15.965 Technology Strategy

A recap on technological innovation, and its co-evolution with the demand opportunity

Michael A M Davies

Agenda for Monday 2nd March 2009

- Feedback on the 1st Short Paper
- Re-cap on technologies and innovation, focusing in particular on ***trade-offs*** and the ***performance envelope***
- Discussion of the demand opportunity
- Insights from each of the case studies so far
- The 2nd Short Paper
- Opportunity for questions and general discussion, and for feedback to the professor and the TAs

Positive feedback on first individual assignment, the technology short paper

- Some very interesting and exciting technology choices
- Good incorporation of outside material related to course
  - people doing some real world analysis
  - people using references from the readings
- Some good linkage between historical evolution and likely future path
- Some insightful thinking about parameters of the technology that are relevant to customers

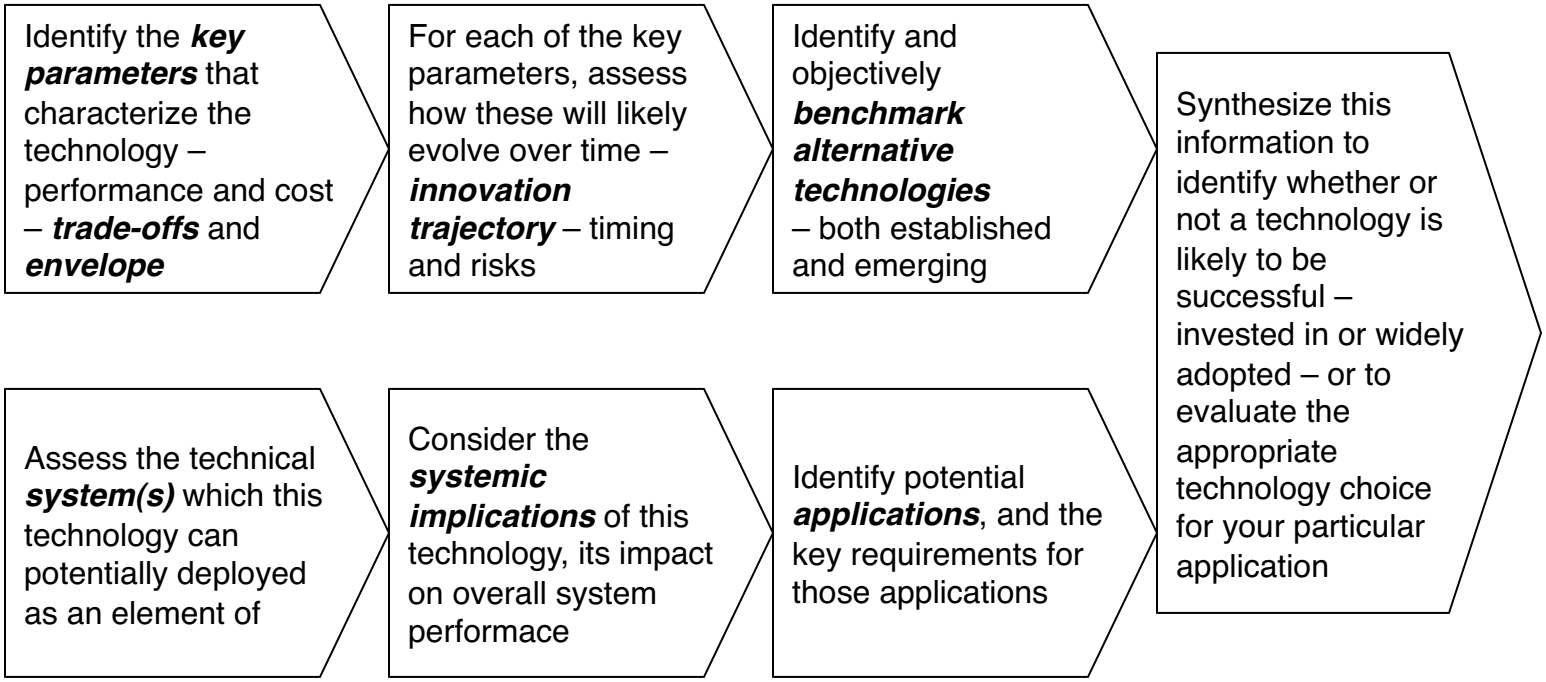
Negative feedback on first individual assignment, the technology short paper

- Answer the questions
  - read the syllabus
  - pay attention to in-class discussions
  - apply the frameworks
- Proofread! – you are graduate students at MIT, with real-world experience and managerial aspirations
- Organization – basic writing skills
- Analysis
  - the 'so what', not just description
  - why do I care?
- Focus on the **key** parameters rather than a laundry list of fuzzy characteristics or attributes

The first step in developing strategy for any high-tech business is anticipation

- What will happen next?
  - how will technologies evolve, what will be their innovation trajectory?
  - how will technological innovations diffuse amongst target customers and become adopted?
  - what demand opportunities does this create that can be met by products that embody novel technologies?

The very first building block is being able to characterize technologies and how they evolve



Technologies compete with each other for potential applications

- At any time, there are typically a range of competing technologies that can be used for any given application
- Each of these technologies can be characterized in terms of its key ***parameters***
- Each technology has some inherent ***trade-offs*** amongst these key parameters, and at any time it has certain performance limits, its ***performance envelope***
- Over time, technologies improve in performance
  - as a result of innovation and investment and learning
  - along an ***innovation trajectory***, a vector describing how they have evolved and will likely evolve
  - rate of change and direction

(Performance) **parameter**

noun

1. one of a set of measurable factors… that define a system and determine its behaviour…[1]
2. a factor that restricts what is possible or what results[1]
3. a distinguishing characteristic or feature[1]

- cost
- size
- speed
- power consumption
- colour gamut
- brightness
- energy density
- discharge rate
- coverage
- bandwidth
- capacity

1: American Heritage® Dictionary, © 2000 Houghton Mifflin

Trade-off

noun

1. the exchange of one thing for another of more or less equal value, especially to effect a compromise[1]
2. an exchange of one thing in return for another, especially relinquishment of one benefit or advantage for another regarded as more desirable[1]

- few colours (greyscale), slower, but low power
- faster discharge, more cycles and safer but more costly
- greater geographical coverage, larger devices and much more costly
- faster read/write

1: Random House Unabridged Dictionary, © Random House Inc. 2006
2: American Heritage® Dictionary, © 2000 Houghton Mifflin

(Performance) envelope

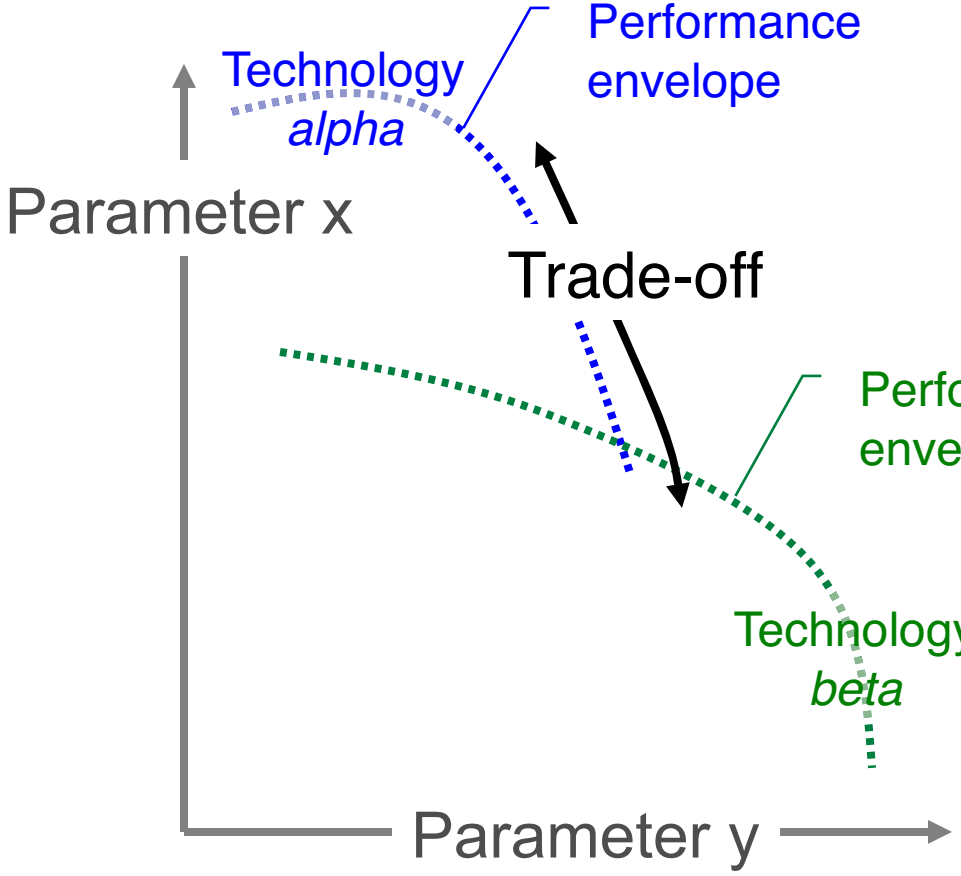
noun

1. the maximum operating capability of a system (especially an aircraft)[1]
2. the technical limits within which an aircraft or electronic system may be safely operated[2]

- 4-bit (16 gray levels), 7:1 contrast ratio, 260 to 740 ms update time 150 to 200 DPI
- 5 to 9.7” size

1: WordNet®, © 2005 Princeton University
2: Random House Unabridged Dictionary, © Random House Inc. 2006

