Winter Operations: Technology Today, Tomorrow, and in 5 Years

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Outline

- Why worry about technological advances?
- Are those advances real?
- If they are real, how much attention do they deserve?
- What sort of technological change will we see?
- How do we decide which technology will enable our winter maintenance activities to excel going forward?
- How do we decide which technologies sound wonderful, but will not in fact help us that much?
- What new problems can we expect from the new technologies that we embrace?


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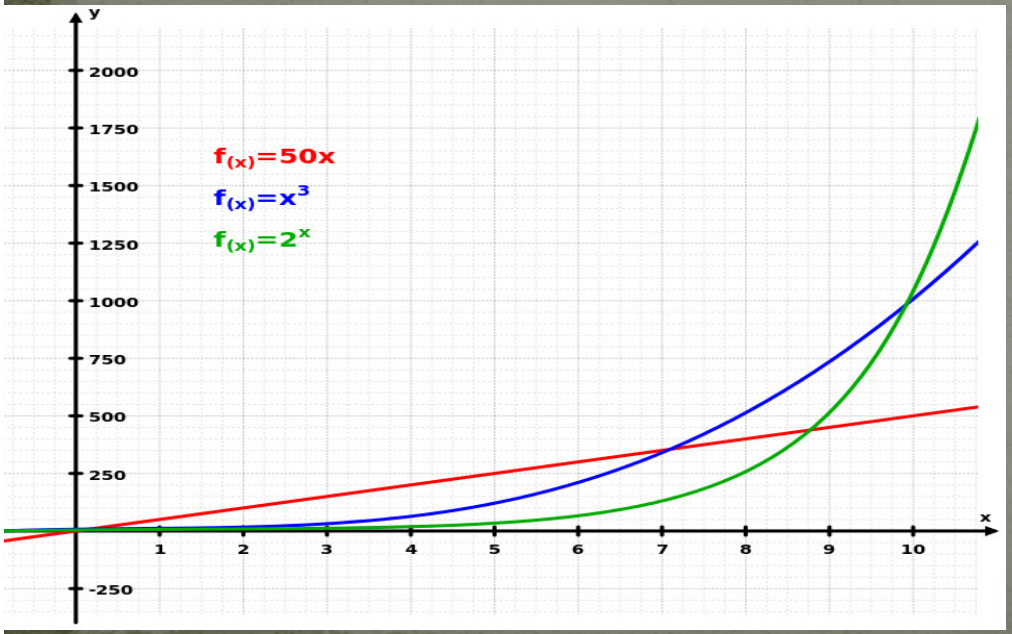
Exponential not Linear



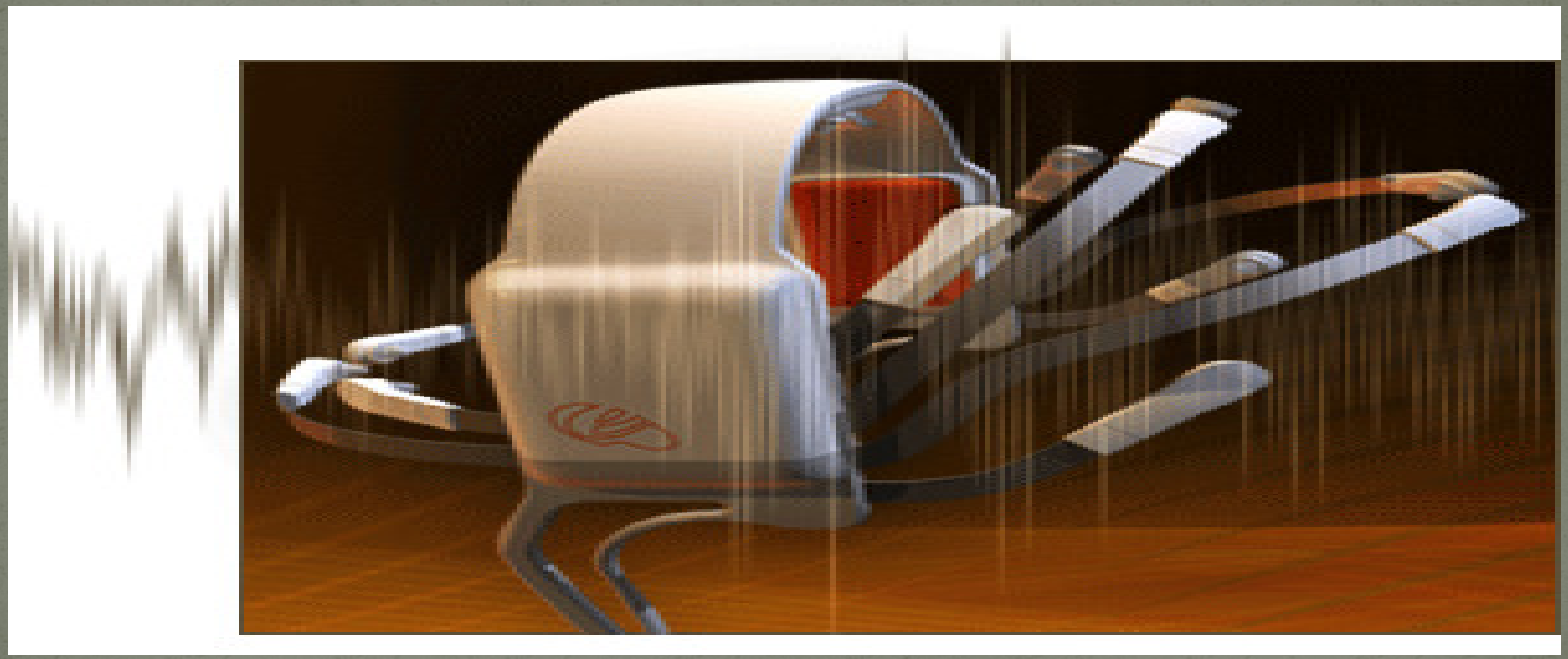
- Appears slow at first
- Then rapid “take off”
- The speed of the take off is unexpected
- Because we think linearly…

