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## Evaluation and Optimisation of Errors in the Reverse Engineering Process

**Gregory Lecrivain, Ian Kennedy and Arezki Slaouti**

Department of Engineering and Technology  
Manchester Metropolitan University  
Manchester, UK



## Outline

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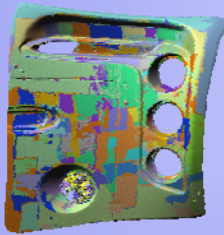
### Application of reverse engineering :

- Cases where no data are available
- Art, industry, medicine
- Reduce product development cycles
- Redesign for improved performance

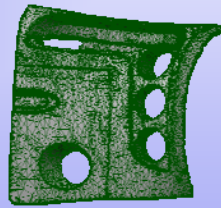
## Outline



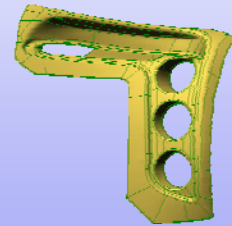
Existing component



Point cloud



Mesh



CAD surfaces

### Reverse engineering procedure

## Outline



### Presentation :

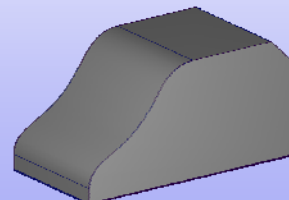
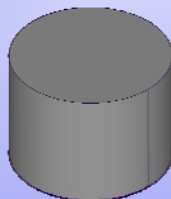
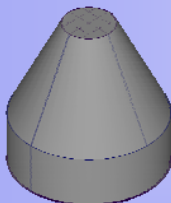
- Remanufacturing of existing components
- Error assessments
- CAD model: surface reconstruction
- Applied example CAD model: TVR Cerbera sportscar
- Linked further work -fluid flow analysis
- Redesign for optimal fluid flow performance

## Equipment: laser scanner



Equipment used to scan the components

## Case study

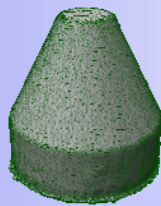


Reverse engineering of geometric shapes

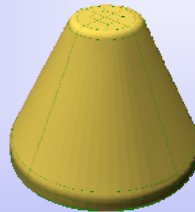
## Embedded errors



Point cloud



Triangulated mesh

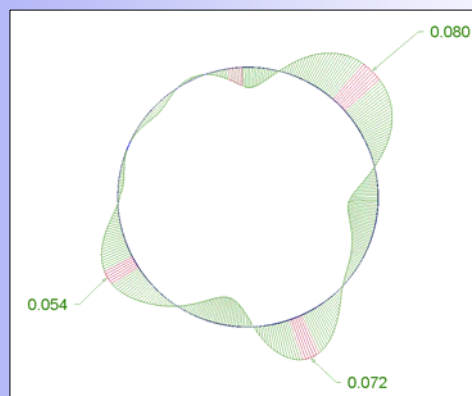


CAD Surfaces (NURBS)



Remanufactured component

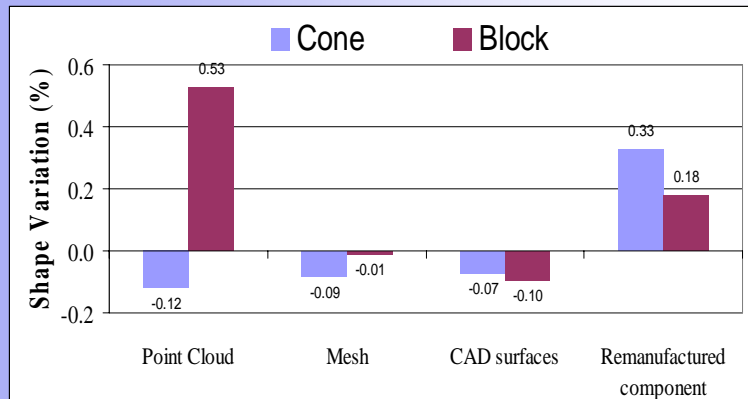
## Fitting a cylinder



Error comb (in mm) on a section between the best-fit cylinder and CAD surfaces

( from initial CAD model diameter of 35 mm )

