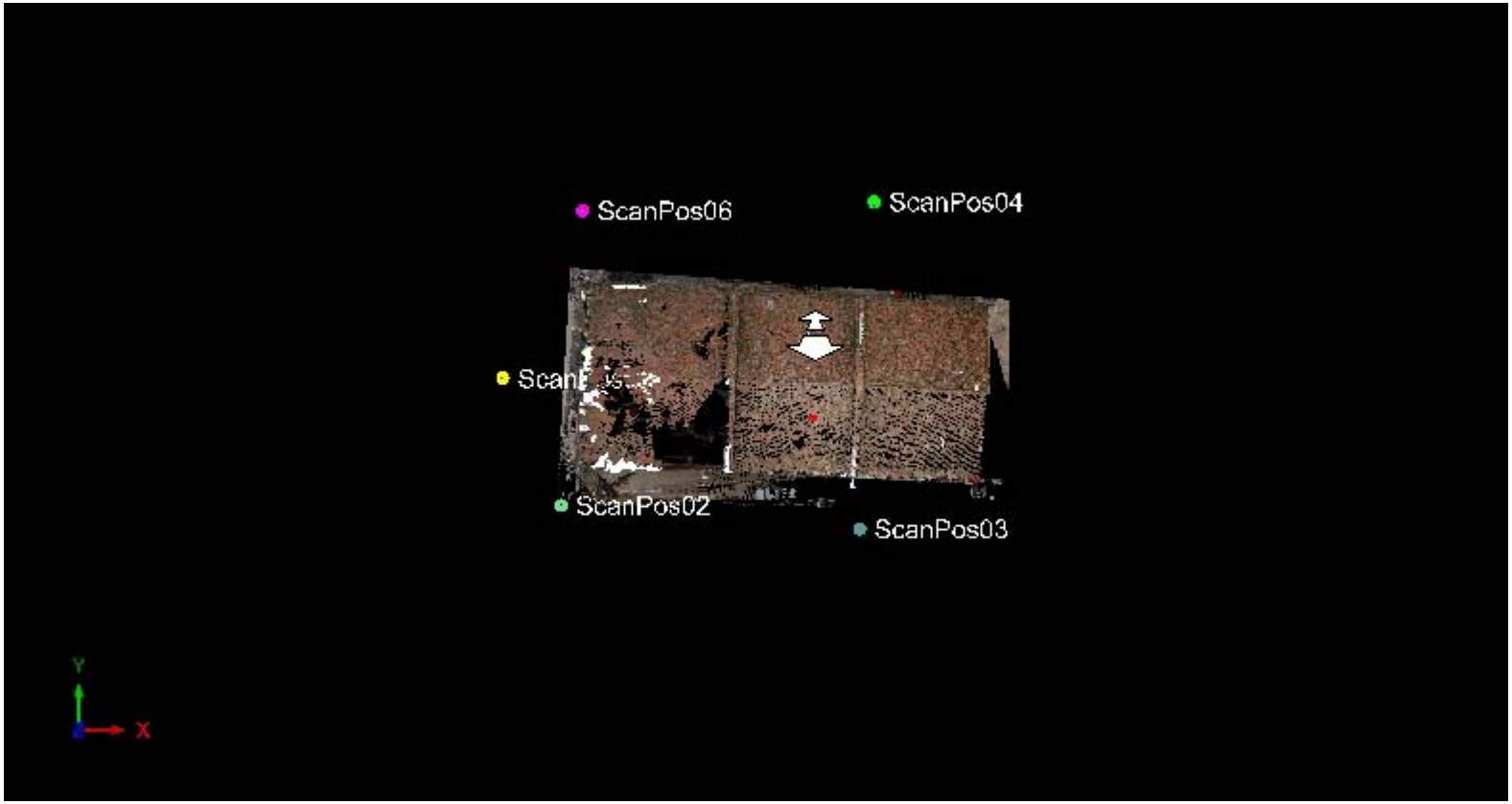
- Ideal for Cultural Heritage Recording and Industrial application
- Medium Cost (25-120KEuros) of Hardware and Software
- Accompanied by calibrated imaging sensor
- Easy to operate
- Hard to manipulate the derived point clouds

From wikipedia

Laser Scanning of the Rotonda

- Creation of a replica in scale 1:250 for the visually impaired
- Laser Scanning accompanied with high resolution panoramic images
- Faro Focus 3D

Point Clouds



Aerial Laser Scanning

- State of the art laser scanners
- Penetration through the vegetation and recording of True DEM (Last Pulse recording)
- Low Altitude flights
- Usually no color

Riegl airborne laser scanner systems

Mobile Mapping Systems

- Includes:
  - Laser scanning (one or multiple)
  - IMU (Inertial Measurement Unit)
  - Single panoramic or several camera sensors
  - GPS (of geodetic accuracy-cm)
  - Odometer (in case of lost GPS signal)

DARPA Urban Challenge

The DARPA Urban Challenge was held on November 3, 2007, at the former George AFB in Victorville, Calif. Building on the success of the 2004 and 2005 Grand Challenges. The event required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections.

Special Applications

- Laser Scanning of Grand Canal in Venice
- 123D Catch

Laser Scanning of Grand Canal in Venice

Conclusions

- Merging of Photogrammetry, Remote Sensing and Laser scanning
- Real time applications
- UAV development and more frequent use of integrated systems
- Computer vision techniques and algorithms will enhance the performance of imaging and point cloud systems

References

- Τσιούκας Β., Σπαταλάς S., Πικριδάς Χ., Φωτίου Α., *Χρήση μη επανδρωμένου αεροναυτικού σκάφους για τη δημιουργία τοπογραφικών διαγραμμάτων μεγάλης κλίμακας, Τμήμα Αγρ. Και Τοπγράφων Μηχ. ΑΠΘ, Τιμητικός τόμος για τον ομότιμό καθηγητή Γ. Βλάχο,2011*
- P. Tokmakidis, S. Spatalas, K. Tokmakidis, V. Tsioukas*, Laser Scanning In the Service of the Visually Impaired, will be presented in the XXII ISPRS International Symposium in August 2012, Melbourne, Australia*
- Anestis Koutsoudis, Fotis Arnaoutoglou, George Pavlidis, Vassilios Tsioukas, Christodoulos Chamzas, *Process Evaluation of 3D Reconstruction Methodologies Targeted to Web Based Virtual Reality*, XXI symposium of CIPA-Cultural Heritage Documentation Athens, 1-6 October, 2007
- Dr. M. Madani, *DMC - Η πλέον ευέλικτη ψηφιακή μηχανή μεγάλου φορμάτ στην αγορά*, από την ημερίδα ΝΕΕΣ ΤΕΧΝΟΛΟΓΙΕΣ ΓΙΑ ΤΗΝ ΣΥΛΛΟΓΗ ΧΩΡΙΚΩΝ ΠΛΗΡΟΦΟΡΙΩΝ που διοργανώθηκε από την ΕΛΛΗΝΙΚΗ ΕΤΑΙΡΕΙΑ ΦΩΤΟΓΡΑΜΜΕΤΡΙΑΣ ΚΑΙ ΤΗΛΕΠΙΣΚΟΠΗΣΗΣ, Αθήνα, 30 Νοεμβρίου 2005
- Peter Fricker, Felix Zuberbühler, Principles and design of the airborne digital sensor ADS40, January 2005