So What Has Changed?

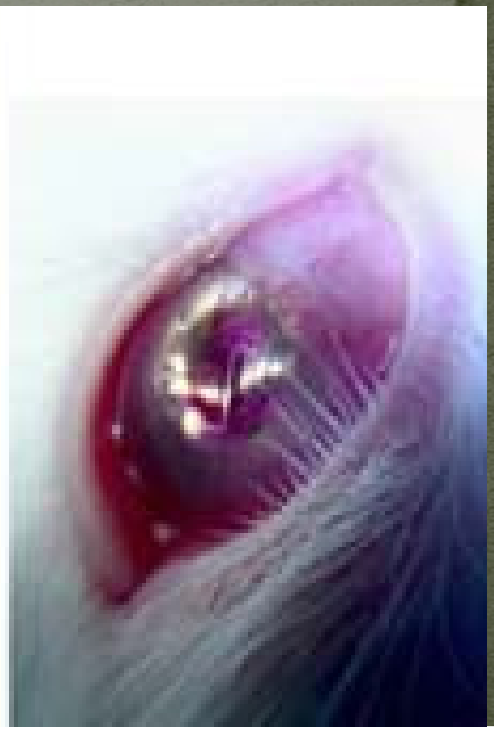
- Great Expectations!
- Also new technology
- Much more information out there about weather on the highways
- Improved vehicle performance (both real and perceived)
- Are we there yet?!


Wind
Voyager 1 & 2
RHESSI
Geotail
Jason-1
Aqua
QuikSCAT
SOHO
TIMED
ERBS
TRACE
ACE
Cluster
ACRIMSAT
IMAGE
Landsat 7
NMP/EO-1
Ulysses
TOREX/Poseidon
Polar
TRMM
FAST
SAGE III/METEOR-3M
SORCE
UARS
GRACE
SeaWiFS
EP-TOMS
Terra
ICESat
Aura

Direct Mind Control of Computers



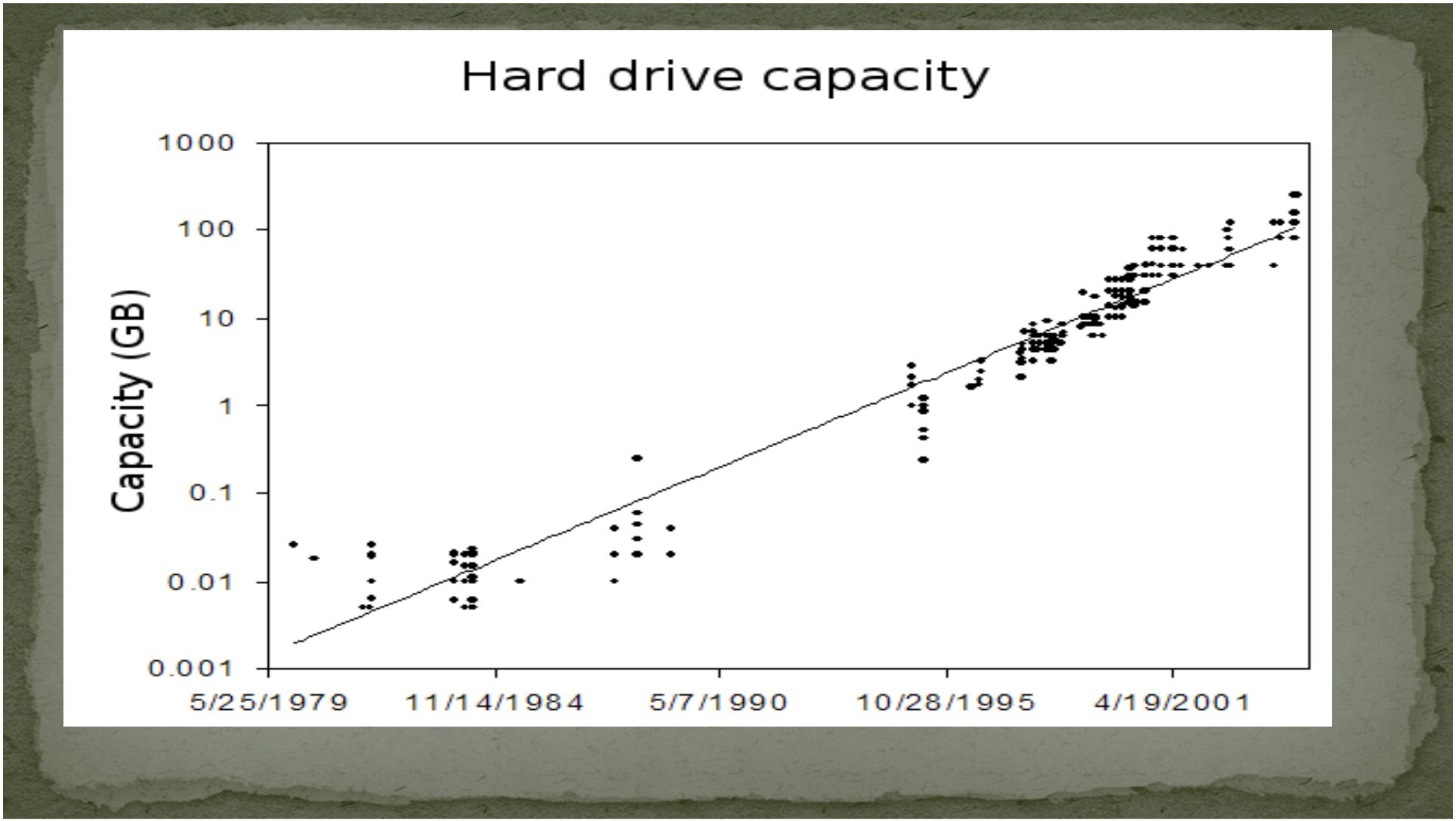
Neat New Technology!