## Results: Cone & cylinder



Shape variation at each stage of the reverse engineering process

## Results: Cone & cylinder



Overall Variation

**< 0.1 %**

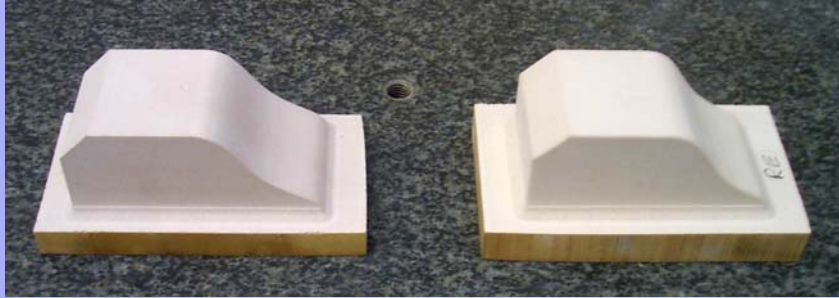
**0.6 %**

Maximum Uncertainty

**0.7 %**

**0.8 %**

## Block-like shape: comparison



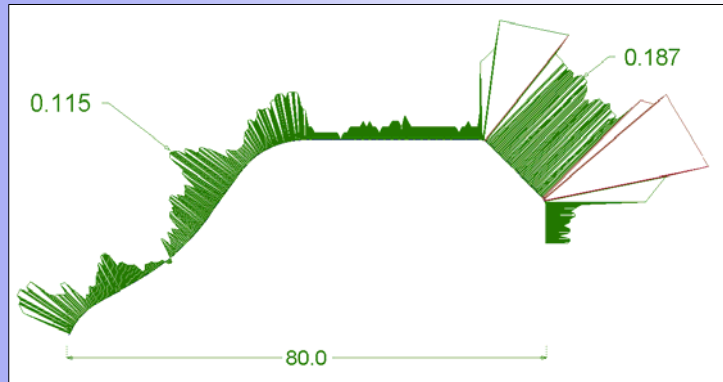
Reverse engineered component and its corresponding original

## Point acquisition



Point acquisition via a three-dimensional measuring machine

## Results: Block-like shape



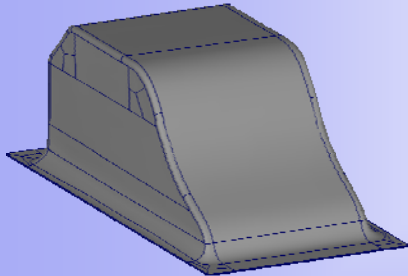
Error comparisons (in mm) between the final reverse engineered component and its original

## Surface reconstruction

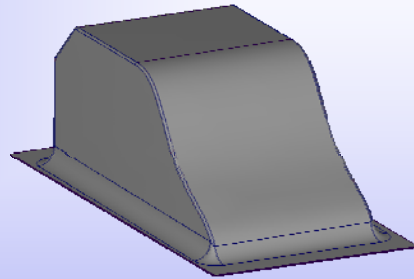


- Traditional procedures
  - Rapid surfacing (RS)
    - fast technique
    - more accurate (smaller surface deviation from mesh)
  - Classical surfacing (CS)
    - time consuming
    - higher quality surface (smoother surface)
- Alternative procedure (AS)
  - Takes advantage of both techniques

## Comparisons



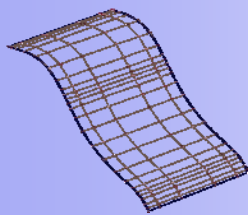
(a)



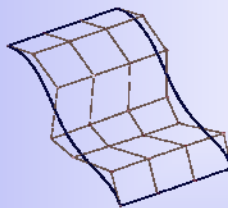
(b)

CAD models obtained via rapid surfacing (a) and classical surfacing (b) techniques

