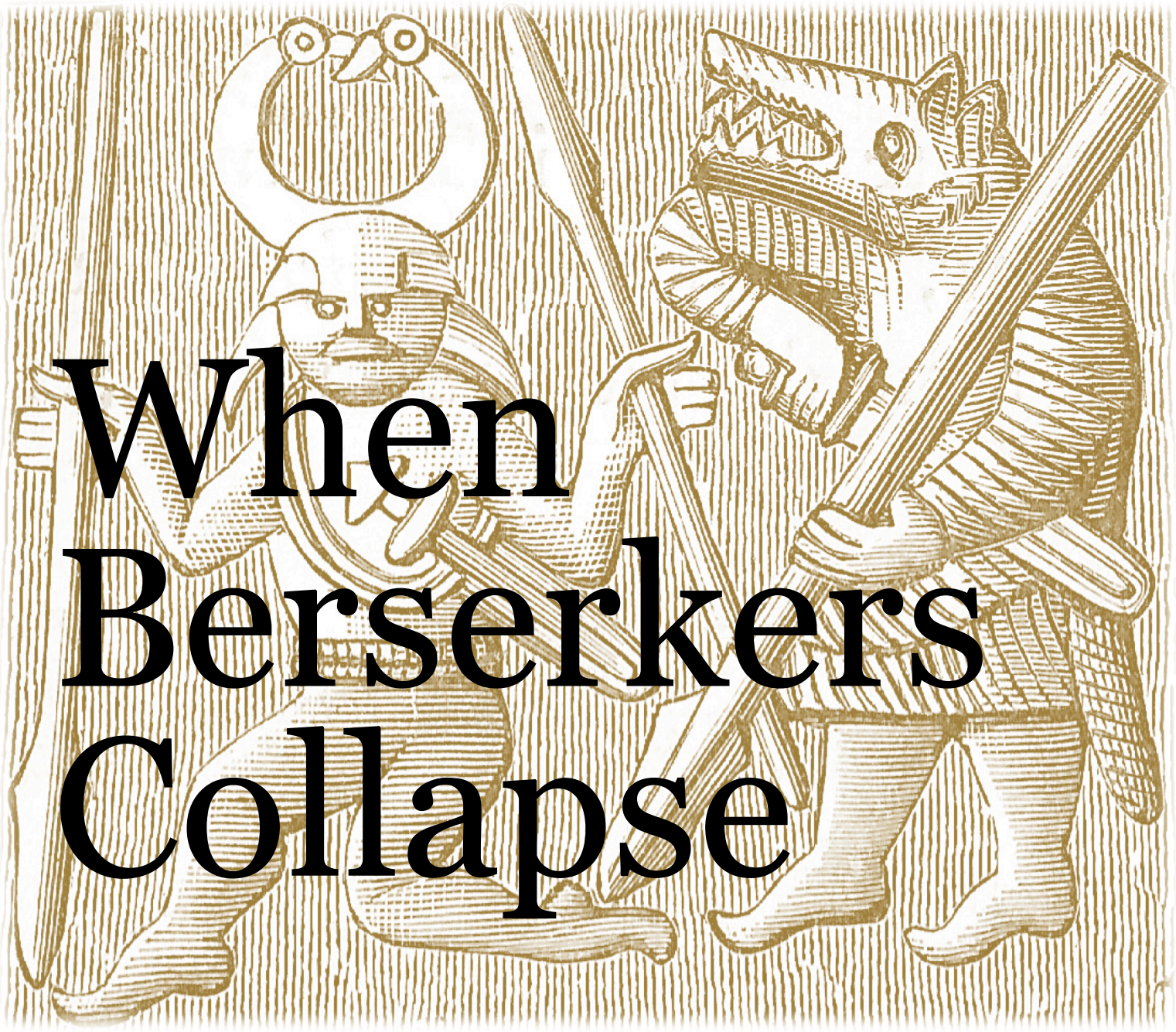


When Berserkers Collapse

When Berserkers Collapse

Presented to the Pacific Northwest Chapter of the Society for Information Display (SID PNW)

24 June 2015 — David Barnes

Forward into the past

- Berserkers were real and really terrifying.
  - Slashed, pierced or burned, they kept fighting… and winning
  - … until they collapsed in exhaustion.

- We might compare berserkers to Asian panel makers.
  - Bleeding money, fixing prices below cost, they kept expanding.
  - Japan; Korea; Taiwan; will China be their last battleground?

- We might learn from the past and prepare to retake the field.
  - The fallacies of technologies
  - The problem with printables
  - The challenge of controllables

In the beginning, US technology led the way… to Japan where it found policy support

- US corporates abandoned or divested FPD assets, generally.
  For a good personal view of the early years, read:
  The Thin Film Transistor—A Late Flowering Bloom by Brody in IEEE Electron Devices Nov '84
- US policy supported PC makers instead of panel makers and belated efforts (USDC, Flamm's report) were too little, too late. Policies seemed flawed on basic principles…
  - Dual-use objectives
  - Capital constraints
  - Magical thoughts: leapfrog, shock & awe…
- Japan's MITI coordinated development of the LCD industry based on Kikkoman-type risk sharing among conglomerates.
  - Gen-1 and Gen-2 AMLCD investments proved unprofitable, so Japanese makers paused, pending productivity improvements.
  - … That's when Korean berserkers rushed onto the field (ca 1994).

US organizations discovered Panel-land and dominated the battlefield…

US display makers did not fail for lack of technology.

I count 72 companies in the market from 1970 to 2010.

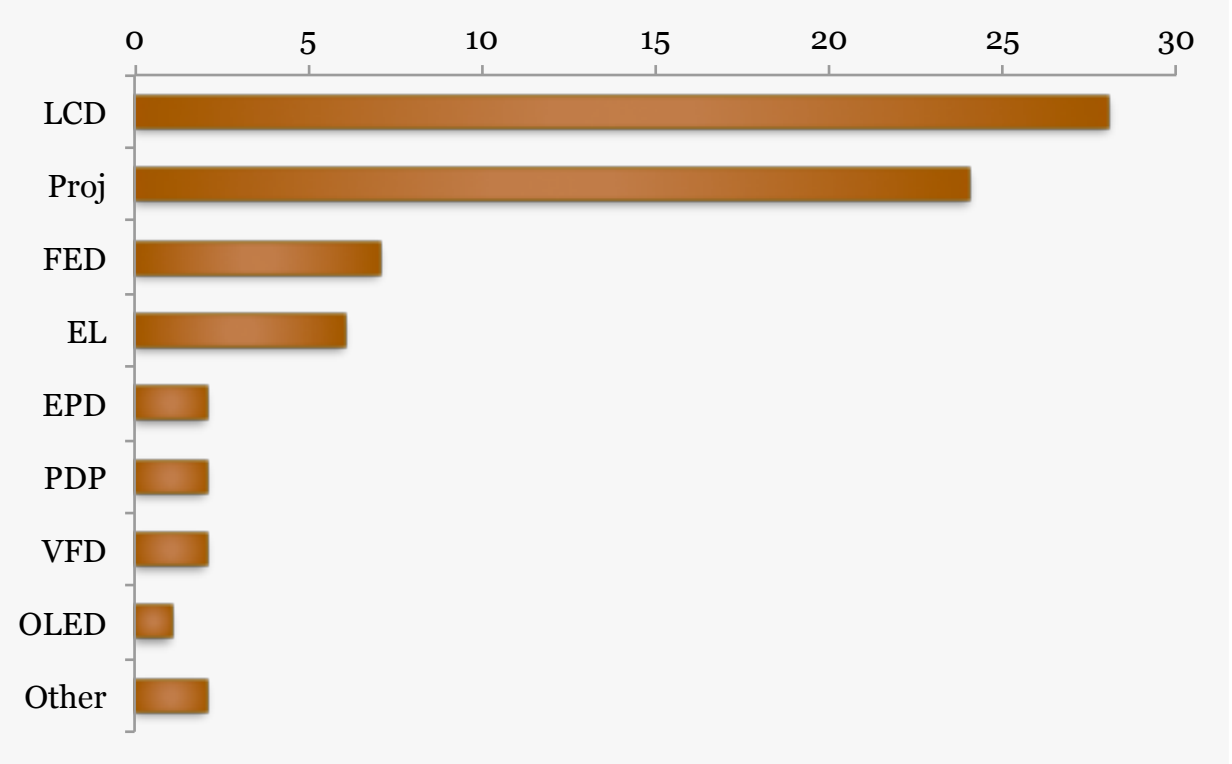
More than 1 in 3 companies concentrated on LCD and nearly as many focused on projection technologies for beamers or HMD systems.

US organizations also pioneered plasma and electrophoretic technologies.

Hix and other entrepreneurs were prolific in the NW of the US!

Raise your hand if you recall PALC…

Number of US Firms by Technology, 1970–2010



Source: Our research and analysis

… then came the berserkers.

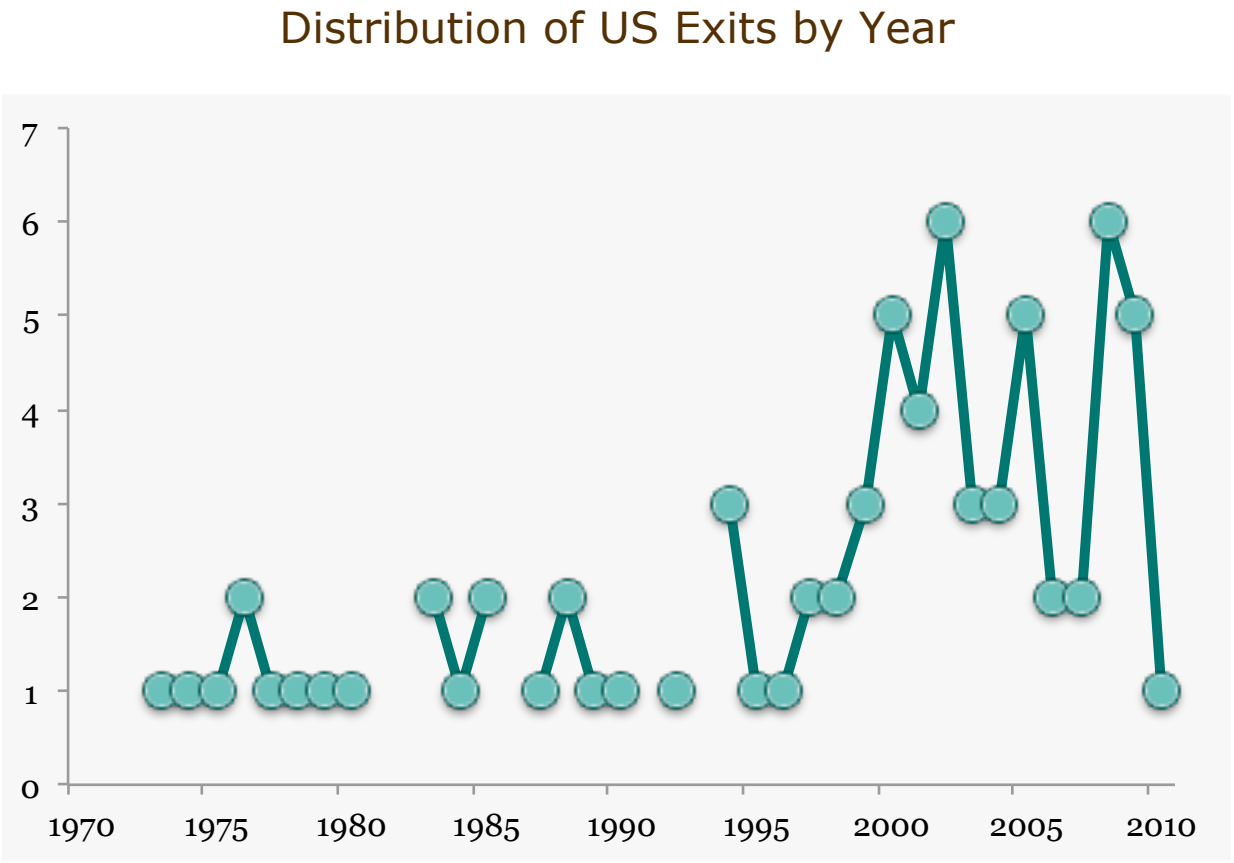
There were many false starts, as one would expect.

