How GNSS Enables Precision Farming

John Deere Intelligent Solutions Group | December 2014

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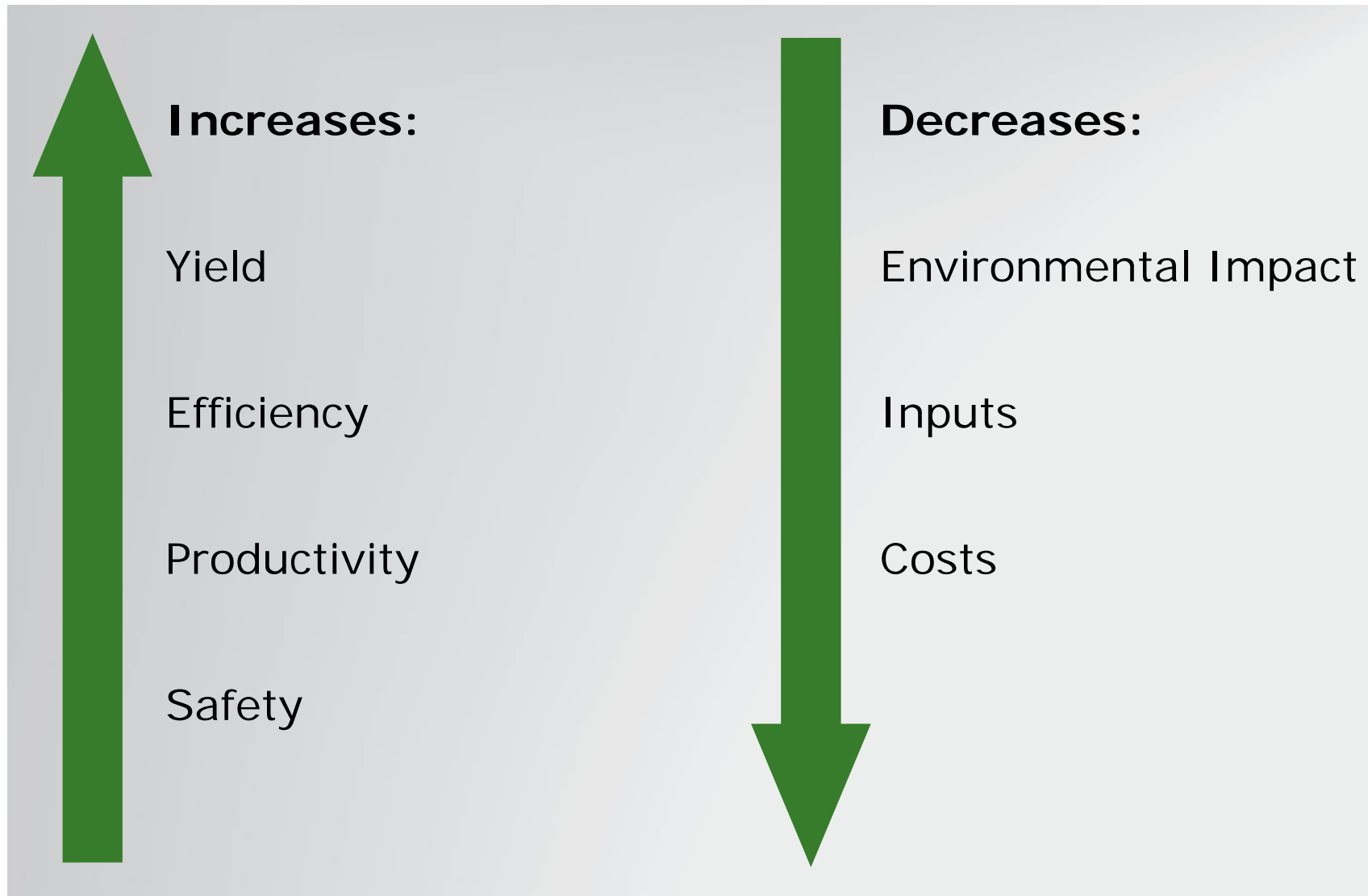# Feeding a Growing Population

Enables those who feed the world.

Immediate and Ongoing Needs

+   population growth (more to feed)

+   urbanization (decrease in arable land)

Double food production by 2050 to meet world demand.

To meet this need – every inch matters.