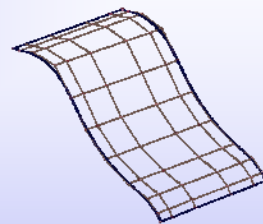
## Alternative Method



Rapid surfacing



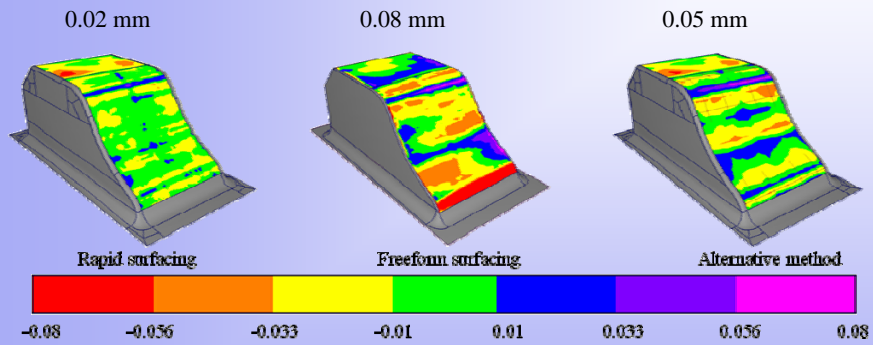
Classical surfacing



Alternative method

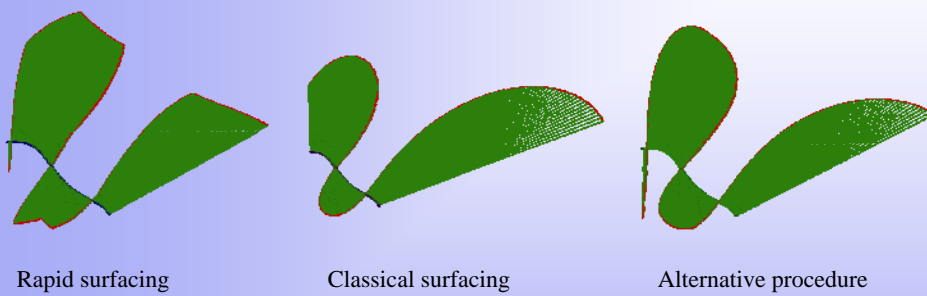
Control point distribution of each procedure

## Results: accuracy



Deviation (in mm) of each final CAD surfaces from the mesh.

## Results: quality



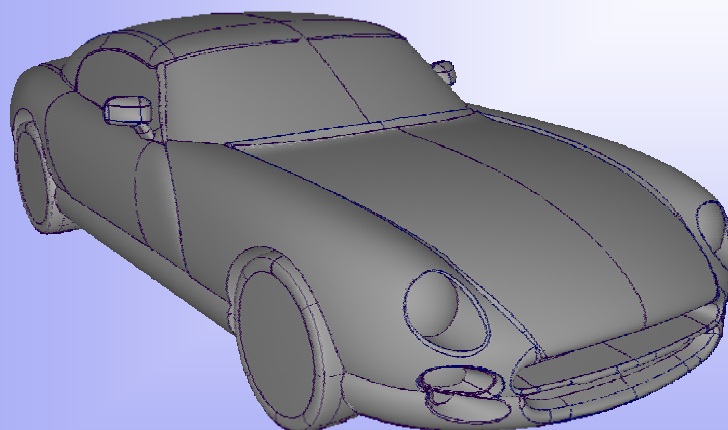
Curvature comb of the complex surface for each corresponding CAD model

## Application: Sportscar



TVR Cerbera

## Application: Sportscar



Final CAD model

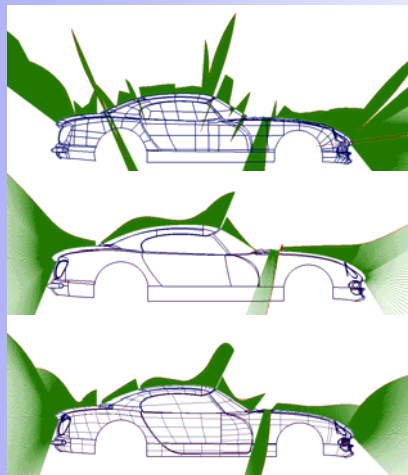
## Sportscar: Accuracy



Procedure	RS	CS	AS
Deviation (mm)	0.3	1.5	0.8

Surface deviation of each procedure

## Sportscar: Surface quality



Rapid Surfacing  
(RS)

Classical Surfacing  
(CS)

Alternative Surfacing  
(AS)

Curvature comb of each procedure

## Sportscar: Time



Task :	Scanning	Mesh creation	RS	CS	AS
Time : (days)	2	0.5	1	5 to 6	3

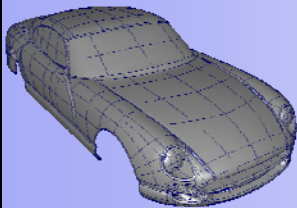
← surface reconstruction →

Time required for each operation

## Summary

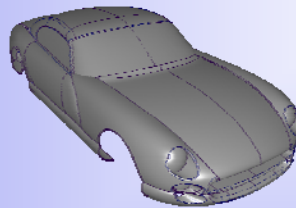


### Rapid surfacing



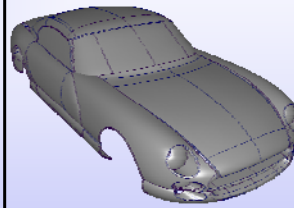
- + Closer fit to the scan
- Lower surface quality
- + Fast procedure

### Classical surfacing



- Greater surface deviation
- + Far higher surface quality
- Prolonged time required

