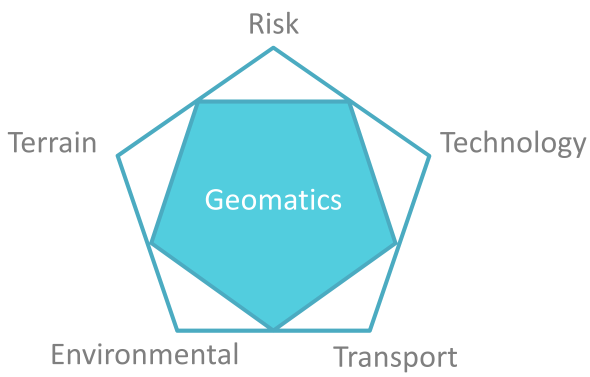
Three-dimensional laser scanning in aircraft surfaces

Universidad de los Andes

Daniel Páez - Luis Miranda

Who are we?



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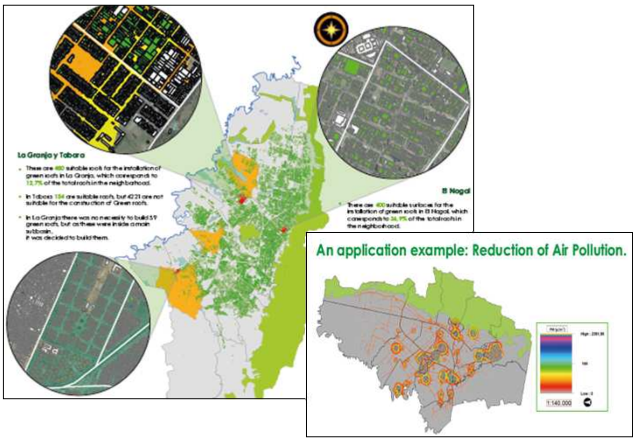
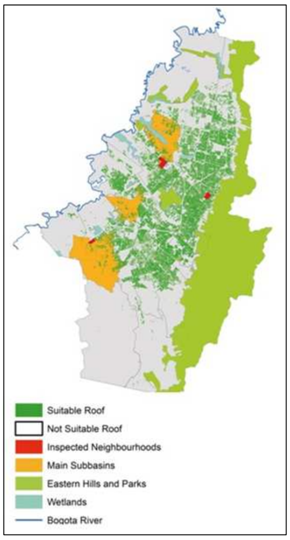
Environmental

Green roof allocation analysis





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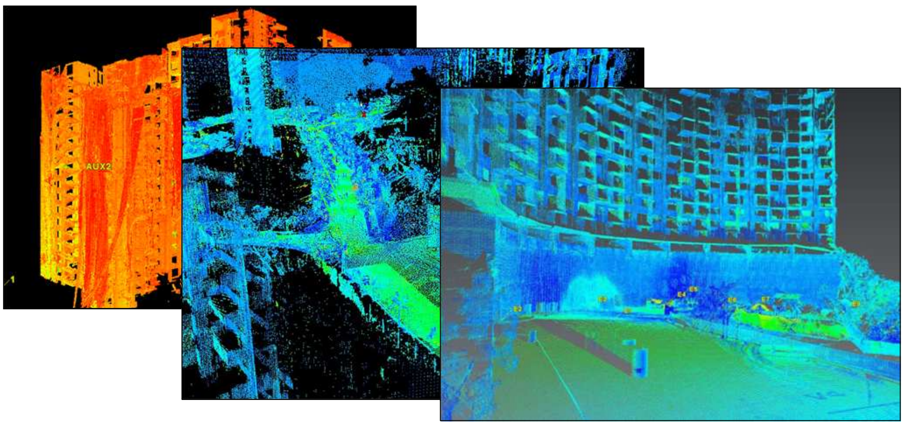
Technology

Laser scanner



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Technology

UAV Applications

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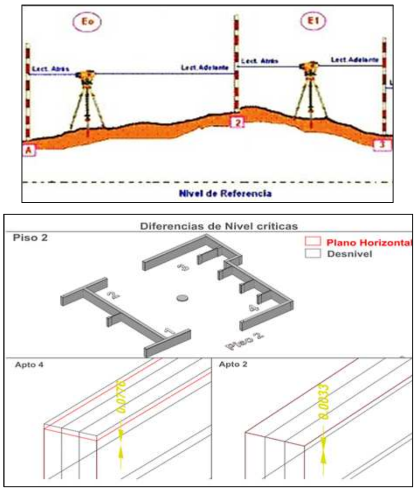
Terrain - Survey studies