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GPS Enabled Precision

Increases:

Yield

Efficiency

Productivity

Safety

Decreases:

Environmental Impact

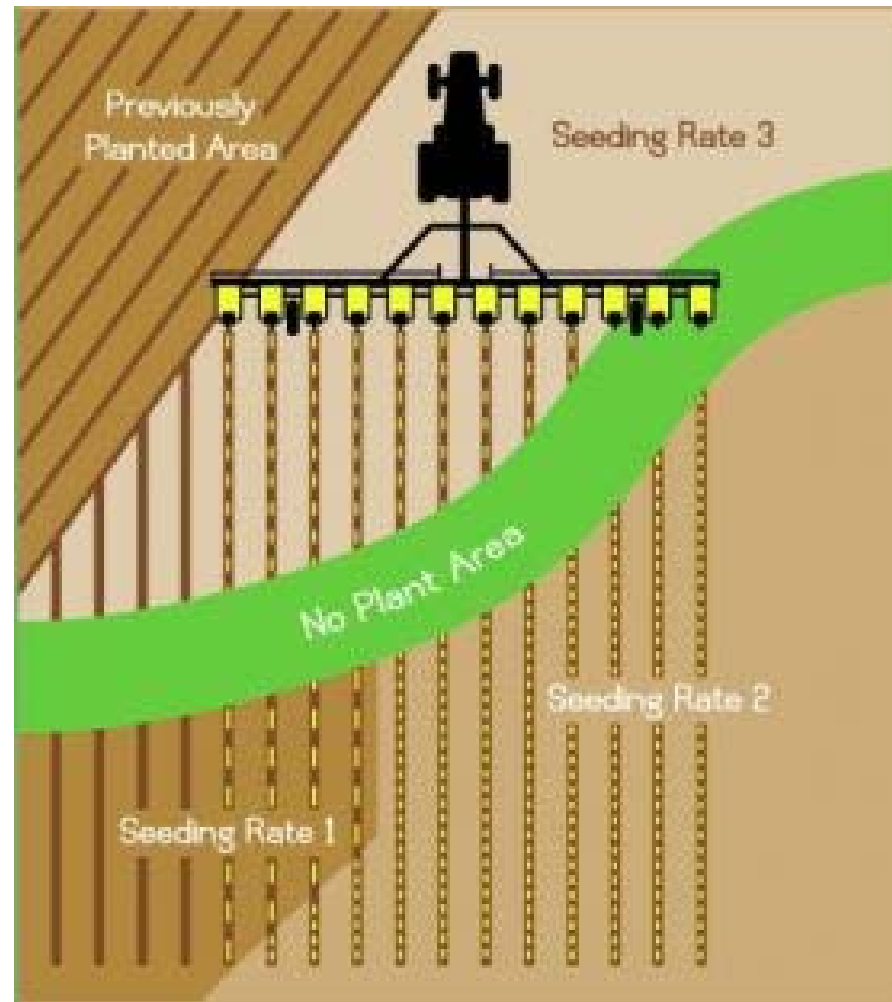Inputs

Costs

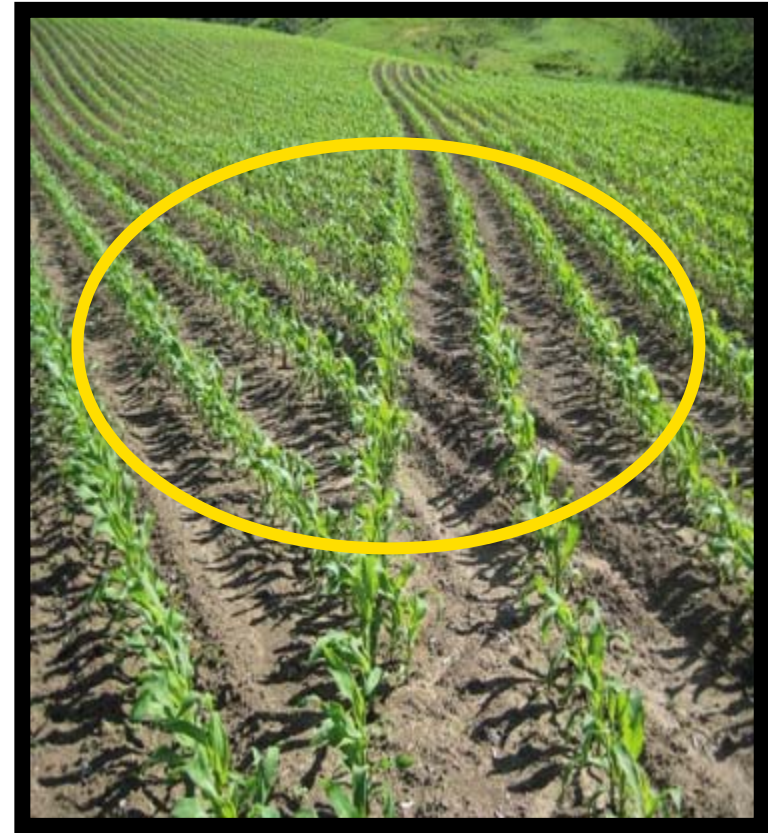JOHN DEERE

Precision Seeding

Image Source: http://farmindustrynews.com/site-files/farmindustrynews.com/files/imagecache/galleryformatter_slide_penton/gallery_images/web07RAVNplantcontrolillus.jpg

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GPS Enabled Precision Ag

Field Planted <u>without</u>
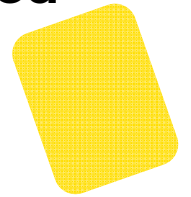Swath Control

Field Planted <u>with</u>
Swath Control Pro™