We see a surge of exits after the ITC rescinded 731-TA-469 in 1993 in favor of PC makers.

After Korean Gen-2.5 AMLCD fabs came on-line in 1996, we see a greater surge of exits.

There are several other explanations, of course. For example, consumer demand for projection displays rose and fell in various markets.

Nevertheless, I think the data shows the effect of Korea, then Taiwan rushing into the fray.



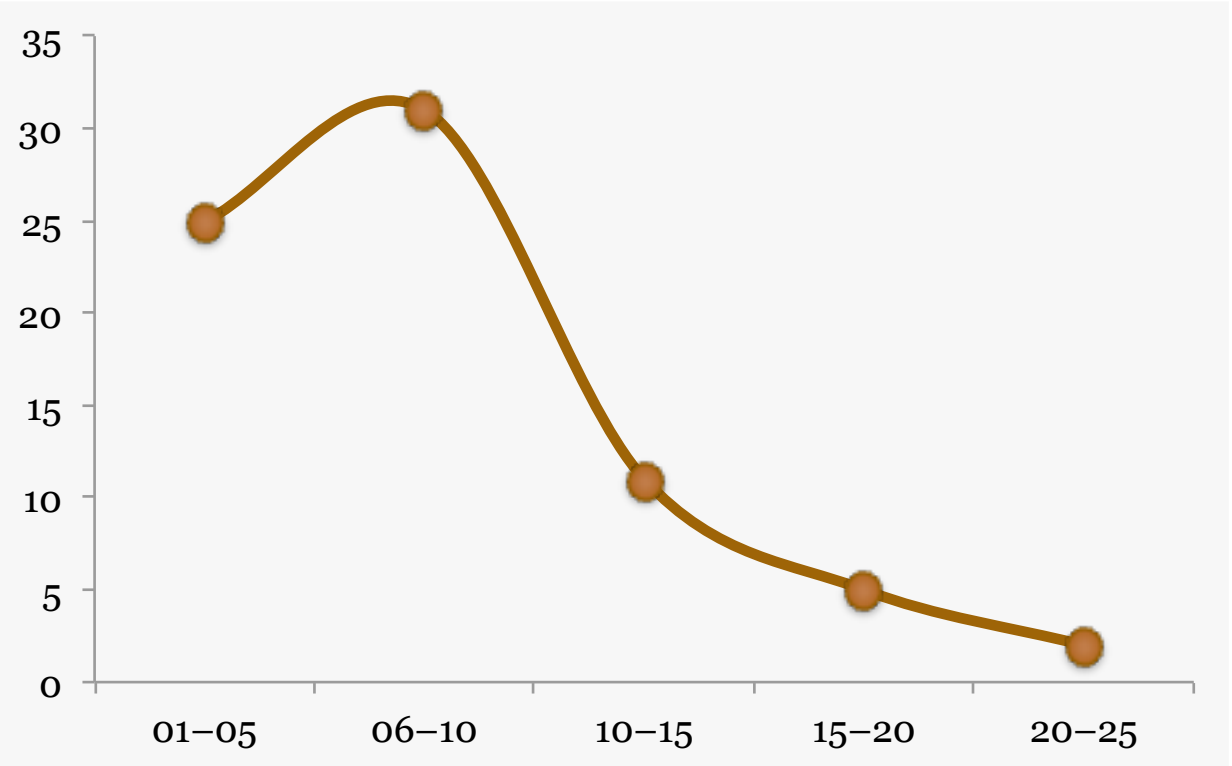
Source: Our research and analysis

Few US fighters live long. Fewer survive.

Looking at the 1970–2010 period in terms of longevity, I note a typical FPD lifetime of 6–10 years but the average was closer to 18 because of outliers such as Planar.

Companies that lasted more than ten years had to be agile and it is tempting to see some of the adaptations as complete restructurings.

In contrast, there were few exits of note in Asia, with the abandonment of DTI by the partners IBM and Toshiba being the most significant.



Source: Our research and analysis

Before the Koreans rushed into Panel-land, it looked as if Japan would remain dominant

Indeed, the coordination in Japan did create a supply chain structure that survives today…

Glass, optical film, chemical and process tool suppliers who supported fabrication enabled industry expansion in Korea, Taiwan and China.

The only real change has been self-sourcing of color filters pioneered in Korea.

Even the shift to open-cell sales is an echo of the initial Kikkoman-type structure.

Japan Inc. was only a decade behind US conglomerates in terms of structural changes…

AMLCD Leaders Twenty Years Ago

AMLCD Maker	1994 Share	Their Fate
Sharp	35%	Decreasing share and restructure
NEC	18%	Divested > SVA > BOE
DTI	13%	Split and part sold to CMO
Hosiden	6%	Sold to Philips > TPO > Innolux
Hitachi	5%	Divested > JDI

Share of Sales from Nikkei Microdevices, 1996

In hindsight, AMLCD berserkers captured almost every square inch of the display market

Active-matrix, flat panel displays comprised 35% of total display sales in 1999.

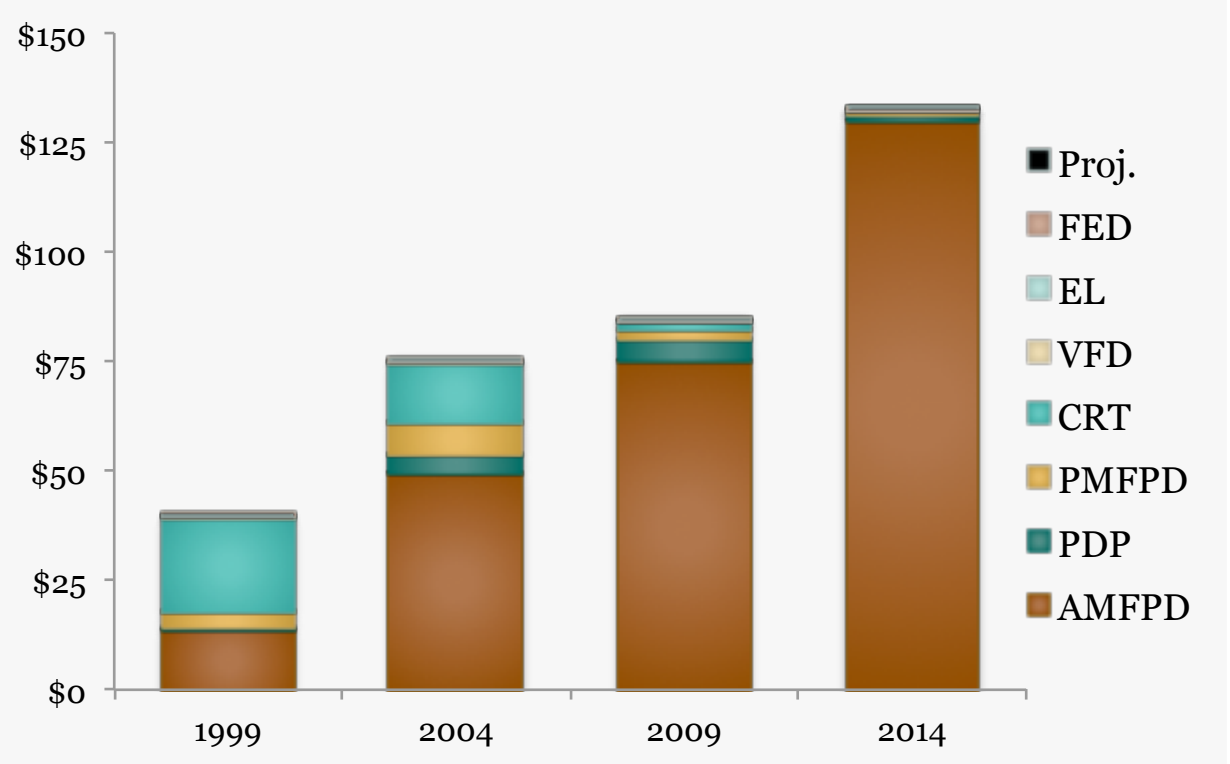
Fifteen years later, that share was a dominant 98%.

Berserkers killed King CRT, Duke PDP, and all the barons contending for the throne.

The areal price of AMLCD declined exponentially near 18% a year until 2009 when macroeconomic conditions forced price decay to slow in the 10% regime.

Most competing technologies were crushed by relentless price pressure.