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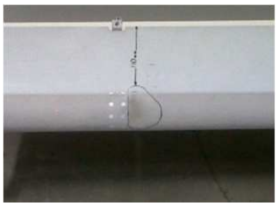

Three-dimensional laser scanning test in aircraft surfaces

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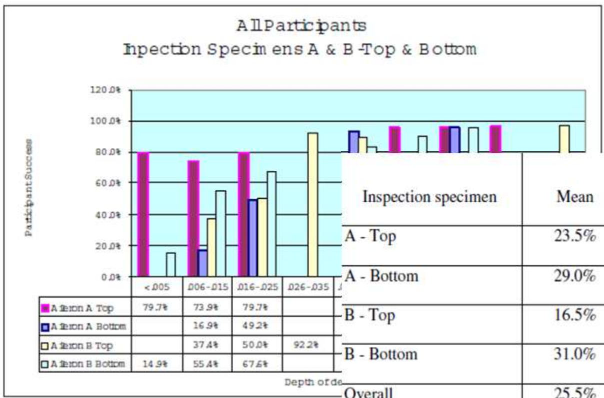
Introduction



Summary graph, participants-inspection speci
Wilhelmsen, 2004)

Inspection specimen	Mean	Median	Standard Deviation
A - Top	23.5%	18.2%	26.5
A - Bottom	29.0%	22.2%	28.9
B - Top	16.5%	9.1%	18.7
B - Bottom	31.0%	25.0%	26.7
Overall	25.5%	18.2%	25.0

SUMMARY OF FALSE POSITIVE (ERCHART, OSTROM, & WILHELMSEN, 2004)

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Background

- **State-of-the-art of non-destructive inspection (NDI) methods**
  - Visual inspection parameters affecting visual inspection
    - Parameters relevant to visual inspection for aircraft study are:
      - Inspection personnel qualifications and training
      - Inspection area access
      - Lighting
      - Pre-cleaning
      - Color.
      - Working environment factors

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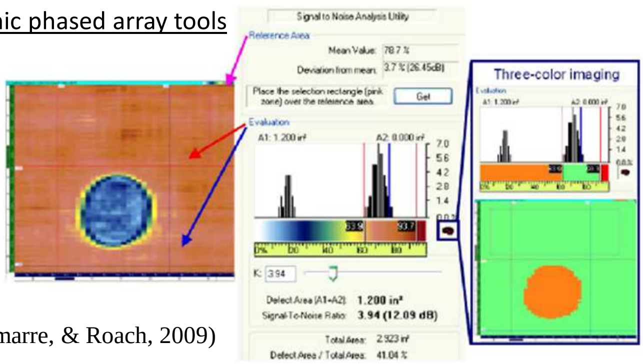
Background

- **State-of-the-art of non-destructive inspection (NDI) methods**
  - Ultrasonic phased array tools



(Habermehl, Lamarre, & Roach, 2009)

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Background

- **State-of-the-art of non-destructive inspection (NDI) methods**

Line scanning thermography	Lamb waves	Lidar
• Dynamic thermal imaging technique • Presence of sub-surface features are revealed as thermal gradients on the surface	• Are elastic waves that are generated in a solid plate with free boundaries • Can be generated using piezoelectric transducers, etc.	• Light detecting and raging • Proved that damage can be detected by a LIDAR scan and identified by human

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Background

- **Damage metrics**

Category 1	Category 2	Category 3	Category 4	Category 5
• Undetected by direct field inspection • Allowable manufacturing defects • Damage below Allowable Damage Limit • Barely visible impact damage	• Detected by direct field inspection • Exterior skin damage • Interior stringer blade damage	• Obvious damage detected within a few flights • Accidental damage to lower fuselage • Lost bonded repair patch	• Discrete source damage immediately known by pilot • Rotor disk cut through fuselage • Severe rudder lightning damage	• Severe damage created by anomalous ground or flight events • Events that are outside of design considerations • Special directed inspections are needed

(Baaran, 2009)