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GPS Enabled Precision

Sprayer nozzles shut-off when not above crop section.

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GPS Enabled Precision Ag

Overlap used to be measured in feet.

With precision GPS, overlap is now measured in inches.

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GPS Enables Operator Efficiency

Decreases Fatigue

Increases Health & Safety

Enables Night-time Operation

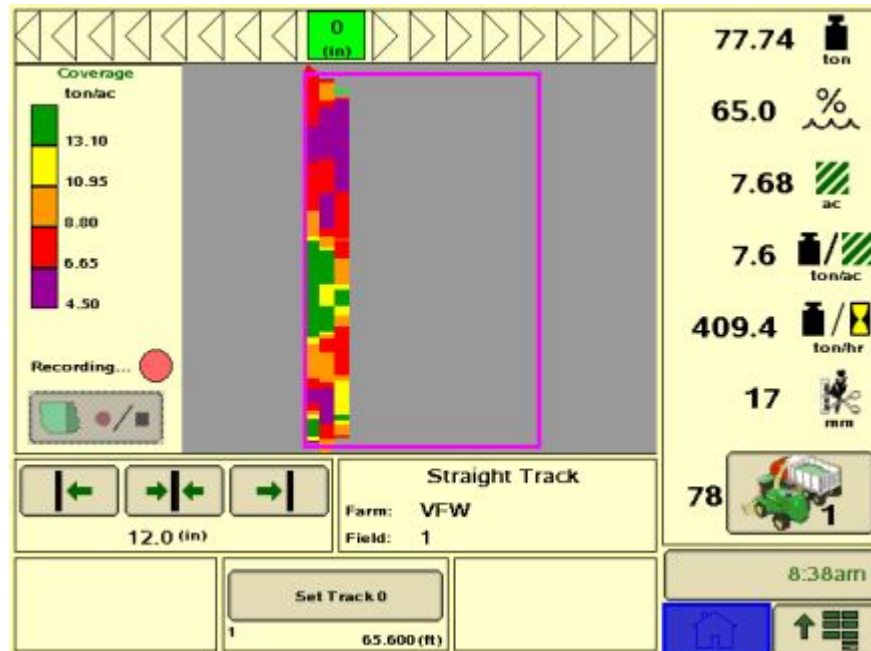JOHN DEERE

Water Optimization & Precise Planting

Irrigation structures easily damaged by machinery
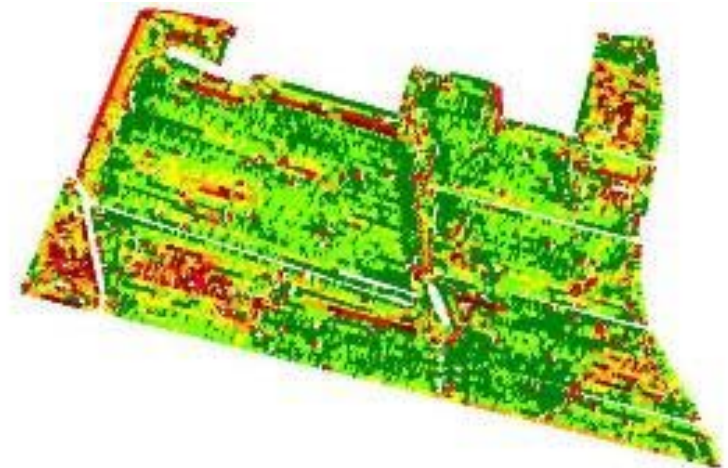
- Especially subsurface tubes and tapes