Global Display Sales by Technology (USD billions)



Source: HIS, our analysis

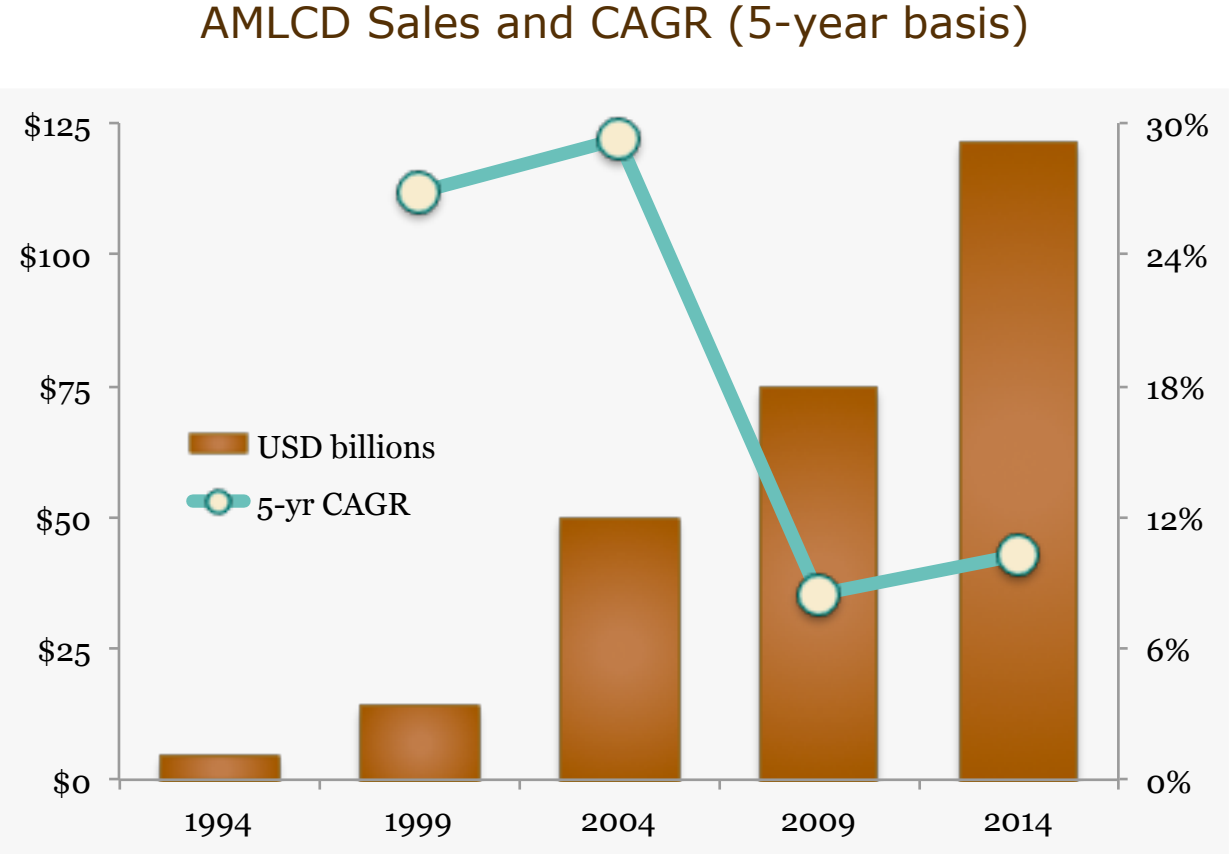
AMLCD sales grew quickly into maturity and a 10% CAGR at scale remains significant

The prospects of fast sales growth in a market left open by EU and US conglomerates excited the berserkers.

In addition to stimulating national industry, facility and labor productivity, AMLCD presented a DRAM-like opportunity for capital leverage (scale economy) in the minds of Asian policy makers, apparently.

Thus, impatient capital did not constrain the berserkers.

In fact, Asian policy makers may have seen large capex as attractive… bigger projects mean more (political) power.



Source: IHS, our analysis

In contrast, impatient capital forced US firms to consider low-capex (e.g. printed) means

Following on the work of Hart et al in the 1990's, Rattan et al have written about the shift from large-scale corporate R&D to small-scale app development and the concomitant decline in long-term technology commitment.

As a consequence, small US or EU organizations have raised modest amounts of capital to fund high-risk approaches to printable electronics or to speculative product markets.

Such ventures now seem less attractive than low-risk "tech" that speculates on social media or uber-propositions.

High Barriers and Limited Means

"Flat Panel Displays in Perspective examines the potential benefits of a domestic, high-volume, FPD industry for the nation, and evaluates the role of government policies in developing it. The report concludes that such an industry would provide both economic and national security benefits. The extent of these benefits is difficult to determine, however, largely because trends in technology development and industry structure are resulting in more displays at declining prices. **The barriers to establishing a high-volume FPD industry are formidable, and government tools to address them are limited.**"

— Roger Herdman, Director, OTA (1995)

Source: U.S. Congress, Office of Technology Assessment, OTA-ITC-631

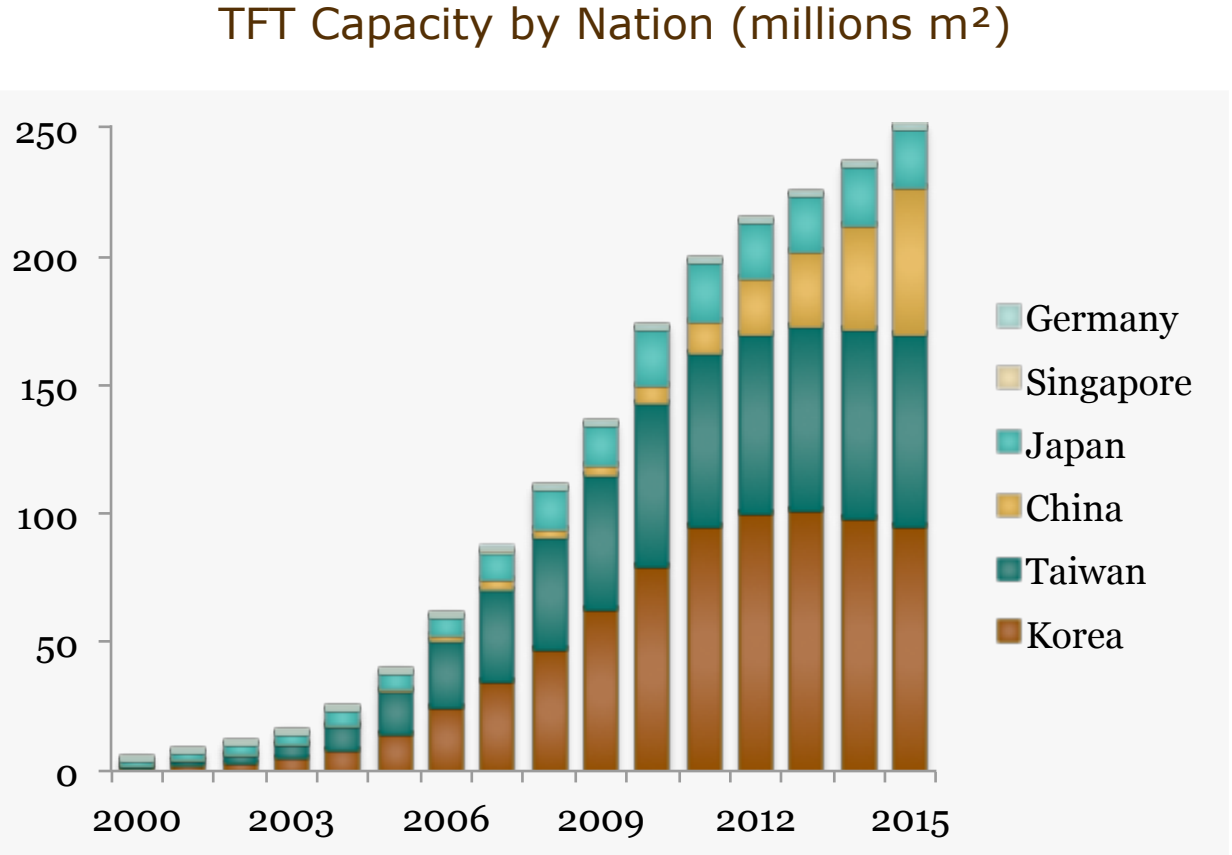
Berserkers were not constrained by capital and they put about $190B into the ground

Knowledgeable estimates range up to $200 billion but I get $190 using LGD numbers…

The point is, that is much more than US conglomerates would want to sink into fixed assets. Flamm expected a 1:2 gearing ratio but Taiwanese expansion shows 3:2… way more than reluctant capital would support.

Historical data shows that Japanese and Korean capacity has peaked. Taiwan's growth has flattened out already…

This leaves Chinese capital as the only force remaining. How long with expansion continue?



Source: IHS, our analysis

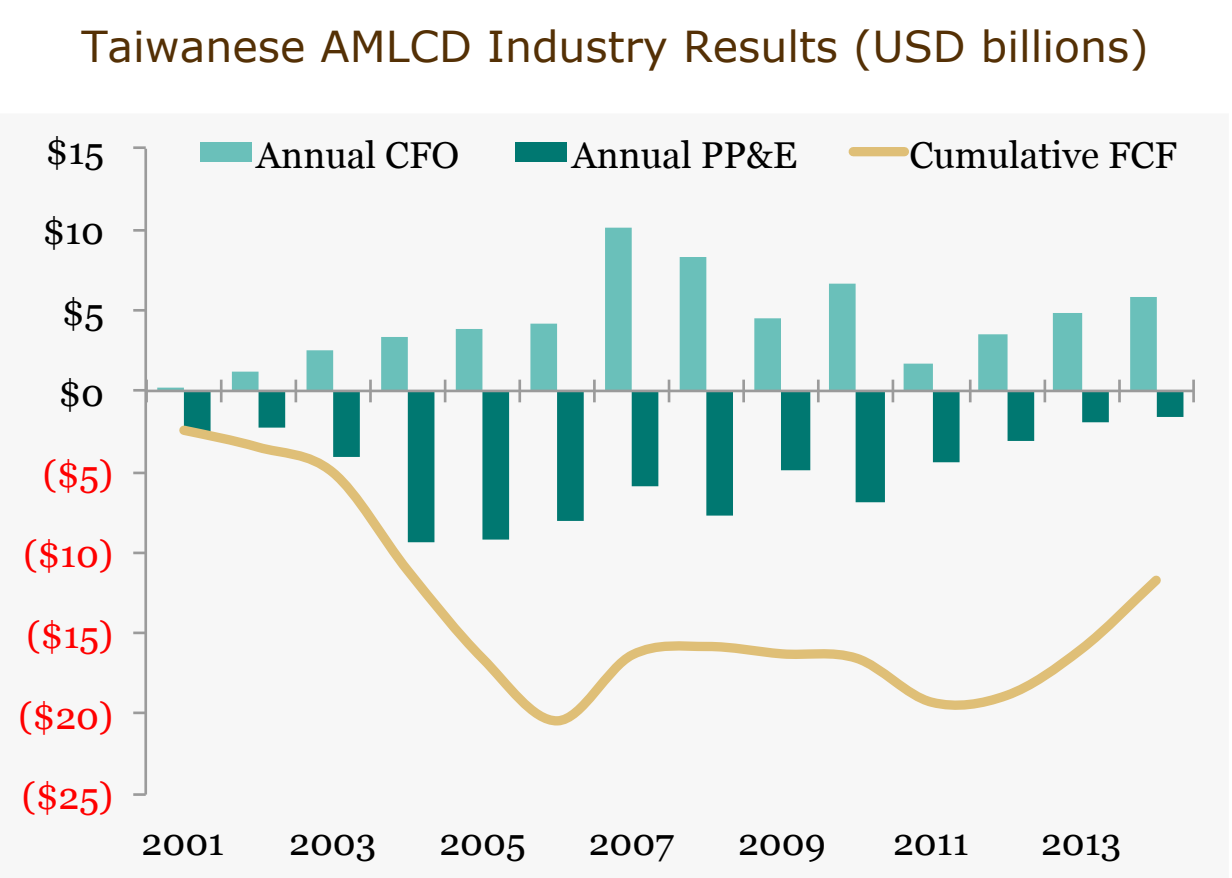
The problem is that money has not come back out of the ground. Panel makers are charities.

