



[https://www.xyft.com/wp-content/uploads/2016/05/1m\\_surv.jpg](https://www.xyft.com/wp-content/uploads/2016/05/1m_surv.jpg)

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### Decision Time: Match the Tool to the Task



Todd Horton, PE, PLS  
February 5, 2025

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<https://i.pinimg.com/736x/4a/7b/15/4a7b1544f915a6c9c5f31e6283a287568c067--land-surveyors-civil-engineering.jpg>

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### Problem Solver

Primary role of  
land survey technician

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### Problem Solver



<https://maxwell-land-surveying.com/wp-content/uploads/2011/07/surveyor4.jpg>

- More than instrument operator
- Understands role in overall project
- Has skills in geometry and math
- Looks for simplest solution
- Performs checks to identify and fix problems
- Proves the quality of solutions

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Problem solvers are learners.



<https://umaine.edu/vt/wp-content/uploads/sites/205/2016/08/TVT-cover-gr1-634953.jpg>

- Learn why your company prefers certain methods.
  - Successful business leaders learn from their mistakes.
  - Assume others know something you need to learn.
- Learn to properly use a broad array of tools and methods.
  - Better to be a generalist than a specialist.
  - Know how to apply the simplest practical solution.

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Learning new stuff



[https://www.gic-europe.eu/sites/default/files/inline-images/gps\\_mapping\\_74.jpg](https://www.gic-europe.eu/sites/default/files/inline-images/gps_mapping_74.jpg)

- With new gear, we ask “How do I know it’s correct?”
- The answer comes from comparing methods.
- Comparison exposes strengths and weaknesses.
- Understanding leads to wise tool and method choices.

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RISK



- Land surveyors are hired to accept risk and minimize it.
  - Client uses survey information to make decisions.
- Risk cannot be fully eliminated.
  - Risk must be managed proactively at all levels.
- Complexity increases risk.

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### Types of Business Risk

- Compliance risk
  - Legal risk
    - Contractual risks
    - Dispute risks
    - Regulatory risks
  - Strategic risk
  - Reputational risk
  - Operational risk
    - Employee errors
    - Damage to assets
    - External fraud
- Human risk
  - Security risk
  - Financial risk
    - Currency risk
    - Default risk
    - Liquidity risk
  - Competition risk
  - Physical risk

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### On-site surveyor = risk manager



- Construction layout
  - Surveyor is last person to review the design.
- Topographic survey
  - Surveyor is first one to see unique issues.
- Boundary survey
  - Surveyor is only one to see subtle, less obvious evidence.

[https://survbase.com/\\_Media/100804\\_1720.jpg](https://survbase.com/_Media/100804_1720.jpg)

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### Risk management for surveyors



- Understand errors, precision and accuracy.
- Know the project requirements.
- Use the simplest practical tool or method.
- Collect redundant measurements.
- Check, recheck and record the results.

<https://imgsurveyequipment.com/wp-content/uploads/2020/08/surveying-equipment-1-1.jpg>

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Fundamental Truth

Every measurement contains error.

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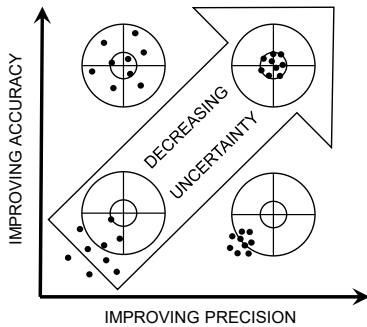
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Mistake ≠ Error



Mistake - a blunder resulting from misunderstanding, carelessness, or poor judgment.

Error - the difference between a measured or calculated value and the true value.

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### Managing Errors



- Mistake
  - Must be removed
- Systematic
  - Must be corrected
- Random
  - Must be minimized

[https://blog.hexagonipr.com/wp-content/uploads/2016/05/Leica\\_Vivo\\_GS16\\_Smart\\_Antenna\\_820x566.jpg](https://blog.hexagonipr.com/wp-content/uploads/2016/05/Leica_Vivo_GS16_Smart_Antenna_820x566.jpg)

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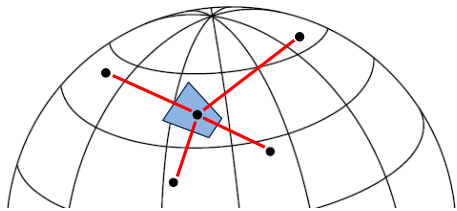
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### Absolute accuracy

Where is the point on the face of earth?  
 How accurate is the position with respect to the CORS stations?



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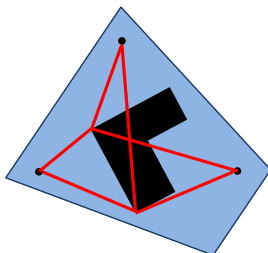
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### Relative accuracy



How well does the project fit itself?

How accurate is the position with respect to related project points?

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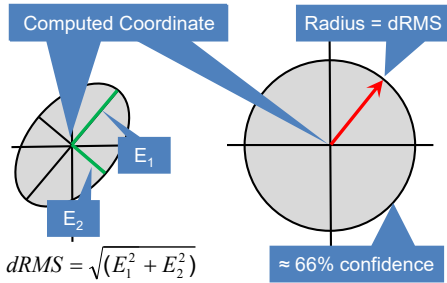
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Coordinate = center of error circle



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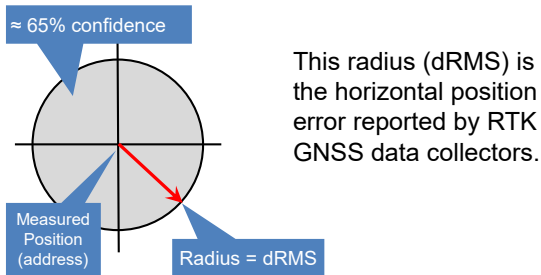
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Distance Root Mean Square



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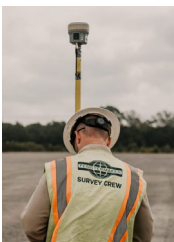
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No single tool solves all problems.