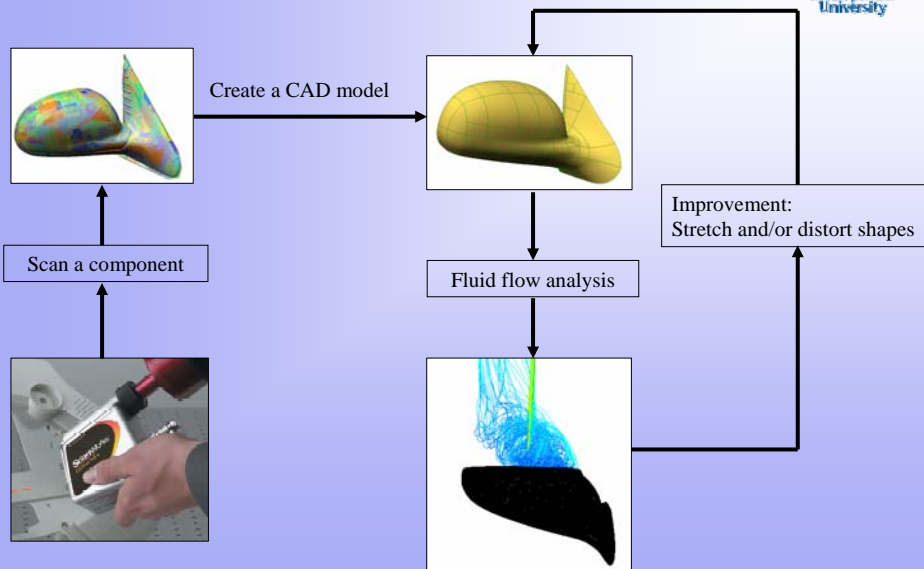
### Alternative surfacing



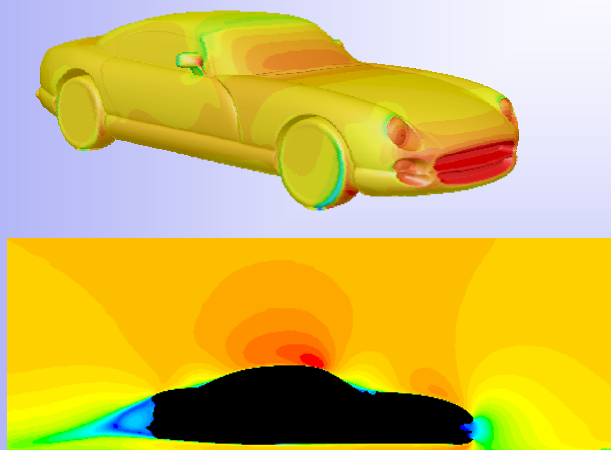
Strikes a balance:

- accuracy
- surface quality
- time

## Further work

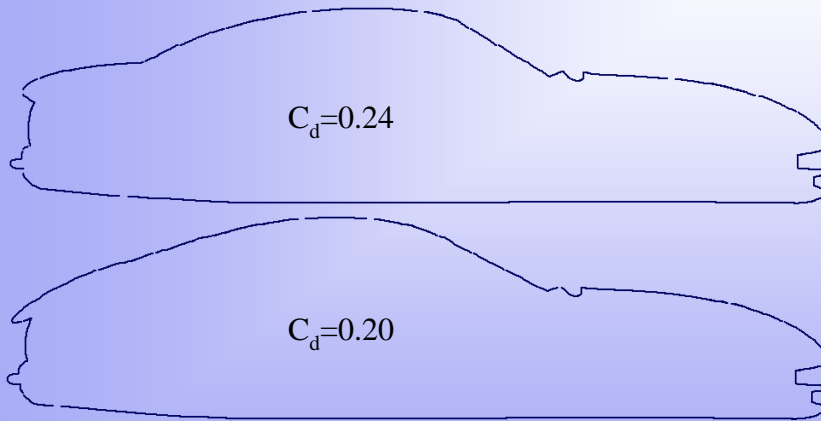


## CFD application



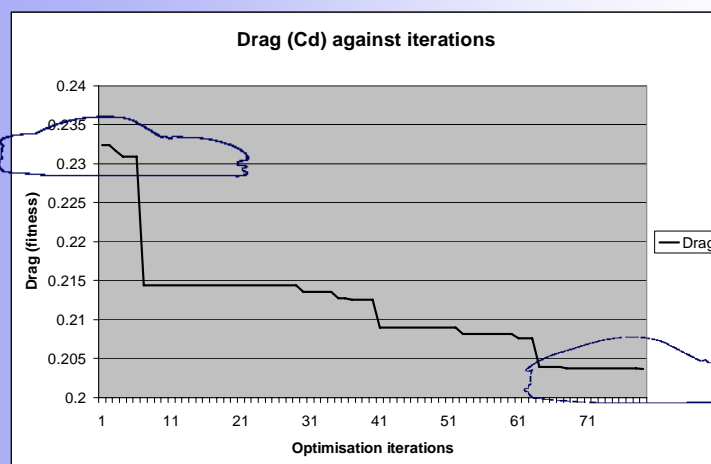
Investigation involving the dynamic interaction of several simulation tools

## On-going research



Shape optimisation of the sportscar (2D simulation)

## On-going research



Shape optimisation of the sportscar (2D simulation)

End

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Any questions ?