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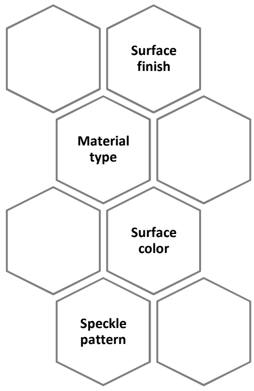
Terrestrial Laser Scanner

Range error	Focus range	Resolution
±2mm @10m	0.6m a 120m	to 70 Mpxl
Speed of measure		**Ranges**
122000-976000 pts/seg		305°/360°

General characteristics, Faro laser scanner (FARO, 2013)

Challenges



(Ross, Harding, & Eric, 2011)

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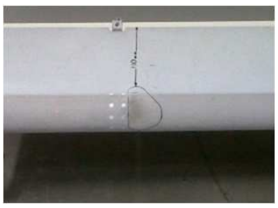
Case of study



Dent on A320 Leading Edge
- Laboratory situation
- Identified dent
- To measure the dent

A320 Nose Radome
- Laboratory situation
- To identify scratch
- To measure scratch

Aircraft wing to be tested
- Simulated practical situation
- To identify potentially harmful dents

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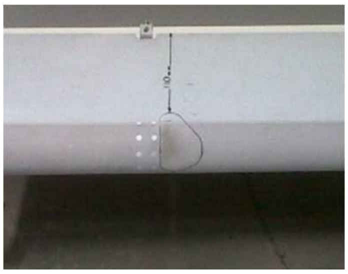
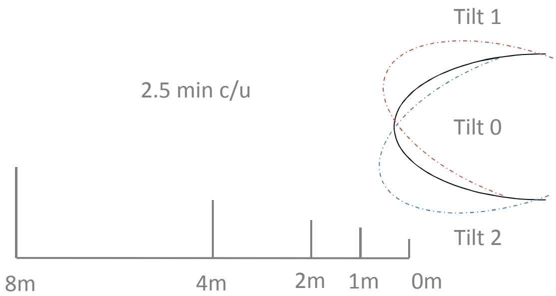
Methodology development

- Measurement planning
  - High efficiency, good accuracy and relatively low density
  - Avoid the challenges and noise mentioned on the Terrestrial laser scanner section





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Methodology development

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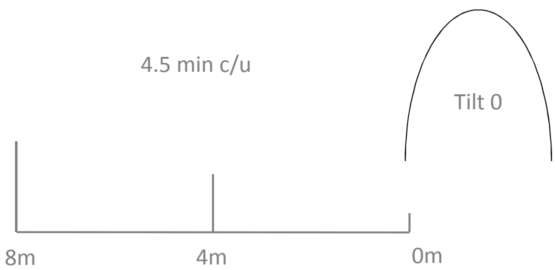

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Methodology development

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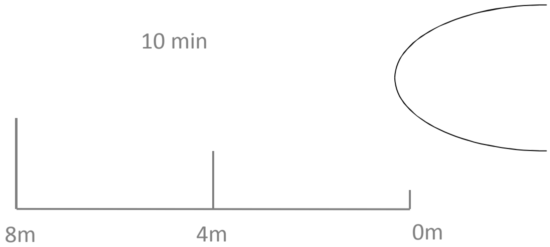

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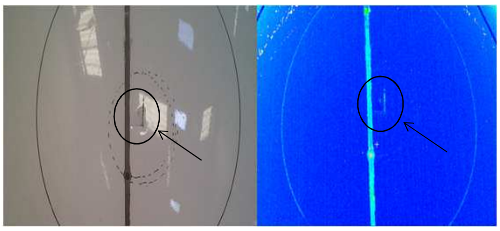
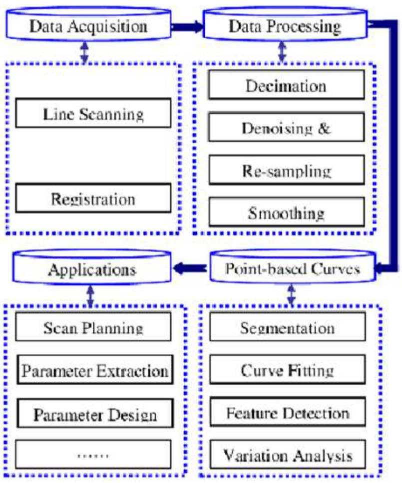
Methodology development

- Identification technics
  - By light intensity





Data pipeline and processing framework (Chen, Du, Jia, & Song, 2010)

