VIRTUAL BOUNDARIES

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- David Danker, Pre-sale Forester, Kaibab National Forest
- Dick Fleishman, Operations Coordinator, 4FRI Operations
- Karen Martinez, FS R3, Regional Measurement Specialist
- Steve Fugate, Forest Restoration GIS Data Coordinator, The Nature Conservancy

What does this work respond to?

- Fremont-Winema National Forests in Region 6 and The Nature Conservancy (TNC) do a limited virtual boundary test in 2016.
- Discussions between Region 6, the 4FRI team and Forest Products Modernization Team regarding virtual boundaries and the potential costs savings and processes associated with virtual boundaries late 2017/early 2018.
- United States Forest Service Forest Products Modernization Team ID's the need for a pilot project regarding virtual boundary to outline process, cost savings, ID potential lessons learned in Summer of 2018.

What was done?

- Representatives from WO Forest and Range Management and Vegetation Ecology, RO Forest Management, 4FRI, and the Kaibab National Forests convene in Fort Collins June 18-22, 2018.
  - Outlined process to establish and check virtual boundaries, manual updates needed, and draft contract language
  - ID'ed pilot project—Parks West in TNC's Future Forest project
- Kaibab National Forest and TNC created and signed a Challenge Cost Share agreement to implement a virtual boundary pilot along with other sale prep innovations on July 19, 2018.
- Current status-draft virtual boundary desk guide published and National webinar scheduled for early 2020.

What was the process?

Manual Direction Updates

- FSH 2409.12 Chapter 70 added in glossary to define virtual boundaries, geo-fence and discernible boundaries. Multiple edits of language adding sale and project area rather than just sale area and major edit to 71.22 Designating Boundaries.
- FSH 2409.12b Chapter 10—edited 11.1 and 11.2 in reference to storing boundary files and utilizing vector file for presale theft prevention
- 2409.15 Chapter 10 14.1 Timber Sale Contract Files—added in need to store vector file
- FSH 2409.18 Chapter 50---created a map symbol for virtual boundary geo fence in 53.54 exhibit 04, added in sections 55.21 cutting unit boundary and 55.21a– Cutting Unit Boundary: Virtual Boundary Geo-Fence that defines need for risk assessment, vector files and procedures when satellites fail.

What was the process?

Modifications to the theft prevention plan

- Forestry, Forest Health and Cooperative Forestry Share Point site
  - Timber Sale Prep and Admin Page
  - Section called Sale Administration Library
  - Folder Timber Theft Plan

What was the process?

Contract language/provision

- Draft Regional provision created for Stewardship Contracts/Agreements R3-K-C-3.0.1#-Cutting Unit Boundaries
  - ID's name and date of official digital vector file
  - Cutting unit boundary designation table
  - ID's what the acceptable distance from the digital geo fence line Forest Service will accept.
  - ID's data accuracy standards that contractor may use and outlines procedures for what happens during disputes and failures of satellites
- Need to ensure long term data file storage method for vector file

What was the process?

Definitions

- Virtual boundaries - Cutting unit boundaries that are unpainted or otherwise unmarked and consists of boundaries placed along a discernible feature or a georeferenced lines established on a digital map, referred to as a geo-fence.
- Discernible boundaries – Cutting unit boundaries that are natural land boundaries, such as roads, trails, sharp ridges, and streams are so conspicuous that they can be identified from the sale area map alone, and if using those features would not cause mistakes to be made when the trees are cut.
- Geo-fence – Cutting unit boundaries that is a virtual geographic boundary, defined by GPS or RFID technology, which enables software to trigger a response when a mobile device enters or leaves a particular area.

These are added in to the updated FSH 2409.12 Chapter 70

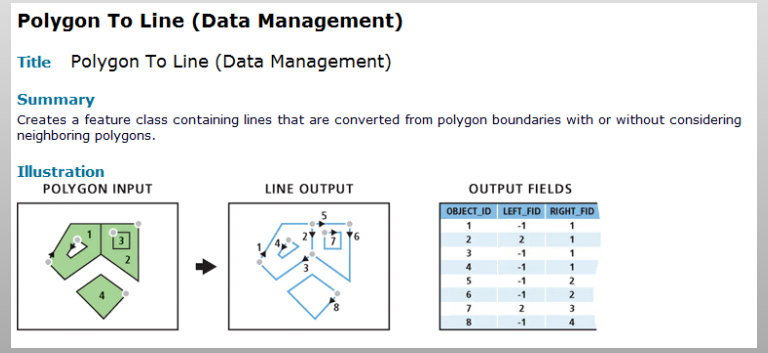
What was the process?

