

# The Use of GPS and Machine Guidance

SH 45 SE Turnpike - Austin, TX

Presented by:

Mike Wehling - T.J. Lambrecht Construction

Derek Madrid - Topcon Positioning Solutions

# Topics of Discussion

- Introduction
- The SH 45 SE Project
- Types of equipment used
- File Preparation
- Establishing “Localized” GPS Site Control
- Use of GPS and Machine Control

*presented by: Derek Madrid, Topcon Positioning Solutions*

- Questions
-

# T.J. Lambrecht Construction, Inc.

- Brown & Lambrecht established in 1947 in Joliet, Illinois
  - Tom Lambrecht purchased Brown & Lambrecht in 1988
  - TJJL opened a permanent office in Texas in 1994
  - Licensed in 19 states and currently operating in 6 states
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# TJL's move to GPS

- Purchased first GPS surveying equipment in 2001
  - Purchased first machine control system in 2002
  - Currently operating
    - 47 machine control systems
    - 43 rovers
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# The SH 45 SE Project



# SH 45 SE Project - Overview

- \$142,000,000 Project
  - 7.4 miles new toll way connecting SH 130 to I-35
  - Project was constructed by a joint venture between Balfour Beatty and T.J. Lambrecht.
    - TJL – Earthwork and Underground
      - 2,200,000 cy Roadway Excavation
      - 360,000 cy Select Material Import
      - 8,200 tons Lime stabilization
      - 52,600 cy Flexbase
    - Balfour Beatty – Bridges and Paving
      - Bridges
      - Paving
-

# Types of GPS Equipment Used

- 1 – GPS base station w/radio repeaters
  - 4 – GPS survey rovers
  - GPS Machine Control
    - 1 – D8 Dozer w/full auto
    - 2 – D-6 Dozers w/full auto
    - 4 – Cat 14M motor graders w/full auto & laser augmentation
    - 1 – Gomaco 9500 Trimmer w/dual laser augmentation
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# TJL Owned the First Two GPS Trimmers in the World

- Purchased both trimmers in 2007
  - TJL's trimmer use on the SH 45 Project was featured in
    - Roads and Bridges
    - Texas Contractor
    - GX Grading and Excavation Contractor
    - Construction Equipment Guide
    - Promotions
      - Topcon & Gomaco
        - ConExpo 2008
        - World of Concrete 2009
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# File Types Created for Survey and Machine Control

- Control files
    - Primary and secondary control points
  - Line work file
    - Files containing 2D line work for visual purposes only
    - How much is too much?
  - Alignment Files
  - Point files
  - 3D surface model
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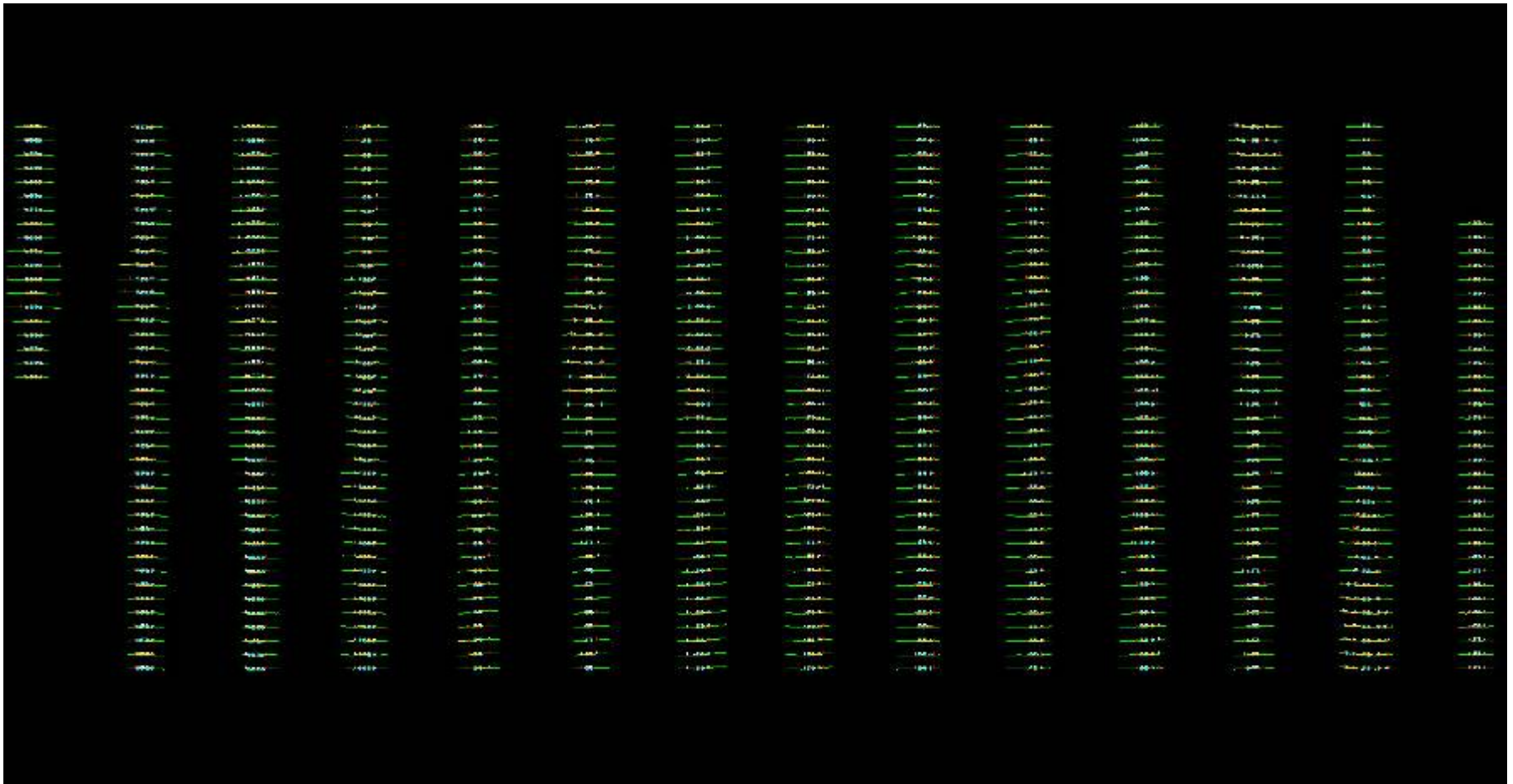
# Establishing “Localized” GPS Control

