Converting Jpeg to 2D Geometry in a CAD System

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Outline

- Background
- Motivation
- The Problem
- The Approach
- The Solution
- Conclusion

Background

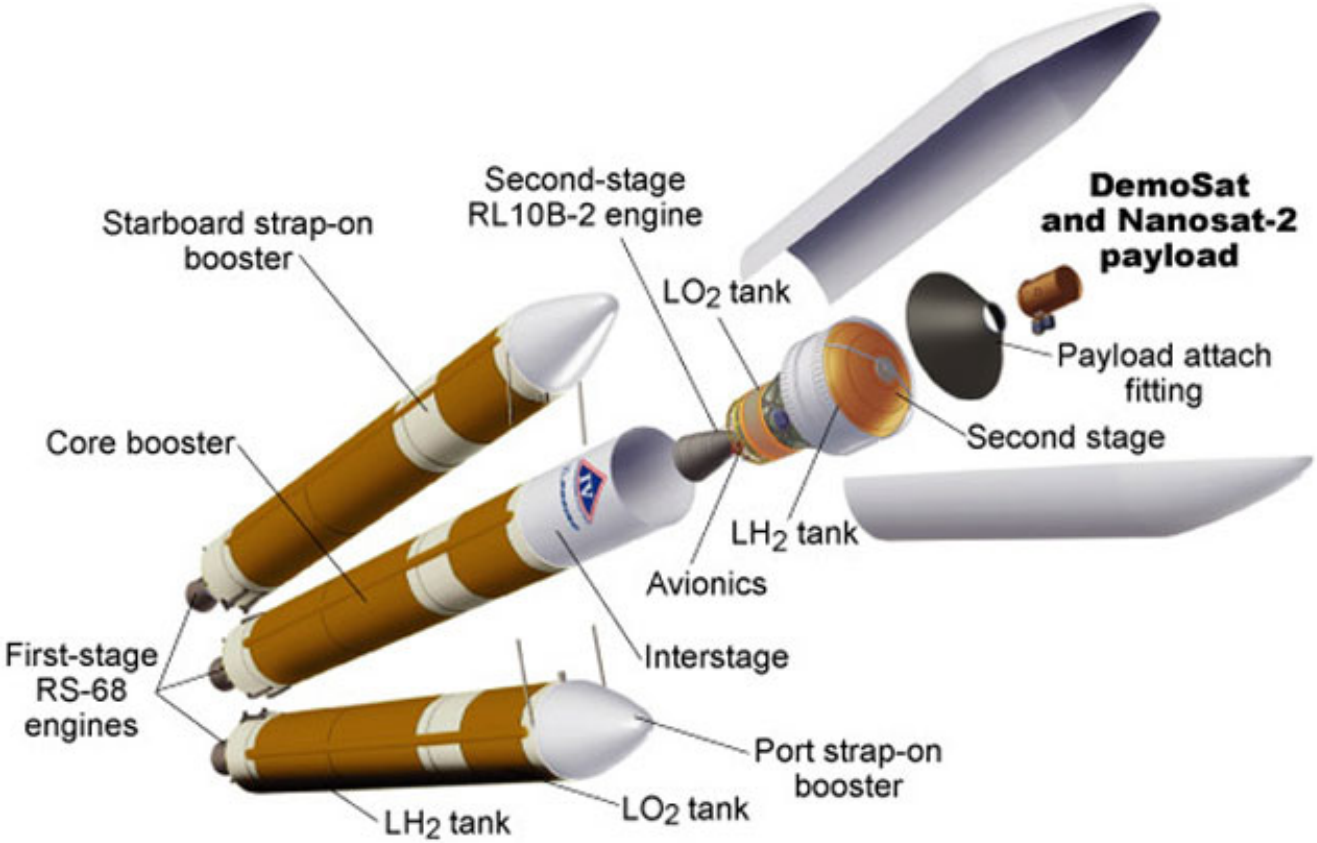
- Mechanical Engineer
- Experience in aerospace

[1]

[3]