Develop procedures for establishing a geo-fence

1. Prework (Stay Organized!)
   a) Risk Assessment
   b) Determine the boundary type
   c) Determine allowable accuracies
   d) Convert units to line segments

Parks_West_Line_Segments

OBJECTID *	Shape *	Line_ID	Shape_Length	Line_Type
1	Polyline	1	262.405685	GPS Geo Fence
2	Polyline	2	1053.892491	GPS Geo Fence
3	Polyline	3	1077.739685	GPS Geo Fence
4	Polyline	4	901.553631	GPS Geo Fence
5	Polyline	5	637.808278	Discernible Digitized
6	Polyline	6	1527.522554	Discernible Digitized
7	Polyline	7	574.365941	Discernible Digitized
8	Polyline	8	834.477472	Discernible Digitized
9	Polyline	9	669.348382	Discernible Digitized
10	Polyline	10	111.609813	Discernible Digitized
11	Polyline	11	1251.964684	Digitized Geo-Fence
12	Polyline	12	765.566279	GPS Geo Fence
13	Polyline	13	1421.602112	GPS Geo Fence



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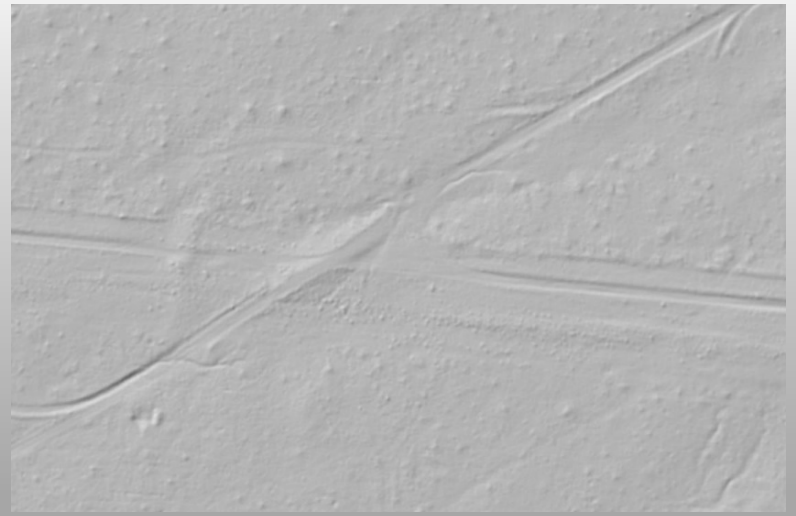
What was the process? – Risk Assessment

Boundary Location	Policy	Considerations	GEO-fence	Discernible	ID #
Land Ownership Boundaries (e.g. private and other public organizations)	Current Policy (FSH 2409.12 Chapter 71.22)	Avoid trespass.	NO	NO, unless have agreement with adjacent landowner for all lands project and is documented in risk assessment and agreement	A
Where NEPA is not in place at the sale area boundary	Current Policy (FSH 2409.12 Chapter 71.22)	Ensure environmental compliance.	NO	YES	B
Cultural sites, federally listed species habitat, or other resources that require protection (e.g. specific soils)	Current Policy (FSH 2409.12 Chapter 71.22)	Avoid damage or unintended impact to important resources that could be outside the effects of a biological opinion or other legal requirement.	NO	NO	C
Separation between different awarded timber sale contracts	Current Policy (FSH 2409.12 Chapter 71.22)	Ensure compliance with timber sale contracts such as differing timber rates or removal of another purchaser's volume. Minimize opportunities for claim.	NO	YES	D
Obvious visible features such as roads, meadow edges, previous harvest units, rock rims, distinct ridges, and streams	Current Policy (FSH 2409.12 Chapter 71.22)	These obvious visible features are discernable on the ground, through orthophoto imagery, and/or remotely-sensed data. Current handbook policy allows for these areas to be unmarked.	N/A	YES	E
Identifiable areas but not discernible	no current direction for geo-fence	Internal and external boundaries to clarify identifiable features.	YES-needs documentation in risk assessment	N/A	F
Shared cutting unit boundaries within the sale area	no current direction for geo-fence	Where shared cutting unit boundaries are within the sale area.	YES-needs documentation in risk assessment	YES	G
External cutting unit boundaries all FS land and does not have adjoining approved NEPA	no current direction for geo-fence	Avoid trespass and resource damage.	NO	YES	H
External cutting unit boundary where product is low value and NEPA coverage extends beyond the sale area and all FS land	no current direction for geo-fence	Avoid trespass and resource damage.	POSSIBLE-needs documentation in risk assessment to utilize	YES	I
GNSS observation conditions are poor (HDOP > 6) or influenced by errors such as blockage or multi-pathing	Current Policy (FSH 2409.12 Chapter 71.22)	Operator cannot implement and FS can't administer.	NO	YES	J
Cut tree mark	no current direction for geo-fence	All trees to be removed are designated.	YES-needs documentation in risk assessment	YES	K
High value product is being removed – not cut tree marked	Current Policy (FSH 2409.12 Chapter 71.22)	Avoid trespass of high value product.	NO	YES	L