Taiwanese executives have said my words are harsh, but they invite me back to advise on strategy, anyway…

The fact is the numbers show that Taiwanese AMLCD firms transferred $11.7 billion from shareholders to suppliers and employees since 2000.

That money benefitted the nation and many domestic businesses, so it is fair to say the panel makers were charitable with their equity.

This illustrates the attraction for other nations, such as China or Brazil and India, to foster such industry… but so far only China has done so.



Free-cash flow (FCF) is cash-flow from operations minus capex (PP&E).

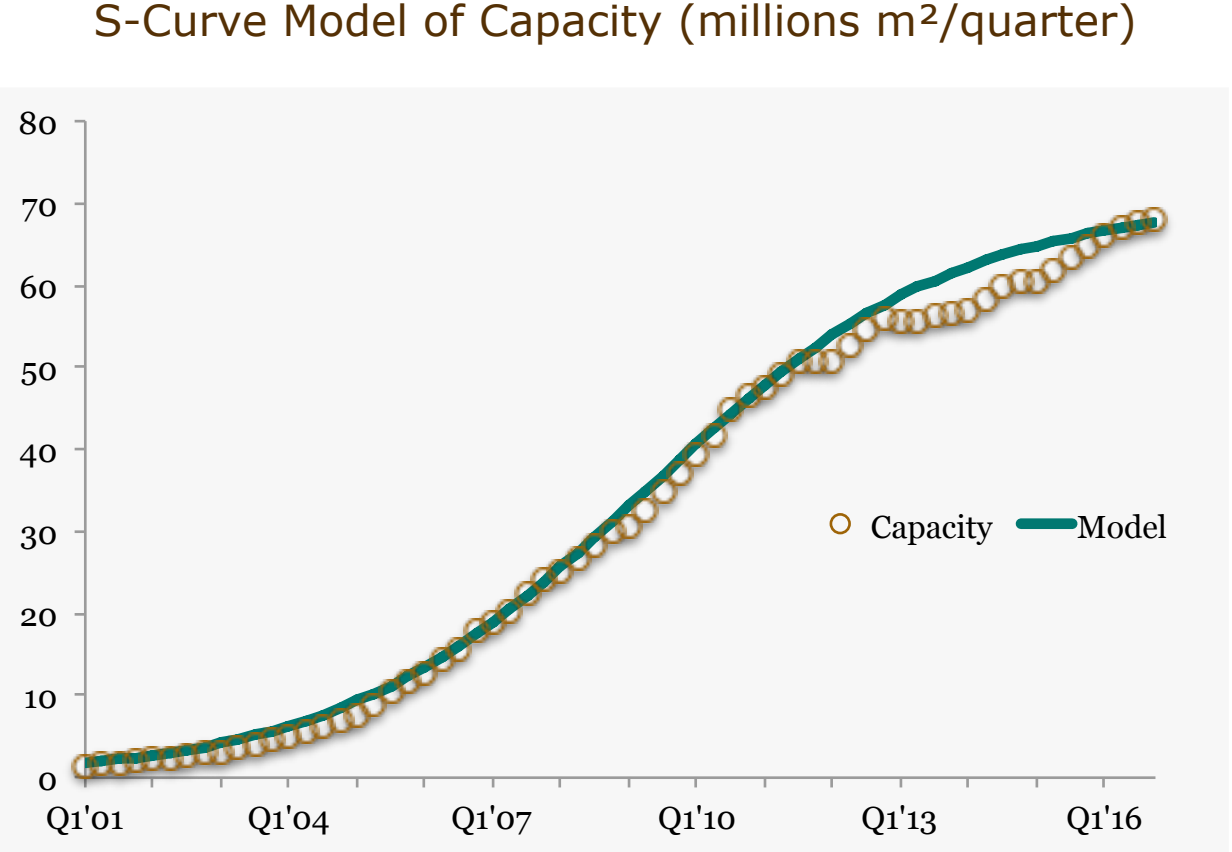
Source: public disclosures; SEC rates and our analysis

TFT capacity began decelerating in 2009… Only Chinese berserkers are rushing-in, now.

Based on Taiwanese history, which was stimulated by national policy (hoping to duplicate its IC success), I assume China is 40% to 50% of the way to maturity.

That suggests a total quarterly capacity in the 80 million m² regime… perhaps 1/3 more than total capacity this year.

While such Chinese-led expansion is substantial, it implies that even the new berserkers might start collapsing from capital exhaustion near the end of this decade.



Pearl-Reed model: 11% growth with 2Q'09 inflection

Source: IHS, our analysis

But what about Brazil or India?
I expect China will signal the end of expansion.

My experience with project plans in both Brazil and India leads me to be skeptical.

National policies seem more tuned to becoming more competitive in advanced technologies rather than to developing commodity production infrastructure.

I anticipate occasional studies and some activities in high-end product integration but there is no reason to expect semiconductor-based effort.

If this view is correct, then berserkers may collapse next decade and open the field to new challengers.

The Future Is Not Black or White

Source: Our conjecture

So what can challengers learn from the past?

- Discern the limits of control and visibility.
  - Entrants seldom have much control. They depend on leaders.
  - Entrants seldom have much visibility; Apple and Corning may have better visibility by many conversations and in Apple's case by leading category developments.
- Avoid magical thinking.
  - Something may not be inevitable. Good enough may be good enough.
  - Shock and awe strategies may not shock or awe global competitors.
  - Low capex processes needing high cost materials can kill you…
- Beware of multi-party game dynamics
  - A producing nation cannot have open markets, rich material suppliers and rich tool suppliers… that is an impossible trinity.
  - US material suppliers (e.g. 3M or Corning) have profited more from the AMLCD industry than have all panel makers. Pick your position.

Some slides from my LOPEC 2014 presentation…

APPENDIX

Innovations are rare because they are uniquely useful and valuable

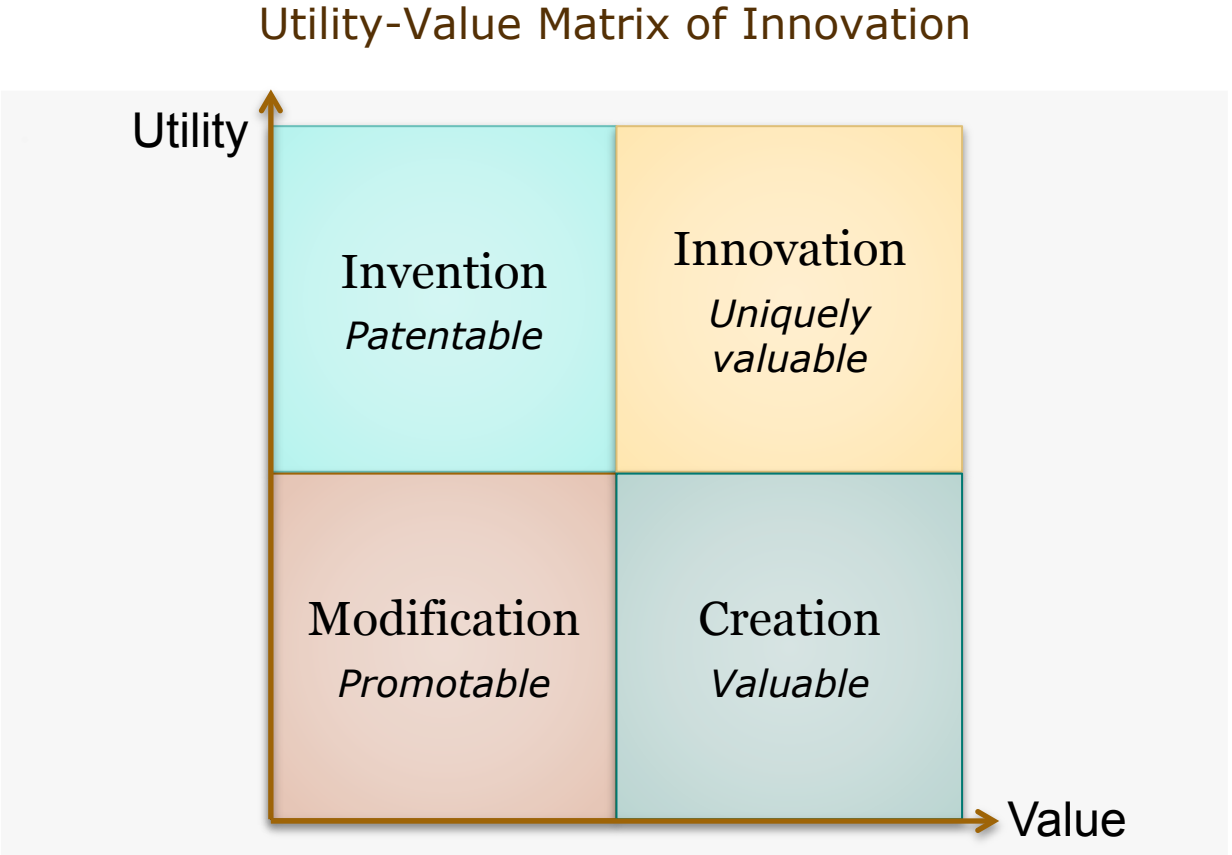
Talk about about innovation is cheap but realizing it is costly and difficult for businesses

In most cases, organizations modify something or offer some novelty: a 753 ppi LCD

Value may be increased by creating a product line or range: a 4K TV sub-brand

Sometimes an organization has a patentable product: IPS/ FFS LCD

More rarely, an organization combines high-resolution with a sub-brand, FSS LCD and software and an apps store to create the iOS business, which is unique, useful and valuable