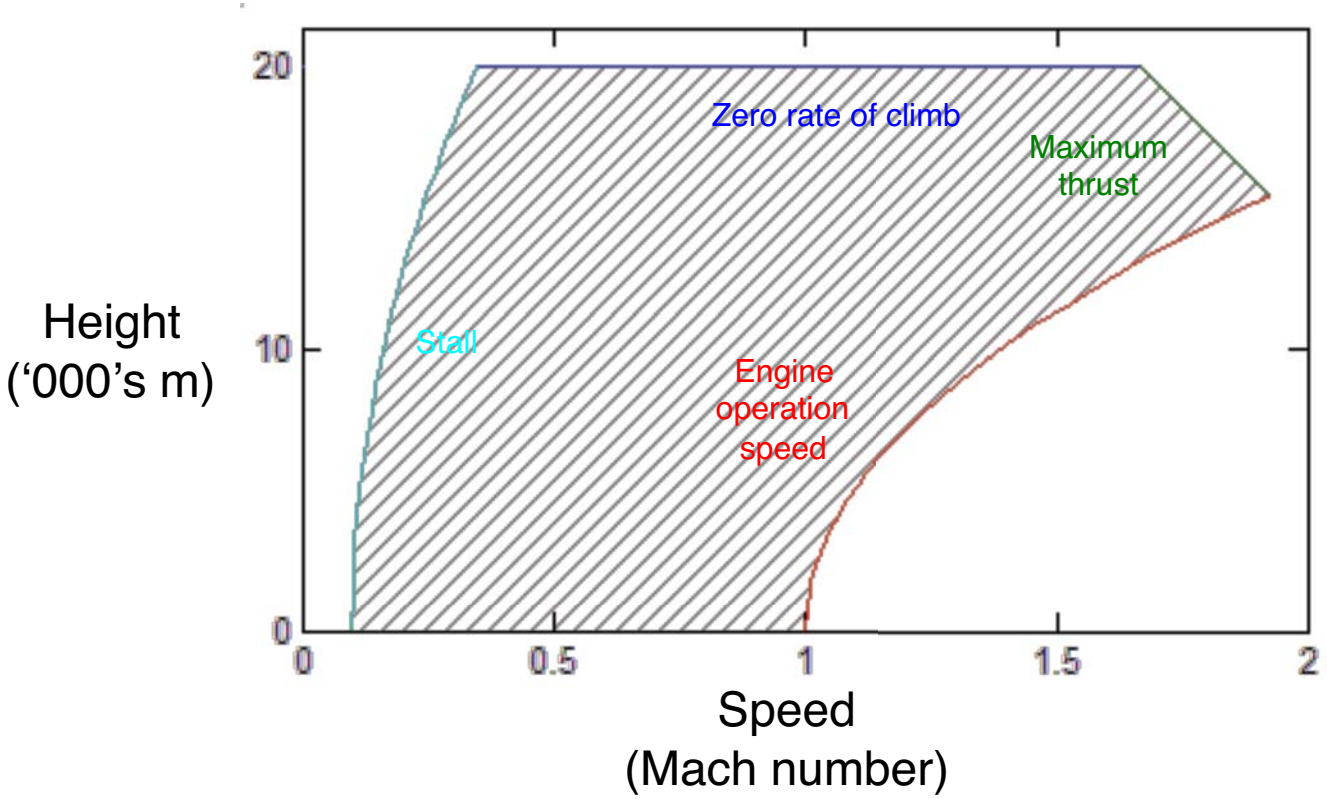
Technology *trade-offs* and *performance envelopes*



Technologies are characterized by trade-offs amongst their key parameters, and by performance envelopes, the limits of what can be done with them

Different technologies have different trade-offs and performance envelopes

A simplified flight envelope



The flight envelope of the V-22 Osprey, relative to a helicopter and a turboprop

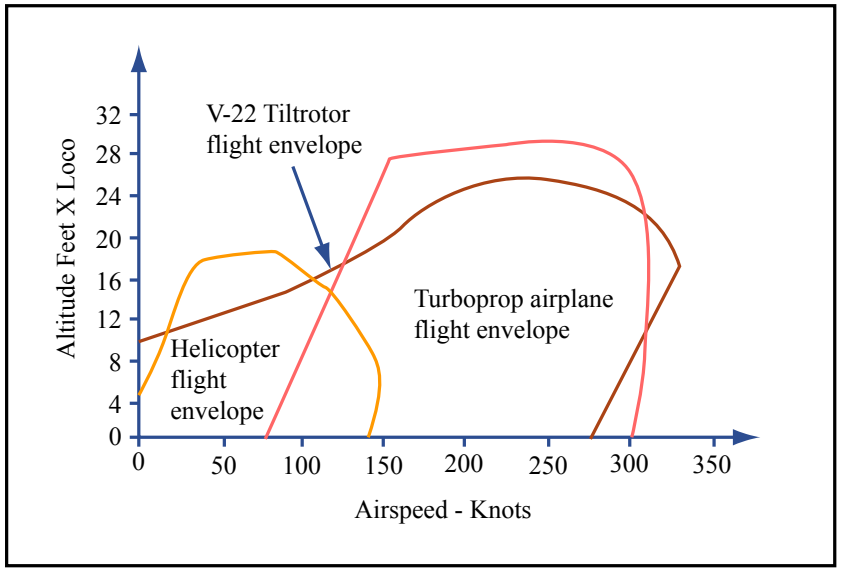
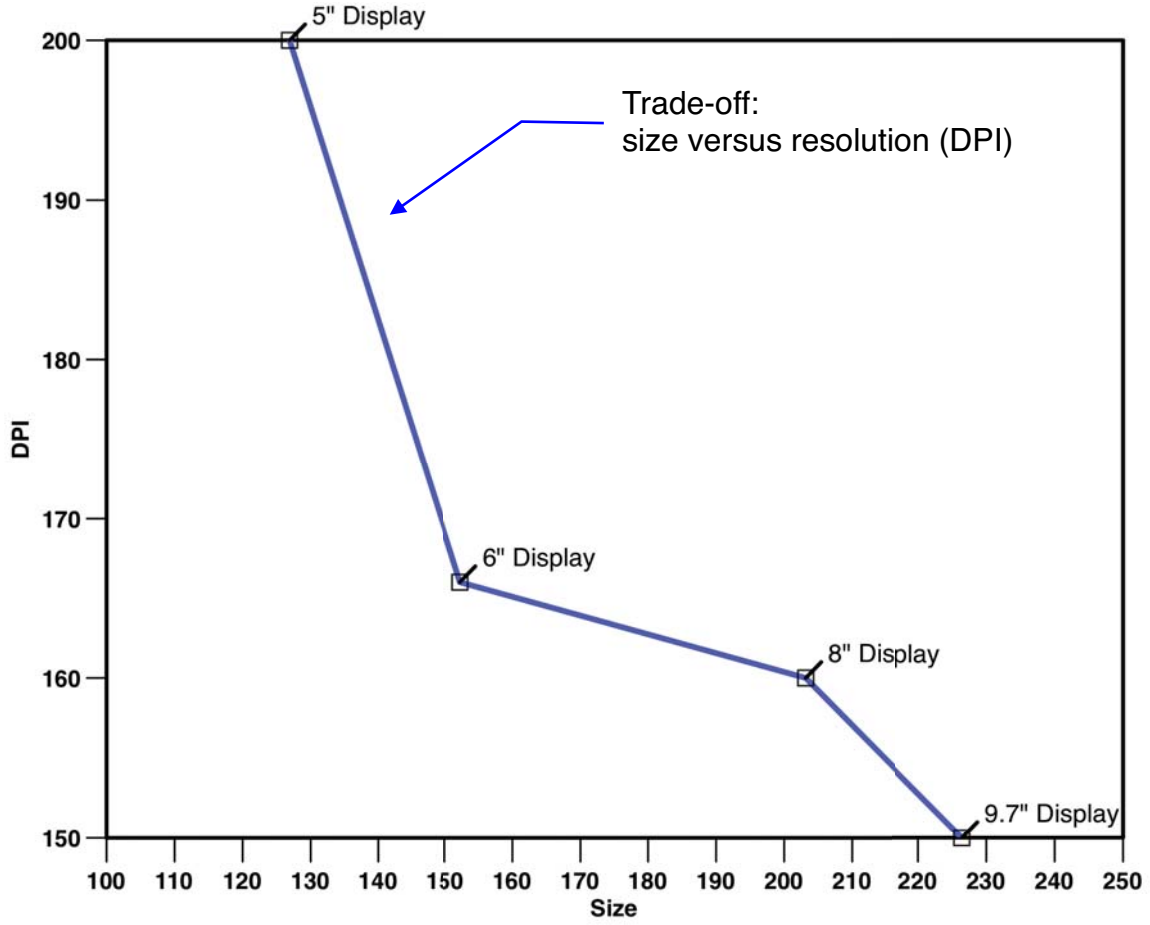


Image by MIT OpenCourseWare.