- If your only tool is a hammer, then every challenge looks like a nail.
- Be smarter than your equipment.
- Tools do not grant skills to the user.
- Skills help the user learn wise tool use.

<https://blog.fenstemaker.com/wp-content/uploads/2023/04/How-To-Become-A-Surveyor-130x628.jpg>

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Horizontal		Vertical	
Short H distances	Long H distances	Short H distances	Long H distances
Steel tape	GNSS	level	GNSS
Total station		Total station	
			level
GNSS	Total station	GNSS	

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Recommended tools for layout tasks

Task	Horizontal	Vertical
Control network checks	TS (short HD), GNSS (long HD)	Level (long HD), GNSS (very long HD)
Stripping limits	GNSS	---
Rough dirt grade	GNSS	GNSS
Gravity pipe	GNSS / TS	Level (flat grades), TS
Pressure pipe	GNSS	---
Pavement	GNSS / TS	Level (flat grades), TS
Civil structures	TS	Level
Buildings	TS	Level
Boundary	TS (short HD), GNSS (long HD)	---

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Tradeoffs



- Speed – field process, office process
- Cost
- Error sources and sizes
- Simplicity / complexity
- Staff skills
- End user needs
- Availability

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How to decide

- What are the project requirements?
- What are the consequences of failure?
- Which tool(s) helps us satisfy project requirements and minimize risk to an acceptable level?
- Which method will help us achieve project goals?
- How will we ensure quality results?

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How to decide



- What are the project requirements?
  - Positional tolerance
  - Coordinate quality
  - Relative accuracy
  - Absolute accuracy
  - Loop closure

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How to decide



- What are the consequences of failure?
  - Rework by others
  - Back charges
  - Project delay
  - Litigation
  - Loss of work
- Be a pragmatic pessimist.
  - Ask "What could go wrong?"

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How to decide

- Which **tool(s)** helps us satisfy project requirements and minimize risk to an acceptable level?



- Evaluate the risks.
  - What are the strengths and weaknesses of each method?

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How to decide



- Which **method** will help us achieve project goals?
  - GNSS
    - OPUS
    - Base & rover
    - VRS
  - Total station
    - Radial stakeout
    - Run lines and turn right angles
  - Level
    - Single wire circuit
    - 3-wire circuit
    - Digital level

<https://i.pinimg.com/originals/4b/71/9a/4b719a3b2800c2a0a202964770c8022.jpg>

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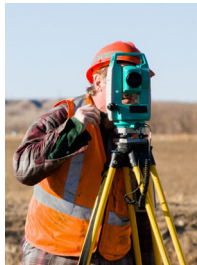
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How to decide



- How will we ensure quality results?
  - Redundant measurements
  - Independent check measurements
- Expect error and manage it well.
  - Build checks into every task.

<https://builder-master.co.uk/wp-content/uploads/2021/11/fand-surveyors-measuring-existing-railroad-bridge-rural-area-3224683.jpg>

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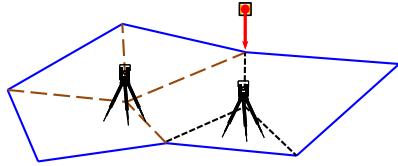
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### Redundant measurements

- Running additional cut-off traverses, or additional traverses to existing control points, creates redundancy.



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### Adding Redundancy: Total Station



- Measure network angles as sets
  - Direct and reverse
  - Multiple sets
- Measure all traverse leg distances twice
  - Foresight and backsight distances
  - Use average distance

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### Adding Redundancy: GNSS



- Repeat the observation with different satellite geometry.
  - Remeasure control points before, during, and after survey session.
  - Allow 1-2 hours between observations.
  - Avoid multiples of 12 hours.

[https://bench-mark.ca/wp-content/uploads/2023/12/image\\_rtk\\_equipment-engineer-1-1568x1045-1-1.jpg](https://bench-mark.ca/wp-content/uploads/2023/12/image_rtk_equipment-engineer-1-1568x1045-1-1.jpg)

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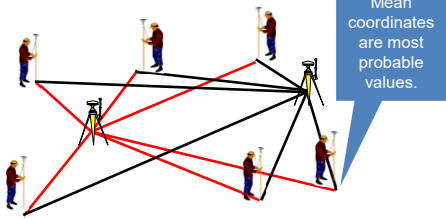
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Redundant measurements

Measuring points in the network that have already been located creates redundancy.



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Independent Methods



- Check total station distances with GNSS.
- Check GNSS elevation differences with total station or level.

Independent observations make redundancy robust.

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Scenario 1

- Topo survey inside state prison compound
  - Client requests no expensive equipment, no pointed objects that can be weaponized
- How should you approach this project?

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Scenario 2

- Monitoring settlement on ice rink concrete floor
  - Indoors
  - Need to compare unfrozen concrete floor with frozen floor
- How should you approach this project?

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Scenario 3

- Reset 6 missing curb stakes
  - 4 on straight line
  - 2 on intersection radius
- How should you approach this task?

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Scenario 4

- Need shot on boundary point under dense pine tree limbs
  - Limbs are 2 feet above ground
- How should you approach this task?

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Match the Tool to the Task



Choose equipment and measurement methods based on accuracy and precision needs of the project.



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