Mapping of irrigation infrastructure allows planting near drip lines

- More water for crop
- Less water for weeds

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Precision Enabled Decision Making

Record and Adjust While Operating

**Actionable Information for
Analysis and Decision Making.**

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Improved Agricultural Productivity

Yield Mapping – used by 80% of grain combine customers in US

- Provides insight for precise seed placement, pesticides and fertilizers

Auto Guidance – used by 65% of the large agriculture producers in US

- Reduced errors in overlap of tillage, seeding and spraying
- Reduced operator fatigue
- Opportunity to use local unskilled operators

Improved Output

- Reduced overlap = fewer passes through the field
- Less compaction implies higher yield
- Less tillage required – less fuel, less carbon release and lower food cost

Future Gains

- Additional advancements needed to feed a growing population

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Specific Input Cost Savings

- **Annual Cost impact: $8.2 billion**
  - Reduced chemical and fertilizer: $4.8 B
  - Reduced seed costs: $1.5 B
  - Reduced fuel consumption $0.5B
  - Labor savings $1.4 B
- **Other Cost impacts**
  - Operation in darkness, fog and high winds
    - 100% GNSS availability essential
  - Optimal planting time can result in difference of 1% yield per day

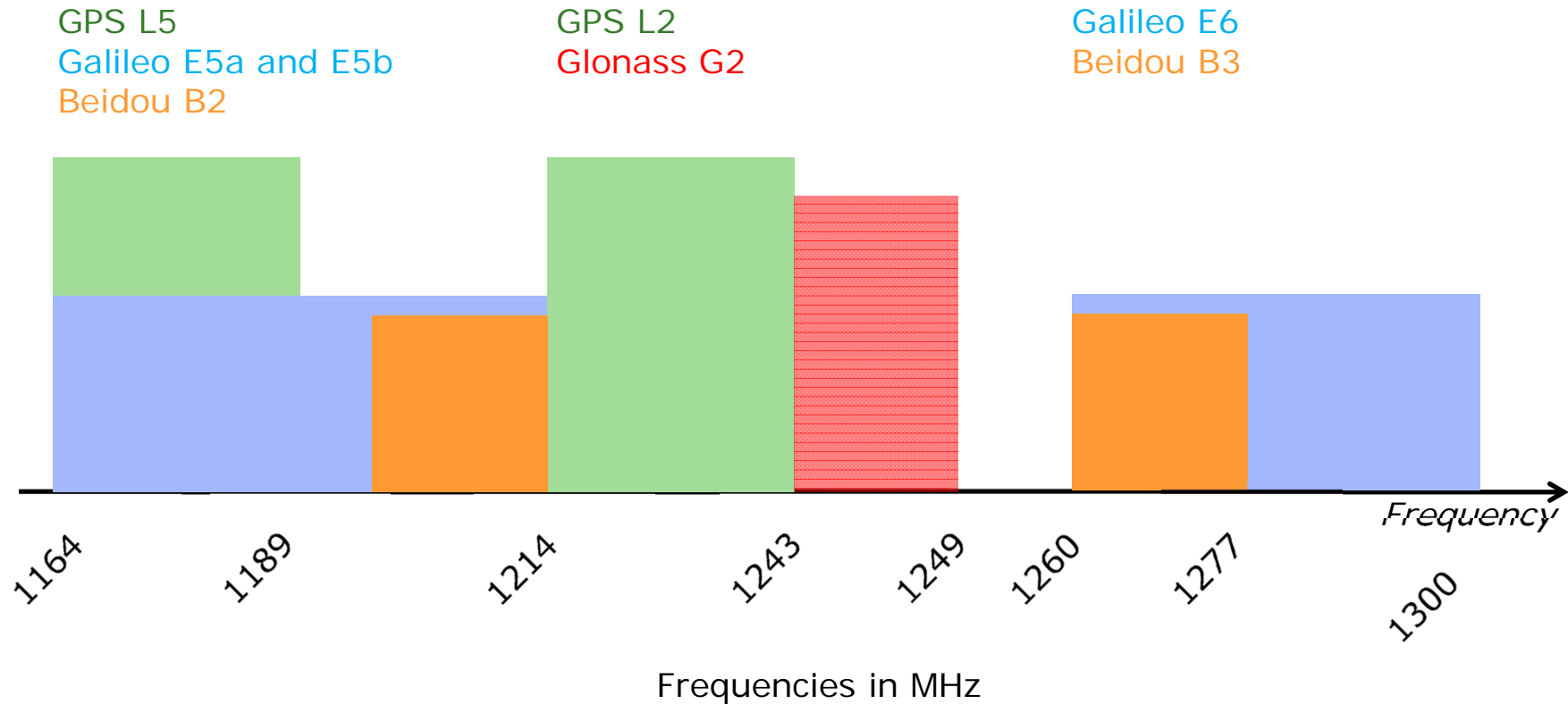JOHN DEERE

Improved Environmental Impact

Reduced pesticide and fertilizer usage

- GPS has saved between 7% to 10% (17.5 to 25 million acres) annually from receiving unneeded pesticide and fertilizer applications.
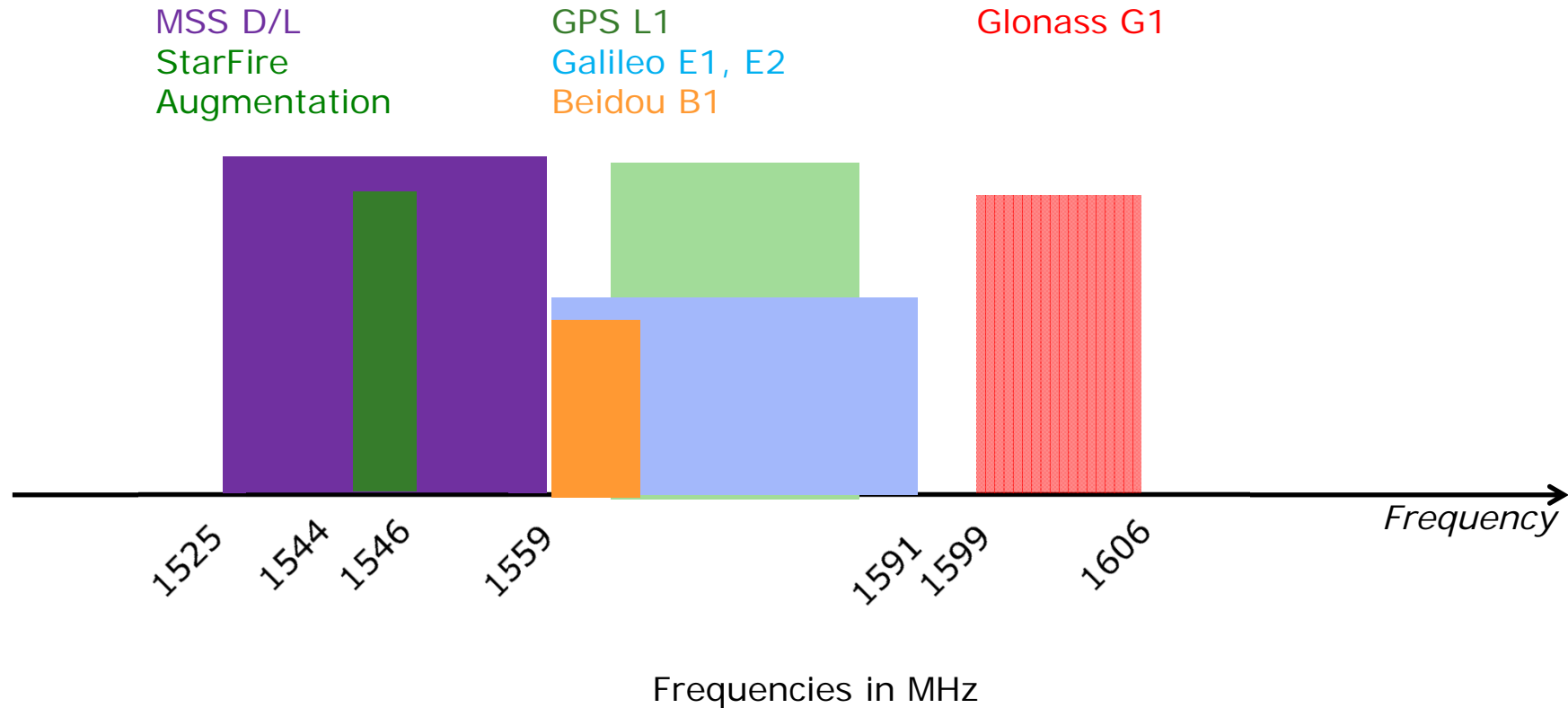
USDA data shows technology impact on corn production—compared to 1987 *(Impossible without GPS)*