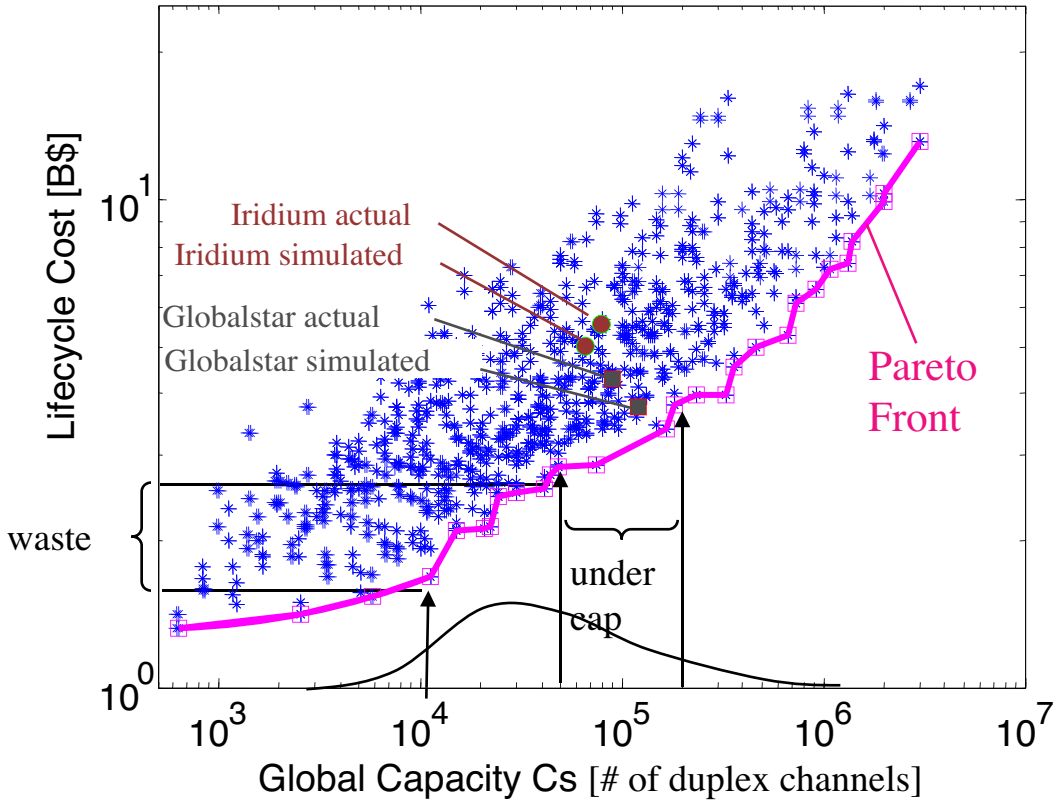
But the V-22 Osprey has a particular challenge at high rates of descent

The.. configuration of the V-22 is susceptible to asymmetric onset of Vortex Ring State (VRS), brought on by descending too quickly. The one-rotor-in/ one-rotor-out conditions results in large rolling moments and **departure from controlled flight**. Such a characteristic is fundamental and cannot be remedied by minor design changes. The only near-term solution is to restrict operations to avoid proximity to VRS region.

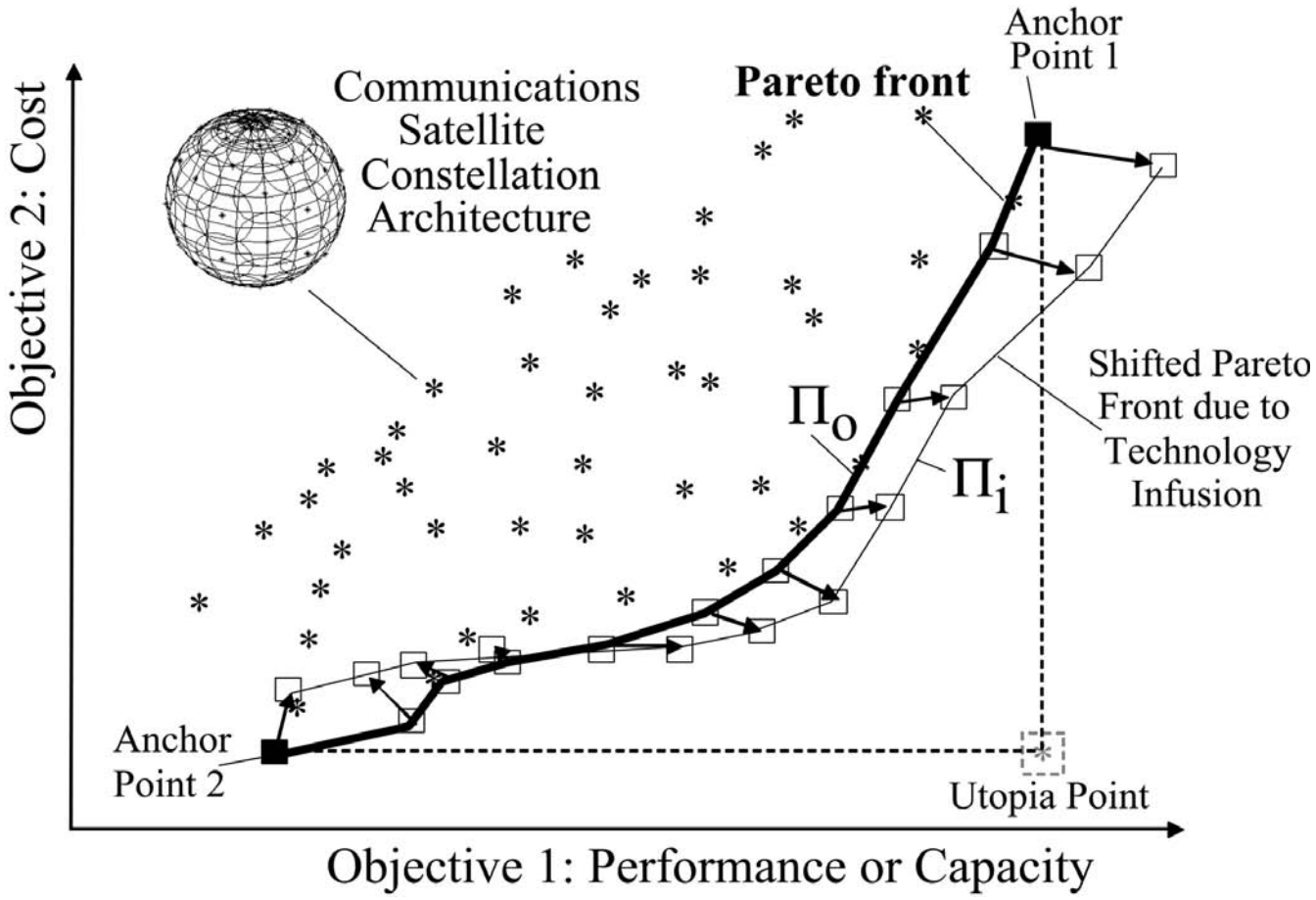
Performance envelope of E-Ink display



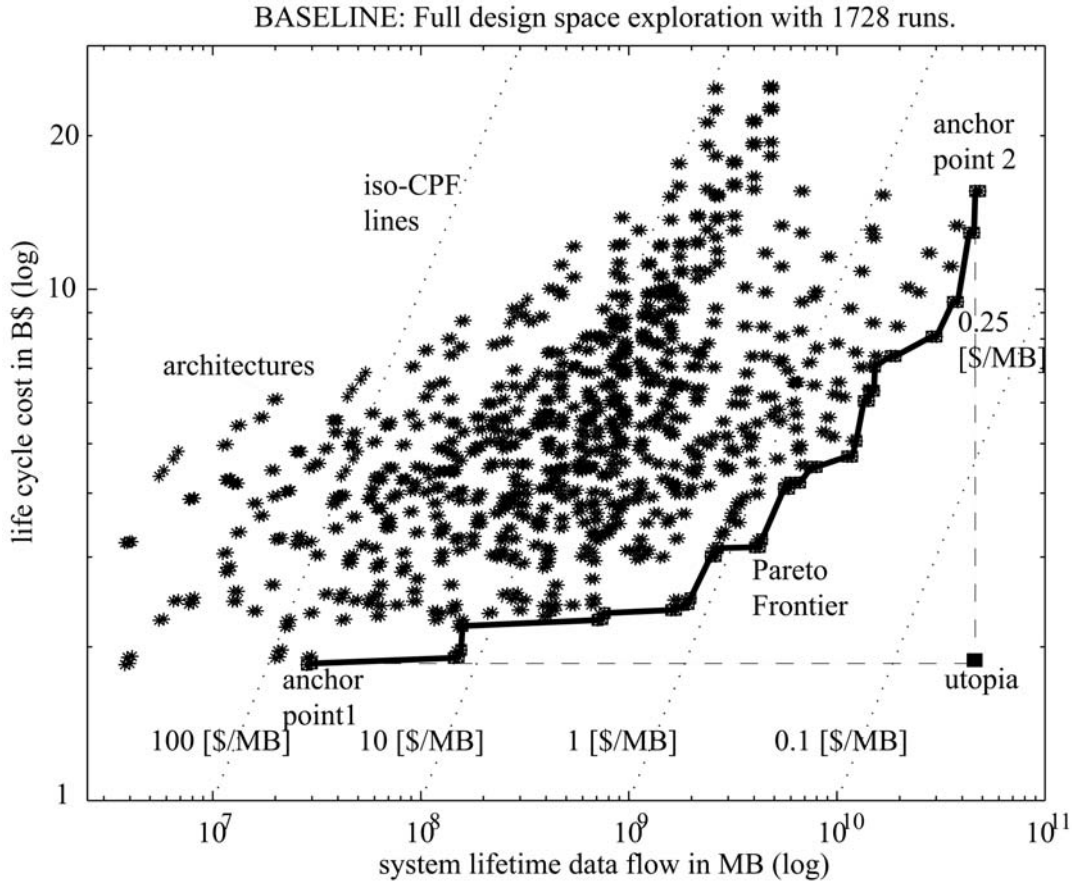
Performance envelope for Low Earth Orbit communications satellite systems