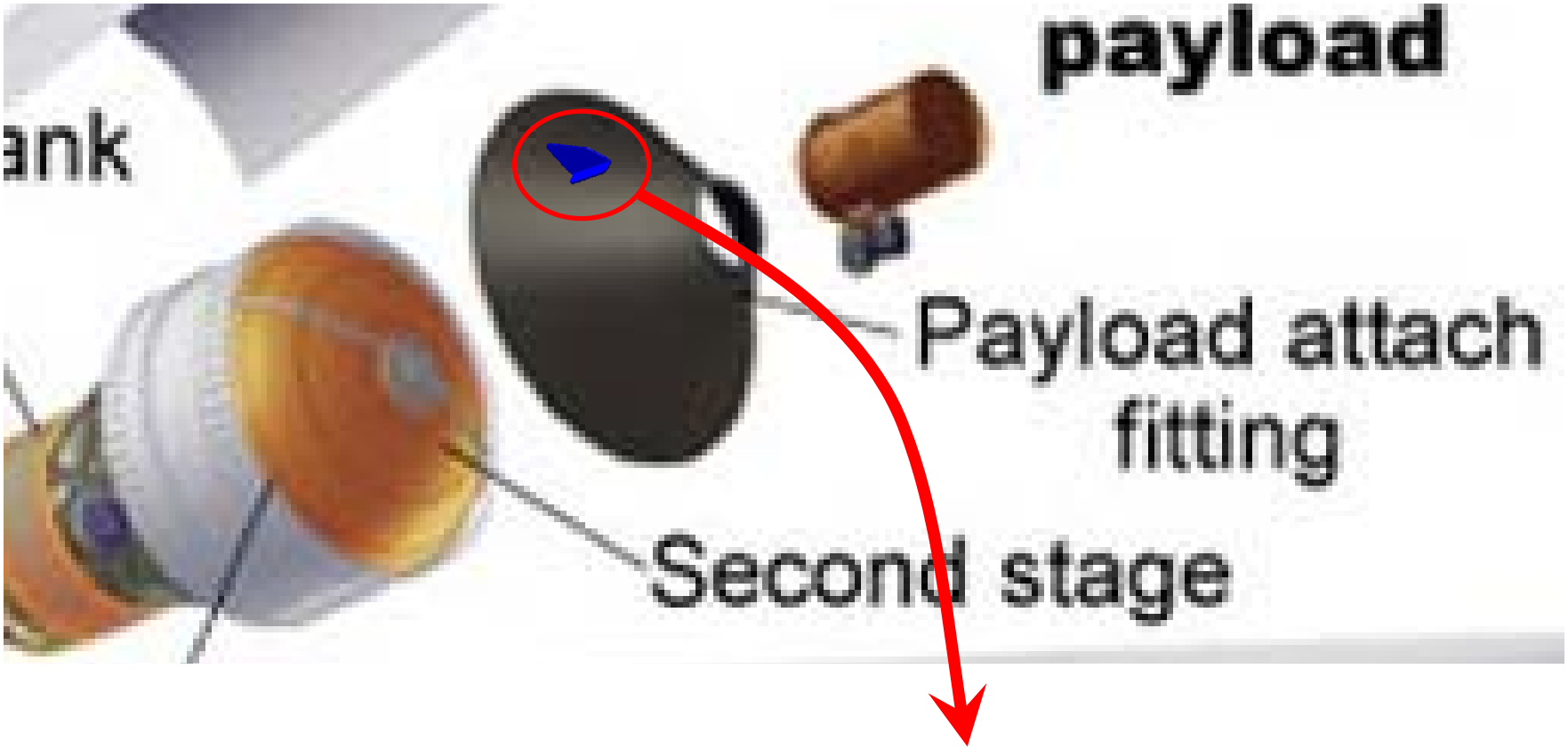
[2]

What’s inside



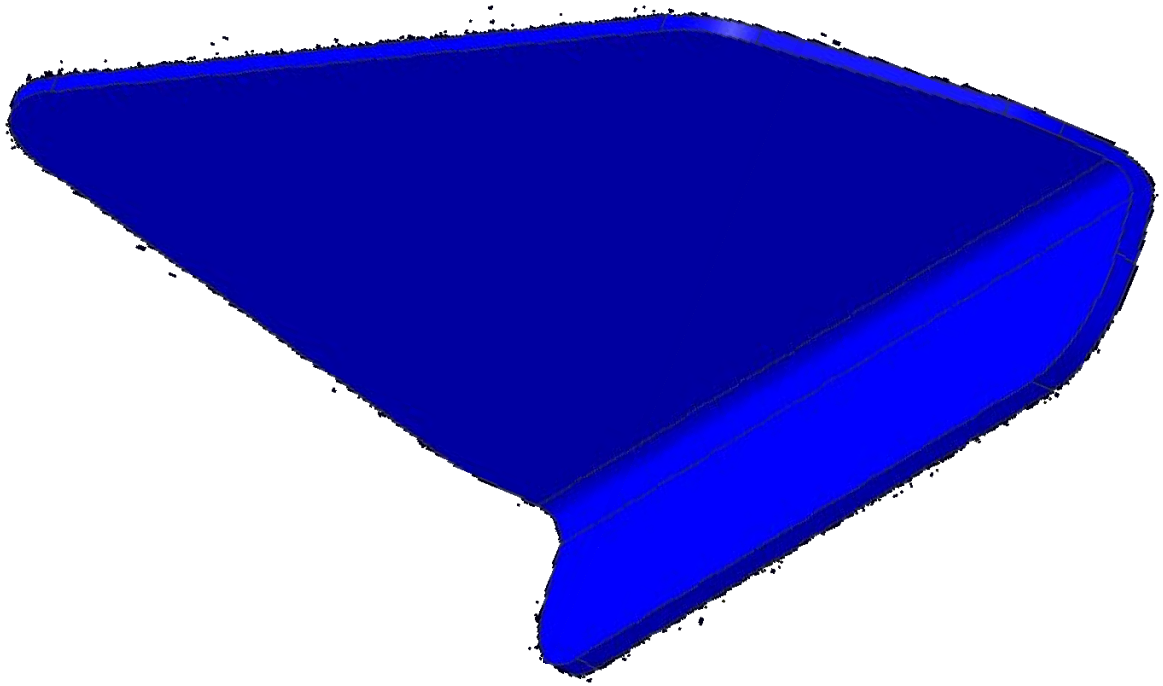
[1]

Some things are the same



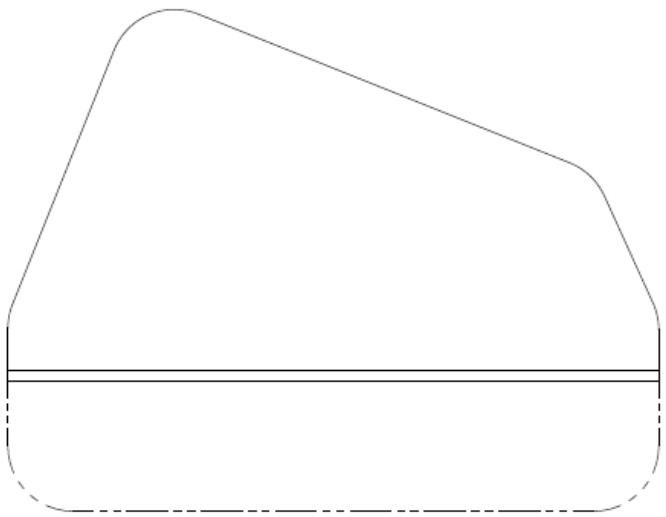
A Generic Bracket

- What is the most economical way to fabricate it?