- Land required to produce a bushel of corn reduced by 37%
- Precision tillage has reduced soil loss by 69%
- Energy required for production reduced by 37%
- Carbon emissions reduced by 30% per bushel

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# Downlink Frequencies Used in Agriculture -Low Bands

GPS L5
Galileo E5a and E5b
Beidou B2

GPS L2
Glonass G2

Galileo E6
Beidou B3

1164 1189 1214 1243 1249 1260 1277 1300

Frequency

Frequencies in MHz

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Downlink Frequencies Used in Agriculture -High Bands

MSS D/L
StarFire
Augmentation

GPS L1
Galileo E1, E2
Beidou B1

Glonass G1

1525   1544   1546   1559   1591   1599   1606

Frequency

Frequencies in MHz

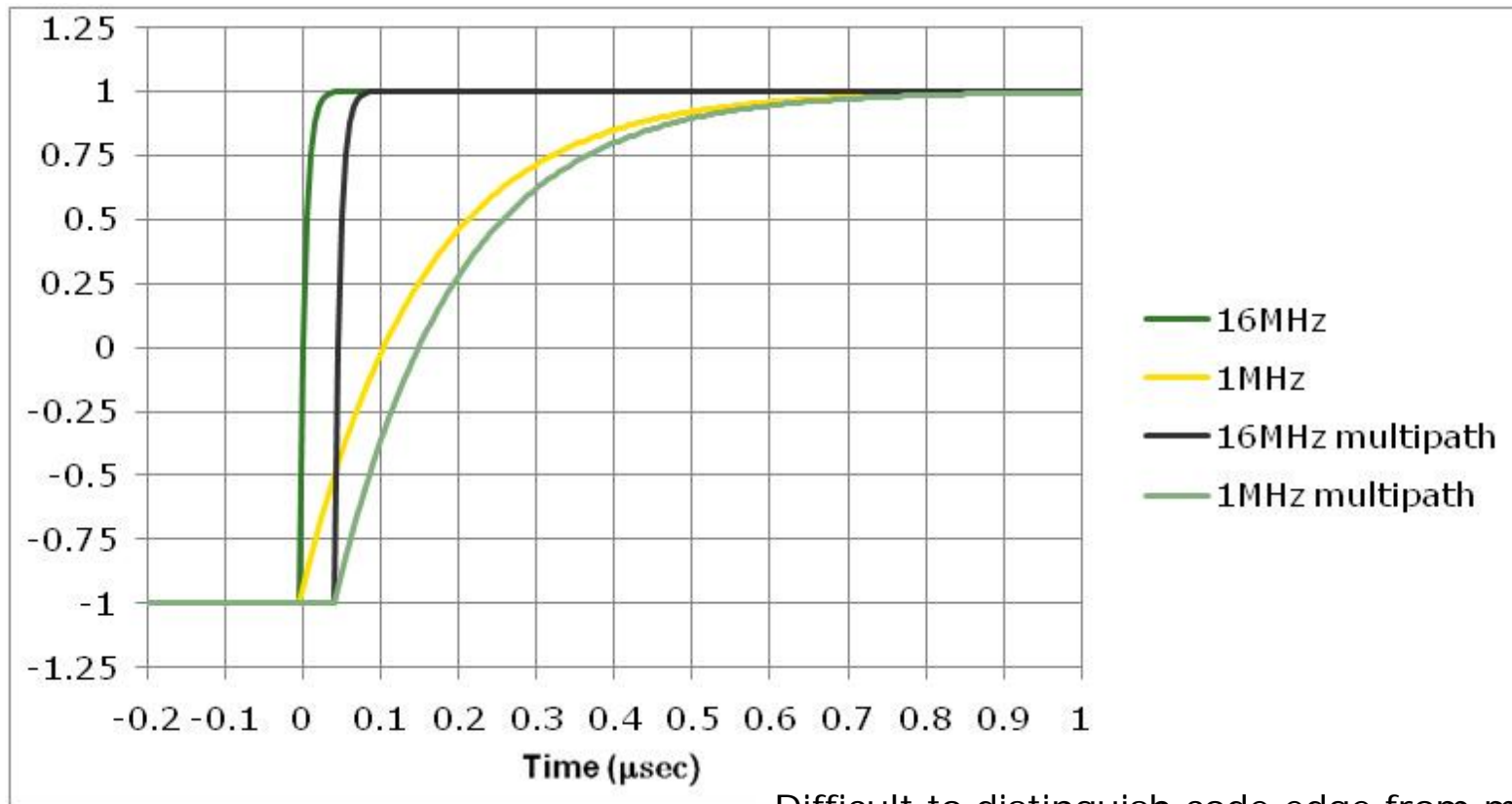JOHN DEERE

GNSS Accuracy is a Function of GNSS Bandwidth

