

## Precision Agriculture with “Normal” Crop Prices



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(formerly Holiday Inn)



### What we are going to talk about:

- How to think through technology investments
- How precision ag is about more than machinery and VRA – it is a way of thinking
- The economics of several precision ag technologies (machinery related)
- A view to the nearby future for precision ag

## Technology

- **Definition:** The application of science to industrial or commercial objectives
- **Broadly, agricultural technologies** are those processes or machines that impact production agriculture, typically by
  - lowering cost, or
  - increasing revenue
- **Requires an investment**
  - so, the natural question is will it pay?

## Technology: Will it pay?

- How much is the investment?
- What is the expected return on investment? (How fast is the payback)
- How confident am I that this will happen?

## If a profit materializes . . .

- I'd like to apply the technology to more units of production (often, acres)
- So, I bid up rent or land values
  - Just a bit if I'm the only one using the technology
  - A whole bunch if many are using the technology
- It takes only a few viable adopters in an area to dramatically drive up rents

## • Early adopters

- Adopt to become more profitable
- See the technology as a great opportunity
- Bid up rents and land values

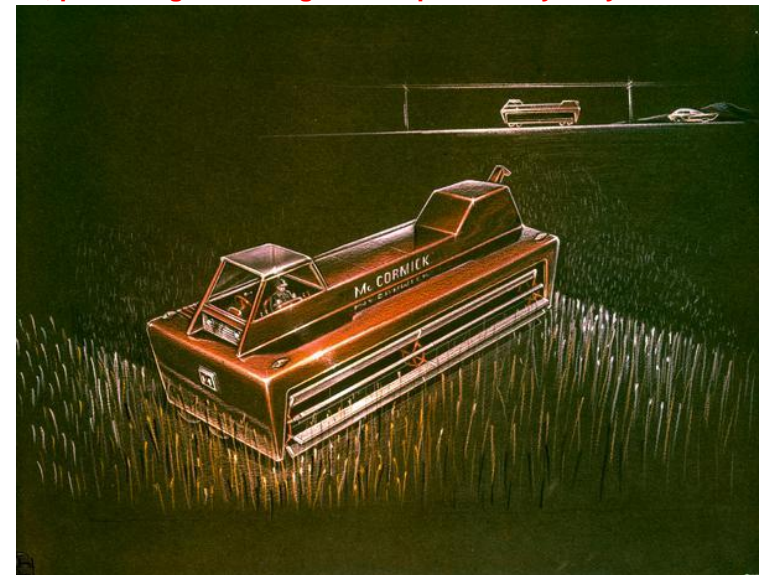
## • Later adopters

- Adopt just to survive
- Sometimes wish things would go back to the way they were
- Sometimes recognize the potential but are too small to justify the investment
- Higher rents mean higher costs, and late adopters find themselves going broke in the face of rents they perceive as “too high”

## Technology: how to get an edge

- Invest in the “duh” technologies quickly
  - You don't have a choice
- Invest in the slow moving technologies
  - The profits will last for years
- Invest in technologies that DO NOT save labor
  - Most people do not; hence the gains last for years

But, predicting technologies isn't particularly easy . . .

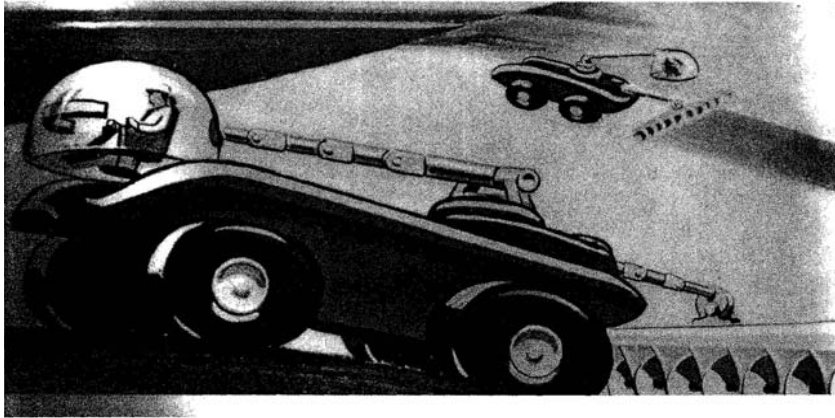


Future McCormick harvester (turns for road travel), 1960s?

Yet, folks in the past were quite insightful conceptually (think of desire to "study" implement workings and how autoguidance allows it today)

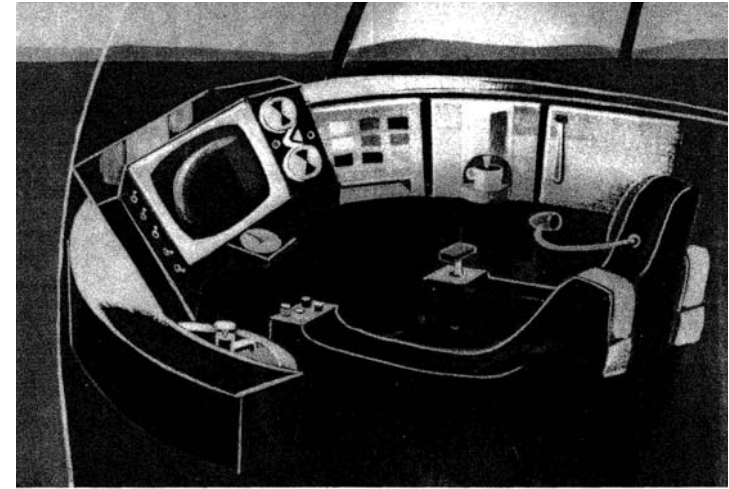
TRACTORS THAT DON'T LOOK LIKE TRACTORS. Another look at what tomorrow's tractors will look like came from the Ford study. The artist's conception shows an air-conditioned bubble-type cab that can be moved back over the equipment to check any problems.