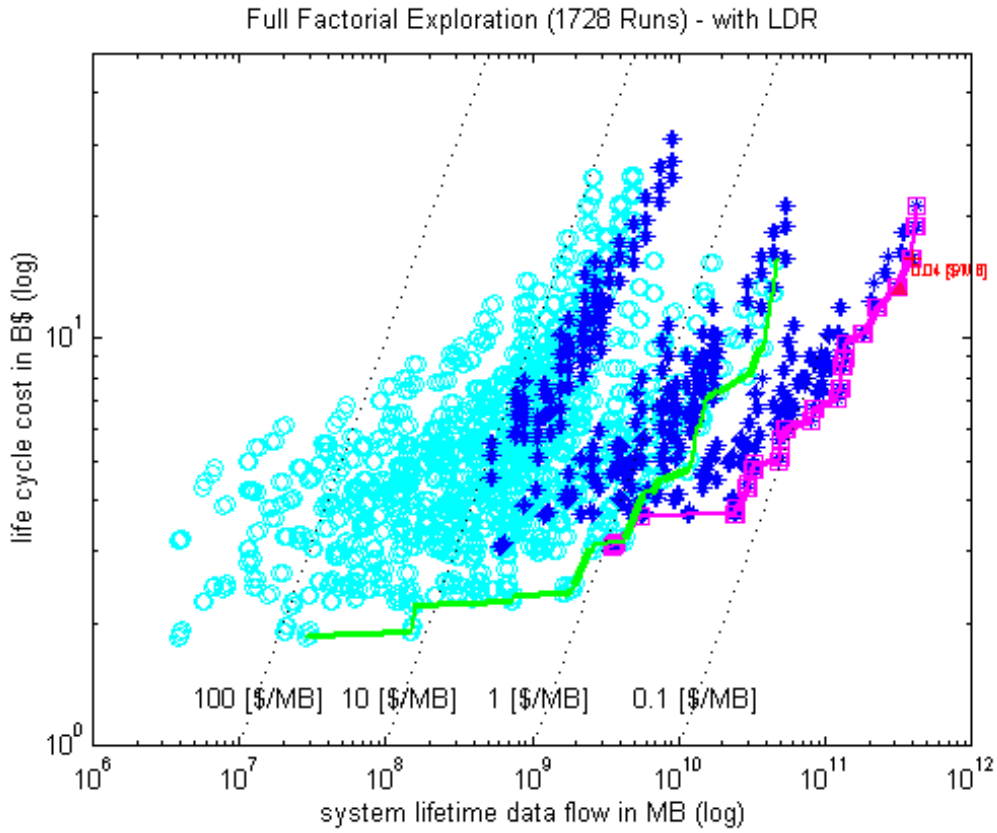
Technological innovation shifts the performance envelope, better performance or lower costs



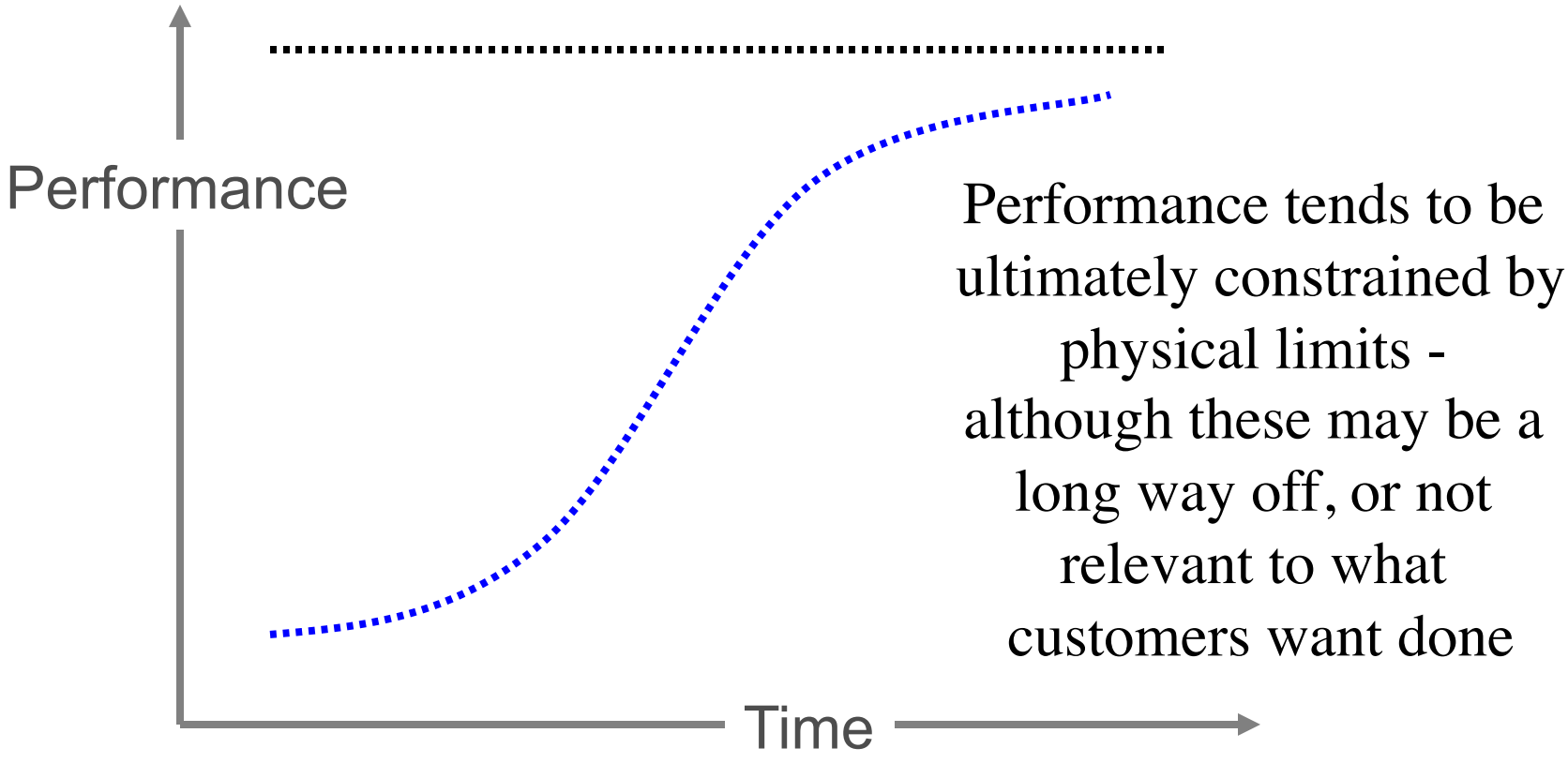
Simulation of performance envelope using mature and stable technologies



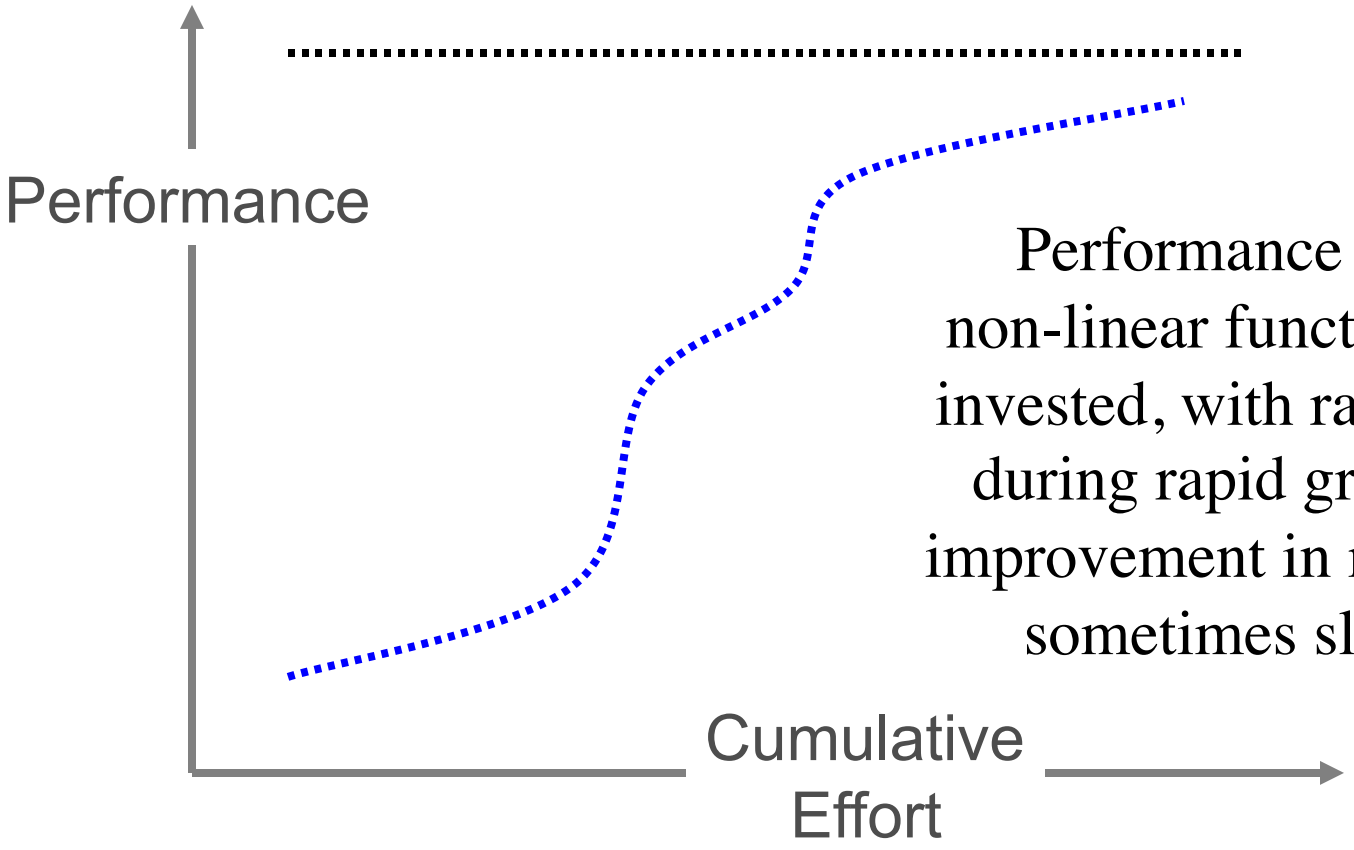
The potential impact of large deployable reflectors on the performance envelope of LEOs