- What is typical GPS accuracy?
  - Horizontal
    - Set with GPS
  - Vertical
    - Leveled
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# Using CAD files provided by the Engineers

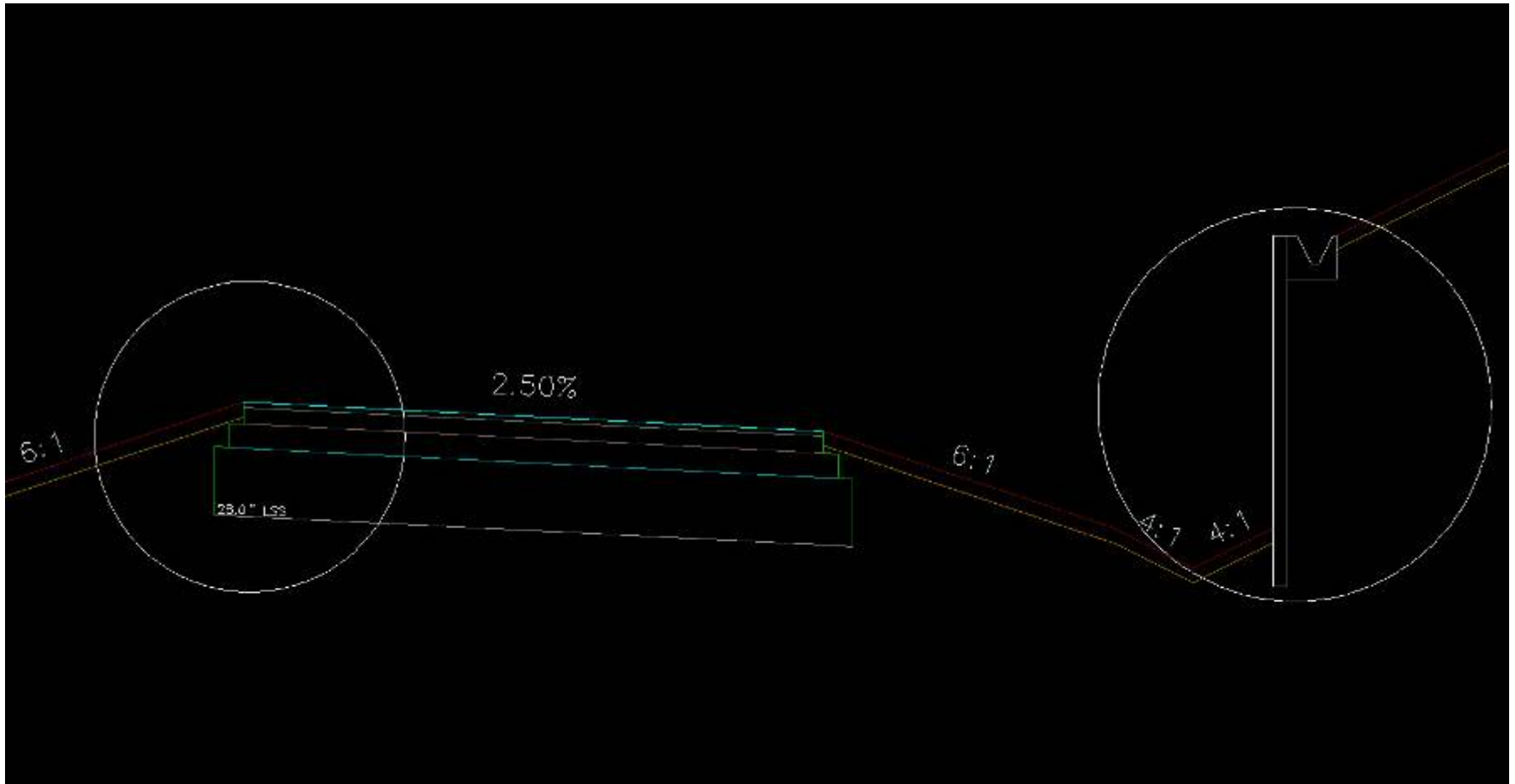
- Choosing the method of preparing the 3D model
  - Template
    - Create templates using the typical sections
    - Run the templates along the horizontal and vertical alignments
  - Cross Sections
    - Turn each cross section line into a 3D polyline
    - Attach the polylines to the baseline
    - Draw breaklines connecting each breakpoint on the sections
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# Creating the 3D Model From Cross Sections