*Courtesy, Ford Tractor Co.*



What 2000 will look like from vantage point of 1960s

Still more historical insight



COMFORTABLE CAB. Predictions from Ford also indicate tractors of the future will be distant cousins of today's farm vehicles and their cabs will be just as advanced. This illustration depicts the cab of a tractor projected for the year 2000. Starting at the driver's right, and moving left, are a refrigerator, coffee maker, food warmer, a television set which is connected either to the farmer's headquarters or to other vehicles, there's even a sink. All controls are within arm's length of the driver so he can perform his jobs quickly and easily. This illustration is from "Agriculture 2000," a study conducted by Ford Motor Company's U. S. Tractor and Implement Operations to project the look of agriculture at the turn of the century.

*Courtesy, Ford Tractor Co.*

What 2000 will look like from vantage point of 1960s

And you thought fuel cells were a current phenomenon!



1959 AC fuel cell concept tractor

Where's today's insight? Size? Roundness?



Future tractor (Case-IH Steiger 1000A), company artist in 2008

## Technology adoption, fast or slow?

- **FAST**
  - GMO crops
  - GPS-assisted steering
  - Boom/section control of planters and sprayers
- **SLOW**
  - No-till
  - VRA of crop inputs

## Technology and farm size

- Large farms adopt technology more quickly
  - Because of investment (economies of size)
- If technologies come out ever faster, then farms will get larger ever faster
- Rapid growth in farm size may become the norm
- End result (intended or not): consolidation

## Scale-neutral Technologies?

- Roundup-ready soybeans?
- Robotic milkers
  - A robot station is rated at 60 cows
  - Will I get a discount if I buy multiple robots?
  - Can't one person check the "attention list" of more than one robot?
  - New semi-robots coming out for large dairies
- Farm machinery
  - Maxes out at some size so is it scale neutral beyond that point?
    - Multi-unit discounts?
    - Multi-unit tracking and servicing?

## But how do I know?

- Think SCIENCE
  - No magic
  - Stay away from foo-foo dust
- Think MARKETS
  - If the returns sound too good to be true they probably are
- Think ENGINEERING
  - What will the technology actually do?
  - What is a technology's potential (opportunity)?
    - After all, costs often fall

## Land Grant Institutions

- Provide a nice check
  - Kept many from using the myriad silage/hay preservatives in the 1970s
    - But, don't carry that mantra too far. After all, some preservatives actually worked!
- Sometimes too slow
  - Focus on high confidence in their statistical tests
  - Business decisions often made at much lower confidence levels
- But, their science is good, so ask them about the science behind a technology you're considering

... precision ag

## Early Precision Ag “Movement”

- GPS signal availability early 1990s
  - Yield monitors
  - Grid soil sampling and VRA
- Dreams
  - Salvation for the little guy (free GPS)
  - Salvation for the big guy (can manage like the little guy)
  - No more excessive environmental pollution
  - Higher yields on less inputs (more efficient production)
  - More profit

## Early Precision Ag “Movement”

- Engineers give us all the cool electronic stuff to work with the GPS signals
- Agronomists help us use the cool electronic stuff to make better crop input decisions
  - Here's where the money was supposed to have been made!

## Early on prescient quotes:

“Precision Ag will allow us to make better uniform (i.e., field-scale) decisions”

– Randy Taylor

- 1) What we learn with PA will give us better field-scale decisions
- 2) Maybe farmers will now “twist the dial” at least at the field scale

“I’m still confused but at a much higher level than before” – MIMC program

PA will induce better questions

## Early on prescient associations of farmer-researchers (like KARA\*)

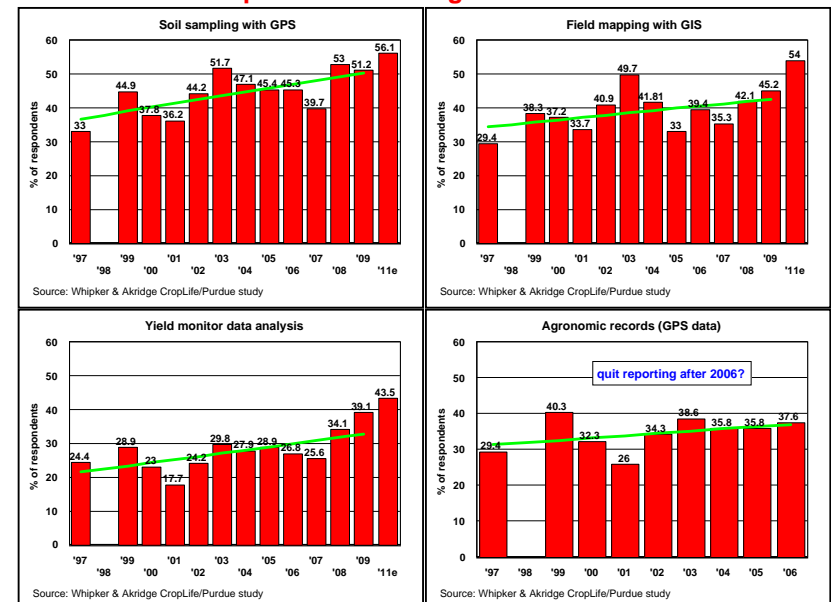
- Involved university folks, farmers, and agribusiness folks from around the area who:
  - Recognized the deficiencies of public providers of the required knowledge for our farms
  - Recognized the value of on-farm research
- Recognized the value of science at the farm level
  - Increase the scientific aspects of how we gain knowledge as farmers – how we learn
  - Improve our presentations of what we learn to others
  - Increase the amount of critical thinking we do
  - Helps us develop thicker skins