GNSS is based on range measurements to the satellites (pseudoranges)

- Measure time of arrival (TOA) of spreading code transitions
- Accuracy of TOA measurement depends on sharp code edges

- Sharpness of code edges depends on bandwidth
  - Most of energy is in 2 MHz for L1 C/A code, but much of the information on sharpness is in the lobes
- Navigation accuracy depends on wide bandwidth

Code Transition for Different Bandwidths

Time (µsec)

16MHz
12MHz
1MHz

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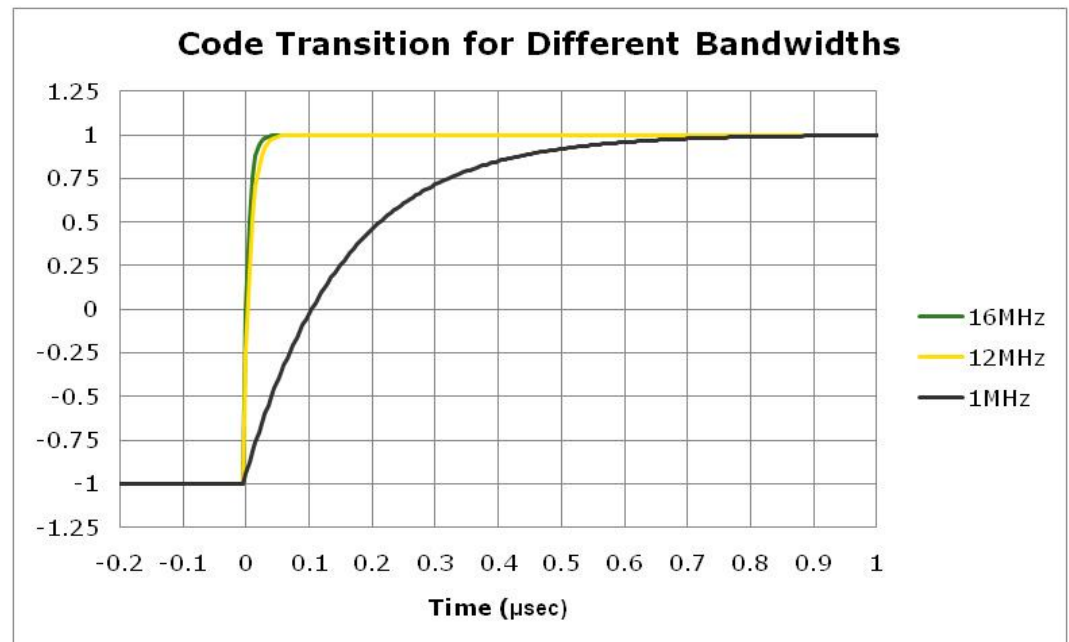
Multipath Mitigation

Difficult to find code edge in multipath-distorted signal

Need sharp code edges to see direct signal before multipath signal

Difficult to distinguish code edge from multipath

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