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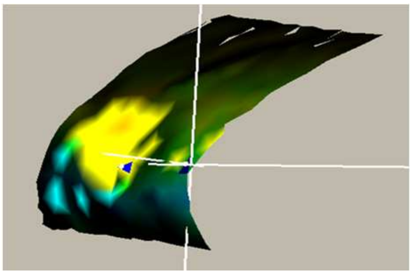
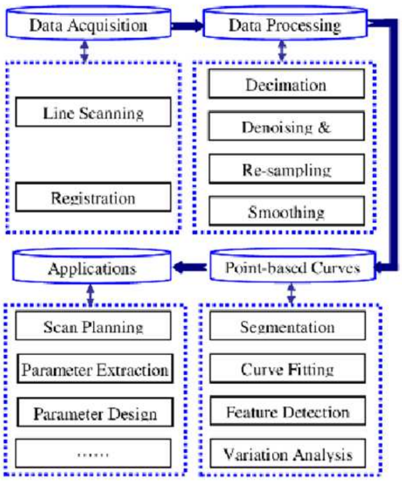
Methodology development

- Identification technics
  - Surface shading based on an imaginary light adjacent to the surface





Data pipeline and processing framework (Chen, Du, Jia, & Song, 2010)

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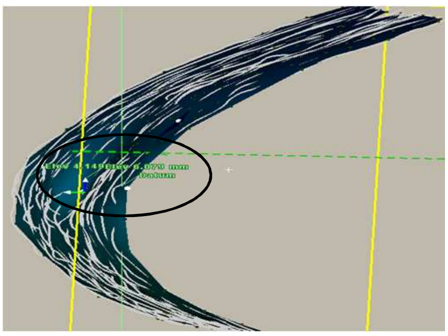
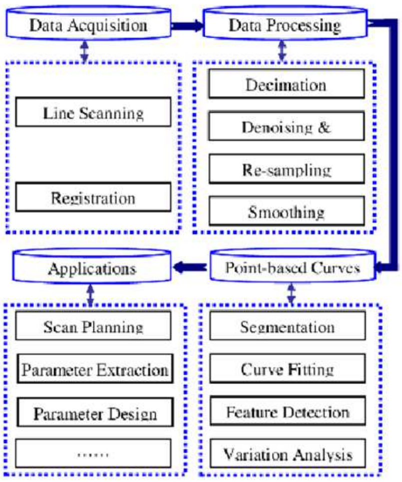
Methodology development

- Mensuration technics
  - By datum and maximum distance





Data pipeline and processing framework (Chen, Du, Jia, & Song, 2010)

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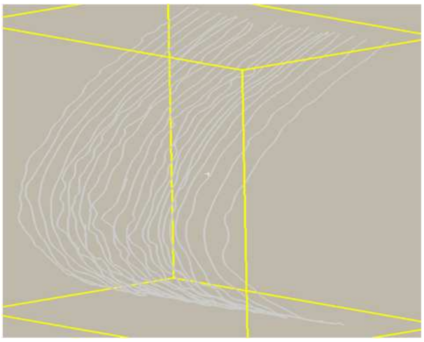
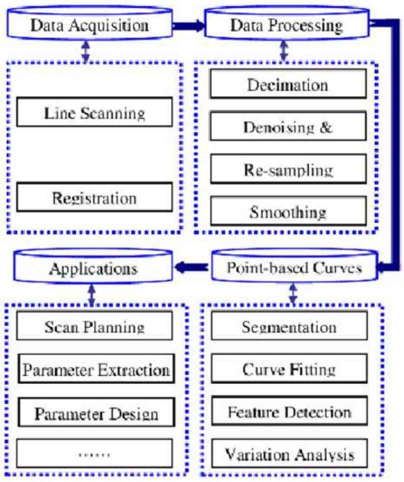
Methodology development

- Mensuration technics
  - Series of cubic splines by slices





Data pipeline and processing framework (Chen, Du, Jia, & Song, 2010)

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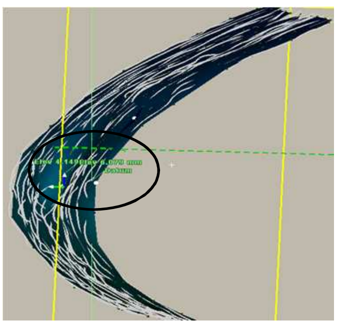
Results and discussion