\*Kansas Agricultural Research Association, [www.ksagresearch.com](http://www.ksagresearch.com)

## Whipker & Akridge CropLife/Purdue Survey

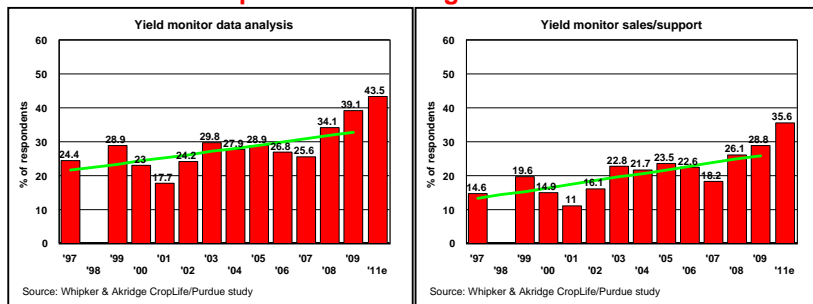
- 1996: what were the greatest opportunities for PA?
  - Better agronomic understanding
  - Improved dealer profit due to offering new services
  - Improved crop yields
- Did it happen? In a 2006 survey all rankings averaged between 3.7 and 4.5 where 1 meant no impact and 7 meant large impact – so sort of ho hum
- Very few (<10%) of dealers believe that PA (essentially VRA) improved crop input efficiency (2006)
  - Apparently, that dream never materialized!

## Percent of service providers offering services



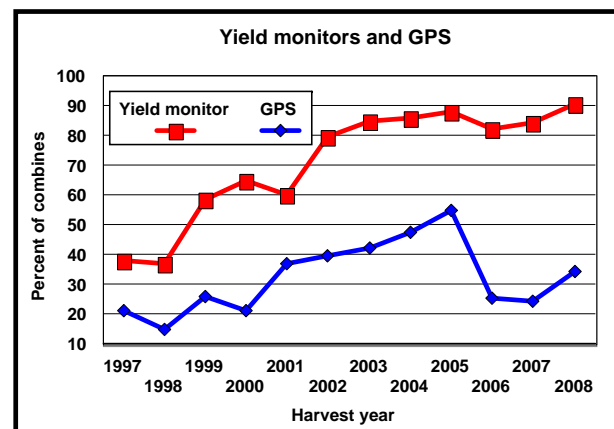
a typical slow-moving technology . . . some things even go away enroute

## Percent of service providers offering services



PA started with collecting and analyzing data from yield monitors 15 years ago, but such activities have been somewhat slow in adoption

## From 151 combines operated by CHAMP members



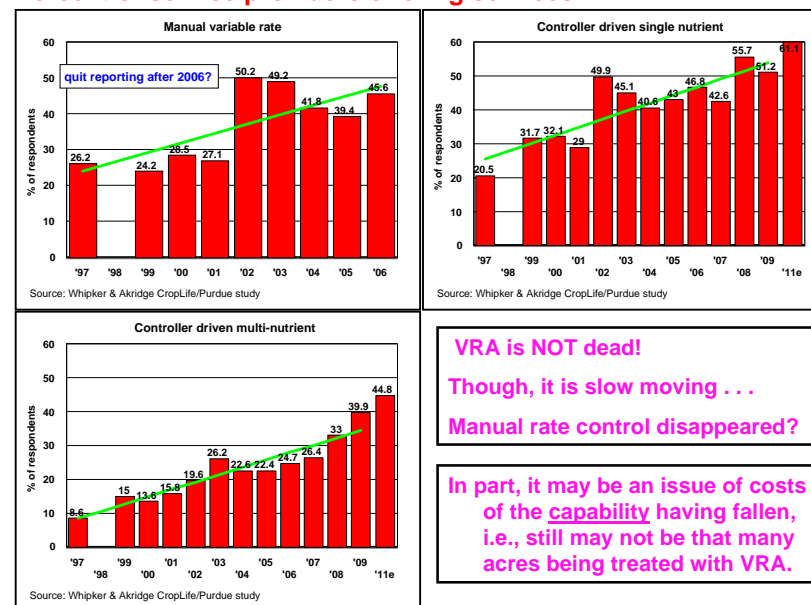
In 2008, 22.2% of CHAMP members providing yield maps  
Of those providing, yield maps were provided for 20.1% of customers

Yield monitoring is a fast moving technology  
Yield mapping is a slow-moving technology

## A few thoughts on VRA and yield monitors

- Input efficiency improvement not that great
  - Hence acres treated with VRA are still low
  - i.e., users don't know how (why?) to do VRA
- Yield mapping slow to be adopted
  - Folks don't know how to analyze the data
  - May be uncomfortable with task of making maps or managing the reams of data that arise
- Yield monitors fast to adopt
  - Require no formal analysis
  - Provide useful subjective & objective information:
    - Grain moisture information is especially valuable
    - Real-time combine performance information, especially along with grain loss monitors
    - Causes operator to think about reasons for yield differences

## Percent of service providers offering services



VRA is NOT dead!  
Though, it is slow moving . . .  
Manual rate control disappeared?