Innovation trajectories



Innovation trajectories



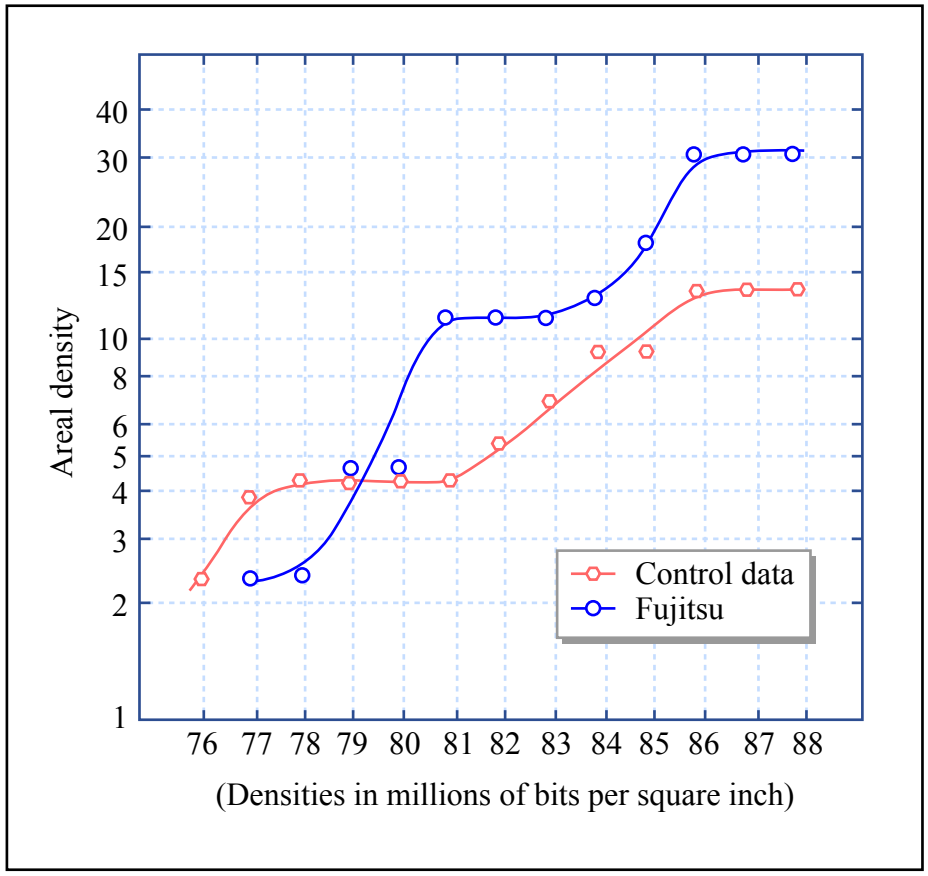
Performance is often a non-linear function of effort invested, with rapid progress during rapid growth, slow improvement in maturity, and sometimes slowdowns

S-curves in the rigid disk drive industry

Image removed due to copyright restrictions.

Clayton Christensen, "Exploring the Limits of the Technology S-Curve - Part I: Component Technologies", Production and Operations Management, Fall 1992, pages 334-357

Within this smooth overall progression, individual businesses move slower or faster



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Production and Operations Management, Fall 1992, pages 334-357

Predicted limits versus realized performance

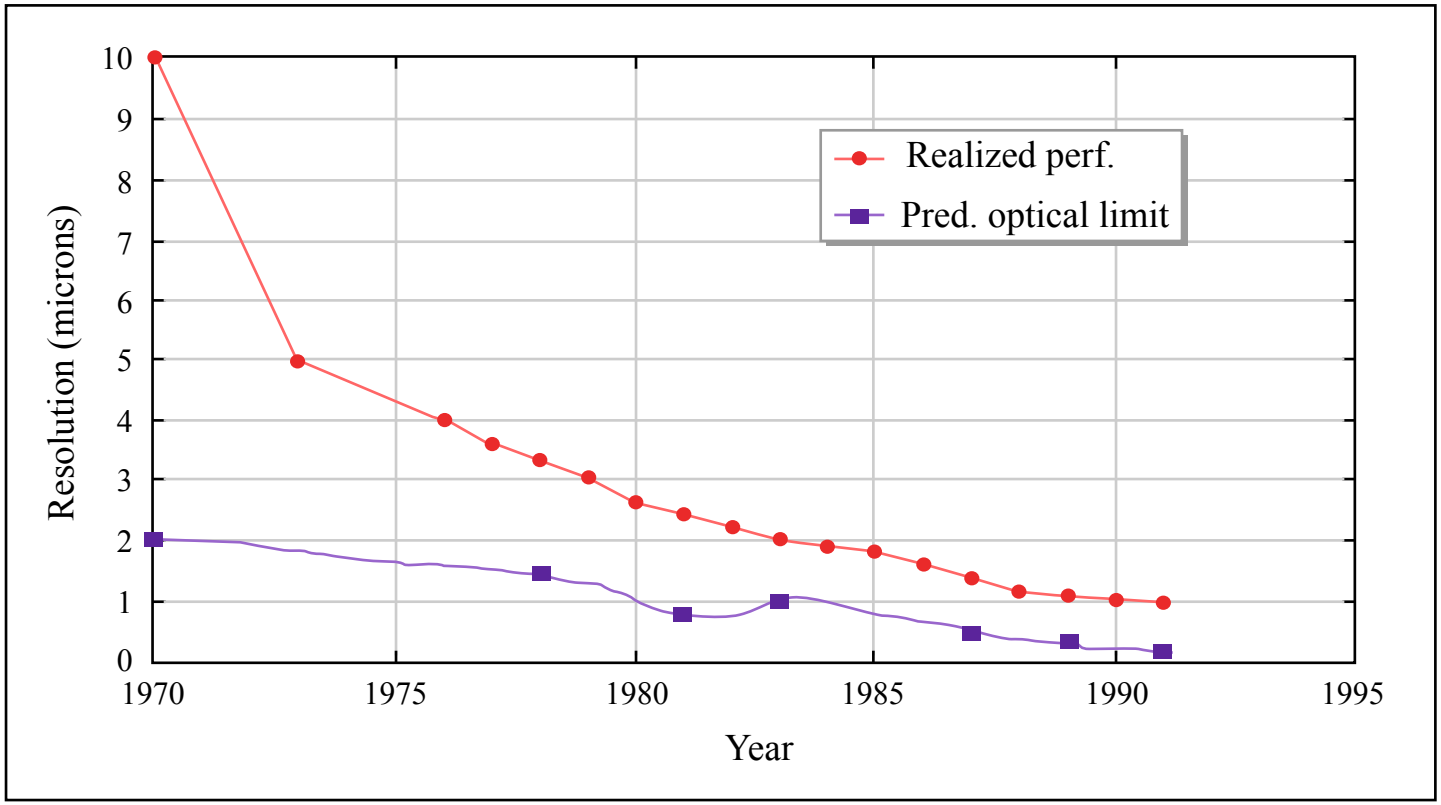
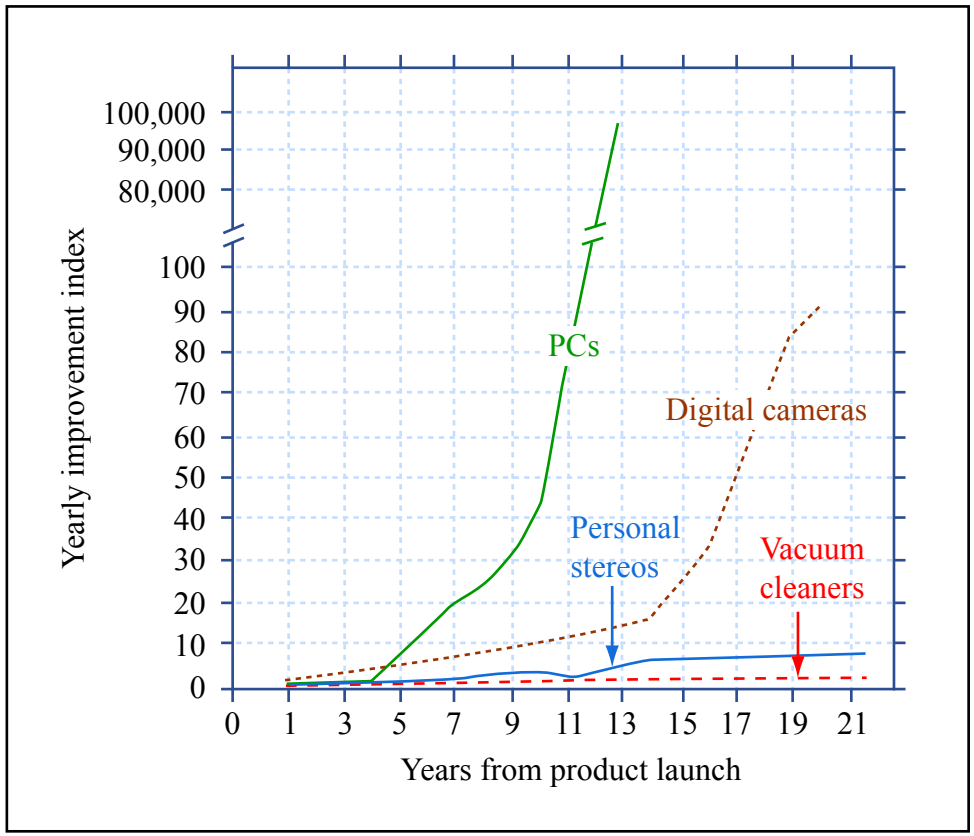


Image by MIT OpenCourseWare.