What was the process?

Procedures for implementing a geo-fence

2. Collect and Digitize lines via the following methods
   - Field surveys
   - Digitizing off remote sensing sources
   - Combination methods



What was the process?

3. Procedures for implementing a geo-fence

- Determining accuracy
  - GPS Accuracy
  - Remote Sensing Data Accuracy
- Re-locating the geo-fence
  - Make sure there are no gaps between line intersections

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What was the process?

3. Procedures for implementing a geo-fence

- Checking for compliance
  - Need to calculate area determination manually at this time
- Terrain problems / complication?

(Accuracy * 3.2808399) * Line Length = individual line area error

Sum the total area error from all line segments that make up the unit. Then divide by the total area of the unit

Unit Line ID	Equipment	Method Used	Perimeter (ft)	Acres	Canopy	GPS Error (meters)	GPS Error (ft)	Perimeter Error (ft)	Area Sq ft	Unit Error	unit error /2
Unit 1						4.523333333				6.65%	
47	NAIP 2017 AZ 60cm	Discernible Digitized	1191.267998	23	NAIP	4	13.1233596	15633.43832	997959.6	1.57%	
48	NAIP 2017 AZ 60cm	Discernible Digitized	1307.207365	23	NAIP	4	13.1233596	17154.95232	997959.6	1.72%	
46	Garmin Glo	GPS Paint	1838.897822	23	Light - Medium	5.57	18.27427824	33604.53047	997959.6	3.37%	
Unit 2						5.046666667				6.44%	
45	Garmin Glo	GPS Geo Fence	3317.162064	37	Light - Medium	5.57	18.27427824	60618.74254	1625659.2	3.73%	
49	NAIP 2017 AZ 60cm	Discernible Digitized	794.2746168	37	NAIP	4	13.1233596	10423.55142	1625659.2	0.64%	
46	Garmin Glo	GPS Paint	1838.897822	37	Light - Medium	5.57	18.27427824	33604.53047	1625659.2	2.07%	

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What was the process?

4. Finalize geo-fence boundaries
    1. Construct polygons from final GPS'ed and digitized lines.
    2. Document procedure in cruise plan
    3. Secure final unit Feature Class