In part, it may be an issue of costs of the capability having fallen, i.e., still may not be that many acres being treated with VRA.

## VRA continues to grow in adoption

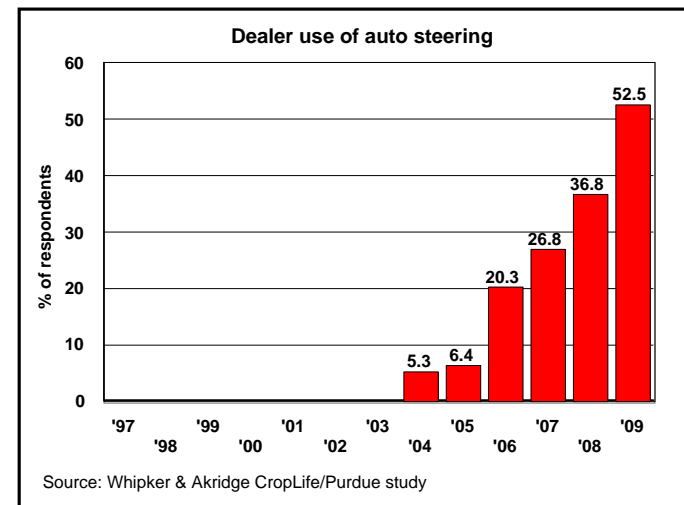
- Likely, users are gradually developing
  - subjective rules from map-based information, or
  - objective rules from area data information
- Likely, rules vary considerably from user to user and year to year – still much experimentation to do
- A very typical slow technology
  - Some figure it out and others do not
  - No clear large benefit to users on average
  - Yet, probably a nice opportunity for long-term profit for those who continue to experiment and learn

## PA after 10 years (unforeseen sleeper #1) presented at KARA conference, January 2007

- PA thinking leads to better crop production decisions outside of VRA
  - Taylor was right
  - MIMC was right
- We're recognizing the value of farm-level science
  - Increase the scientific aspects of how we gain knowledge as farmers – how we learn
  - Improve our presentations of what we learn to others
  - Increase the amount of critical thinking we do
  - Helps us develop thicker skins
- Do we care if these things are called precision ag?

## PA after 10+ years (unforeseen sleeper #2) presented at KARA conference, January 2007

- Improvements in machinery efficiency
  - Light bars
  - GPS autoguidance
  - Machine control
- Never underestimate the economic importance of improved machinery decisions
  - COST, not revenue differences explain profit differences
  - Machinery costs is the most important cost category



a very fast moving technology – improved accuracy of driving and reduced operator pressure likely make it obvious

## More recent machinery enhancements

- Boom and section shutoff of
  - Sprayers
  - Fertilizer applicators
  - Planters and seeders
- KSU-GPSguidance.xls
  - Available at [www.agmanager.info](http://www.agmanager.info)
  - An updated version, sponsored by CropLife, will soon be available at its website
  - Shows high return on investment in these machine control add-ons
    - If you don't believe it, use the spreadsheet and you'll see that boom and section shutoff controls are no-brainers for many

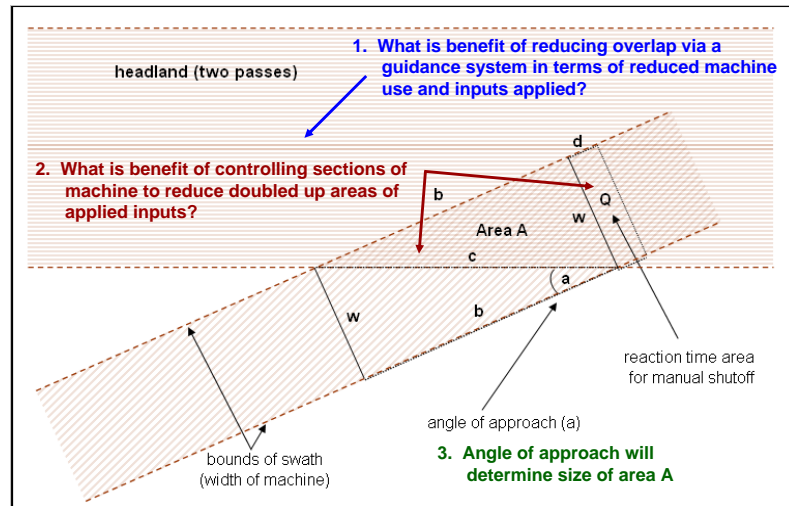


## Examples of the economics of autoguidance and boom/section control...



- Sprayer -- returns to guidance system and section controller
- Planter -- returns to individual row controllers
- Vary acres "covered" per year
- Vary cost of input (i.e., herbicide and seed)
- Field size/shape held constant

### Field headland



Areas A and Q and turnaround counterparts will have a) doubling-up of inputs and b) possible yield losses due to this doubling-up. After the turnaround there will be overlap along b, also accounted for.

Microsoft Excel - Guidance & Section Control Economics - KSU & Precision Agriculture Institute(10.14.09) - KARA(Jan2010).xls

Modified version of KSU-GPSguidance.xls -- coming soon...