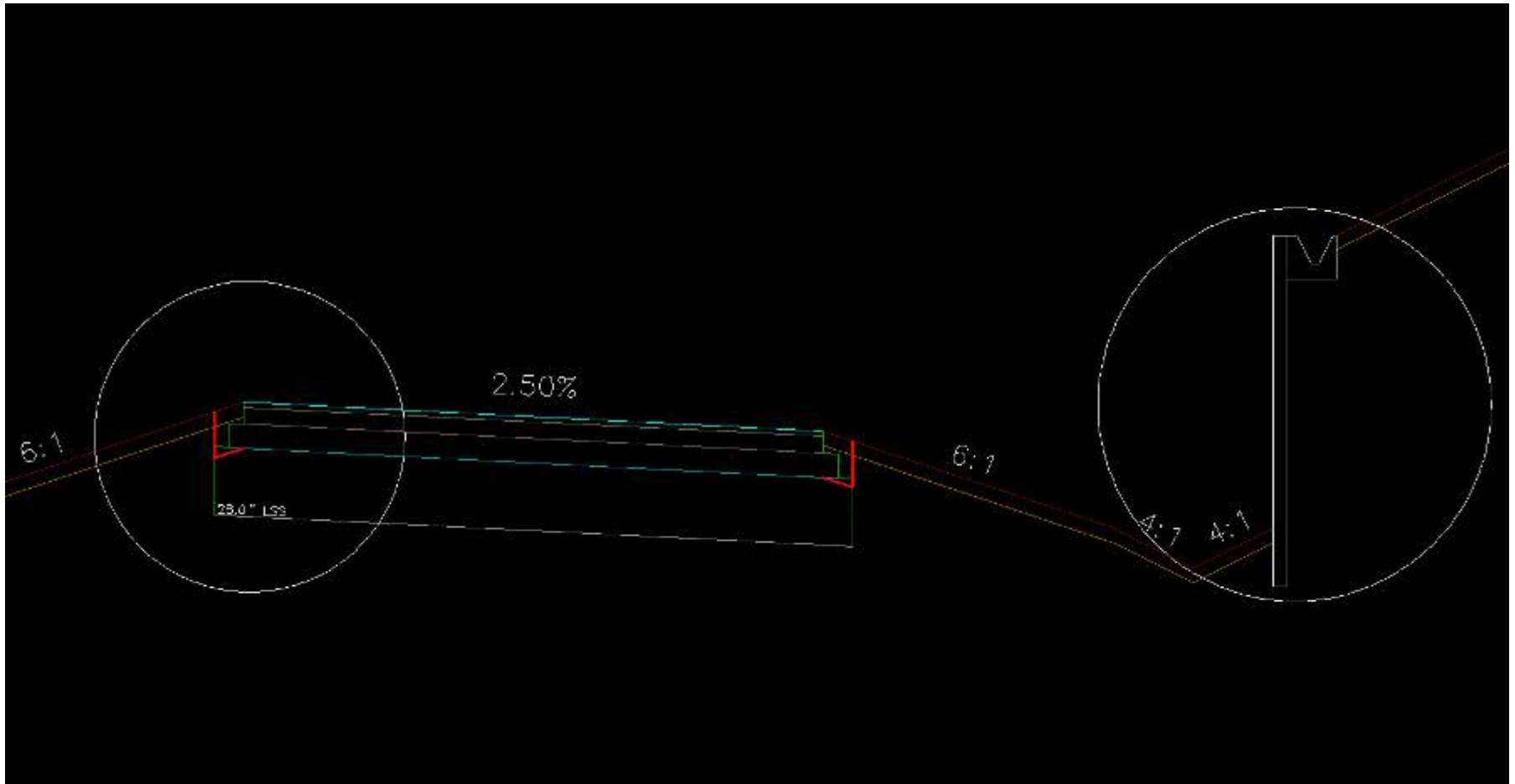


# Problem Areas for Machine Control



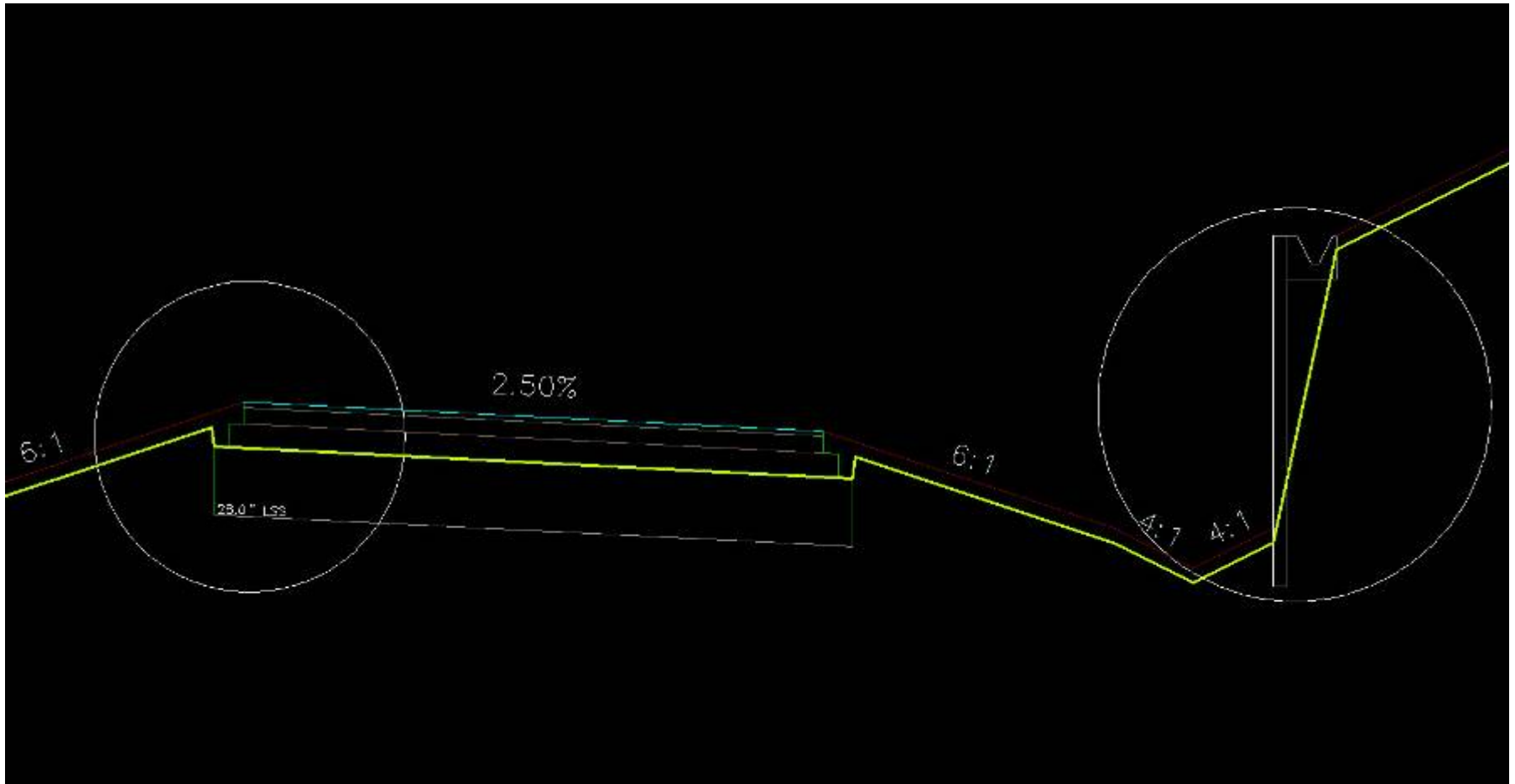


# Vertical Offsets



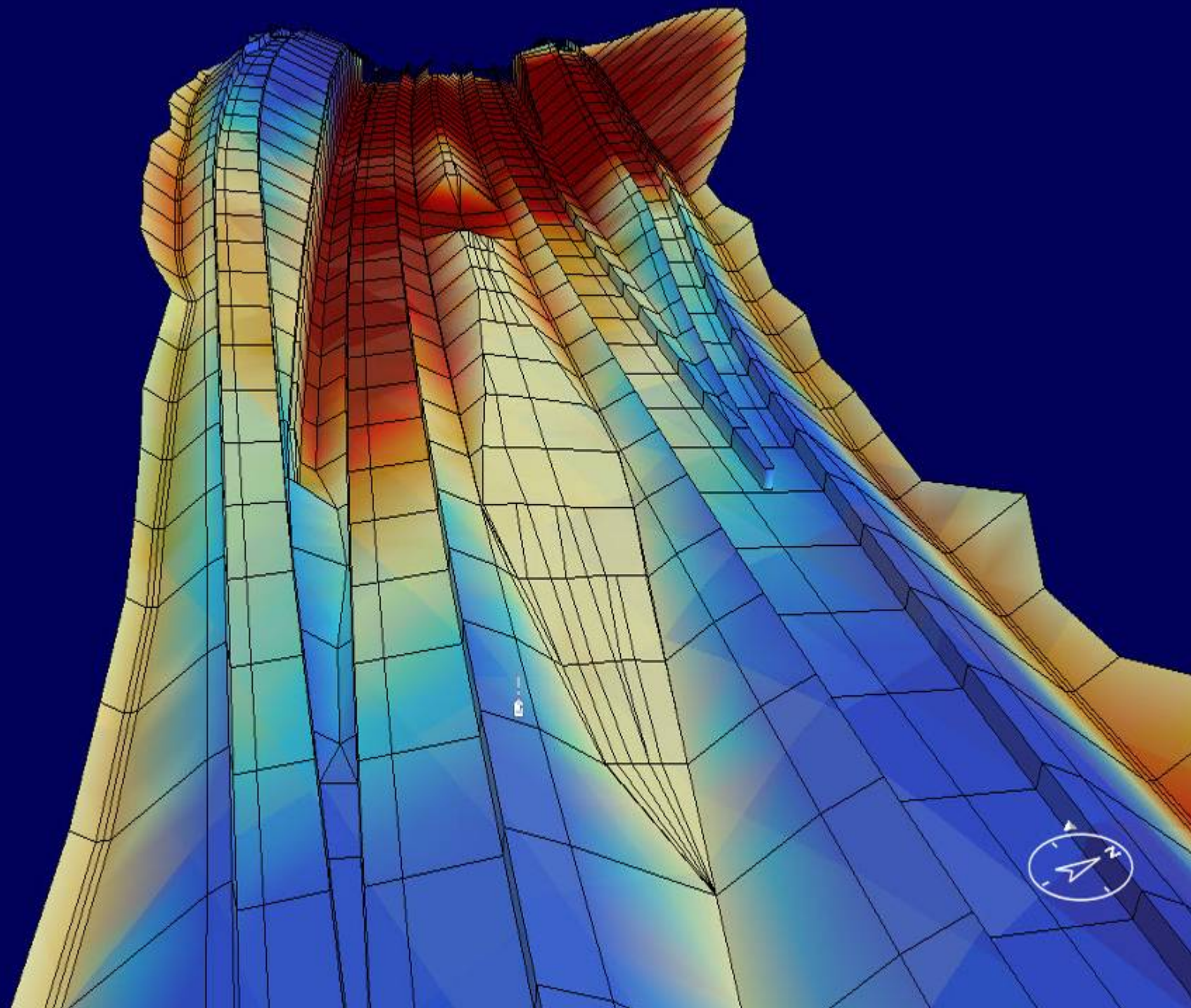


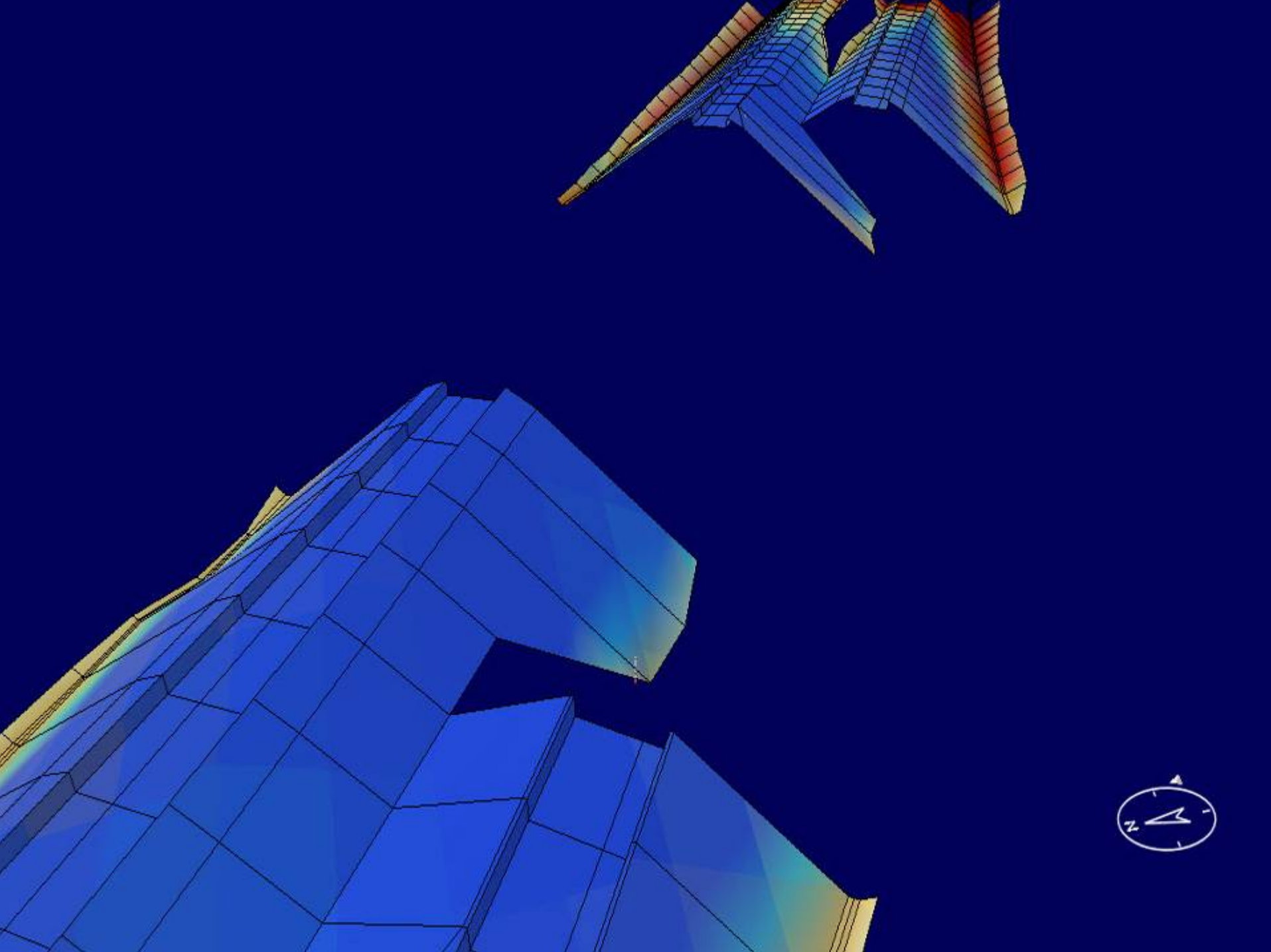
# SG Line



# Final Model





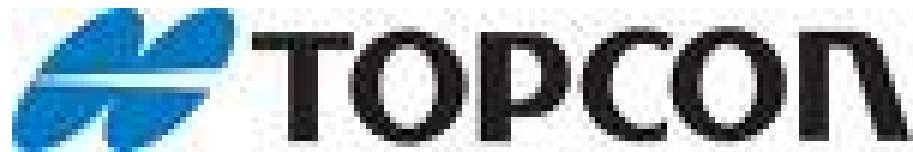


# Other GPS Related Problems We Encountered

- Different control localizations