Our conceptual diagram

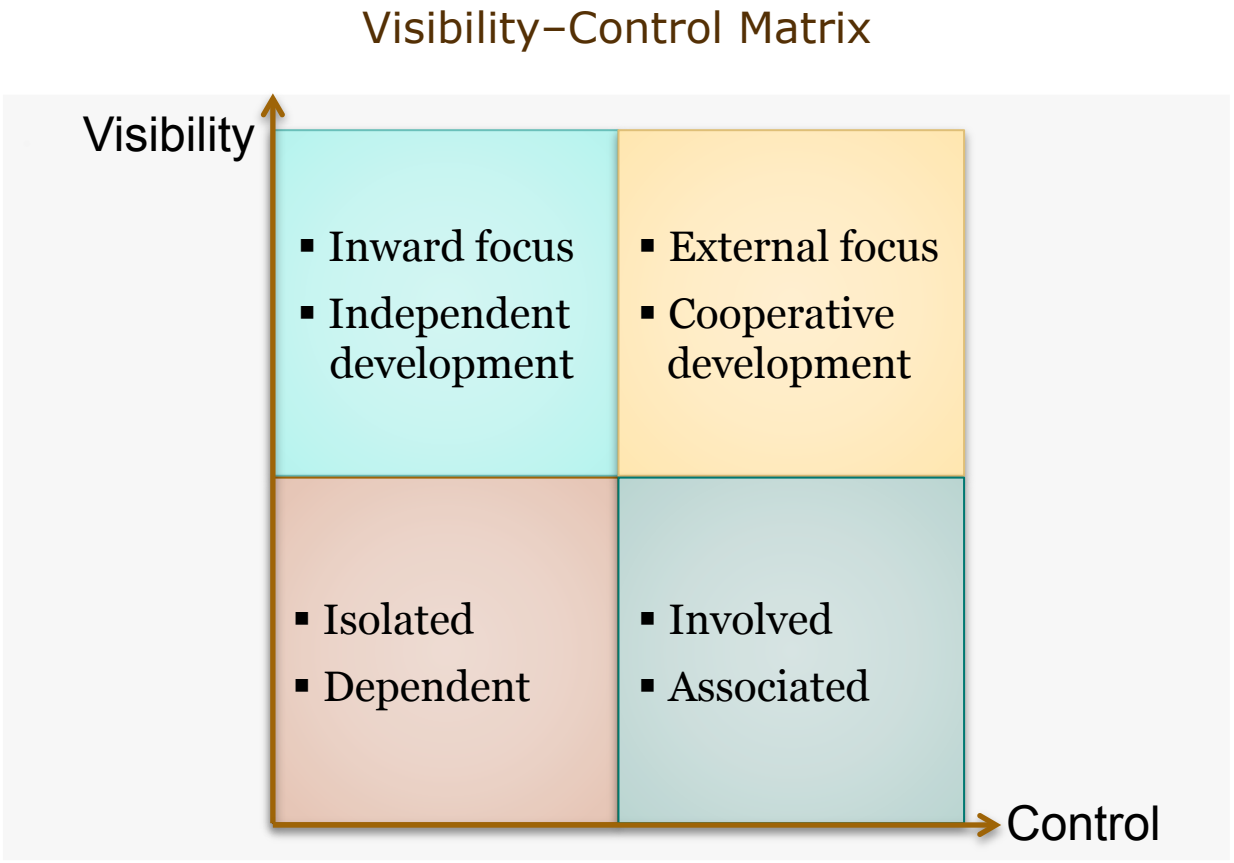
Being approximately correct rather than being precisely wrong requires sincere assessment

All organizations have limited visibility and control… some more than others.

Few can sustain an external focus and coordinate co-op development, long term.

Ironically, materials suppliers are often isolated and very dependent on other tech or market developments, yet they often profit most from merging technologies.

A combinations of inaccurate mental maps, dependencies and untested assumptions lead to unfortunate forecasts for others assuming more visibility or control.



Our conceptual diagram

The map is not the territory
… ways we fool ourselves into foolish actions

Johannes Vingboons, ca 1650

Logic Bubbles
… isn't obvious that_____?

- When an Asian businessman hears that a project will take a lot of capital, he says, "Good!"
  - More money will be, "spread around." He will gain face.
  - Big projects are wanted for big populations.
- When a Western businessman hears a project will take a lot of capital, he says, "Bad!"
  - Investors want big returns on small amounts.
  - "Let's make it R2R, then."
- We all tend to think others know and understand our constraints… but they don't.

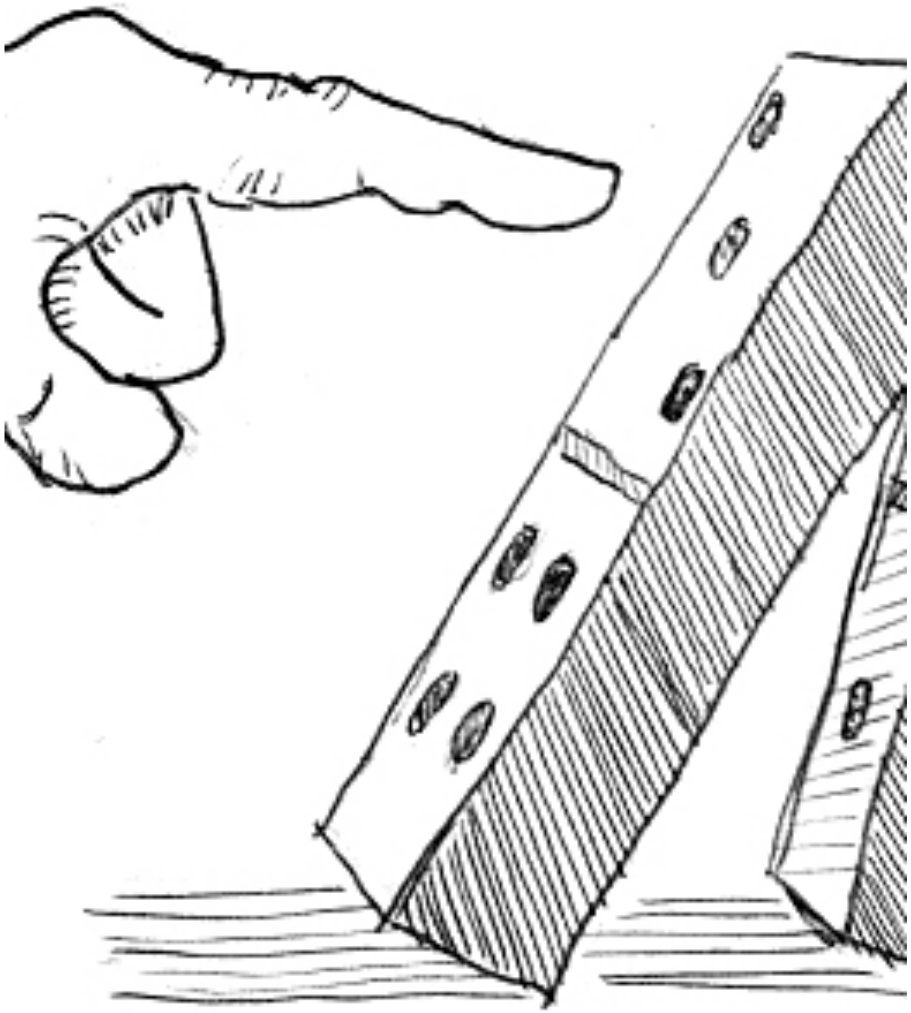
Leapfrog
… so we'll jump way ahead of them!

- The history of US display and printable electronics provides many examples…
- After deciding finance, mergers, acquisitions or real estate was preferable to capex, US companies let others do the heavy lifting.
- But disappointed engineers dreamed of new things and it looked like they could jump ahead of slower-moving Asian competitors.
- This became a corollary to the US military's dual-use doctrine: US companies should work on advanced projects so they can leapfrog others.
- OK, but two questions:
  - Will others stand still long enough?
  - Can I vault high enough?

Shock and Awe
… our new _____ will change everything!

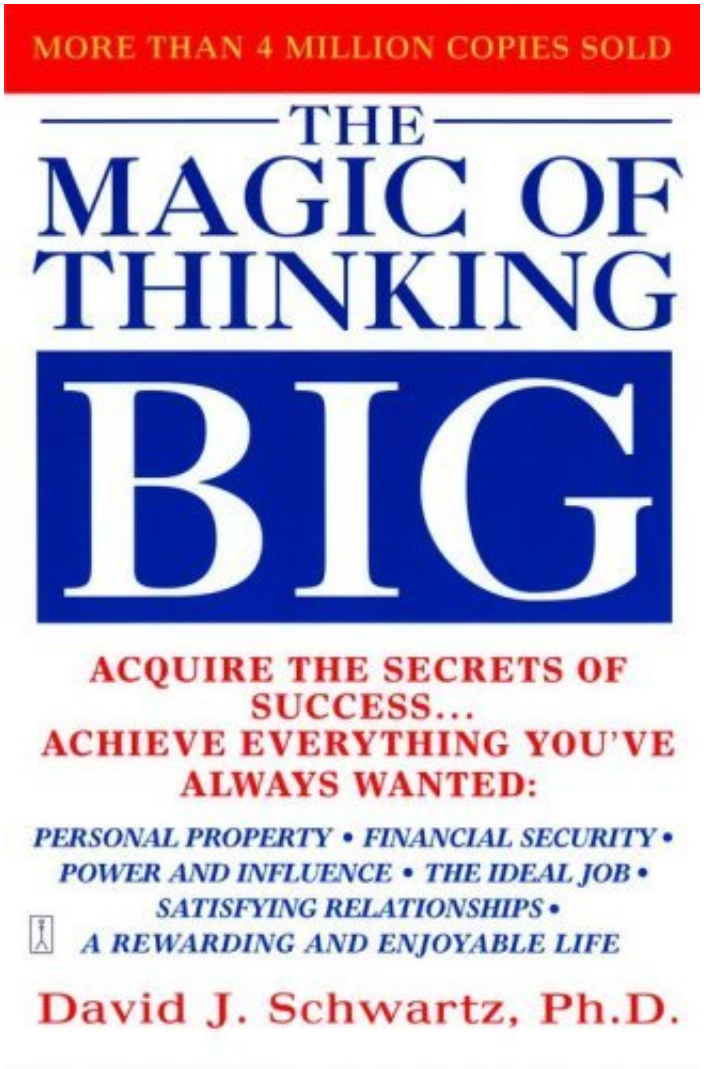
- This is another US-centric motif but one that may resonate with veterans of EU Framework projects.
- While it may be is tempting to think that incumbent suppliers might roll over and give up when you announce, they might not even pause their relentless progress toward more for less.
- Worse, they may alter course and change the playing field before you realize it.
- Getting to Baghdad is just the beginning…

Determinism
… all we have to do is _____.



- If we ____, then they must ____.
- This fallacy has some parallel to Marx's historical determinism… which might not be wrong, just late.
- It also intertwines with logic bubbles
- … they must know that they have no alternative once we enter the market.
- If I had a euro for each cost forecast I've seen that showed Tech-X would beat all others because… I'd retire.
- Why do you assume they plan to be profitable, ever?
- The point here is that people have different constraints and preferences than you do and that you should not assume something is inevitable.