- Measurement of the leading edge
  - By datum and maximum distance



Measure	Distance [m]	Separation of scan lines [mm]	Separation scan point in line [mm]	Density scan mesh[pts/cm^2]
Leading Edge (tilt 1)	1	Not measurable	Not measurable	-
	8	1.407	1.2	59
Leading Edge (tilt 2)	1	Not measurable	Not measurable	-
	2	1.09	0.754	122
	8	2.3	1.27	34

	Estimate of damage			Range error
Measure	Extension[mm]	Height [mm]	Depth [mm]	Measured [mm]
Flap (tilt 1)	-	-	-	6.2
	53.72	71.8	9.898	3.94
Flap (tilt 2)	-	-	-	5.6
	52.814	72.674	7.4	2.1
	53.9	71.18	10.372	2.5

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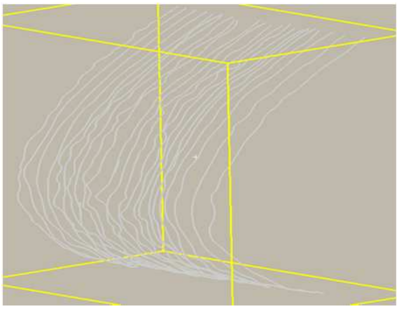
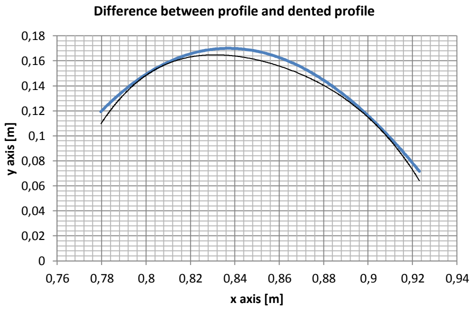
Results and discussion

- Measurement of the leading edge
  - Series of cubic splines by slices





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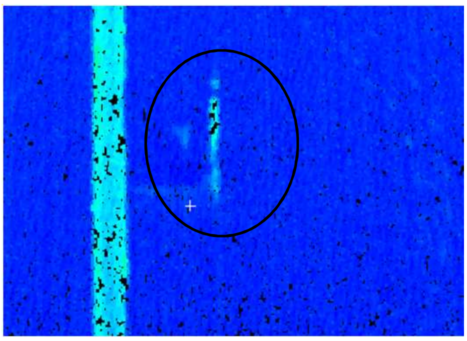
Results and discussion

- Identification on the nose radome
  - By light intensity



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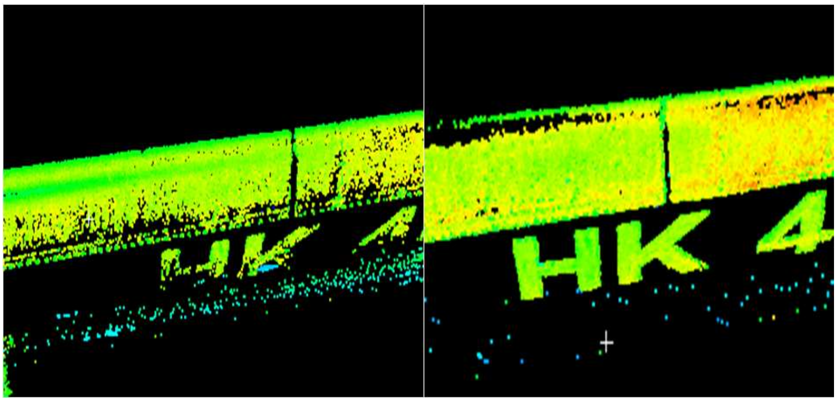
Results and discussion

- Identification on the aircraft wing



Conclusions

- The **light intensity technic** for identification of damages in an aircraft surface appears as a powerful tool
- We found that TLS for aircraft surface inspection is not recommendable to measure at **high incidence angles** and at distances **between 2 and 5 meters.**
- The most reliable solution for the shiny surfaces challenge is to **coat the surface**. This might not be a viable solution for aircraft inspection because of cost and extra time required.
- With the mensuration technics analyzed, the best way was found to be a mean or **approximate datum** of the dispersion of the data and the range error.
- The described analysis of the laser scanner data **does not describe a proved more reliable inspection than a technical human visual inspection**.

Questions?

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