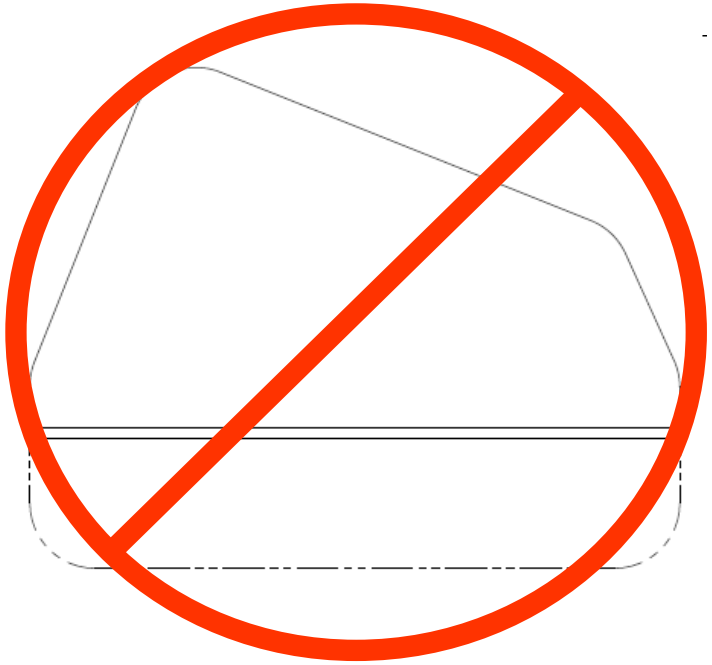
Fabricating the Part

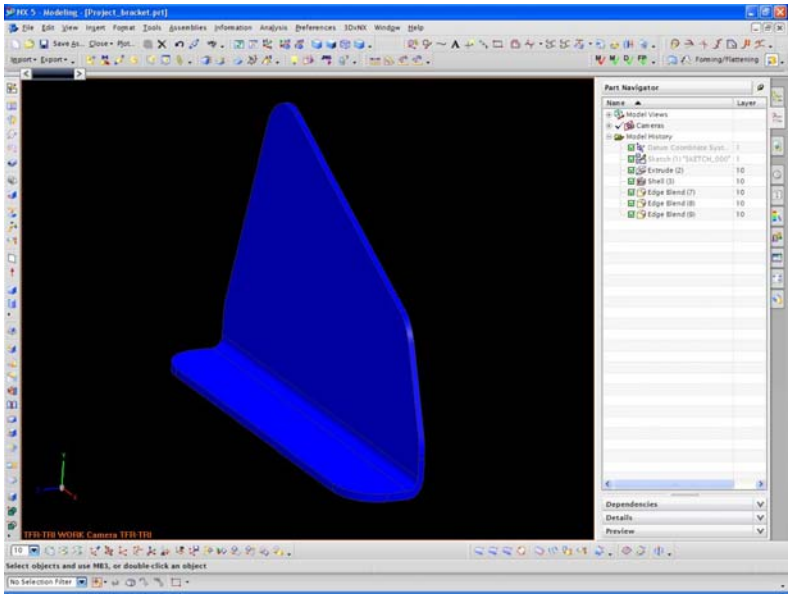
- Drawing produced by hand.
  - Full-scale.
  - Un-dimensioned.
- Supplied to fabricator.
- Image transferred to sheet metal.
- Sheet metal cut out by a skilled machinist.



Motivation

- Hand drawings are out.
- Electronic definition is in.



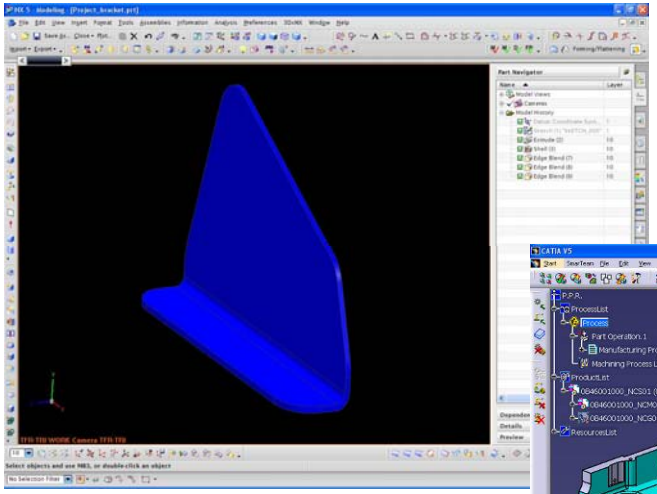


Electronic Definition

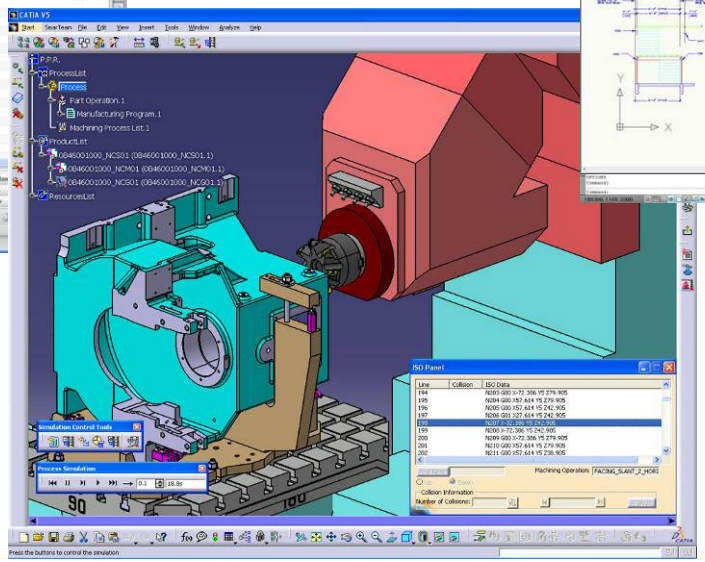
- Fabricators use automated machines.
- They require computer-based data.
- Answer:

CAD (**Computer-aided design):** The use of computer technology for the design of objects, real or virtual. [4]

Computer-Aided Design

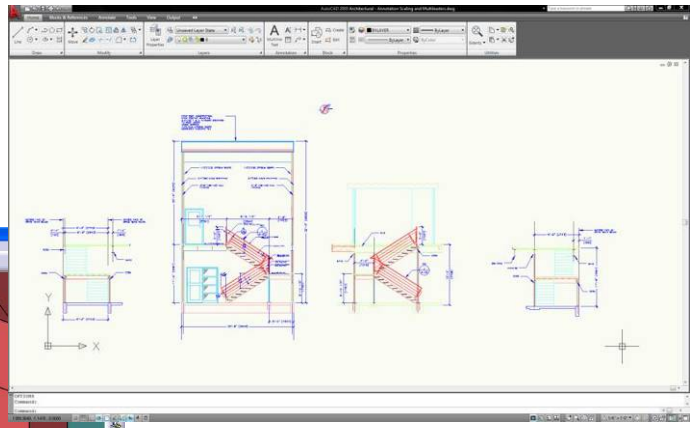


Unigraphics



CATIA

[6]

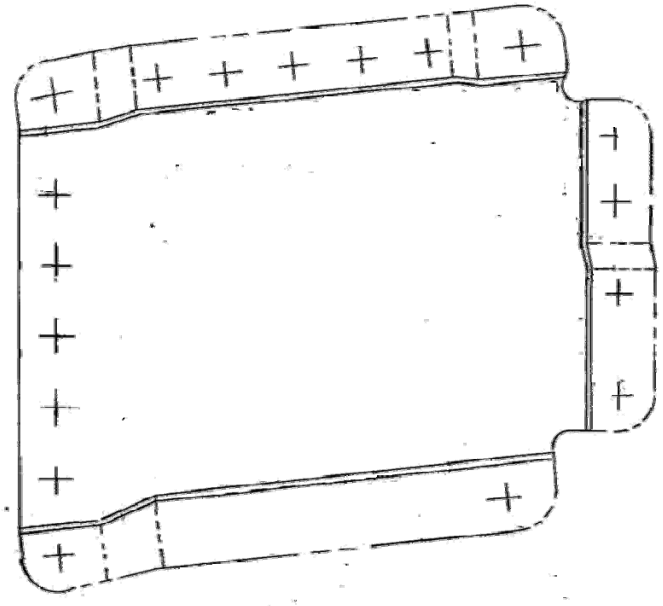


AutoCAD

[5]

Why care about those old hand drawings?

- Need to replace a worn or broken part.
- Desire an improvement to an old design.
- New design interfaces with old.

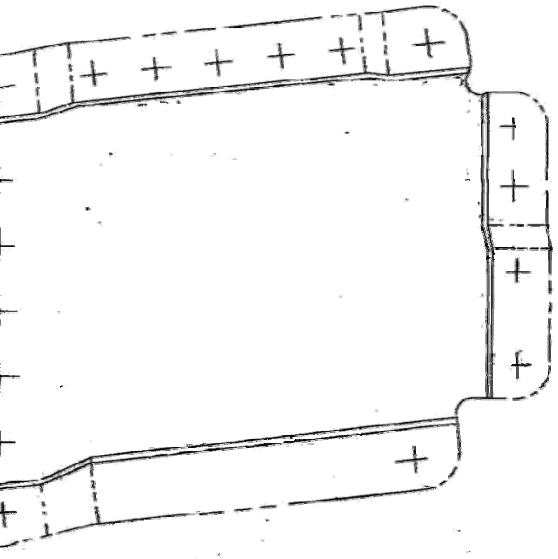


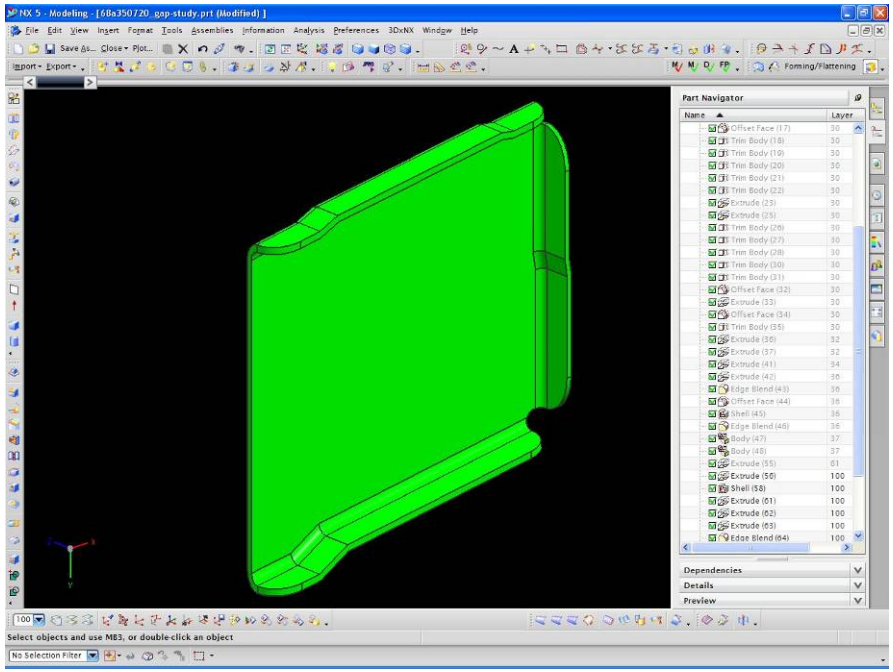
Can’t just use the old data as is?

- Very difficult to find someone who still uses the older technology.
- Electronic copy of data reduces error and eliminates guess-work.