The complexity for minimum component costs has increased at a rate of roughly a factor of two per year ... Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years. That means by 1975, the number of components per integrated circuit for minimum cost will be 65,000. I believe that such a large circuit can be built on a single wafer.

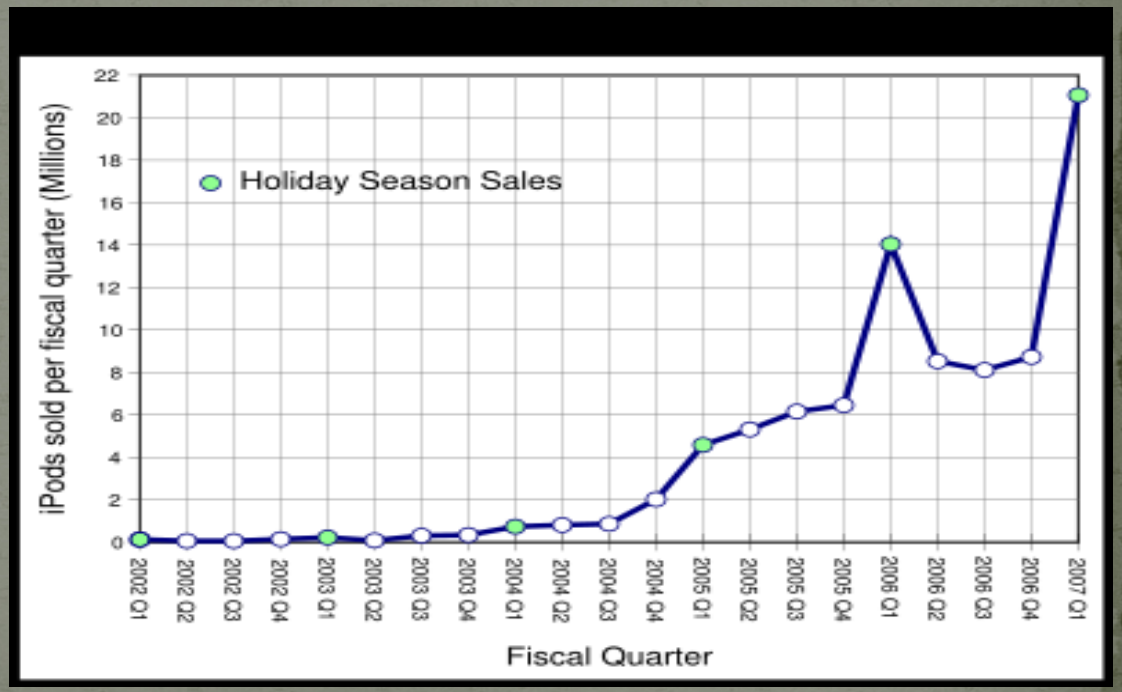
Moore's Law

- If chip density is a measure of complexity then complexity is doubling at an increasing rate
- Originally once every two years, now taken as once every 18 months
- Is there a limit?
- Does it apply to other technologies?


Hard drive capacity
Capacity (GB)
1000
100
10
1
0.1
0.01
0.001
5/25/1979
11/14/1984
5/7/1990
10/28/1995
4/19/2001

Not Just the Base Components

- Exponential Growth in iPods
- October 2001 – first iPod on sale – 5 GB



Moore's Law and Other Stuff...

Suppose a data-transmission solution costs you $1,000 per block of data moved today

- In 18 months, it will cost $300
- In 36 months it will cost $100
- In 54 months it will cost $30
- In 72 months (6 years) it will cost $10
- Is it affordable then?