  - Different Base Stations
  - Different 3D Models
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# Topcon Positioning Solutions

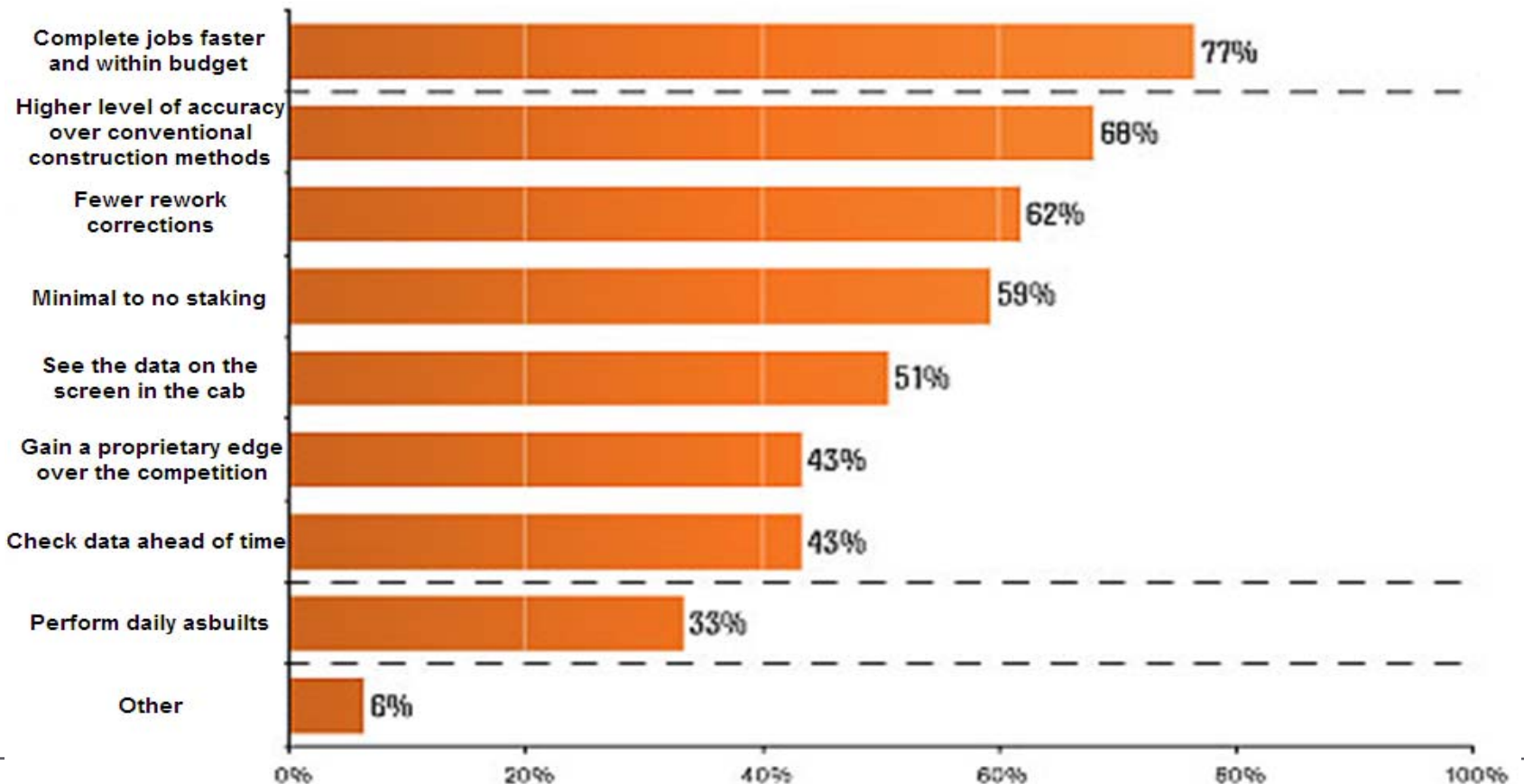
**Derek Madrid**





# Benefits of Using Machine Control

## Greatest Benefits of Machine Control Technology



# Benefits of Using Machine Control

## Production Payback Example...

- Crew Grades 1/4 mile per day
- Grader takes 4 passes to cut to grade
- Average Crew Cost per Day = \$2,600
- Grader and Roller w/ operators, water truck, foreman, grade checker
- Number of days to grade 1 mile      X4  
Crew Cost per mile            \$10,400

- Using 3D MC Crew Reduces Number of grading passes by 1.

$$\frac{1 \text{ pass saved}}{4 \text{ original passes}} = 25\% \text{ increase}$$