Economic Analysis of Guidance Systems and Section Controls									
<b>Section A: Whole-farm information -- INPUTS</b>									
Size of typical field	acres	75							
Maximum width of field, perpendicular to direction of swaths (passes)	feet	2,571							
Running distance of headlands to cover for field	feet	9,000							
Average angle of approach to headland in degrees (0-90)	degrees	40.00							
Interest rate for investment analysis, percent	interest	8.00%							
Number of years for amortization	years	4							
Annual non-ownership costs for current technology (e.g., subscriptions, fees, support)	\$/farm	10							
Annual non-ownership costs expected for new technology (e.g., subscriptions, fees, support)	\$/farm	\$2,500							
Percent of category to include in net benefits total									
Machine costs		1							
Input costs		1							
Yield revenue		1							
Non-ownership costs		0							
Include in whole-farm analysis (1=Yes, 0=No)									
	units	Sprayer	Planter	Fertilizer	Other	Other	Farm	Total Buy	
		1	1	1					
<b>Section B: Equipment-specific information -- INPUTS</b>									
Number of swaths (passes) needed to cover headlands	count	1	2	2				1	
Width of machine	feet	90	40	40				68	
Turnaround speed is this portion of field speed	percent	75%	75%	75%				75%	
Area in headlands	acres	18.53	14.55	14.55	0.00	0.00		15.85	
Number of machine or boom sections to be controlled	count	5	16	4				6.6	
Reaction distance (overlap) on manual shutoff of boom	feet	15	10	10				13	
Custom rate of machine operation, \$/ application acre		\$5.00	\$14.00	\$0.00				\$7.33	
Cost of input (fertilizer, herbicide, etc.), \$/application acre		\$12.00	\$60.00	\$35.00				\$28.39	
Last yield revenue for doubling up, \$/doubled-up acre		\$0.00	\$35.00	\$0.00				\$5.83	
Current overlap to consider	percent	7.00%	0.00%	7.00%				5.83%	
Expected overlap to consider	percent	1.75%	0.00%	1.75%				1.46%	
Total acres of use annually	acres	10,000	3,000	5,000				18,000	
Expected autoguidance investment									
autoguidance	dollars	\$15,000	\$7,500	\$7,500				\$30,000	
boom section/control	dollars	\$10,000	\$10,000	\$10,000				\$30,000	
autoguidance, \$/acre		\$1.50	\$2.50	\$1.50	n/a	n/a		\$1.07	
boom/section control, \$/acre		\$1.00	\$3.00	\$2.00	n/a	n/a		\$2.11	

Average angle is similar to what it would be if field were a circle.

Modified version of KSU-GPSguidance.xls -- coming soon...

Economic Analysis of Guidance Systems and Section Controls

**Section A: Whole-farm information -- INPUTS**

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Annual non-ownership costs for current technology (e.g., subscriptions, fees, support)	\$/farm	\$0
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Percent of category to include in net benefits total

Machine costs	1
Input costs	1
Yield revenue	1
Non-ownership costs	0

Include in whole-farm analysis (1=Yes, 0=No)

units	Sprayer	Planter	Fertilizer	Other	Other	Farm Total Avg
	1	1	1			

**Section B: Equipment-specific information -- INPUTS**

Number of swaths (passes) needed to cover headlands	count	1	2	2		1
Width of machine	feet	90	40	40		68
Turnaround speed is this portion of field speed	percent	75%	75%	75%		75%
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boom section/control	dollars	\$10,000	\$10,000	\$10,000		\$30,000
autoguidance, \$/acre	\$1.50	\$2.50	\$1.50	n/a	n/a	\$1.67
boom/insection control, \$/acre	\$1.00	\$6.00	\$2.00	n/a	n/a	\$2.11

Non-ownership costs -- might these be negative?

Modified version of KSU-GPSguidance.xls -- coming soon...

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Yield revenue	1
Non-ownership costs	0

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units	Sprayer	Planter	Fertilizer	Other	Other	Farm Total Avg
	1	1	1			

**Section B: Equipment-specific information -- INPUTS**

Number of swaths (passes) needed to cover headlands	count	1	2	2		1
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Toggle lets user include any or all impacts...

Modified version of KSU-GPSguidance.xls -- coming soon...

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Can include multiple machines to get results for whole farm.

Modified version of KSU-GPSguidance.xls -- coming soon...