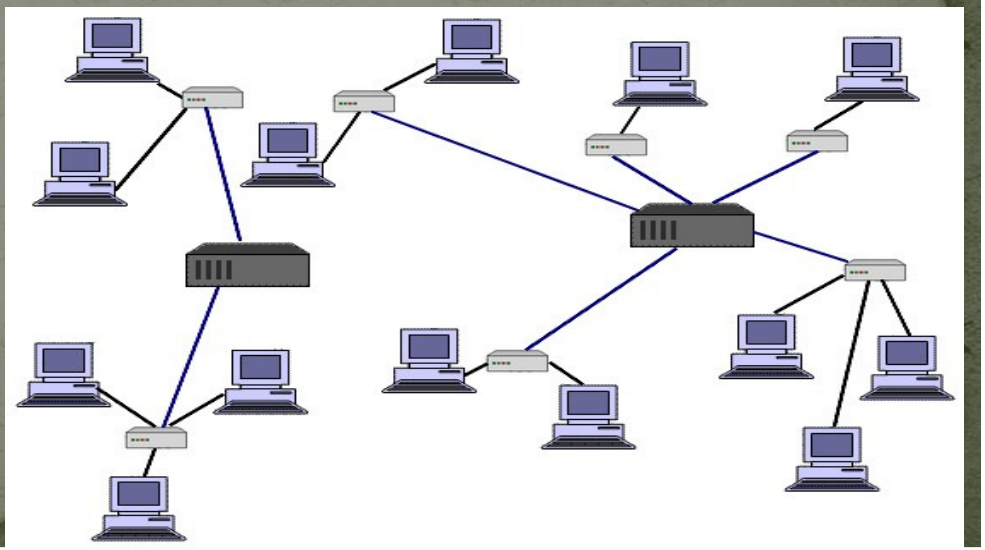
Meaning?

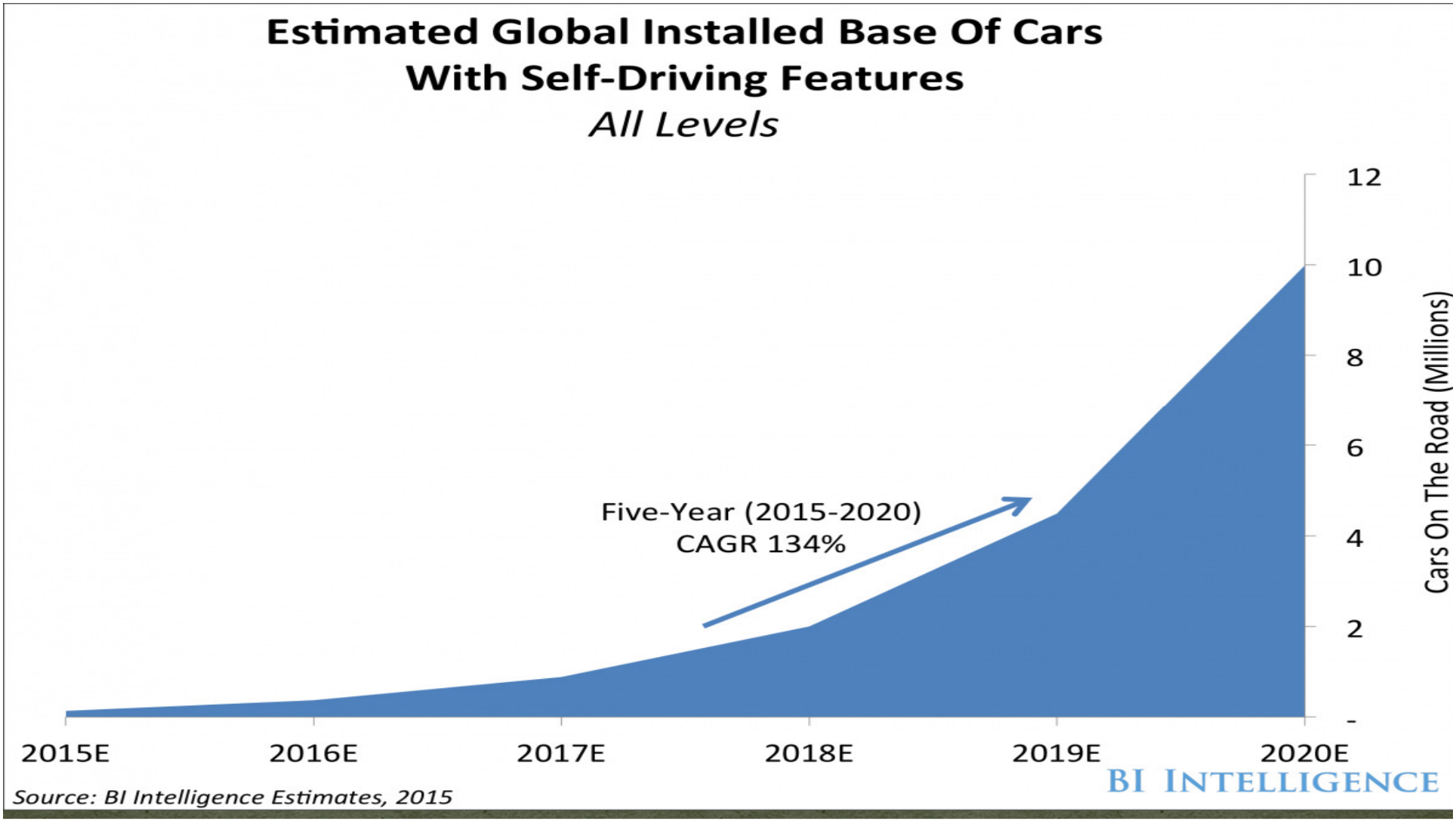
- Not easy to say, but things will definitely be changing!
- Interesting Bill Gates quote:

We typically overestimate the change that will occur in the next two years And underestimate the change that will occur in the next ten years…

So, What Changes in the Next 5 Years?