Rebecca Henderson
"Of Life Cycles Real and Imaginary: The Unexpectedly Long Old Age of Optical Lithography", Research Policy, Volume 24, pages 631-643

The rate at which performance improves can vary dramatically



Fernando Suarez and Gianvito Lanzolla, "The Half-Truth of First-Mover Advantage", Harvard Business Review, April 2005, pages 121-127

For high-tech businesses, marketing is more about the *demand opportunity* than current market

Market

- Current products meet current customers
- Needs well understood and stable
- Substitutes for existing products within category
- Selection, and resulting market share
- Size of market, ease of addressing it

Demand Opportunity

- Novel products, often targeting non-users
- Needs not well-defined, likely to change
- Creating new categories of demand
- Rate of adoption and penetration
- Potential benefits *versus* behavioral change

Users' needs are diverse, they change over time, and users respond to technological innovation

- ***Heterogeneous*** - potential customers or users have a range of different needs (jobs they want done) and values that they put on getting those jobs done
  - may be related to demographic characteristics
  - but not necessarily, so in many cases other bases of segmentation may be more useful
  - psychographic segmentations often useful
- ***Exogenous*** - what users and customers want changes over time in response to, amongst other things, their own changing circumstances and broad societal shifts
- ***Endogenous*** - users and customers' beliefs and behavior also change in response to technological innovation – information about new possibilities

Conventional approaches to market research are less effective when products are more novel

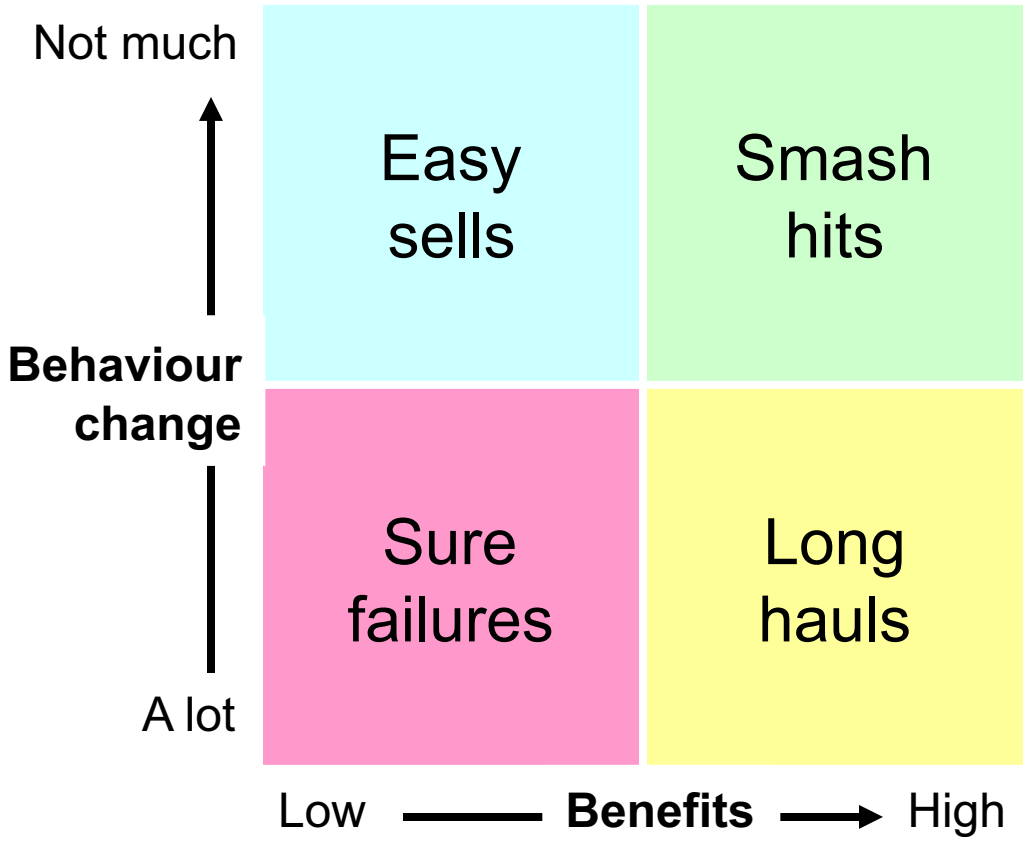
- Focus groups
- Market surveys
- Concept tests
- Conjoint studies
- Test markets

It's not easy to get customers to adopt novel products that embody technological innovation

- Most customers, most of the time are loath to change their behavior
  - requires investment of time and effort
  - involves uncertainty, induces anxiety
- Customers are (necessarily) unfamiliar with novel products and their potential benefits
- Novel products almost always involve ***trade-offs***
- They evaluate products based on **perceived** value, relative to products they already use to do a job, and are overly sensitive to dis-benefits - ***"loss aversion"***
- At the same time, businesses (full of technologists) tend to underestimate the switching costs, and overestimate the potential benefits

John Gourville, "Eager Sellers and Stony Buyers", Harvard Business Review, June 2006, pages 98-106

So we find ourselves with eager sellers and stony buyers



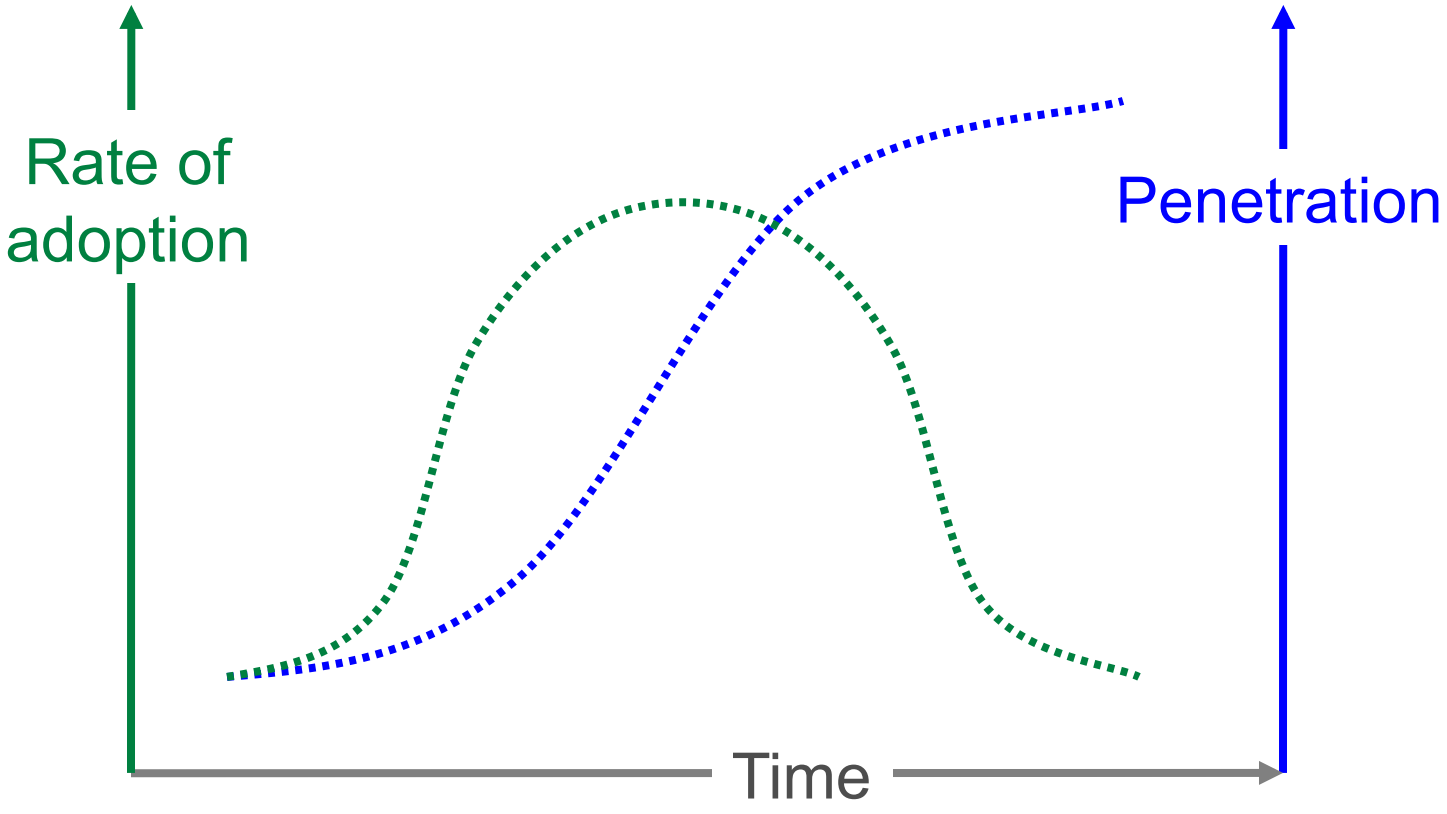
John Gourville, "Eager Sellers and Stony Buyers", Harvard Business Review, June 2006, pages 98-106

Over time, however, successful innovations diffuse amongst users and get widely adopted

- ***Probit*** adoption
  - potential users or customers weigh costs and benefits
  - ***heterogeneity*** of preferences means that different users or customers adopt at different times
- ***Epidemic*** adoption
  - adoption limited by availability of information
  - as potential users and customers become aware of what it does and how to use it, they will adopt
- ***Information cascades*** and ***path dependence***
  - a technology becomes established, it works and is better, and its features well known, legitimizing it
  - once established, network effects take over