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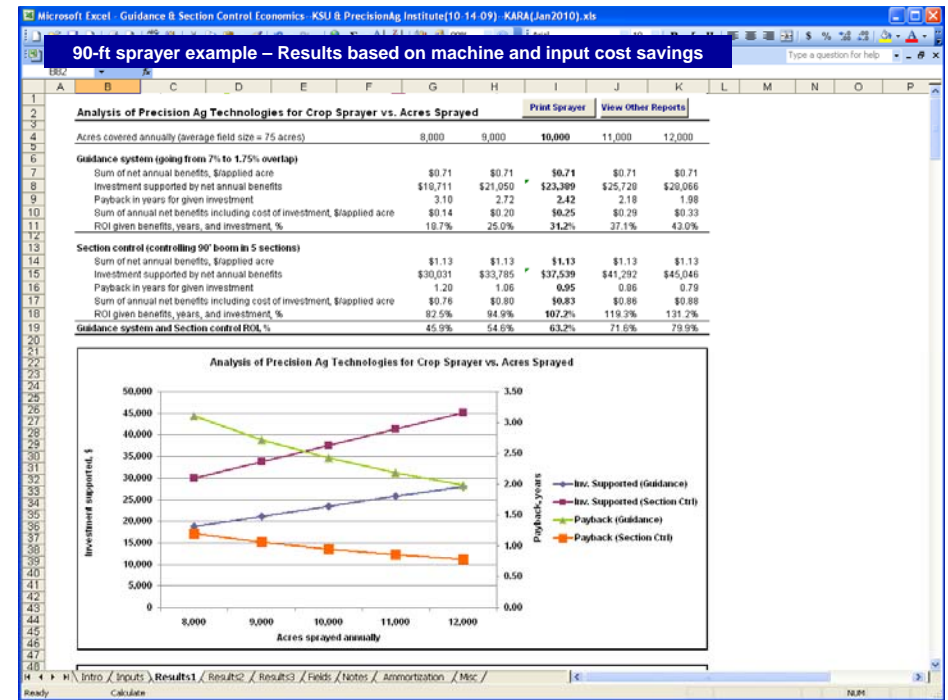
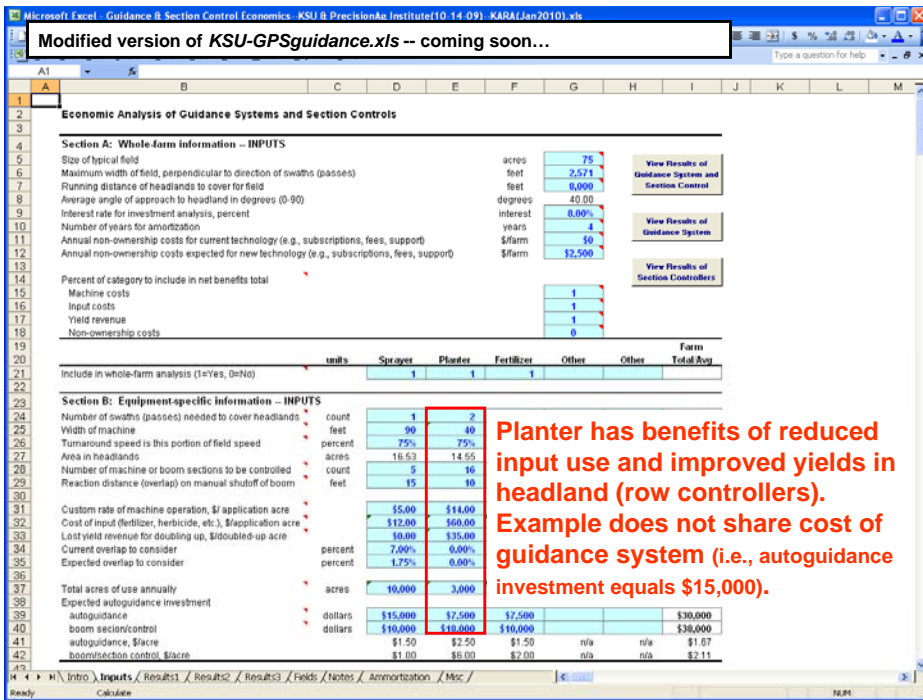
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Expected autoguidance investment	dollars	\$15,000	\$7,500	\$7,500		\$30,000
boom section/control	dollars	\$10,000	\$10,000	\$10,000		\$30,000
autoguidance, \$/acre	\$1.50	\$2.50	\$1.50	n/a	n/a	\$1.67
boom/insection control, \$/acre	\$1.00	\$6.00	\$2.00	n/a	n/a	\$2.11

Sprayer has benefits of both reduced overlap (i.e., guidance) and reduced input use (section controllers), no yield effect.



**KARA** 90-ft sprayer example – results based on machine and input cost savings

**KARA** 90-ft sprayer example – results based on machine and input cost savings

Annual acres	Investment supported <sup>2</sup>	Return on investment <sup>2,3</sup>	Payback years <sup>3</sup>
14,000	\$32,744	54.3%	1.7
12,000	\$28,066	43.0%	2.0
10,000	\$23,389	31.2%	2.4
8,000	\$18,711	18.7%	3.1
6,000	\$14,033	5.1%	4.3
4,000	\$9,355	-10.4%	7.2
2,000	\$4,678	-30.2%	24.6

Annual acres	Investment supported <sup>2</sup>	Return on investment <sup>2,3</sup>	Payback years <sup>3</sup>
14,000	\$52,554	154.9%	0.7
12,000	\$45,046	131.2%	0.8
10,000	\$37,539	107.2%	1.0
8,000	\$30,031	82.5%	1.2
6,000	\$22,523	56.7%	1.6
4,000	\$15,015	28.9%	2.5
2,000	\$7,508	-3.8%	5.7

Annual acres	Average cost of input, \$/application acre	ROI
14,000	\$4.00	11.4%
12,000	\$8.00	4.5%
10,000	\$12.00	-2.9%
8,000	\$16.00	-10.9%
6,000	\$20.00	-19.9%
4,000	\$24.00	-30.5%
2,000	\$28.00	-44.6%

Annual acres	Average cost of input, \$/application acre	ROI
14,000	\$4.00	38.5%
12,000	\$8.00	28.9%
10,000	\$12.00	18.8%
8,000	\$16.00	8.0%
6,000	\$20.00	-3.8%
4,000	\$24.00	-17.5%
2,000	\$28.00	-35.1%

<sup>1</sup> Machine and input cost savings reducing overlap from 7.0% to 1.75%  
<sup>2</sup> Based on four-year amortization  
<sup>3</sup> Given \$15,000 investment

<sup>1</sup> Automatic control of 5 boom sections, input cost savings (guidance exists)  
<sup>2</sup> Based on four-year amortization  
<sup>3</sup> Given \$10,000 investment

<sup>1</sup> Machine and input cost savings reducing overlap from 7.0% to 1.75%  
 Based on four-year amortization  
 Given \$15,000 investment

<sup>1</sup> Automatic control of 5 boom sections, input cost savings (guidance exists)  
 Based on four-year amortization  
 Given \$10,000 investment

As with most all technologies, the returns to investing in guidance systems and section controls is not scale neutral...