- Hmmm!
- Most likely in the area of information gathering (sensors, networks) and information management (big data etc.)




Estimated Global Installed Base Of Cars
With Self-Driving Features
All Levels
12
10
8
6
4
2
-
Cars On The Road (Millions)
Five-Year (2015-2020)
CAGR 134%
2015E
2016E
2017E
2018E
2019E
2020E
Source: BI Intelligence Estimates, 2015
BI INTELLIGENCE


Audi
Baidu 百度
BOSCH
DAIMLER
DELPHI
Ford
GM
SAIC
上汽集团
SAIC MOTOR
Google
HONDA
HYUNDAI
JAGUAR
LAND ROVER
Mercedes-Benz
MOBILEYE
NISSAN
RENAULT
SCANIA
TATA ELXSI
engineering creativity
TESLA
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YUTONG
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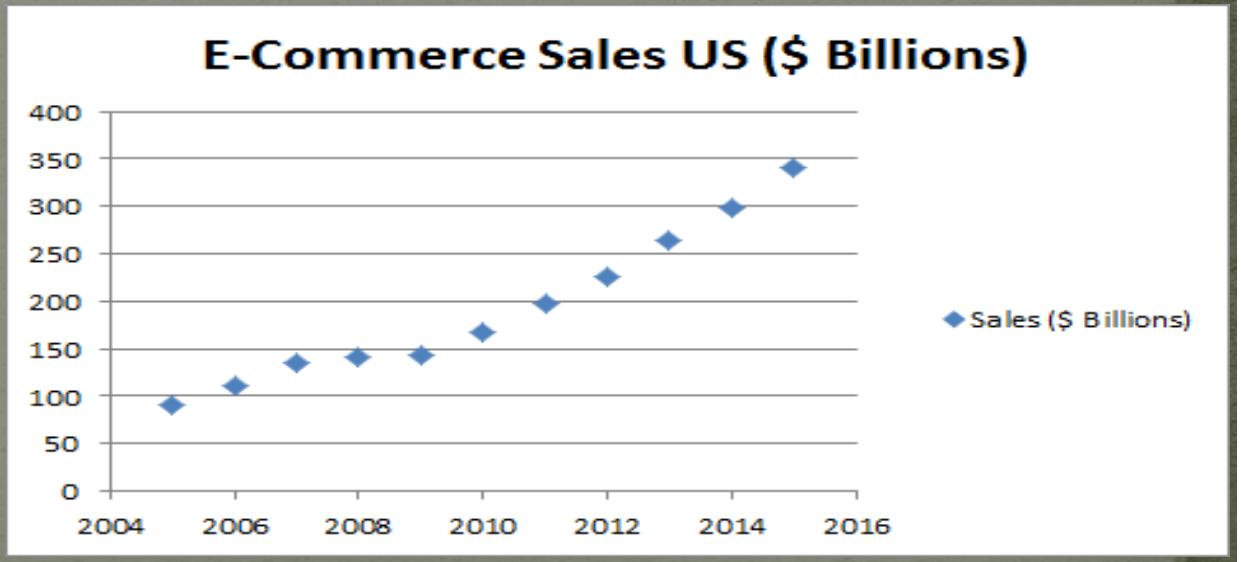
Impact of Autonomous Vehicles

- Expect to be surprised!
- Weather is going to be a major concern
- Most likely we will see this first in freight and commercial applications
  - Why? Because that is where money can be saved most quickly…
- So, where else will we be seeing folks trying to save money in ways that impact transportation?

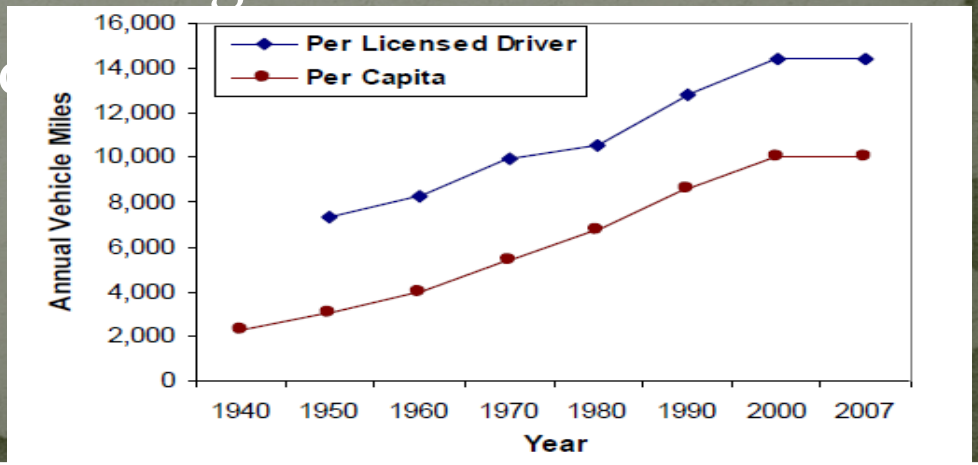
Commerce Patterns for Individuals

- It used to be if we wanted to buy something, we went to the store
- Now? Amazon!