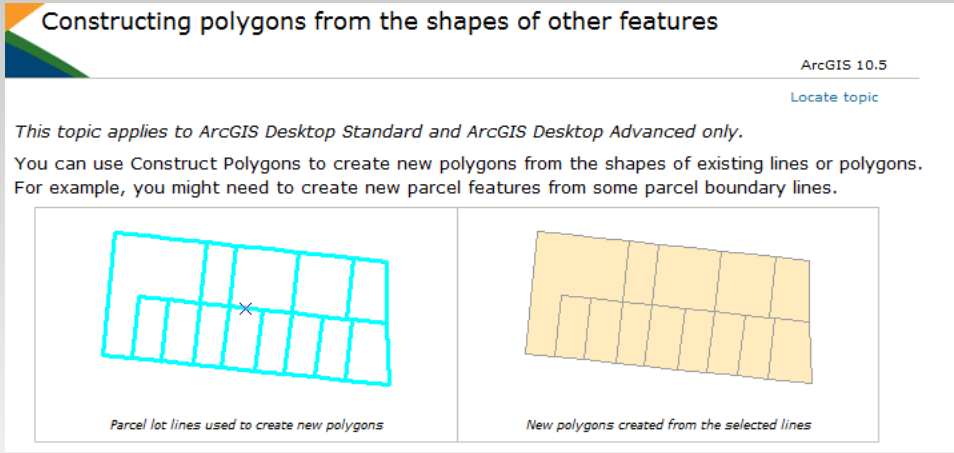
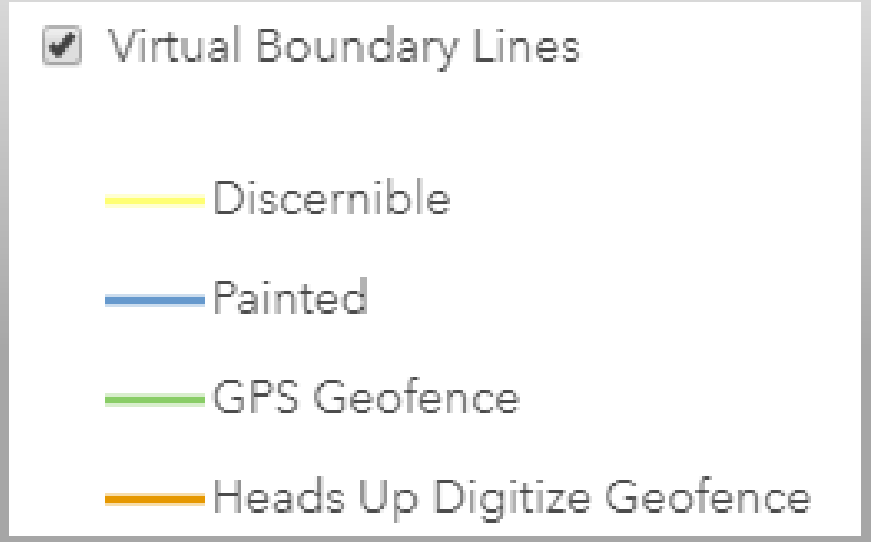