Paul Geroski, "Models of technology diffusion", Research Policy, 2000 pages 603-625

Diffusion of innovations



One widely used model for the diffusion of innovations is the 'Bass model'

$$S(t) = [p + (q/m)N(t-1)][m - N(t-1)]$$

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S(t): customers adopting during time period *t*

N(t): customers who have adopted through time period *t*

N(t-1): customers who have adopted through time period *t-1*

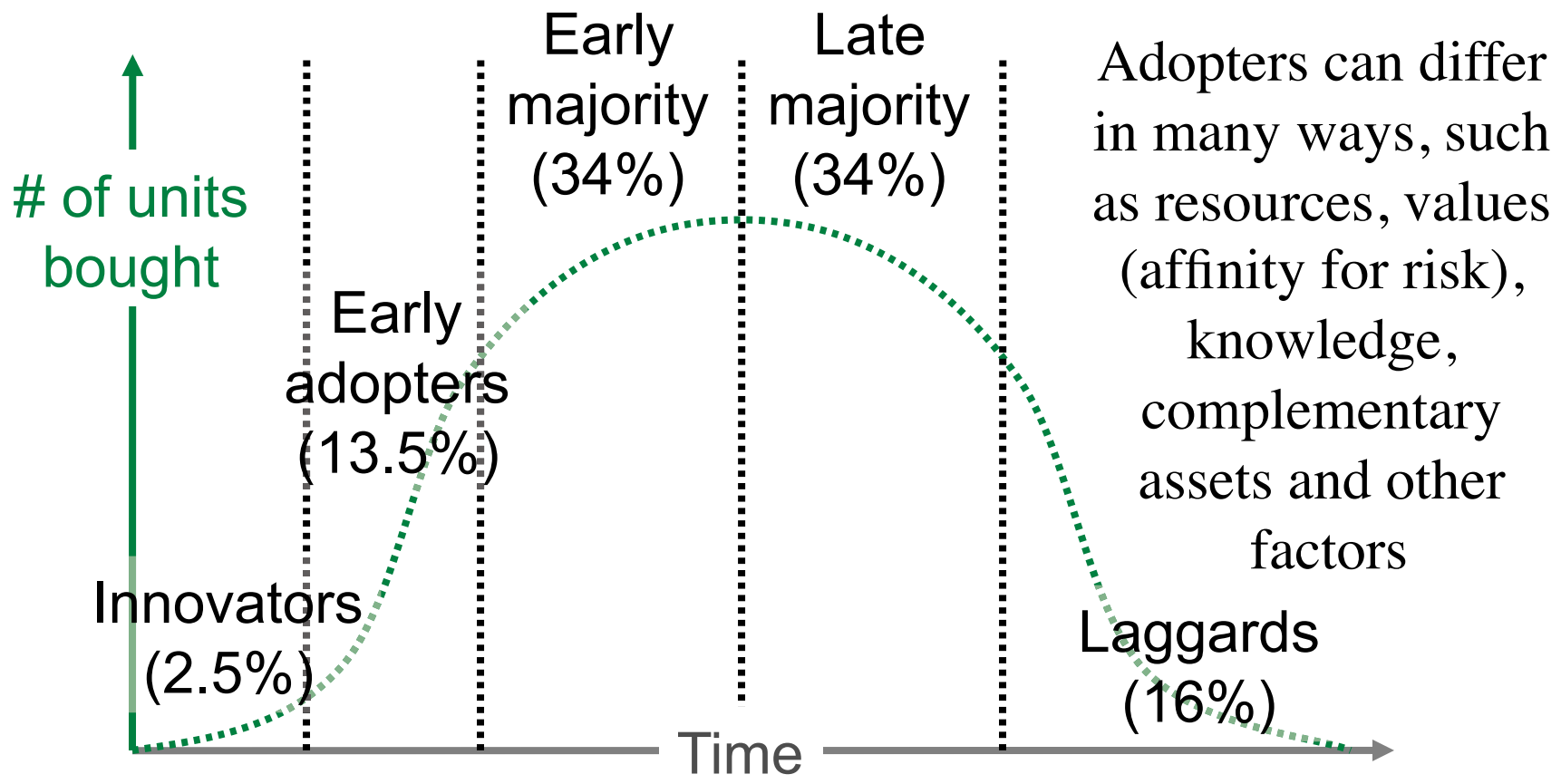
m: total market size

p: coefficient of innovation, probability that an innovator will adopt at time *t*

q: coefficient of imitation, accounts for diffusion of information

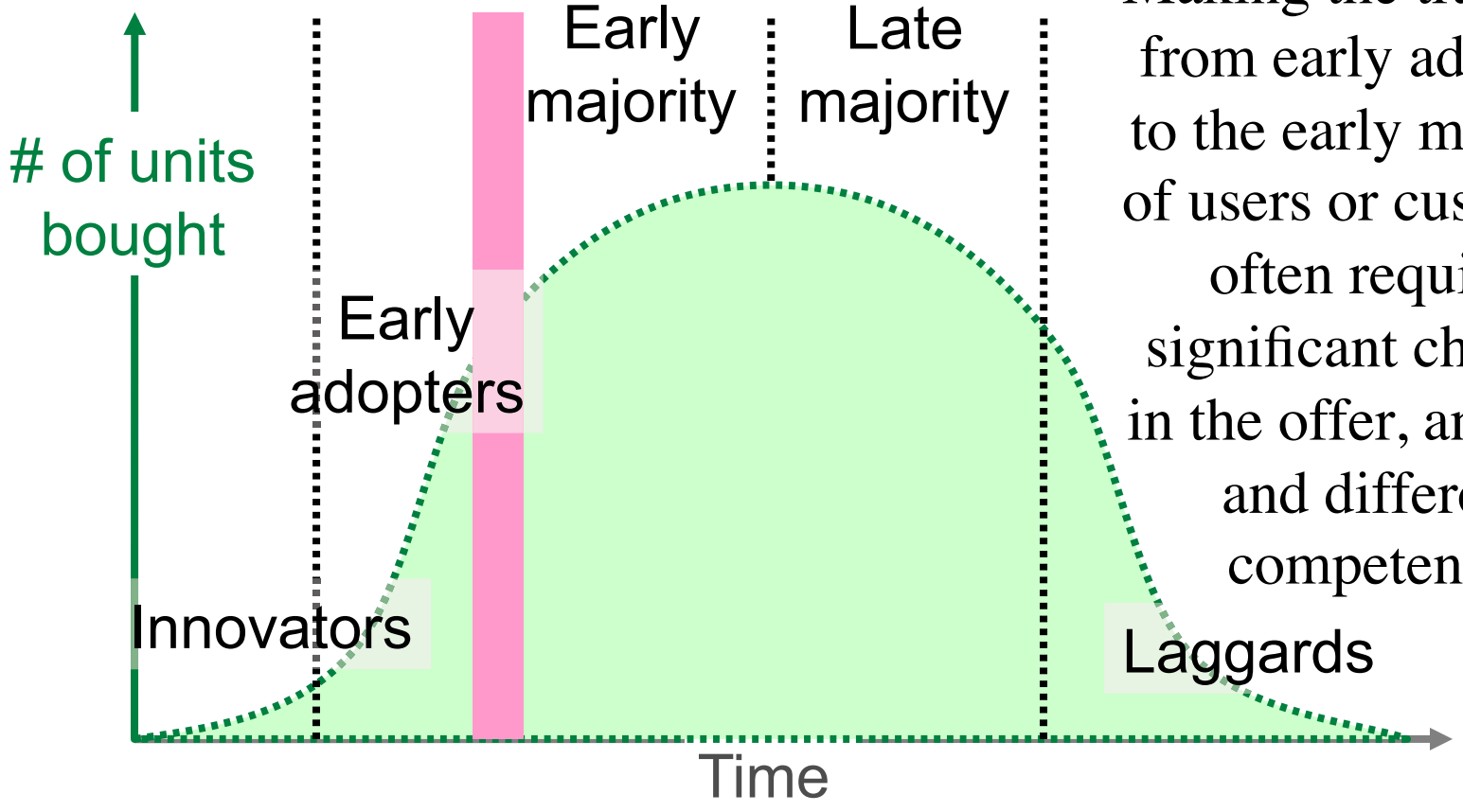
Frank Bass, "A new product growth model for consumer durables", Management Science Volume 15, Issue 5, 1969 pages 215–227

Everett Rogers' segmentation



Everett Rogers, "Diffusion of Innovations", 5th Edition, Free Press, New York, NY, 2003

Geoffrey Moore's *chasm* focuses on *psychographic* characteristics of users or customers



Making the transition from early adopters to the early majority of users or customers often requires significant changes in the offer, and new and different competences