Car Ownership and Usage

- Car sharing companies like Zipcar
- Ride sharing like Uber
- Growth in tele-commuting?
- Alternative modes of commuting?
- In US we MAY see a redu



So What Does it Mean?

- On the one hand, there might be less traffic on the road, but…
- The road user expectations are most likely to continue rising
- Budgets? Well, would you bet on them increasing?
- So, how will technology impact winter maintenance up through the year 2021?

The Major Impact - Measurements

- New, cheap sensors
- Able to measure all sorts of things
- Means that if we want to, we can know exactly what our trucks are doing…
- How can that help?

Measurements

- They will all be geo-tagged (or they can be if you want them to be)
- So we can know inputs, outputs and outcomes at every point on the network that we have to manage
- Wait, what are these inputs, outputs and outcomes?

Inputs

- What is the condition of the road before you have taken actions
- Base information
  - where the road goes,
  - how many lanes, any passing lanes,
  - what the desired levels of service and the assigned priority for the road are
- Micro-climate type information like:
  - Shading
  - Nearby bodies of water
  - Elevation
- Can all be in your GIS

Outputs

- What have you and the storm done to the road network before, during and after the storm
  - Application rates and plowing cycles
  - Pavement temperatures
  - Other in-storm weather data
  - Accident response activities
- Will be GPS tagged, and will involve a variety of sensors on the truck, as well as infrastructure sensors.

Outcomes

- Did you achieve your level of service?
- Depends how you measure it:
  - Bare pavement
  - Grip level
  - Traffic speeds
- How big a hurdle was it to get there? Storm severity?

End Result

- Measured to a fare-thee-well…
- But, will it make a difference?
- Depends what you do with it…

Making a Difference

- What is the point of all these measurements?
- What do you want the point to be?
- What do your customers want from all this information?

If you get new technology, and you do not change your operations, then the technology was completely wasted

So How Do We Handle This?

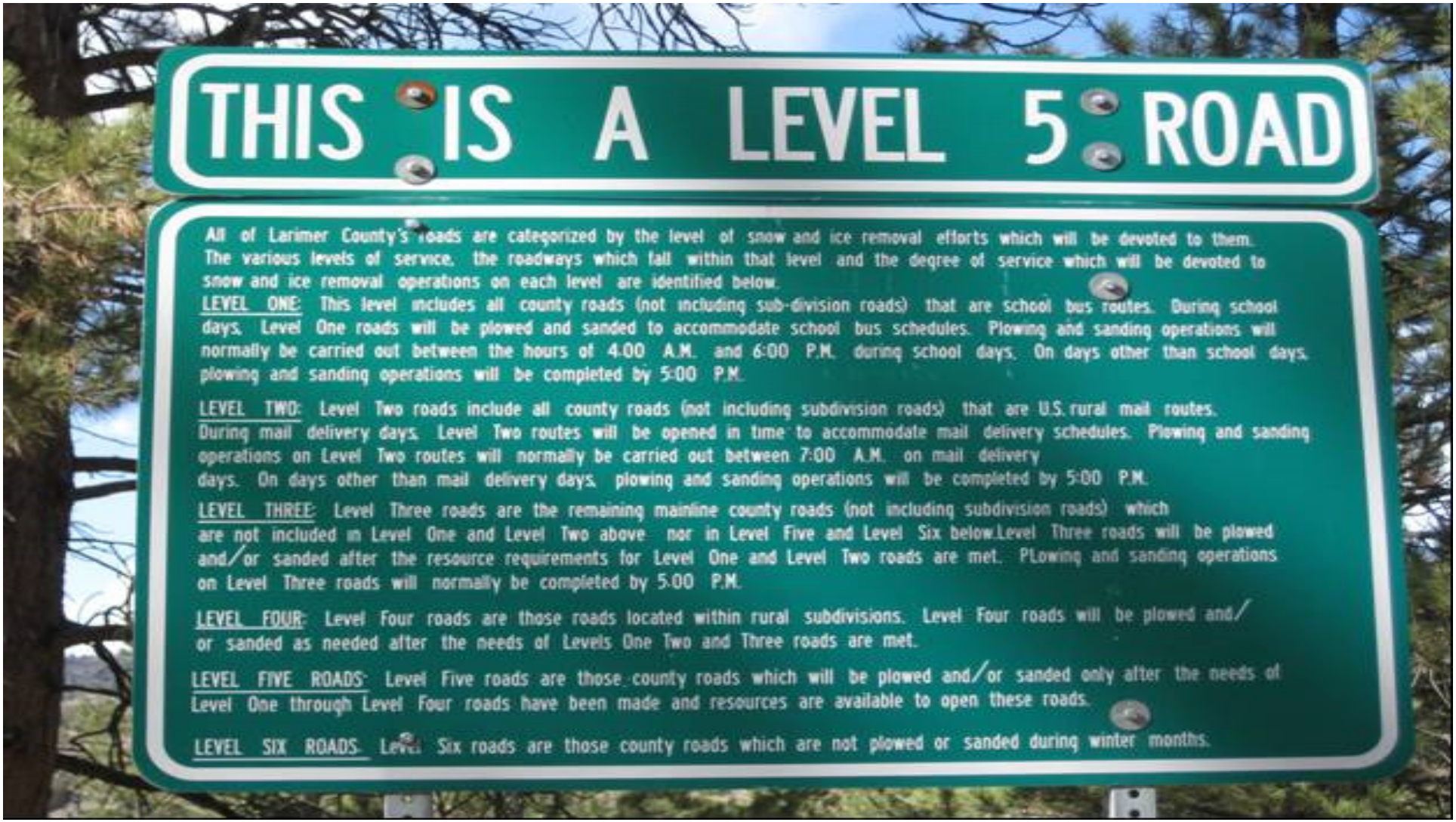
- The issue is NOT what technology can we use?
- BUT, what do we want to do that we cannot unless we get new technology?