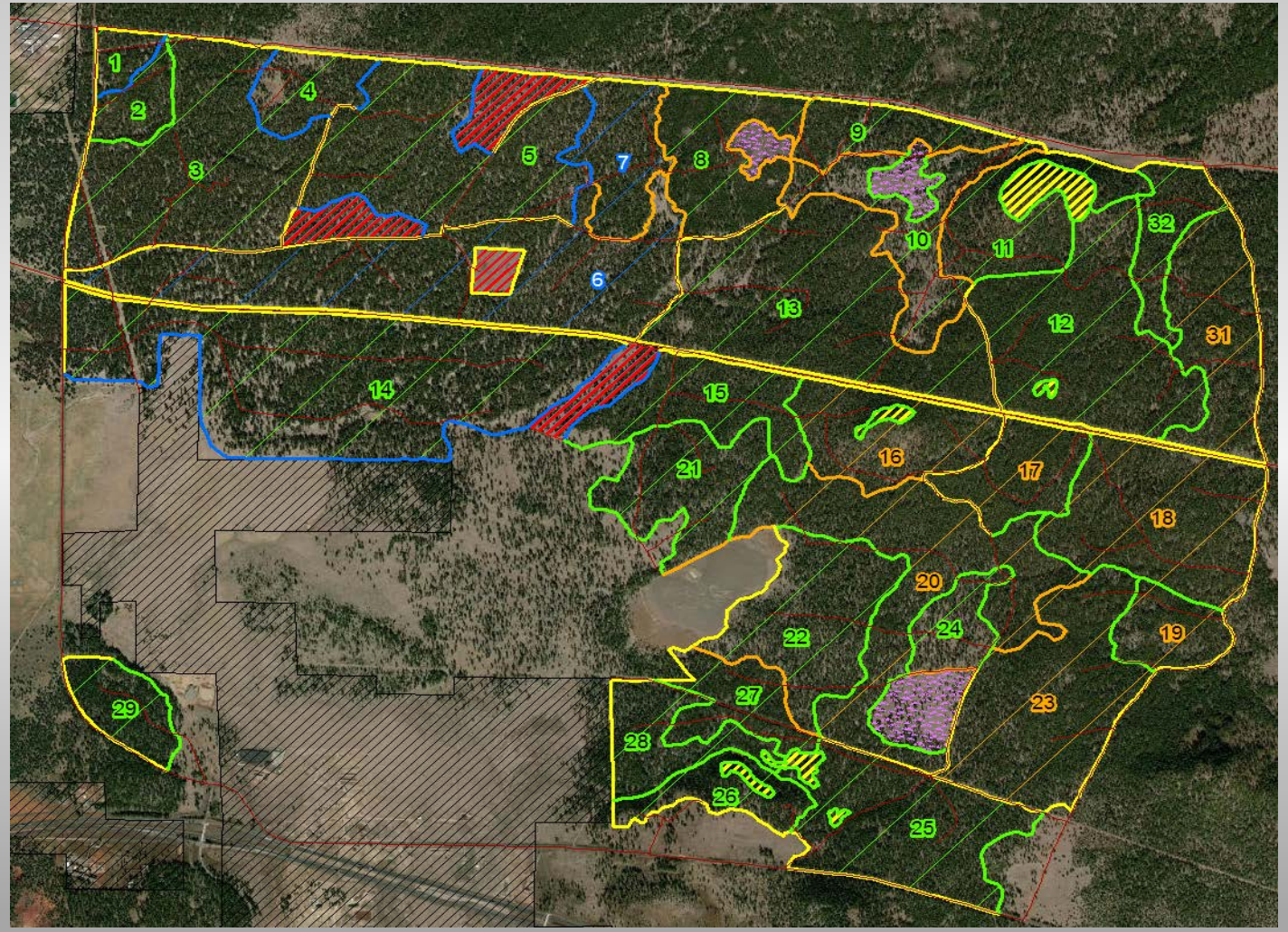
Table 5. Boundary Info Table

Boundary Segment Number	Boundary Type	Accuracy	Risk Category
1	GPS Geo-Fence	5.57	G
2	GPS Geo-Fence	5.57	G
3	GPS Geo-Fence	5.57	G
4	GPS Geo-Fence	5.57	G
5	Discernible Digitized	4	E
6	Discernible Digitized	4	E

What worked well?

- We used ESRI Arc GIS Online to
  - Identify risk of each boundary
  - Label boundary types
  - Coordinate field surveys using TwoTrails





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What worked well?

- Approximately 52 miles of virtual boundaries not painted-(89%)
- Discernable boundary type
  - Approx. 26 miles
  - GEO-fence boundary type
    - Approx. 18 miles of GPS'd GEO-fence
    - Approx. 8 miles heads up digitized GEO-fence
- Painted boundary type
  - Approx. 6 miles
- Paint Saved!
  - 1 Gallon of pain will cover approximately 2500 ft or half a mile
  - About 110 gallons of paint saved

What worked well?

- “Fire team” approach to working out all steps of the process
- Partners resources in technology/planning
- Partner working well with logger to implement technology
- Willingness from everybody to try something different

What did not work well?

- Accuracy of GPS in heavy cover
- Using existing layers/data
- NEPA lines – Firm or intent?
- Need a lead/final decision maker
- Communication—good for the most, but did not get all of the participants involved at all times
- Tracking time spent to determine efficiencies-hard to do when are determining the procedures

Key points for implementation

- Actual Area of Risk
- Partner must stay within Area of Risk by any method they choose
- Contract will explain what method the Sales Administrator will use:
  - Equipment accuracy from NTDP (MTDC) Accuracy matrix
  - Ordinarily use the 60 averaged points in open-canopy (modify if there is more canopy)

Key points for implementation

- In-cab mapping software on GPS enabled tablets mounted in operating equipment has many implications for boundary layout
- Discernable boundaries are plainly visible from the ground and in-cab technology is not required by operators for implementation
- Geo-Fence boundaries are not visible from the ground and in-cab technology is required by operators for implementation
- In many cases, the accuracy of the base map surpasses that of the GPS unit and the accuracy of lines digitized referencing a base map exceed the accuracy of lines digitized from a GPS unit

Key points for implementation

- Receiver example is a Geode
  - 0.84 meters in open sky
    - Usual case but use other canopy values if canopy is not open
  - **For ease of this lesson, we will use 1 meter**
- Note: averaging 60 measurement for one point is the proper way to measure one stand-alone location

NTDP GPS Receiver Horizontal Accuracy Reports

NTDP has been testing GPS receivers of various grades in order to determine their horizontal accuracy in different cond
some cases, different settings. Select a make and model to see the accuracy reports for that receiver.