Magic
… and then, _____ will happen.



- Leap of faith
  … a noble thing at times but dangerous.
- "Presto" is nice to say but difficult to do.
- Magical thinking comes in two general forms.
  - Sympathy: A is similar to B so if I do this to A, then B will change also.
  - Correspondence: B changed when A changed, so C will change when D changes.
- Governments and organizations succumb to magical thinking frequently, so the only good antidote is a strong sense of history
  … and remembering that correlation does not imply causation.

Example of a misleading mental map … the rise and fall (and rise and fall?) of LTPS

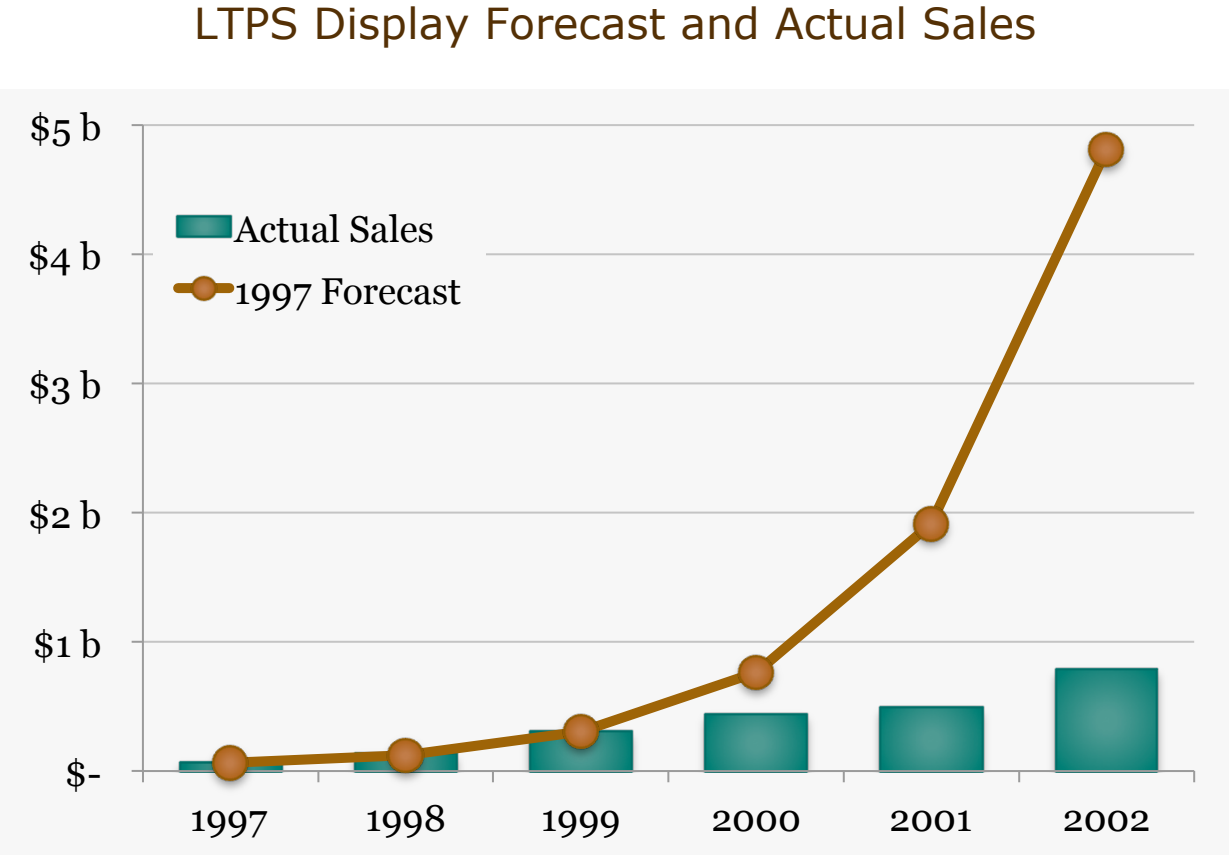
A famous market research firm forecasted LTPS-based display sales would rise 141% a year from 1997 to 2002 and reach $4,800 million.

In hindsight, sales increased 62% a year to reach $784 m.

The forecast proved to be 5X too high 5 years later.

What went wrong?

- Tools: no way to pattern IC resolutions at TV sizes
- Momenta: no way to catch-up with a-Si:H TFT
- Costs: on-glass integration more costly than parts (DIC)
- Values: a-Si technology was good enough for most things



Our analysis of a Q2'97 report and a Q2'05 report by the same firm

Assumptions—
Are you sure things will change quickly?

David Sarnoff and RCA had a wonderful vision of TV sets you could hang on the wall

… and we could 50 years later.

It took more than a few things to change.

It took materials, tools, many breakthroughs and euros.

… spent by many companies

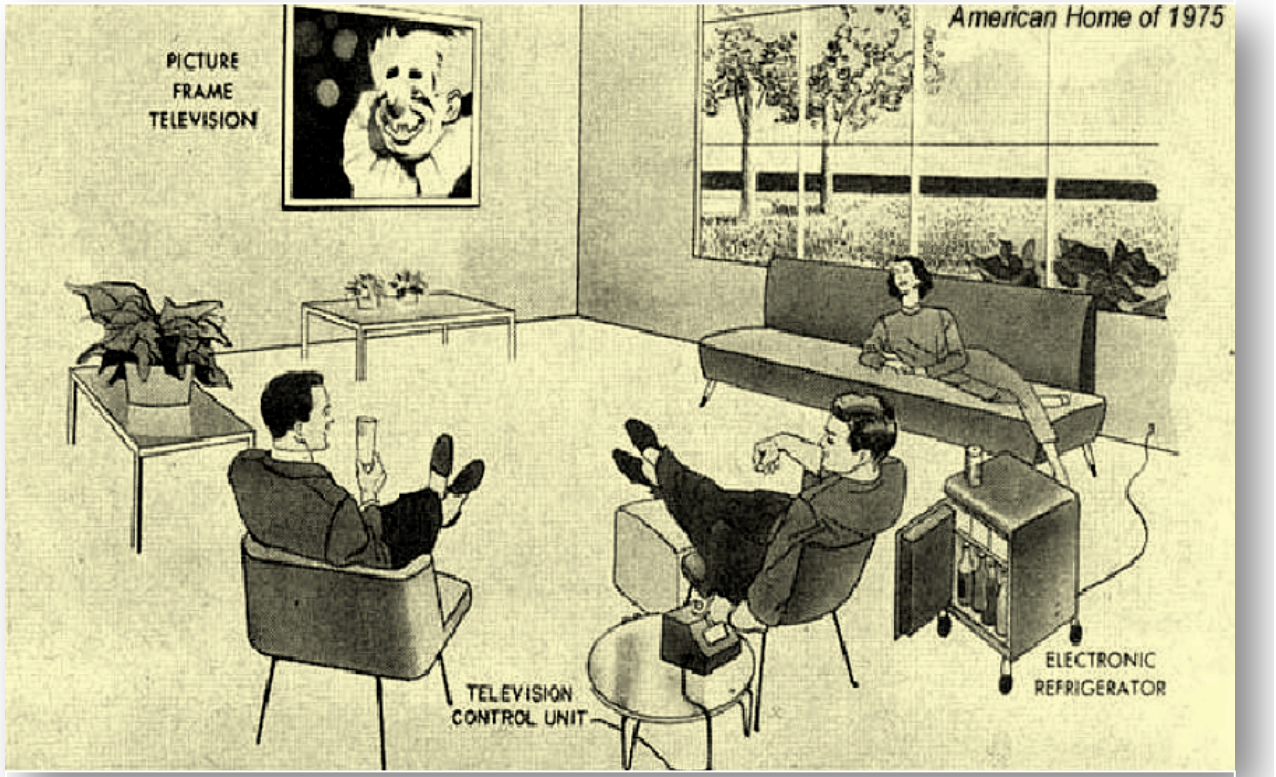
… over many years

… with some success

… and lots of failure

So today, we can say "nothing's on" our TV made by companies that make no money for investors.

RCA's Vision of the Future in 1955



Source: Technician Magazine, Oct '55

Assumptions—
Are you sure things will change slowly?

We live in a non-linear world and momentum matters.

Aim where incumbents are going, not where they are.

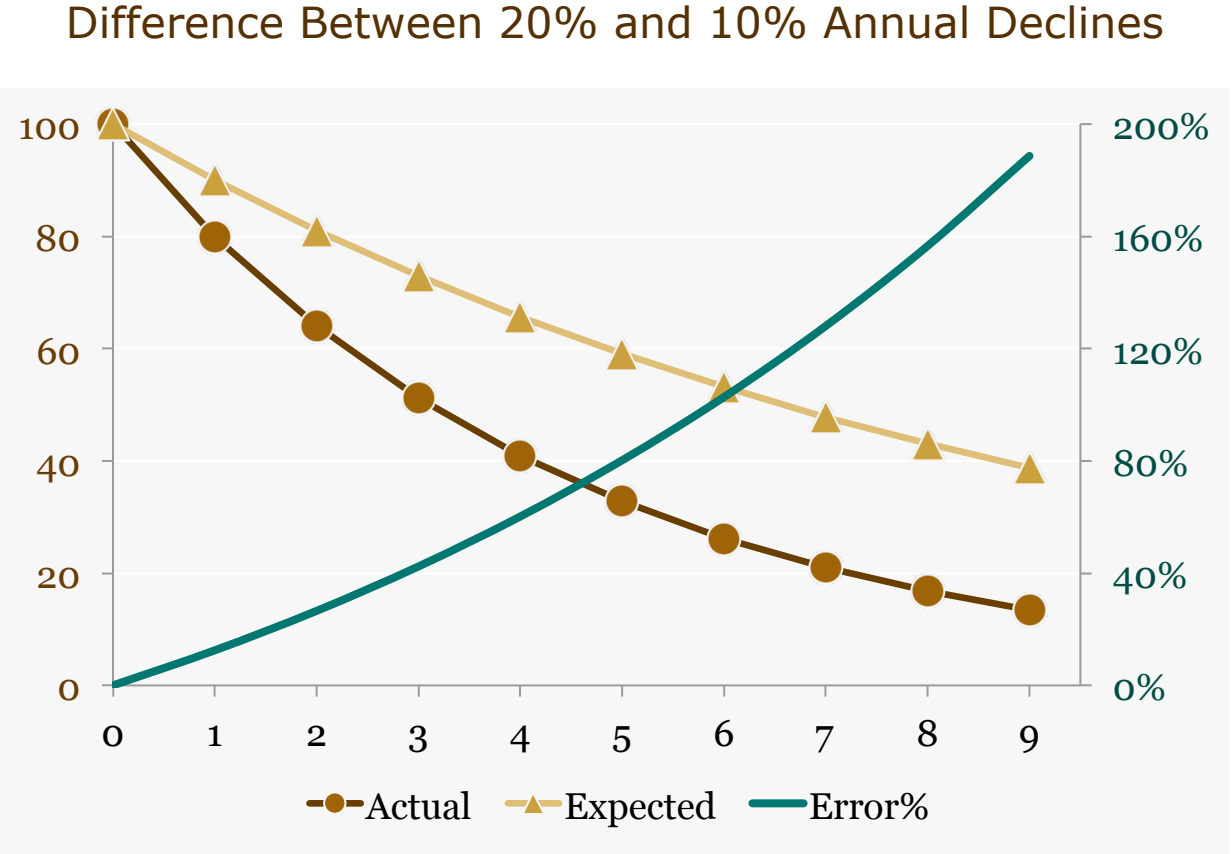
Study historical trends.