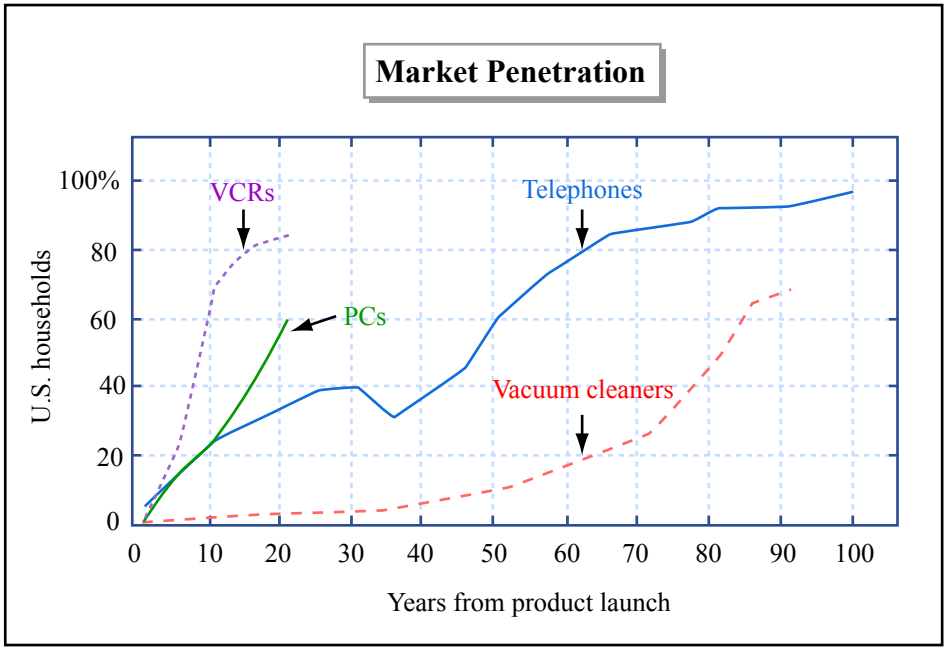
Everett Rogers identified five product-based factors that governed the rate of diffusion

- ***Relative advantage*** - the degree to which a product is better than the product that it replaces

- ***Compatibility*** - degree to which product is consistent with users' context, in particular values and experiences
- ***Complexity*** - degree to which a product is difficult to understand and use

- ***Trialability*** - the degree to which a product may be experimented with on a limited basis
- ***Observability*** - the degree to which product usage and impact are visible to others

As a result of these factors, the rate at which new technologies diffuse can vary widely



Fernando Suarez and Gianvito Lanzolla, "The Half-Truth of First-Mover Advantage", Harvard Business Review, April 2005, pages 121-127

What can you to do drive rapid adoption of novel products?

Accept Resistance

- Be patient
  - anticipate a long drawn out adoption process
  - manage accordingly
- Strive for ≥10x gain
  - make the relative benefits so great they overcome customers' overweighting of potential losses

Minimize Resistance

- Target non-users
  - don't use products now, no change needed
  - the unendowed
- Target customer segments whose behavior change is minimal, who don't give up sp much
- Make behaviorally compatible products

Unfortunately, you can't figure out what the demand opportunity is by asking customers…

- "…customers can say what they want if they are asked to make selections within a familiar product category"
- "But when customers are asked to make new product recommendations or to venture into territory about which they have limited or no knowledge, they…run into…blocks"
  - " 'functional fixedness' – the human tendency to fixate on the way products or services are normally used, making people unable to imagine alternative functions"
  - "…people may not be able to conceive of a solution because they have apparently contradictory needs"

Anthony Ulwick, "Turn Customer Input into Innovation", Harvard Business Review, Volume 80, January 2002, pages 91-97

"What customers can't tell you might be just what you need to develop successful new products"

- "It is the additional information gained from seeing your customers actually use your product or service in their own physical environment that makes empathic design an imperative"

- Triggers of Use
- Interactions with the User's Environment
- User Customization
- Intangible Attributes of the Product
- Unarticulated User Needs

Dorothy Leonard and Jeffrey Rayport, "Spark Innovation through Empathic Design", Harvard Business Review, Volume 75, Issue 6, November/December 1997, pages 102-113

What's the difference between conventional inquiry and empathic observation?

Inquiry	Observation
People can't ask for what they don't know	Well-chosen observers know what's technically possible
People are generally highly unreliable reporters of their own behavior	Observers rely on real actions rather than reported behavior
People tend to give answers they think are expected or desired	Observers can use nonverbal cues of feelings and responses through body language, in addition to spontaneous, unsolicited comments
People are less likely to recall their feelings about intangible characteristics of products and services when they aren't in the process of using them	Using the actual product or a prototype, or engaging in the actual activity, stimulates comments about intangibles associated with the product's use
People's imaginations – and hence desires – are bounded by experience; they accept inadequacies and deficiencies as normal	Trained, technically sophisticated observers can see solutions to unarticulated needs
Questions are often biased and reflect inquirers' unrecognized assumptions	Observation is open ended and varied; trained observers cancel outbiases
Questioning interrupts the usual flow of people's natural activity	Observation interrupts normal activities less than questioning does
Questioning stifles opportunities for users to suggest innovations	Observers in the field can identify user innovations that can be duplicated and improved for the rest of the market

Dorothy Leonard and Jeffrey Rayport, "Spark Innovation through Empathic Design", Harvard Business Review, Volume 75, Issue 6, November/December 1997, pages 102-113

The process of empathic design typically involves five steps

1. Observation
   - who should be observed?
   - who should do the observing?
   - what behavior should be observed?
   - when and where should it be observed?
2. Capturing Data
3. Reflection and Analysis
4. Brainstorming for Solutions
5. Developing Prototypes of Possible Solutions

Dorothy Leonard and Jeffrey Rayport, "Spark Innovation through Empathic Design", Harvard Business Review, Volume 75, Issue 6, November/December 1997, pages 102-113

Think about the job, to get to product-independent motivation, and the total customer experience

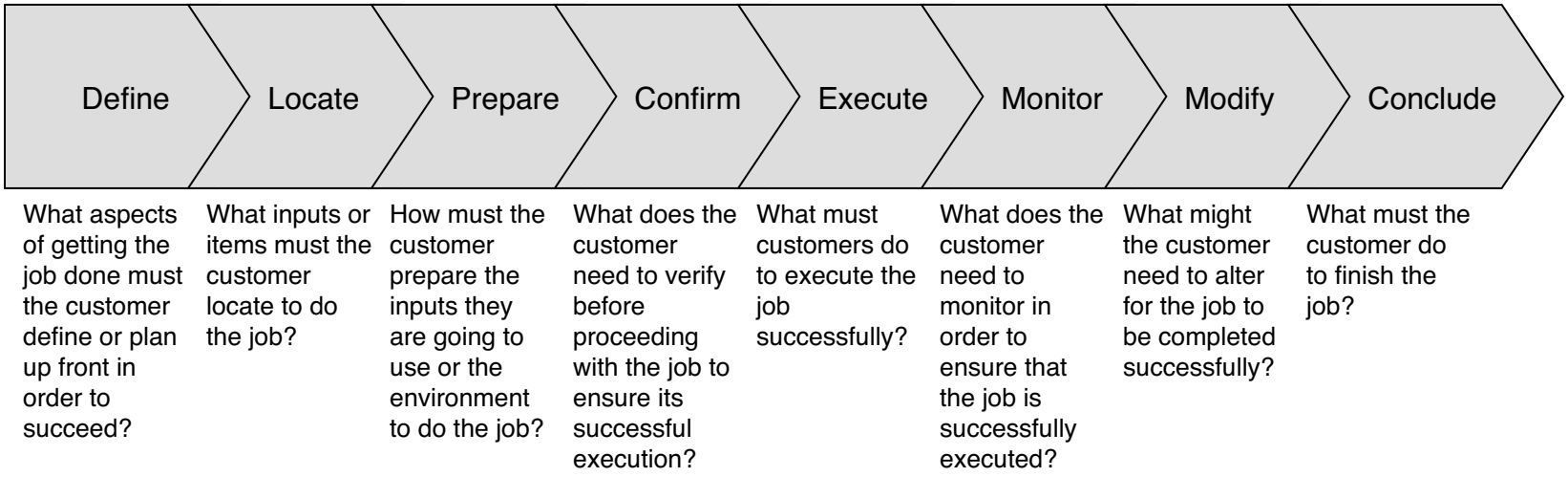
Image removed due to copyright restrictions

Clayton Christensen and David Sundahl, "Getting the Job Done: Matching the Right New Product with the Right Market", Harvard Business School Working Paper 02-025, 2001

There are three distinct types of inputs that are helpful in doing this

Jobs to be Done	Desired Outcomes	Constraints
Customers buy products and services when they need help in getting a job done	Customers may want to get a specific job done better, more easily or more effectively	Customers may need help to overcome constraints that inhibit them from getting a job done

This may involve detailed mapping of the complete process by which the job gets done



Lance Bettencourt and Anthony Ulwick, "The Customer-Centered Innovation Map", Harvard Business Review, Volume 86, May 2008, pages 109-114

One way to develop breakthrough products is to work with 'lead users'

- For very novel products or in product categories in which change is rapid, most potential users will not have the experience needed to solve problems or articulate their needs
- ***'Lead users'*** however have present strong needs ***that will become general*** in a marketplace in the future

Eric von Hippel, "Lead Users: A Source of Novel Product Concepts", Management Science, Volume 32, Issue 7, July 1986, pages 791-805

New technologies now enable companies to work directly with customers to innovate new products

Image removed due to copyright restrictions

Stefan Thomke and Eric von Hippel, "Customers as Innovators: A New Way to Create Value", Harvard Business Review, Volume 80, April 2002, pages 67-75

Demand opportunity: summary

- Novel products
  - can't ask customers
  - needs change
- Adoption and penetration
- Potential benefits *versus* behavioral change
- Perceived value, relative to current reference
- "Loss aversion"
- Probit and epidemic adoption
- Bass curve
- Product-based factors
  - relative advantage
  - complexity and compatibility
  - trialability and observability
- Accept or minimize resistance
- Use empathic design
- Get to product-independent motivation and the total customer experience
- Jobs to be done
- Desired outcomes
- Working with lead users
- Customers as innovators

Second Short Paper: Demand Opportunity

- What are they key **customer segments** and **potential applications** for these technologies?
- What **jobs** can customers use it to get done?
- How have **customer needs evolved** over time?
- What are the key factors in **diffusion and adoption** in this domain now?
- What do you **anticipate** that they will be in the future?
- What **strategies** have been adopted to market products within this domain, and to drive adoption and diffusion?

15.965 Technology Strategy for System Design and Management

Spring 2009