Manufacturer

Juniper

Model

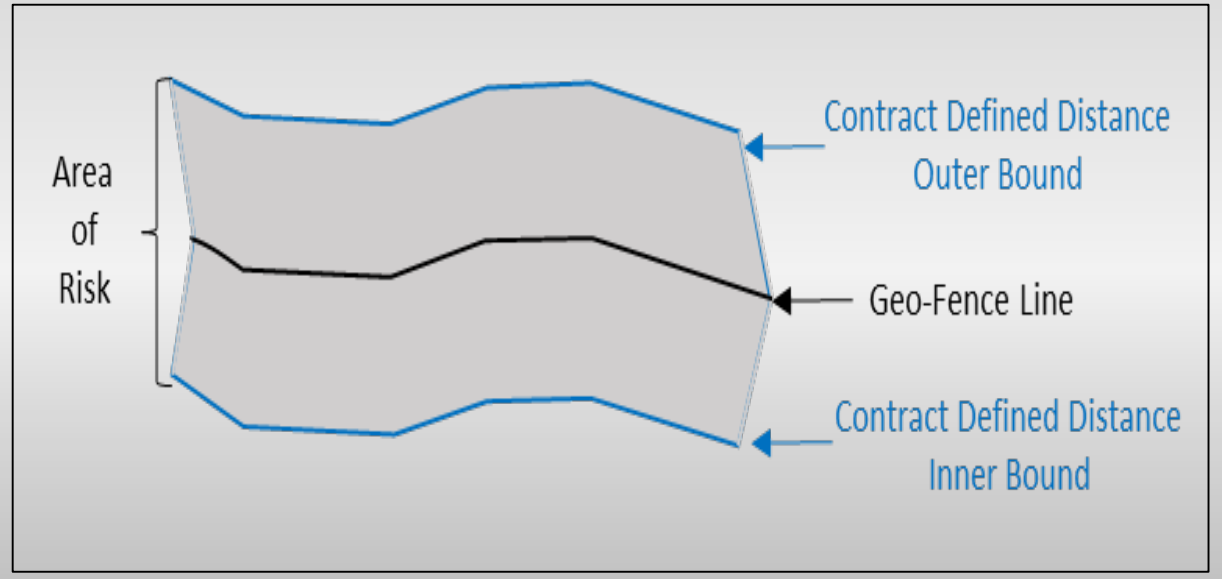
Geode (2019)

Juniper Geode (2019)

External Antenna	Real Time Correction	Glonass	Post Process	# of Positions Averaged	Tested Accuracies By Canopy Type NSSDA(units in meters) Open	Light-Medium	Heavy-Closed
No	WAAS	Yes	No	1	0.62	2.58	4.19
No	WAAS	Yes	No	5	0.71	2.33	3.94
No	WAAS	Yes	No	60	0.84	1.44	2.76