So…

- We need our Jpeg image…
- Translated into CAD data…





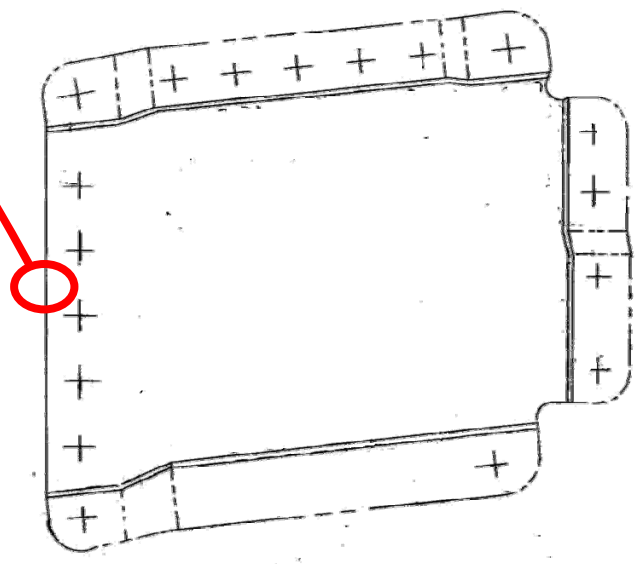
The Problem

- How to translating Jpeg to CAD?
  - Translate the pixel coordinates as points.
  - Extract the lines, arcs, and splines, then translate.

Pixel Coordinates as Points

- Looking at the image in Matlab…

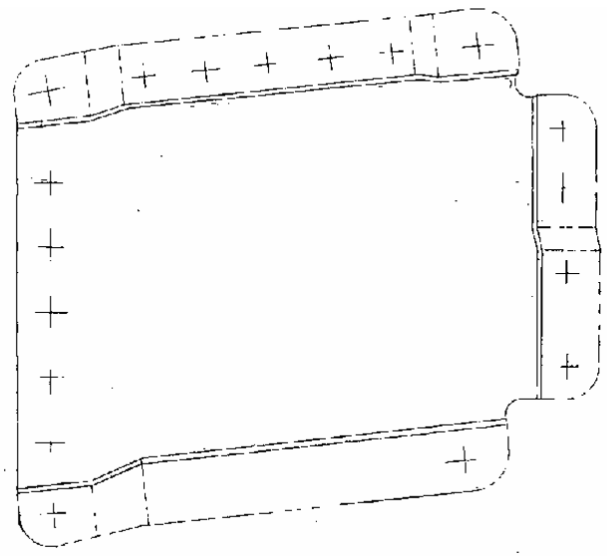
255	249	92	79	255	254
255	255	106	78	255	255
255	252	102	77	255	255
255	254	102	76	254	255
255	255	106	73	251	254
253	250	100	76	253	255



- The white pixels have a value of 255.
- The “black” pixels are… ~76.

Translate pixel coordinates

- Any pixels less than 80:



10,766 points

Extract and Translate

- Clarify image.
- Identify the lines, arcs, and splines.
- Derive equations.
- Translate to CAD.

The Approach

- Find a method to clarify the image.
- Identify curve (line, arc, spline) geometry from pixel coordinates.
- Define which equations best fit or define a curve entity to the pixel coordinates.
- Generate a neutral format data file to translate the curve entities.

Clarify the Image

- Sobel Edge Detector
- Wavelet decomposition
- Sharpening

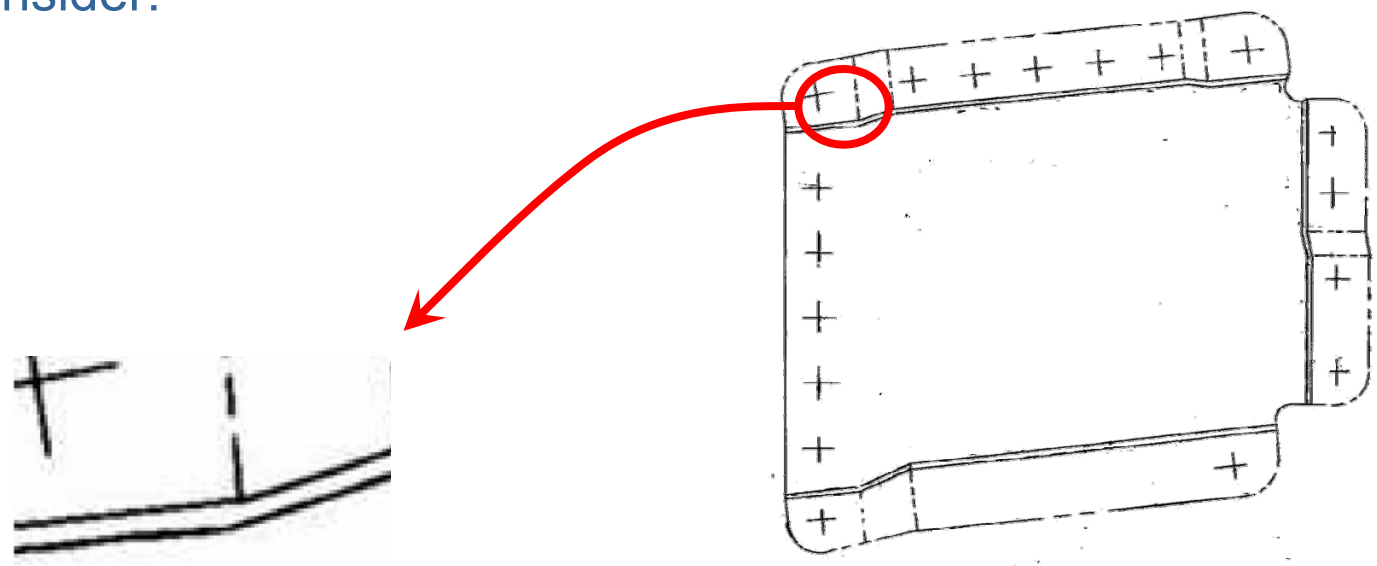
Sobel Edge Detector

- Sobel Edge Detector:

1	2	1
0	0	0
-1	-2	-1

[7] [8]

- Consider:

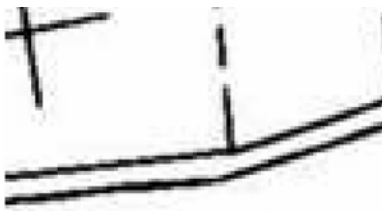


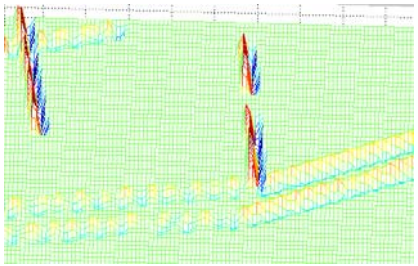
Sobel Edge Detector

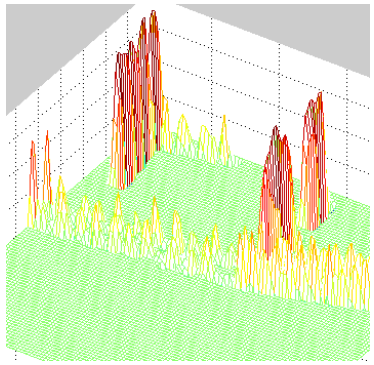
- Sobel Edge Detector

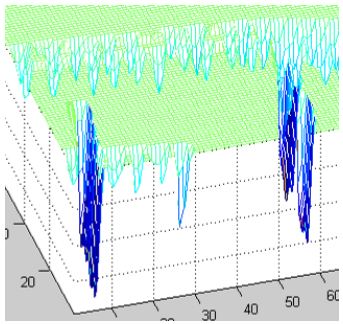
1	2	1
0	0	0
-1	-2	-1

convolve









Wavelet Decomposition

- Add the horizontal and vertical components.

Horizontal
omponent

+

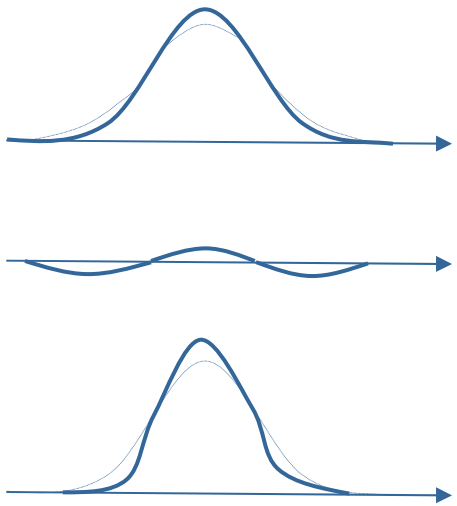
Vertical
omponent

⇒

Sharpening

- Procedure:
  1) Smooth the image with an averaging filter.
  2) Subtract the smoothed image from the original.
  3) Add this difference to the original. [9]

1-D Example:

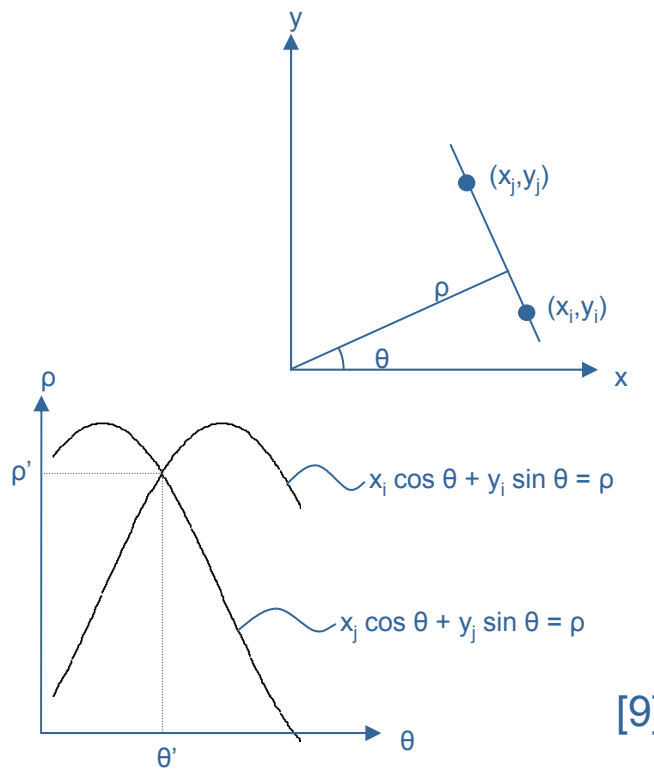


Identifying a Curve

- **Bézier curve:** A parametric curve important in computer graphics and related fields. [10]
- **Hough transform** (pronounced 'huff'): A feature extraction technique used in image analysis, computer vision, and digital image processing. [9] [11]

Hough Transform

- Polar form of equation for a line: $x \cos\theta + y \sin\theta = \rho$
  - Create a matrix whose rows represent rho and columns represent theta.
  - Define Rho between –Maxrho and +Maxrho where Maxrho is the diagonal length of the image.
  - Define Theta between -90 and +90.
  - This matrix represents all possible lines through the image.
  - For each “line”, count the number of intersections with pixels in the image.



[9]

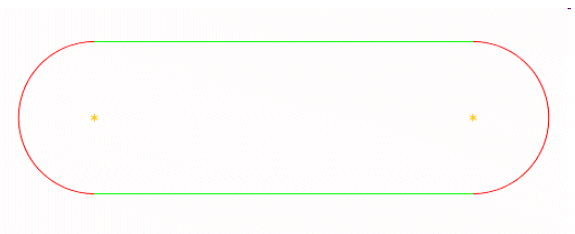
Derive Equations

- Use polyfit in Matlab.
  - Easily produces coefficients line and spline equations.