Production Savings per mile = \$10,400 X .25 = \$2,600

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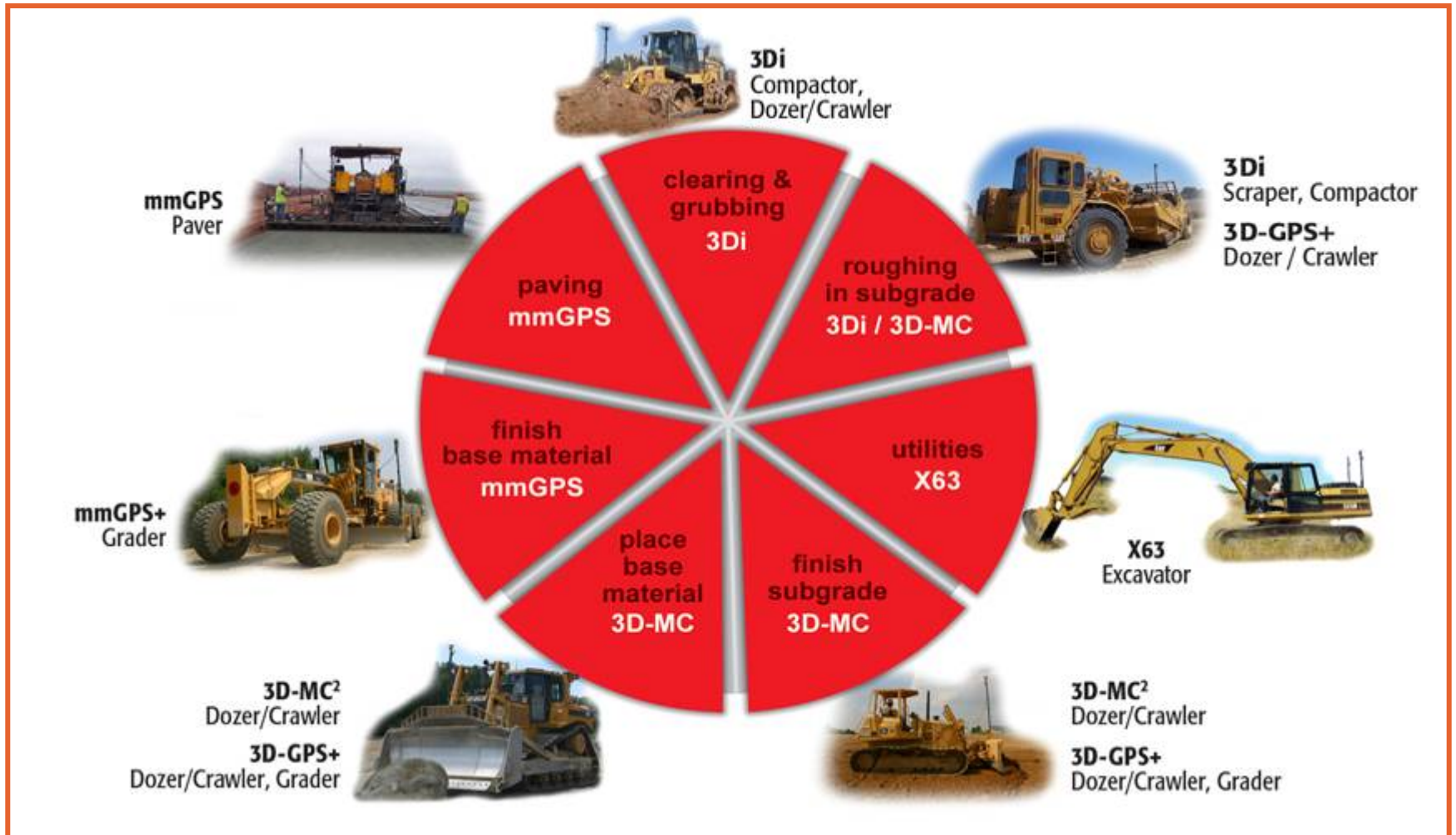


# Benefits of Using Machine Control

## Material Payback Example...

- 1 mile of Road: 5,280'
  - Width of Road: x 42'
    - square footage: 221,760
  - Save 1 hundredth Material: x .01
    - cubic footage: 2,217.6
  - Weight per cubic foot: x 144
    - number of pounds: 319,334.4
    - Divide by one ton: / 2000
    - number of tons: 159.6
  - Cost per ton: x \$12.00
  - Savings per hundredth: \$1,916.00
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# Machine Control Applications



# 3D Machine Control Equipment

## •GPS

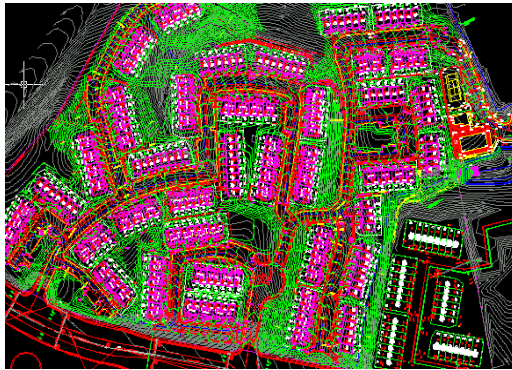
- Most commonly used system for machine control applications
- Tolerances range from +/- 3' (SBAS, etc) to +/- 0.01' (laser augmented systems)
- Simple indicate systems to fully automatic systems
- Limitations to sky visibility and accuracy

## •Total Stations

- Common system for road projects, tunnels & bridges
  - Tolerance of +/- 0.01'
  - Simple indicate systems to fully automatic systems
  - Limitations on line of sight and 1:1 ratio of Machine vs. Total Station
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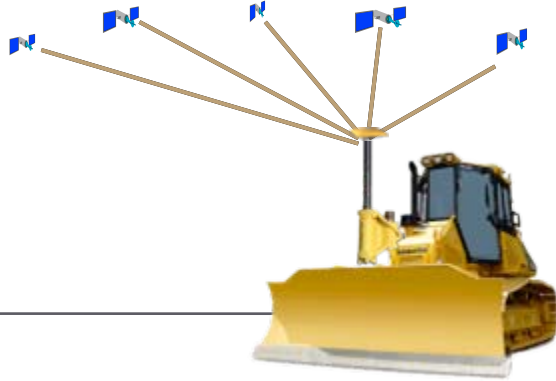
# 3D Machine Control Automation

Job file reports the Design elevation =  
396.54'



Control box determines  
Cut or Fill:

GNSS says the current elevation =  
396.84'



396.84'  
- 396.54'