So, what do you want to do?

The Level of Service Issue

- This is our roadmap
- Often expressed in terms of a road condition goal
  - Bare pavement
  - Bare wheeltracks
- Within a certain period of time
  - 3 hours after the end of a storm
- But there are a couple of things missing in this

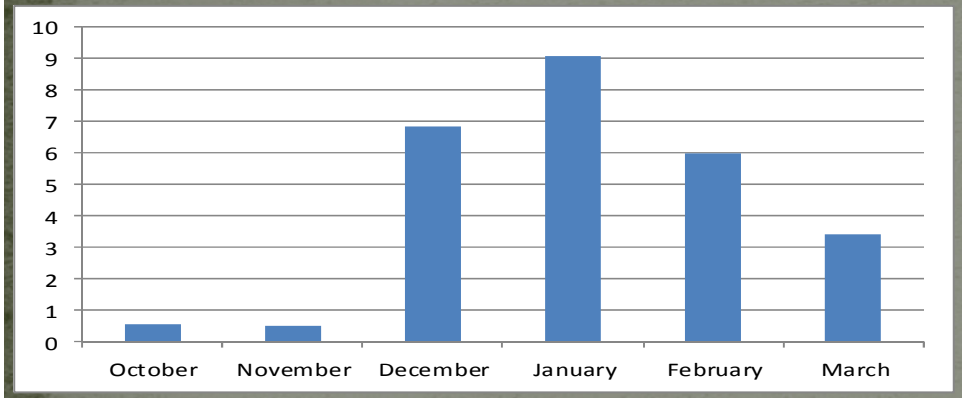
How Clean is Clean Enough?