Neutral Format Data File

- IGES (**Initial Graphics Exchange Specification)** (pronounced *eye-jess*): Defines a neutral data format that allows the digital exchange of information among Computer-aided design (CAD) systems. [12]

```
                                                                        S      1
H;,4HSLOT,37H$1$DUA2:[IGESLIB.BDRAFT.B2I]SLOT.IGS;,                     G      1
avo3 BravoDRAFT,31HBravo3->IGES V3.002 (02-Oct-87),32,38,6,38,15,       G      2
T,1.,1,4HINCH,8,0.08,13H871006.192927,1.E-06,6.,                        G      3
 A. Harrod, Tel. 313/995-6333,24HAPPLICON - Ann Arbor, MI,4,0;          G      4
116       1       0       1       0       0       0       0       1D      1
116       1       5       1       0                               0D      2
116       2       0       1       0       0       0       0       1D      3
116       1       5       1       0                               0D      4
100       3       0       1       0       0       0       0       1D      5
100       1       2       1       0                               0D      6
100       4       0       1       0       0       0       0       1D      7
100       1       2       1       0                               0D      8
110       5       0       1       0       0       0       0       1D      9
110       1       3       1       0                               0D     10
110       6       0       1       0       0       0       0       1D     11
110       1       3       1       0                               0D     12
.,0.,0.,0,0,0;                                                    1P      1
.,0.,0.,0,0,0;                                                    3P      2
.,0.,0.,0.,1.,0.,-1.,0,0;                                         5P      3
.,5.,0.,5.,-1.,5.,1.,0,0;                                         7P      4
.,-1.,0.,5.,-1.,0.,0,0;                                           9P      5
.,1.,0.,5.,1.,0.,0,0;                                            11P      6
  1G      4D     12P      6                                       T      1
```



Type 100: CIRCULAR ARC

Type 110: LINE

Type 116: POINT

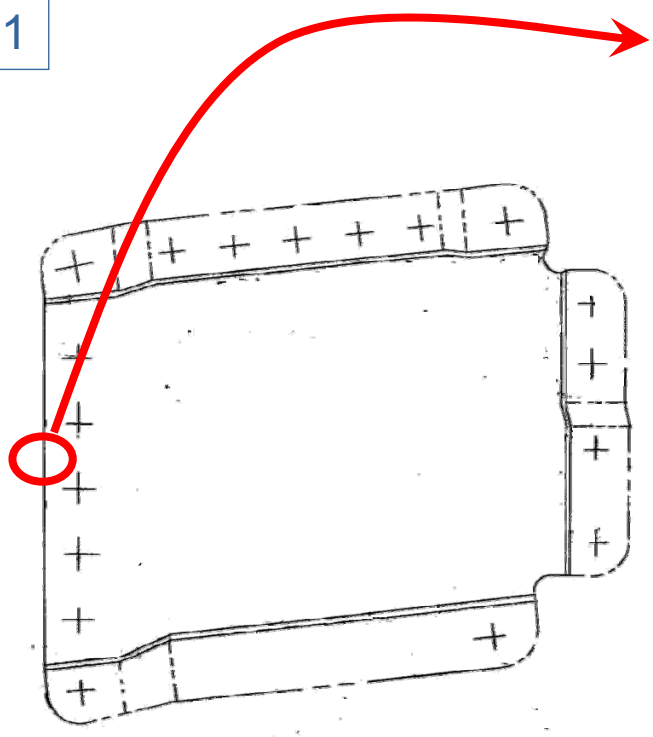
The Solution

- Use sharpening to clarify the image.
- Use Hough Transform to identify curve geometry.
- Use polyfit to define curve entities.
- Use IGES to translate data for import to CAD.

Sharpening the image

1/9 X

1	1	1
1	1	1
1	1	1



Original

255	249	92	79	255	254
255	255	106	78	255	255
255	252	102	77	255	255
255	254	102	76	254	255
255	255	106	73	251	254
253	250	100	76	253	255

One pass

255	255	109	80	255	255
255	255	131	75	255	255
255	255	123	72	255	255
255	255	123	71	255	255
255	255	131	65	255	255
255	255	119	71	255	255

Two passes

255	255	116	54	255	255
255	255	152	38	255	255
255	255	134	33	255	255
255	255	136	31	255	255
255	255	153	20	255	255
255	255	129	32	255	255

Using Hough Transform

- Processing the image through a Hough Transform yielded the following:
  - Max number of intersections: 354