= 0.30' Cut

# 3D Machine Control Automation



MILLIMETER  
**GPS**

Mast

MC-A1 Antenna

Control Box

Valve

Valve

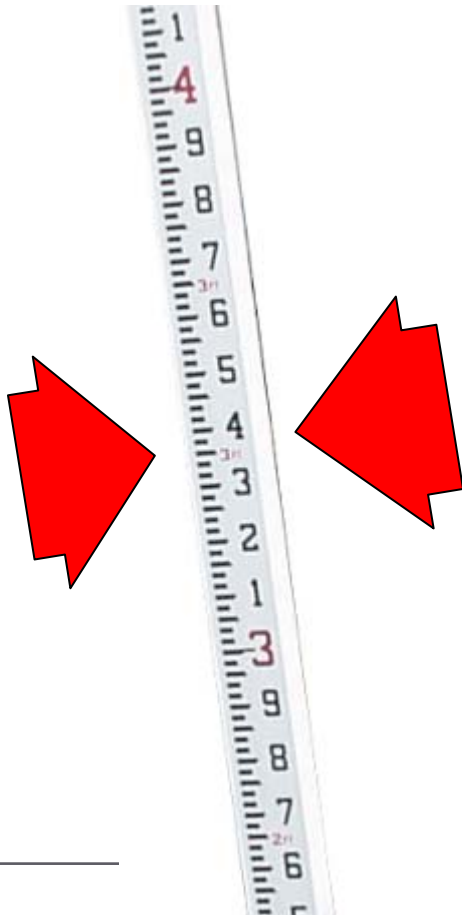
MC 2.5 GPS+ Receiver

mmGPS



# Machine Control - GNSS

## Satellite Positioning Weakness:



**Vertical Accuracy:**

**+/- 0.1 ft**

# Machine Control - GNSS

## Laser Augmented GNSS...

- Much more accurate than GNSS alone
- Multiple user RTK advantages with vertical precision of a laser
- More versatile than robotic machine control



# Machine Control – LPS





# Machine Control - LPS

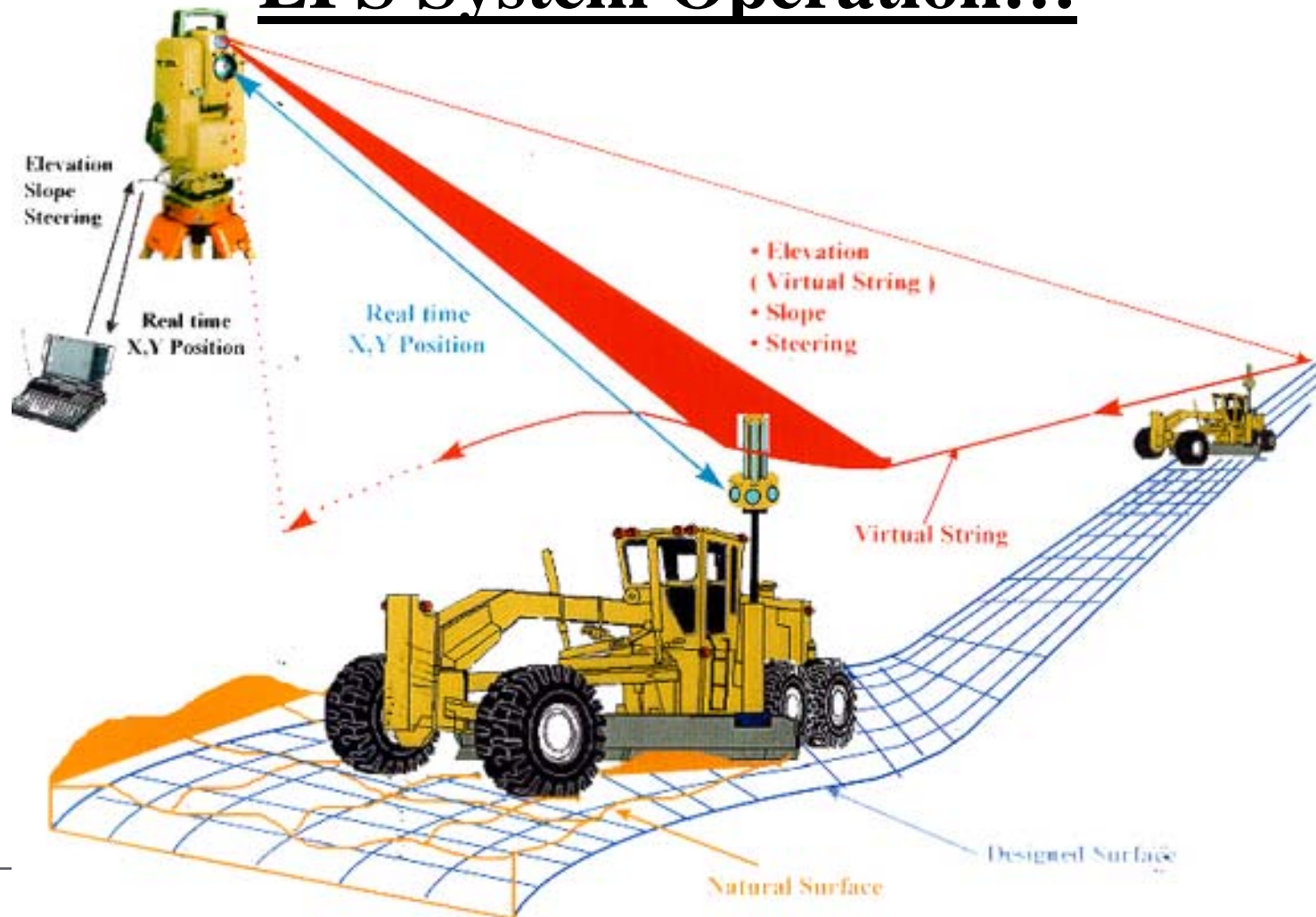
## LPS System Solution to GPS...