Question forecasts.

Ask yourself, what if we are a few years (or quarters) late?

Think about industries or markets as snowballs rolling down hill.

Why will snowballs change vectors if you ___?



Source: Our experience in display and IC industries, 1974–2014

Assumptions—
The trend is your friend, until the end.

You can model the areal price of AMLCD with a simple sine wave riding on an exponential decay line.

The problem with this is you can find data to support any trend you want

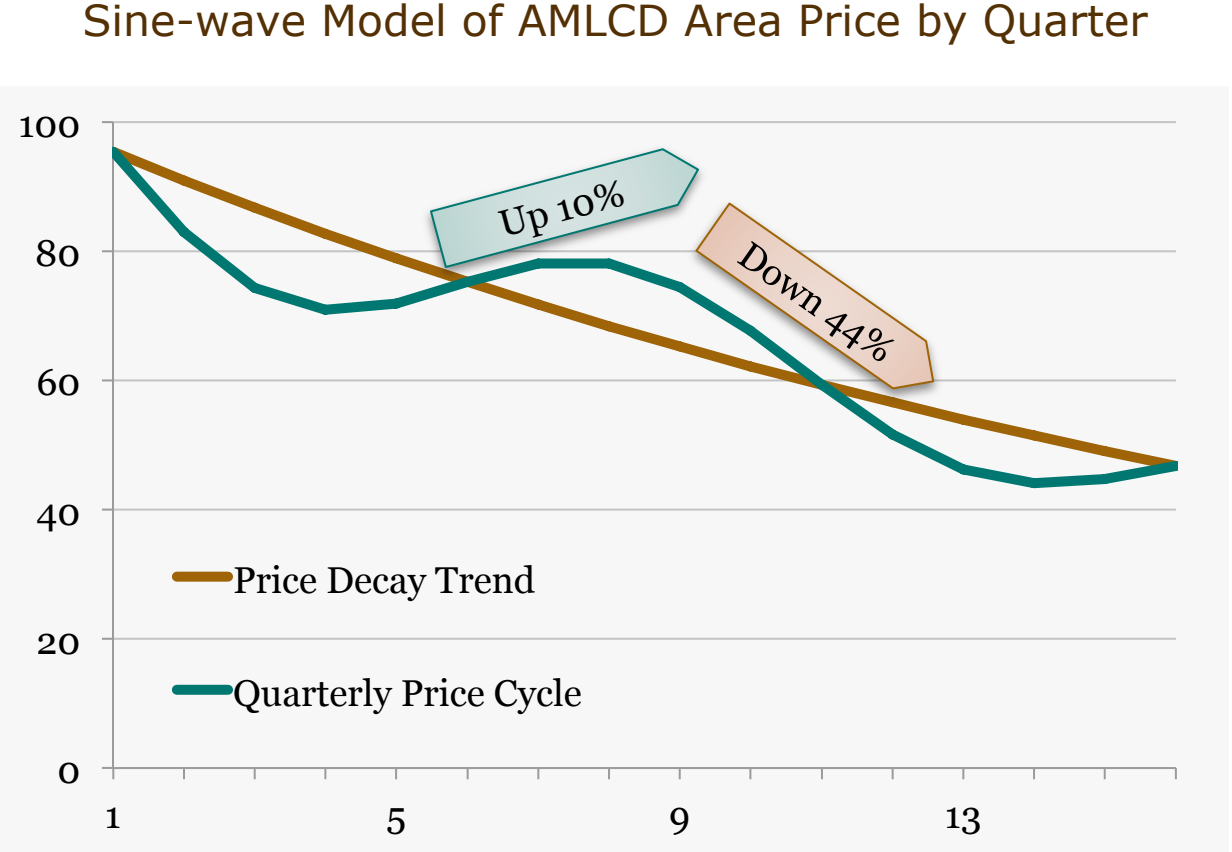
… if you think short-term.

The AMLCD industry has a nominal ten-quarter cycle based on capital and people resources, so you need to look back three or more years to see the real historical trend.

Momentum matters.

Are you moving fast enough

… in the right direction?

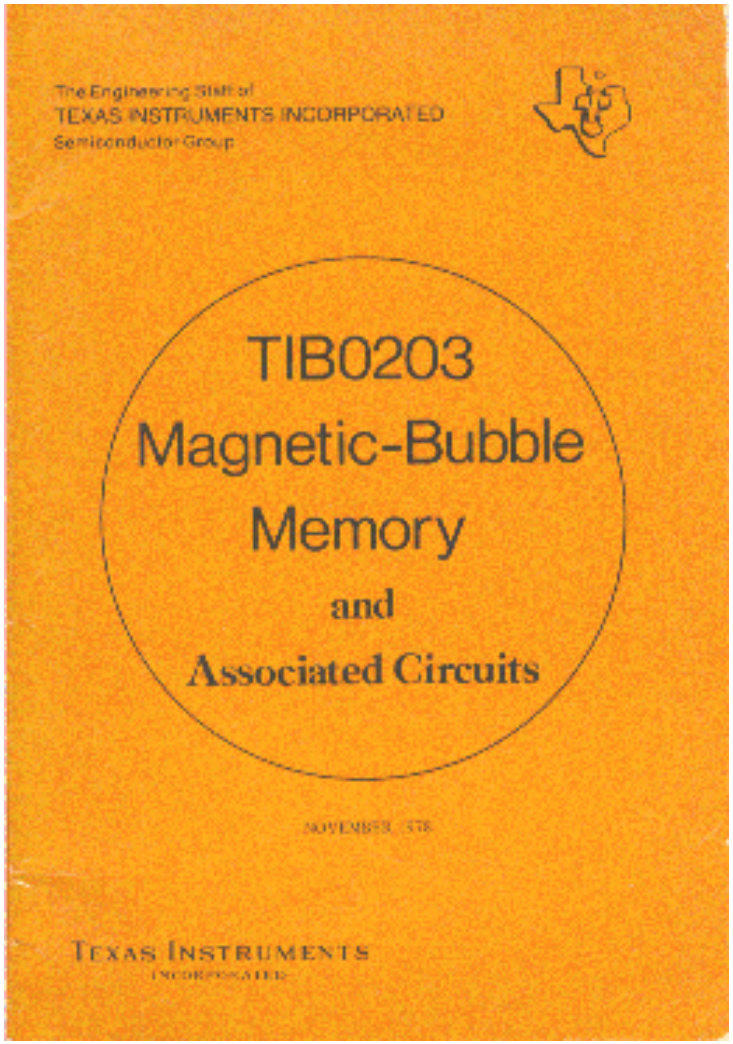


Our analysis circa 2006

Assumptions—
Are you solving the right problem?

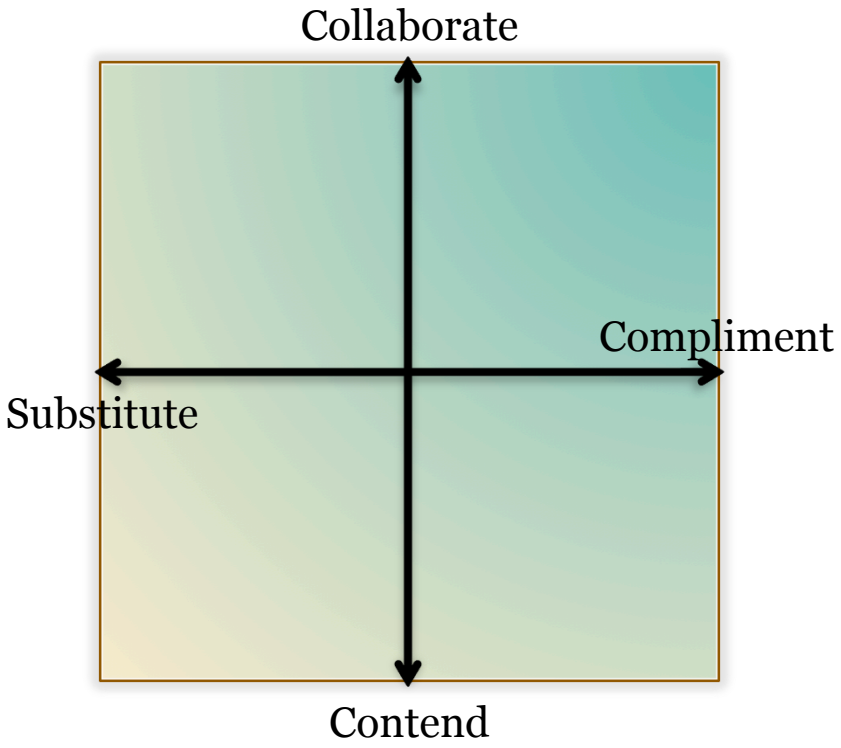
The problem is how to get rid of mice, not how to catch them.

- Bubble memory was the better mouse trap of the 1970's.
  - TI introduced a 92 kb MBM in 1978.
  - By 1979, Rockwell, IBM, TI and Intel had over 500 engineers involved.
  - By 1981, all projects were abandoned.
- EEPROM was better, faster and cheaper.
  - It evolved from conventional IC technology.
  - It required less design and production infrastructure change.
- The problem was how to keep data, not how to write data.