    at $\theta = -89.7°$

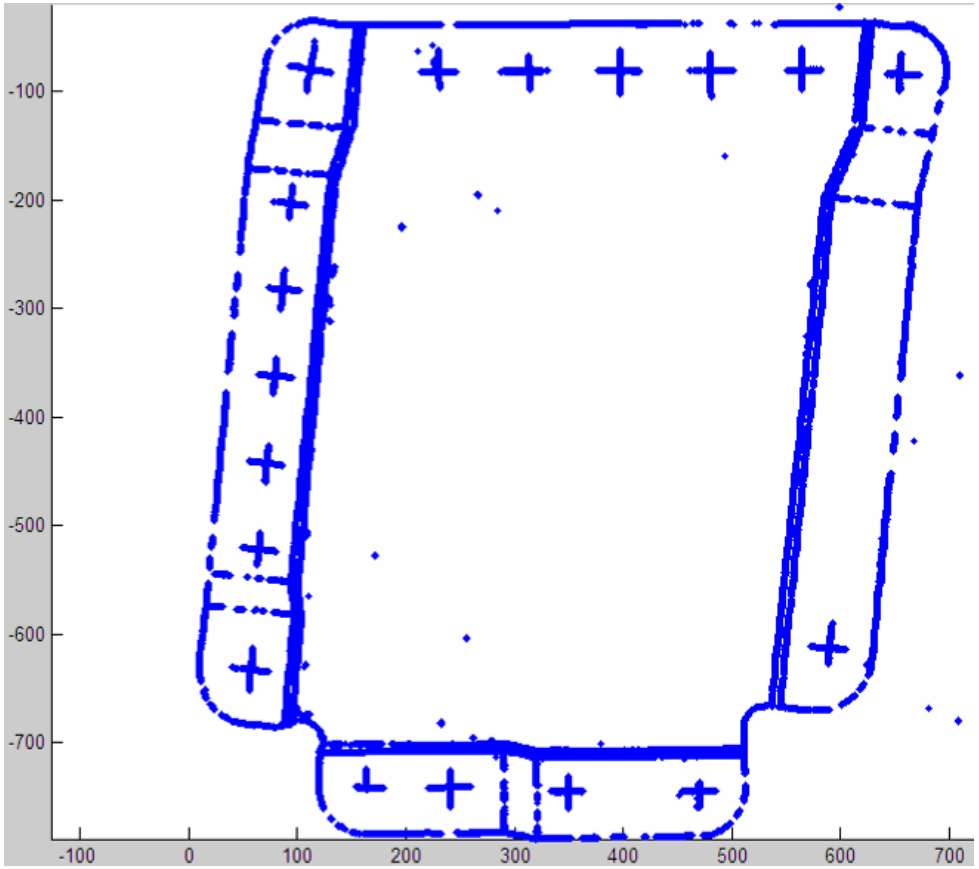
    and $\rho = -707.7$
  - Next max: 311

    at $\theta = -89.7°$

    and $\rho = -39$

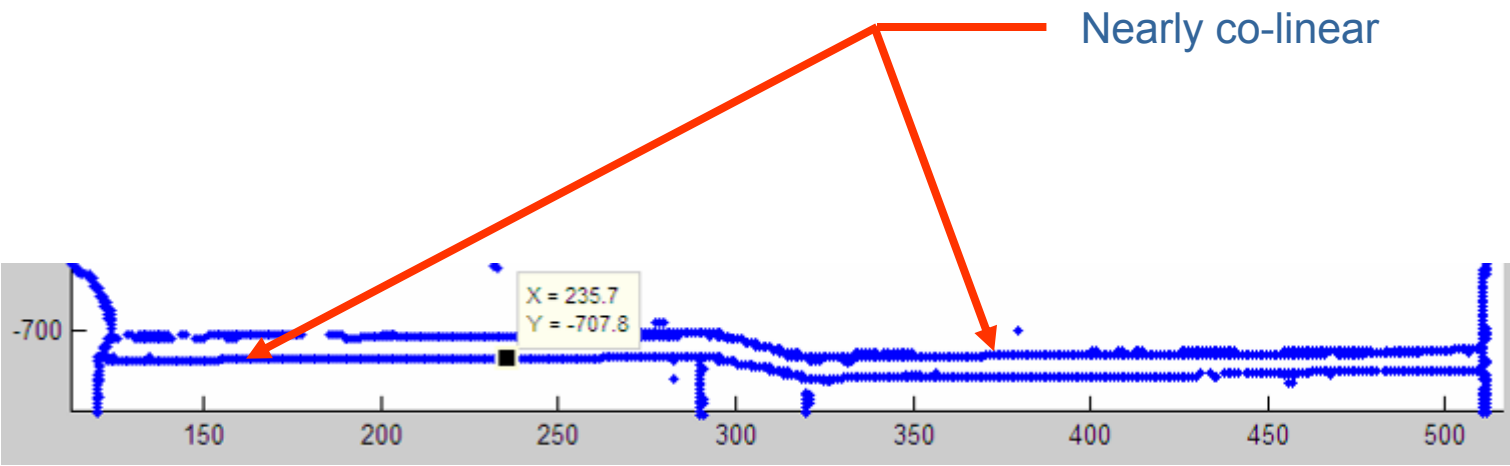
Using Hough Transform

- Rotate x,y coordinates of image by -89.7° and scatter plot:



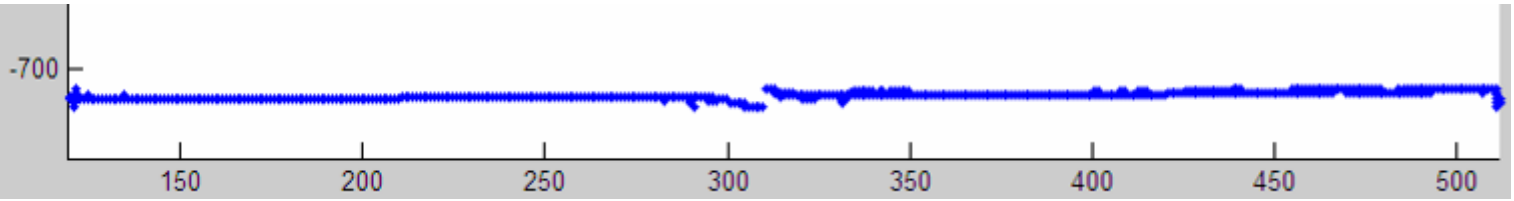
Using Hough Transform

- The transform actually found two lines.



Polyfit and clean up

- Extract points within a 6 pixel wide band around ρ = -707.7.
- Use polyfit with degree 1 to find a best fit line.



- Remove points which are too far from the line.
- Check for gaps and deal with individual line segments separately.

Curve definition and output

- Take line end points and reverse the rotation.
- Write those coordinates to a text file.
- Change the extension of the file from .txt to .igs.
- Import to CAD.

Conclusion

- Achieved:
  - Found a line.
  - Determined sufficient definition of the line for translation.
- Future:
  - Find the remainder of the linear entities.
  - Find arcs and splines.
  - Connect the ends of the lines, arcs, etc.
  - Do actual translation.

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