Problem with GPS solution: Limited satellite availability



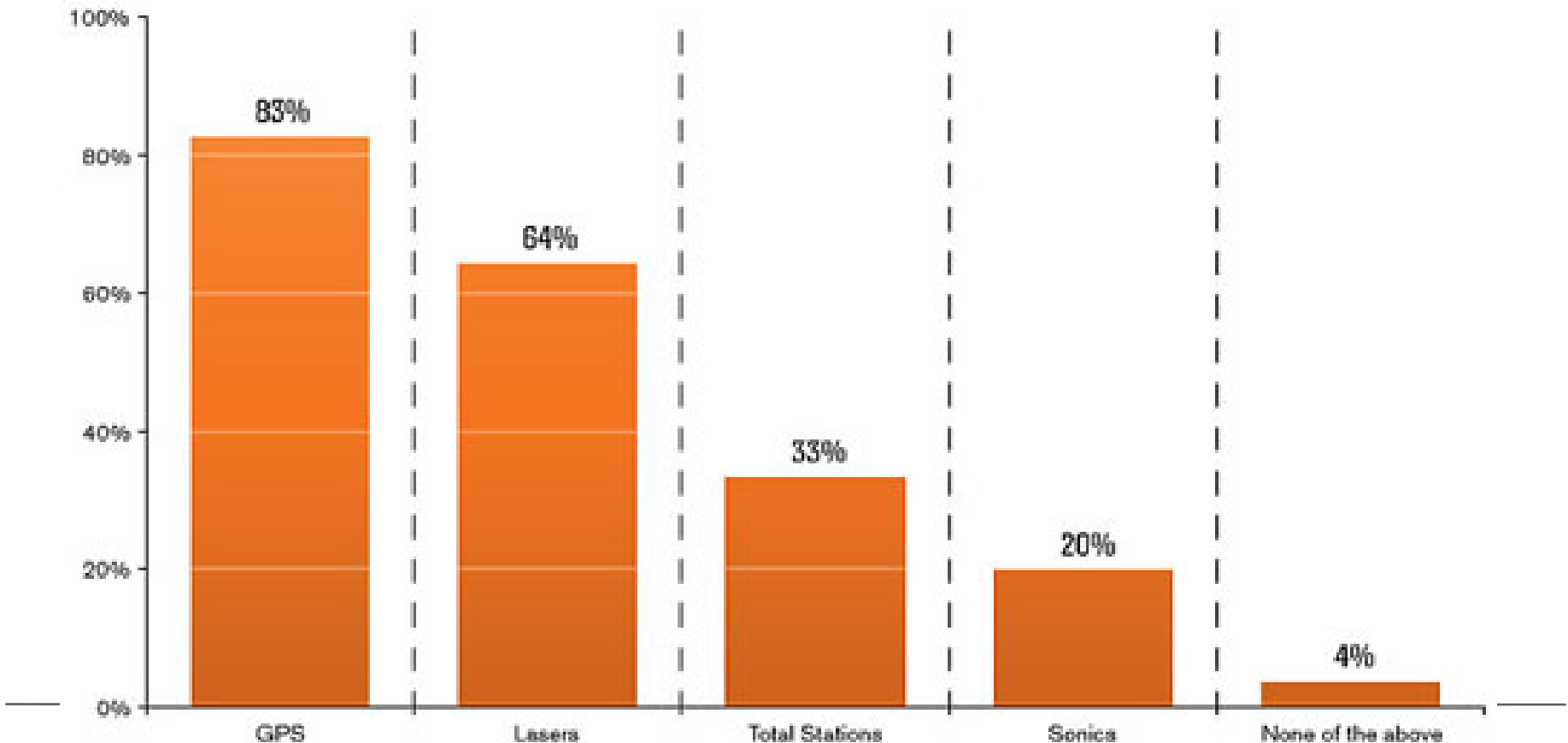
# Machine Control - LPS

## LPS System Operation...



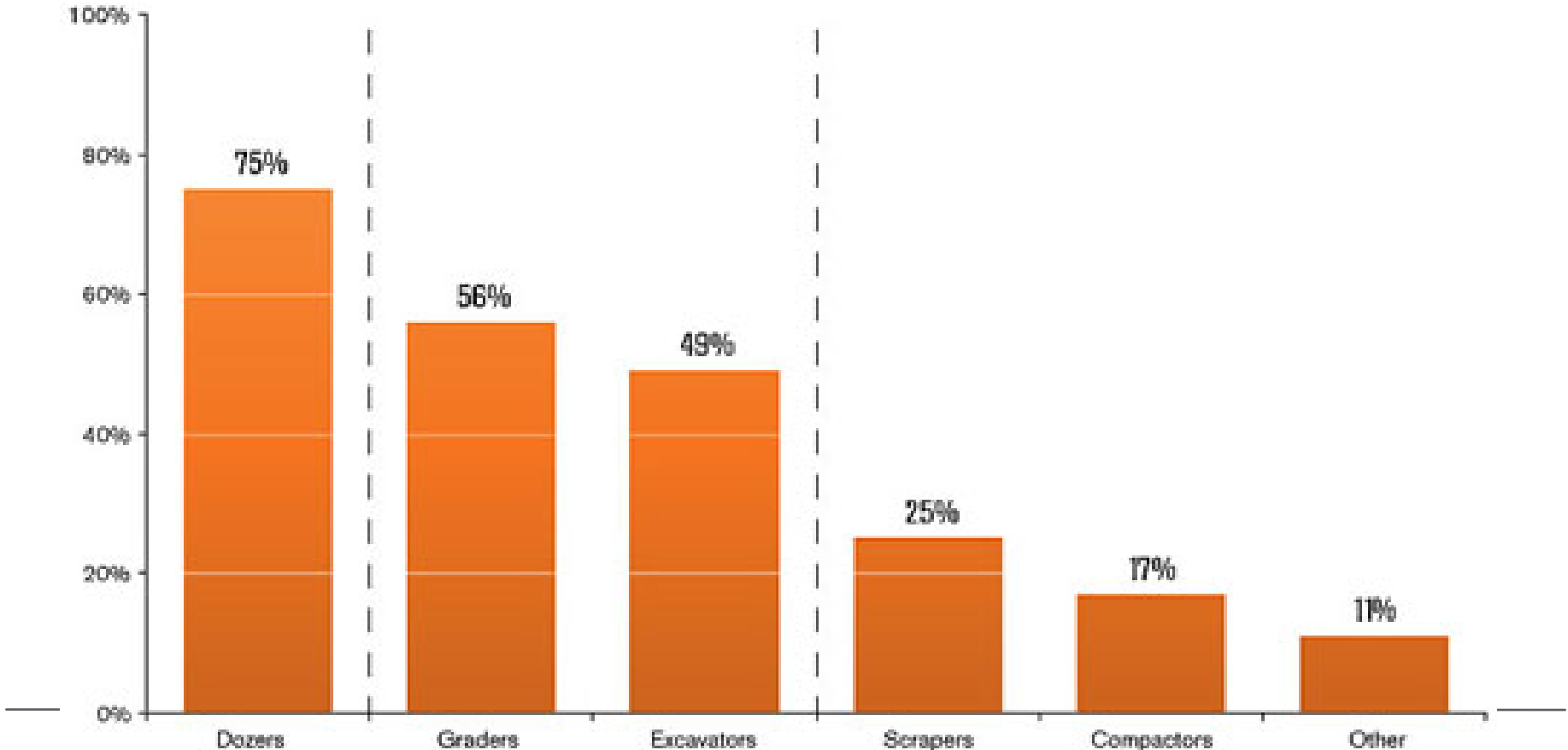
# Types of 3D Machine Control

## Types of Positioning Equipment to Be Used in Machine Control Systems



# Types of Heavy Equipment

## Types of Heavy Equipment Users Plan to Install with Machine Control Technology



# Conclusion

- GPS has dramatically changed the way we bid and construct projects.
    - If used properly, GPS will increase productivity
    - GPS will dramatically increase the quality of the product that we deliver
  - Questions???
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