Key points for implementation

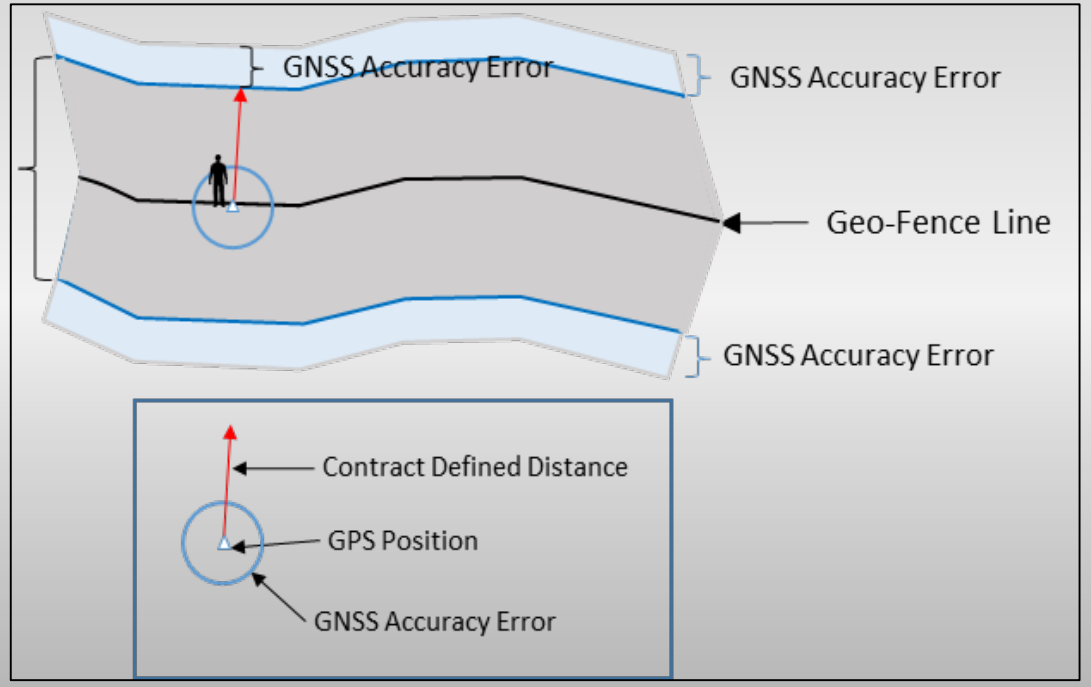
- Contract Defined Distance
  - Inner Bound – Up to
  - Outer Bound – No further away
- Grey area represents the Area of Risk
  - The resource treatment may be applied inconsistently, sometimes not reaching the geo-fence line while sometimes going over the geo-fence line.
- Black line represents Geo-Fence Line.



Key points for implementation

Additional source of error

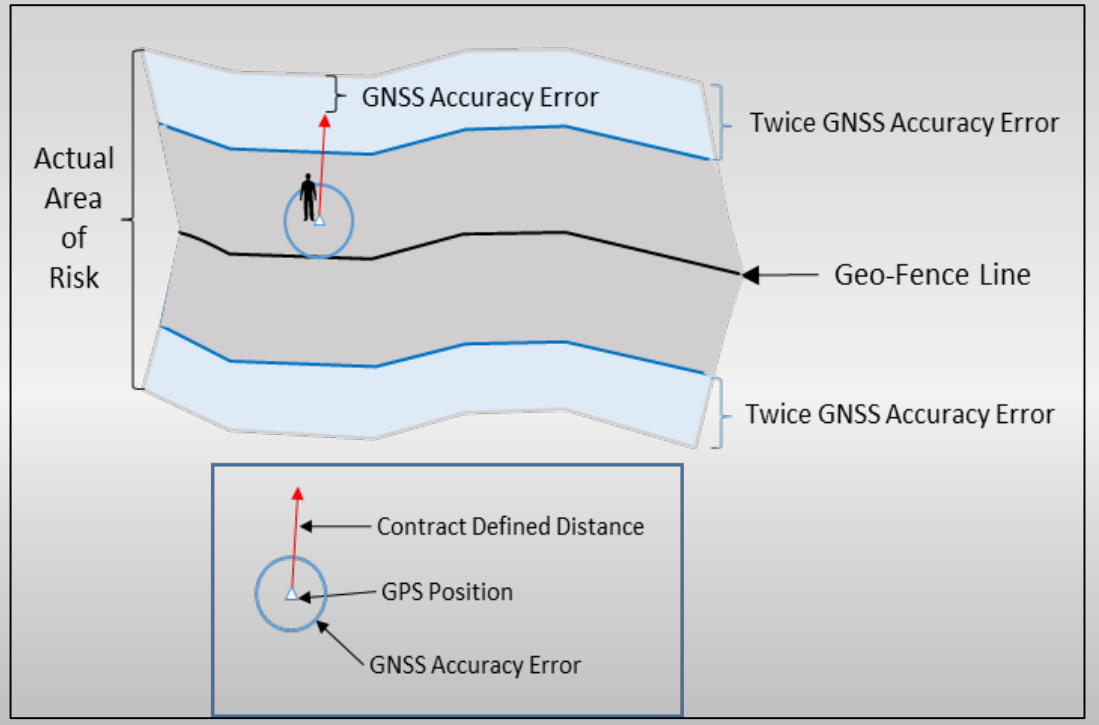
- GNSS Accuracy error
  - SA-accuracy error with the device
- Contract defined distance determined by adding the Contract defined distance to the GPS position.
- Contract Defined Distance is set at a specific distance, the ability to determine contract compliance requires the addition of the GNSS error.