Given the assumptions for this example, the returns to investing in section controls are much higher than guidance systems (but you need the guidance system to realize these benefits)

... but, as input costs increase, these technologies will pay for smaller operations as well (additionally, investment required likely will fall over time).



## 90-ft sprayer example – results based on machine and input cost savings

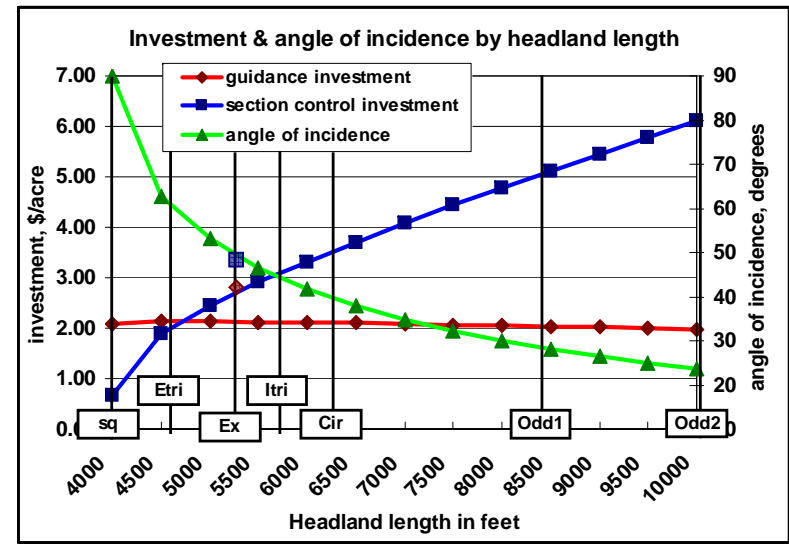
... but, as input costs increase, these technologies will pay for smaller operations as well (plus investment required likely will fall over time).

Annual acres	Guidance System and Section Control ROI <sup>1</sup>				
	Average cost of input, \$/application acre				
	\$4.00	\$8.00	\$12.00	\$16.00	\$20.00
14,000	22.8%	61.2%	96.0%	129.3%	161.8%
12,000	14.8%	49.1%	79.9%	109.0%	137.3%
10,000	6.3%	36.6%	63.2%	88.2%	112.3%
8,000	-2.9%	23.3%	45.9%	66.8%	86.7%
6,000	-13.0%	8.9%	27.4%	44.2%	60.1%
4,000	-24.9%	-7.4%	6.9%	19.6%	31.4%
2,000	-40.5%	-28.1%	-18.3%	-9.8%	-2.2%

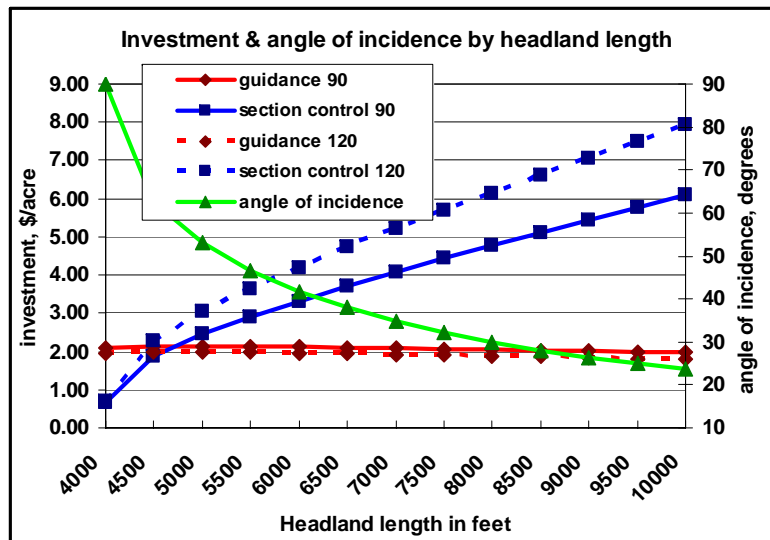
<sup>1</sup> Machine and input cost savings reducing overlap from 7.0% to 1.75%  
Automatic control of 5 boom sections, input cost savings  
Based on four-year ammortization  
Given \$25,000 investment



## As a reminder, results depend heavily on field shape . . .



## As a reminder, results depend heavily on field shape and equipment size.



Comparing a 120-foot sprayer with the 90-foot one



## 16-row planter example – results based on input savings and yield improvement

Impact of Acres Covered on Economics of Section Control <sup>1</sup>			
Annual acres	Investment supported <sup>2</sup>	Return on investment <sup>2,3</sup>	Payback years <sup>3</sup>
4,000	\$65,387	103.2%	1.0
3,500	\$57,213	88.3%	1.1
3,000	\$49,040	73.1%	1.3
2,500	\$40,867	57.4%	1.6
2,000	\$32,693	40.9%	2.1
1,500	\$24,520	23.4%	2.8
1,000	\$16,347	3.8%	4.5