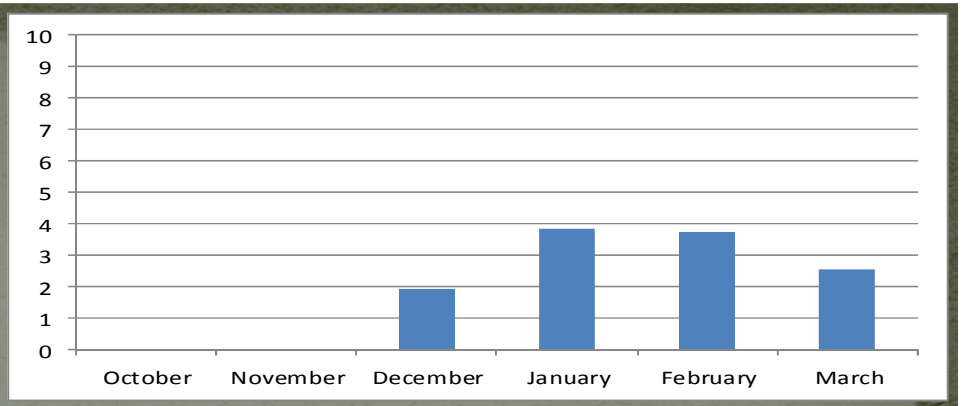

THIS IS A LEVEL 5 ROAD
All of Larimer County's roads are categorized by the level of snow and ice removal efforts which will be devoted to them. The various levels of service, the roadways which fall within that level and the degree of service which will be devoted to snow and ice removal operations on each level are identified below.
LEVEL ONE: This level includes all county roads (not including sub-division roads) that are school bus routes. During school days, Level One roads will be plowed and sanded to accommodate school bus schedules. Plowing and sanding operations will normally be carried out between the hours of 4:00 A.M. and 6:00 P.M. during school days. On days other than school days, plowing and sanding operations will be completed by 5:00 P.M.
LEVEL TWO: Level Two roads include all county roads (not including subdivision roads) that are U.S. rural mail routes. During mail delivery days, Level Two routes will be opened in time to accommodate mail delivery schedules. Plowing and sanding operations on Level Two routes will normally be carried out between 7:00 A.M. on mail delivery days. On days other than mail delivery days, plowing and sanding operations will be completed by 5:00 P.M.
LEVEL THREE: Level Three roads are the remaining mainline county roads (not including subdivision roads) which are not included in Level One and Level Two above nor in Level Five and Level Six below.Level Three roads will be plowed and/or sanded after the resource requirements for Level One and Level Two roads are met. PLowing and sanding operations on Level Three roads will normally be completed by 5:00 P.M.
LEVEL FOUR: Level Four roads are those roads located within rural subdivisions. Level Four roads will be plowed and/or sanded as needed after the needs of Levels One Two and Three roads are met.
LEVEL FIVE ROADS: Level Five roads are those county roads which will be plowed and/or sanded only after the needs of Level One through Level Four roads have been made and resources are available to open these roads.
LEVEL SIX ROADS: Level Six roads are those county roads which are not plowed or sanded during winter months.

What's Missing – Part 1

- What is the weather like?
- Some storms are easy, some are not!
- All those measurements could give us a clear idea of how bad the storm was
- Generally through some form of storm index
- If we want, we can sum the storm indices over a winter, and get a winter index…

Moline 2013-14
Total Salt Used = 13,420 Tons
Tons/Index Point = 499





Moline 2012-13
Total Salt Used = 11,200 Tons
Tons/Index Point = 848

Some Form of Winter Index

Is that all?

- How about calculating the storm severity on an hour by hour basis, for each mile of your system?
- How about communicating that to the public in near real-time?
- How about communicating your level of service in real-time to the public (like the Iowa Track-a-Plow system)?
- How about communicating the cost of lost mobility to the public on an hour by hour basis?

What Could Go Wrong?!


Trucks a plow

Why Bother?

- Better information for your customers…
- Better knowledge for you
  - Where are we doing a good job?
  - Where are we not doing so well?
  - Perhaps, why are we not doing so well?
  - Do we really know our trouble spots?
  - And if we do, do we take care of them appropriately?
- All allow us to get to our level of service more effectively…

What's Missing Part 2

- How efficiently are we getting to our level of service?
- Are we "applying the right amount of material, in the right place, at the right time, and keeping it there," or do we just think we are?
- Can we identify systemic inefficiencies and remove them?
- Even if we have detailed application rate programs, are we actually following them (an example!)?

Salt Application Rate Guidelines

Prewetted salt @ 12' wide lane (assume 2-hr route)							
Surface Temperature (º Fahrenheit)		***32-30***	***29-27***	***26-24***	***23-21***	***20-18***	***17-15***
lbs of salt to be applied per lane mile	Heavy Frost, Mist, Light Snow	50	75	95	120	140	170
	Drizzle, Medium Snow 1/2" per hour	75	100	120	145	165	200
	Light Rain, Heavy Snow 1" per hour	100	140	182	250	300	350

Prewetted salt @ 12' wide lane (assume 3-hr route)							
Surface Temperature (º Fahrenheit)		***32-30***	***29-27***	***26-24***	***23-21***	***20-18***	***17-15***
lbs of salt to be applied per lane mile	Heavy Frost, Mist, Light Snow	75	115	145	180	210	255
	Drizzle, Medium Snow 1/2" per hour	115	150	180	220	250	300
	Light Rain, Heavy Snow 1" per hour	150	210	275	375	450	525

The Iowa Experience (Part 2)

- They had a great concept
- Adjust application rates to allow for differences in:
  - Pavement temperature
  - Storm type
  - Cycle time
- But they discovered they were not really following them
- Getting serious about using the rates (i.e. tracking who did what, when they did it, and why) got them 20% savings…

Perceived Dangers…

- Isn't having that information dangerous? Won't it open us up to law suits?
- How on earth will we store all that data?
- What if we get bogged down in the technology and the implementation of it?

Dangerous Information…

- It is conceivably possible that tracking all this information will reveal occasions when your agency did not do what should have been done…
  - In that case, if litigation is involved, you settle as quickly as possible.
- It is much more likely that the information will show that the agency acted correctly, or that you could not possibly have put a stone into that car window, or…
- So, yes, there are risks, but the information is much more likely to reduce risk than to increase it, unless…
- You do not think you are doing a good job…?

Storing the Data

- A BIG issue! As you instrument everything, you will start to get not just gigabytes of data, but petabytes (one petabyte is 1,000,000 gigabytes)
- You will need an archiving policy
- For example, how long will you keep photos?
  - Some agencies keep them for 1 year, some for 1 day, some for 1 hour.
  - Which of these you choose is not critical, but having a policy and sticking to it is critical
- Data that does not get used, does not serve a purpose…

The Implementation Issue

- Remember, the goal is not to have the technology, but to achieve your purpose, whatever it may be
- The technology is just a tool that may make it easier to achieve your purpose
- It is not the end goal, it is not the "point of the exercise" it is a force multiplier, nothing more.

Conclusions

- The rate of technological change is only going to increase going forward
- Exact predictions are so tough as to be meaningless, but likely sensor measurements will be growing rapidly
- Technology is not an end in itself – it is a tool and a force multiplier