Key points for implementation

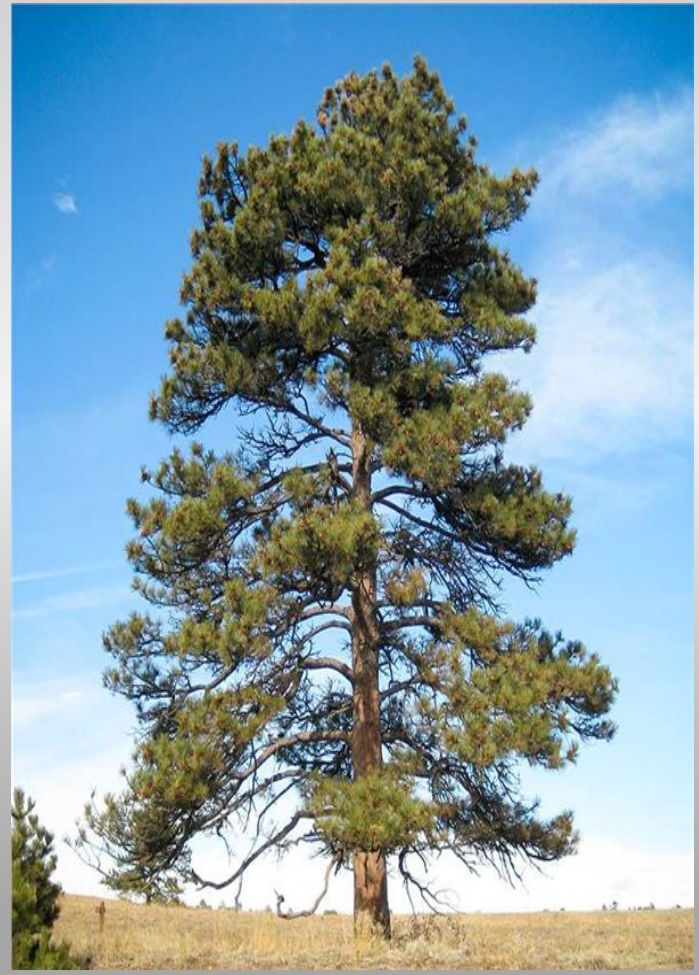
Worst case scenario

- Actual Area of Risk is defined by the Contract Defined Distance plus twice the GNSS accuracy error from the receiver used by the Sale Administrator.
- Type of GNSS receiver the Sale Administrator is going to use needs to be known during the Sale Preparation phase. The higher the quality of GNSS receiver the Sale Administrator will use, the lower the Actual Area of Risk.



Key points for implementation

- Virtual boundaries Risk assessment and cutting unit boundary designation needs to be an attachment to the cruise plan.
- Willingness of logger to use technology
- Simple layout shapes easier to use
- Does that tree matter?



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Recommendations

- Re-assess the value of GPS field validation of GEO-fences when considering:
  - The return on investment of highly accurate GEO-fences
  - Field validation is time consuming and introduces GPS error
  - In-cab technology will be used during operations to display the GPS location of harvest equipment relative to virtual boundary lines and base map
- Consider optimizing heads up digitized GEO-fences without GPS field validation if:
  - They are identifiable by the imagery
  - They are shared cutting unit boundaries within a timber sale
  - They are external boundaries where product is low value and NEPA coverage extends beyond the sale area on FS land

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Recommendations

- Risk assessment is the key to utilizing virtual boundaries—spend the time and be thorough on this step.
- Engage industry on virtual boundary.
- Can utilize government furnished property for tablet for purchaser/contractor.
- Engage RO Timber to assist with implementation of virtual boundaries.
- Virtual boundary needs to be part of cruise design, in sale prospectus highlighted as a special condition, highlighted at pre-bid and pre-work meetings.
- Better NEPA lines.
- Keep experimenting with LiDAR.
- Keep up with technology.

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