<sup>1</sup> Automatic control of individual rows, input cost savings and yield benefit  
<sup>2</sup> Based on four-year ammortization  
<sup>3</sup> Given \$18,000 investment – guidance already exists

Impact of Acres Covered on Economics of Section Control <sup>1</sup>			
Annual acres	Investment supported <sup>2</sup>	Return on investment <sup>2,3</sup>	Payback years <sup>3</sup>
4,000	\$65,387	47.0%	1.9
3,500	\$57,213	37.8%	2.2
3,000	\$49,040	28.3%	2.6
2,500	\$40,867	18.3%	3.1
2,000	\$32,693	7.6%	4.0
1,500	\$24,520	-4.2%	5.7
1,000	\$16,347	-17.8%	-17.8

<sup>1</sup> Automatic control of individual rows, input cost savings and yield benefit  
<sup>2</sup> Based on four-year ammortization  
<sup>3</sup> Given \$33,000 investment – guidance investment included

Investing in individual row controllers is pretty much a “no brainer” for operations with sufficient acres, especially if auto-guidance system already exists...



## 16-row planter example – results based on input savings and yield improvement

Impact of Acres Covered and Input Cost on Section Control ROI <sup>1</sup>					
Annual acres	Average cost of input, \$/application acre				
	\$30.00	\$45.00	\$60.00	\$75.00	\$90.00
4,000	64.9%	84.4%	103.2%	121.7%	140.0%
3,500	54.0%	71.5%	88.3%	104.8%	121.0%
3,000	42.7%	58.2%	73.1%	87.5%	101.7%
2,500	31.0%	44.5%	57.4%	69.8%	82.0%
2,000	18.5%	30.0%	40.9%	51.4%	61.6%
1,500	4.9%	14.4%	23.4%	31.9%	40.0%
1,000	-10.6%	-3.1%	3.8%	10.3%	16.5%

<sup>1</sup>No machine and input cost savings associated with overlap reduction  
Automatic control of individual rows, input cost savings and yield benefit  
Based on four-year amortization  
Given \$18,000 investment -- guidance already exists

Guidance System and Section Control ROI <sup>1</sup>					
Annual acres	Average cost of input, \$/application acre				
	\$30.00	\$45.00	\$60.00	\$75.00	\$90.00
4,000	23.1%	35.4%	47.0%	58.2%	69.1%
3,500	16.1%	27.3%	37.8%	48.0%	57.8%
3,000	8.8%	18.8%	28.3%	37.4%	46.1%
2,500	0.0%	9.9%	18.3%	26.3%	33.9%
2,000	-7.6%	0.0%	7.6%	14.4%	21.0%
1,500	-17.0%	-10.3%	-4.2%	1.5%	7.0%
1,000	-28.1%	-22.7%	-17.8%	-13.2%	-8.9%

<sup>1</sup>No machine and input cost savings associated with overlap reduction  
Automatic control of individual rows, input cost savings and yield benefit  
Based on four-year amortization  
Given \$33,000 investment -- guidance investment included

... and as input costs increase, these technologies will pay for smaller operations as well (additionally, investment required likely will fall over time).

## Still needed machinery technologies: improved real time communication

- between multiple machines operating in same field
  - Would reduce overlap in headland passes
  - Would allow overlap-reducing boom/section shutoffs
- between grain cart tractors and combines
- between tendering vehicles and field machines
- between tech support people and machine operators
- between office and field
- needs to be pictorial (maps) and data

## Impediments to adoption of cool machinery stuff

- Could use better dealer support of electronics
  - Few dealers provide dedicated individuals
  - Enhanced websites/communication mechanisms are needed between dealers and farmers
  - Improved training and support is needed
  - More direct links between engineers and farmers
- Younger generation, more savvy to electronics will help adoption (more accepting of “change”)
- Farm size too small
- Operator too close to retirement
- Few “bolt right on” solutions for complicated tasks

## Impediments to adoption of machine control



Standard two product VRA setup (Bluetooth?)

## Still needed agronomic technologies: VRA

- No universal “black box” solutions
- Need better algorithms for:
  - Fertilizer rates
  - Seeding rates
  - Herbicide rates
- Still no “cheap” way of getting spatial soil fertility information
  - Intense manual grid sampling
  - Direct automatic soil sampling (like AgroBotics AutoProbe)
  - indirect sampling technologies (like electrical conductivity)
  - Remote sensing approaches
    - airborne, satellite, in-field solutions
- Still need individuals who can compile, process, prepare and make operational the data needed for VRA – *Don't forget validation!*

## Where is precision ag heading?

- Most machinery enhancements likely will be adopted quickly unless
  - Better tech support at machinery dealers does not emerge
    - (we believe it will emerge)
  - Farm owners have trouble finding qualified, often younger at this point, folks who can handle electronics & computers
    - (we believe this will happen as farms get bigger)
- VRA will continue to be adopted slowly unless
  - We find less expensive ways of gathering spatial soil data
    - (improvements here are very slow in coming)
  - Or, we find ways of moving beyond soil-test-based fertilizer rate recommendations
    - (improvements here are emerging)
- Farms will do ever more scientific research in-house

**Questions ???**



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