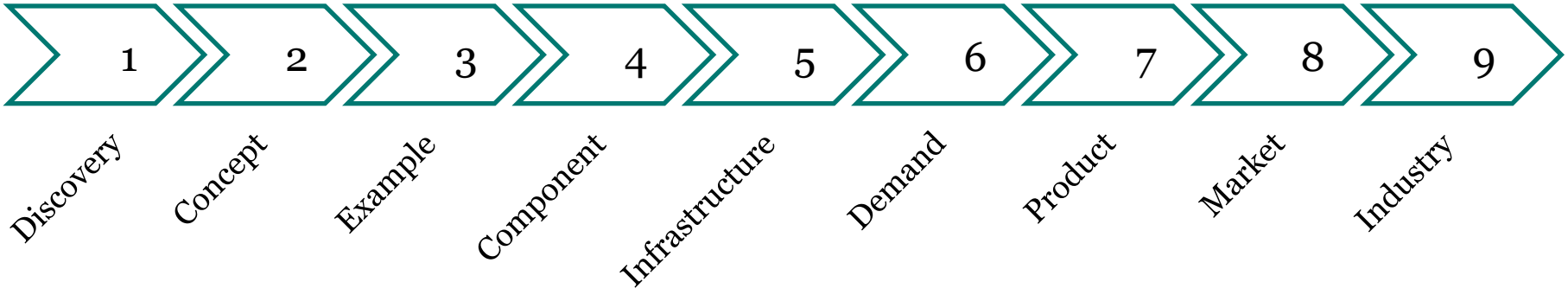


Precedence and Dependence
… another way to say visibility and control

- No organization is an island.
- Each must decide
  - … to collaborate or contend with incumbents;
  - … to compliment existing products or to replace them with new ones.
- In general, if you cannot find and defend a market segment for contending and substituting … then you should seek one in which you can collaborate and compliment.
- The following slides show phases of development any new technology passes through on the way to market



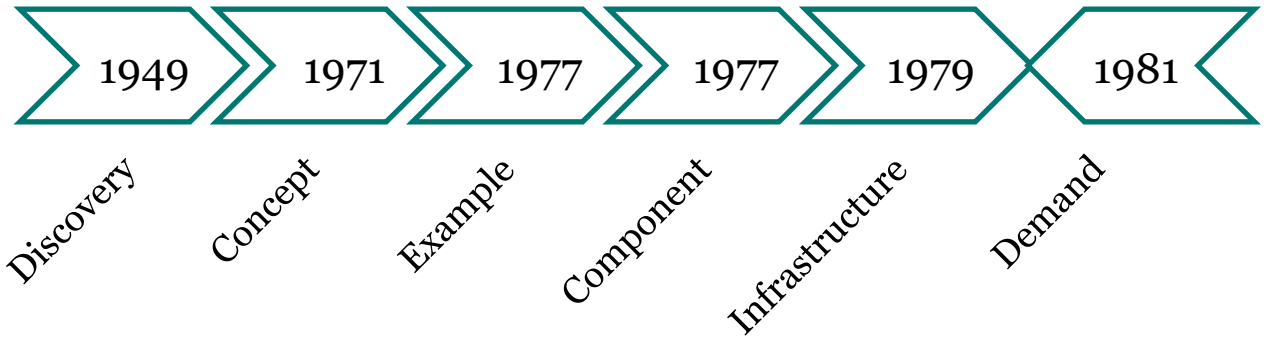
Speaking of dependences
… here are nine phase gates to negotiate

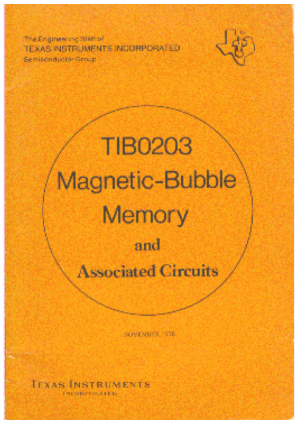


- Revolutionary technologies must go through all nine steps to commercialization.
  - Bubble memories
  - LCD
- Disruptive technologies may start at the point of demand (6), developing a business model or value proposition, and build on existing infrastructure.
  - Small disk drives
  - OLED (?)
- Evolutionary technologies may start at the point of finding a new product "carrier" or identifying a new market (8). IGZO might be an example of this.

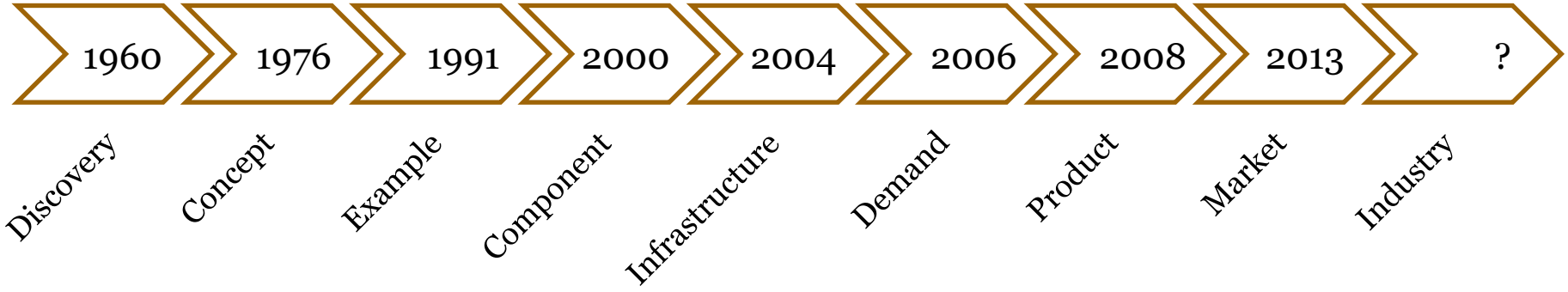
For example, computer memories

Core Memory — Forrester, MIT





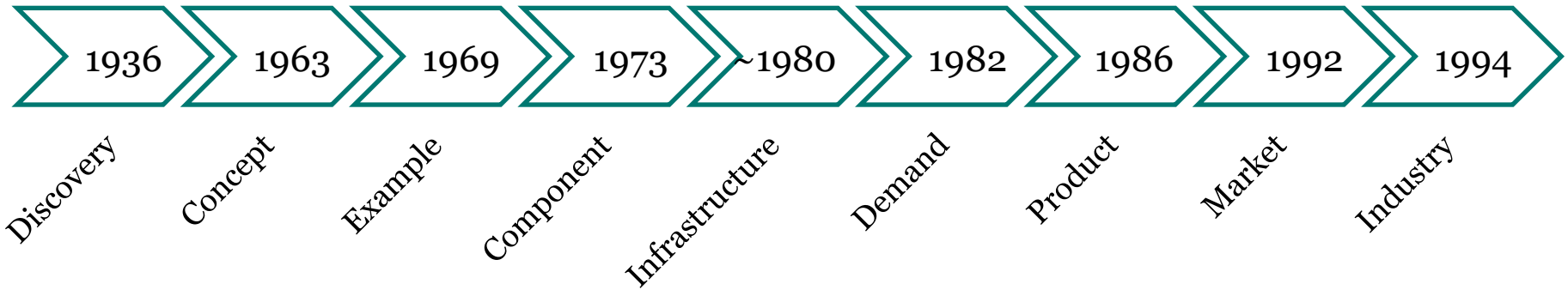
Tunneling Junction — Giaever, GE



- MBM got as far as a manufacturing infrastructure before demand failed to appear. The IBM project met all its targets but DRAM, EEPROM and Disk Drives had evolved too far.
- MRAM sales of $190 m in 2013 leads to forecasts of 67% annual growth into 2019…

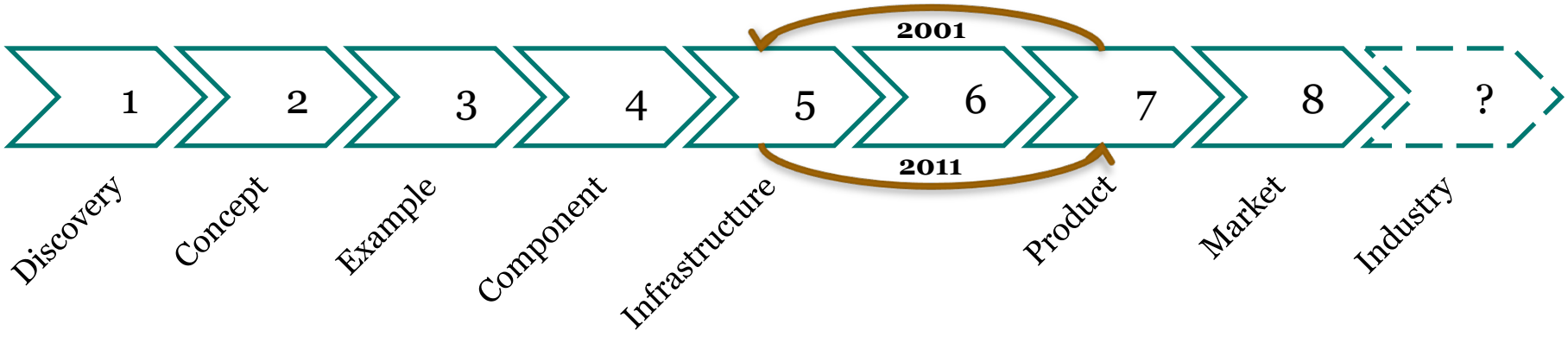
… and AMLCD
Industrialization can take 27 years, or more.

Liquid Crystal Light Valve — Marconi



- Marconi patented the LC light valve concept in 1936 but the TN mode wasn't developed until 1969.
- It took billions of dollars and MITI (Japan) coordination to build AMLCD scale and infrastructure.
- NEC introduced the LCD notebook PC in 1986.
- The modern AMLCD industry was not in place until 1994… thirty years after RCA developed the TV on a wall concept on the work of Richard Williams.
- Affordable LCD TV you could hang on the wall did not appear until 2003–2004… forty years after the concept was announced at Rockefeller Center.

LTPS is an example of a rebound … or perhaps not.



- Even an evolutionary technology like LTPS (p-Si AMLCD) can hit a barrier.
- The incumbent technology does not stay still, so if you aim for where it is today…
- Tomorrow, the incumbent technology will be faster, better, cheaper.
- LTPS lacked a “killer app” to carry it into the market. Handheld TV wasn’t it, until Samsung funded the AMOLED smartphone (that used LTPS backplanes).
- In 2001, LTPS producers found themselves competing with AMLCD producers who have a better cost structure and mature infrastructure.
- In 2011, (Galaxy) AMOLED smartphones became viable products but we wonder when Samsung will industrialize AMOLED TV sets.

Summary

There are two ways to slide easily through life: to believe everything or to doubt everything; both ways save us from thinking.

— Alfred Korzybski

... who also said:

The map is not the territory.

Flex/Displays is a difficult business… Our analysts are here to help

Growth	Performance	CapEx	Sourcing
▪ Market entry ▪ Business structure ▪ Phase gates, R&D	▪ Price position ▪ Cost reduction ▪ Portfolio balance	▪ Factory plans ▪ Tool selections ▪ Plant conversions	▪ Make/buy ▪ Value chains ▪ Supplier selection

Technologies	Alliances	Plans	Materials
▪ Market sensing ▪ Market & IP value ▪ Consortia synergy	▪ M&A candidates ▪ Partnerships, JVs ▪ Integration plans	▪ Strategic audits ▪ Investor insights ▪ Business valuation	▪ Pricing policies ▪ Market strategies ▪ Licenses, royalties