15.356
Creating "breakthrough" products and services

Professor Eric von Hippel
MIT Sloan School of Management

MITSloan

Agenda

- Introduction
- Who really develops breakthroughs?
- Course Structure & Logistics

Who am I?

- Head of the Technological Innovation and Entrepreneurship Group (TIE) at Sloan
- You may find it comforting to know that I have real-world innovation experience as a venture co-founder and R&D manager
- Research focus: The "fuzzy front end" of the innovation process – how it works, how to make it better.
- Studies in: Industrial products (like semiconductors); consumer products (sports equipment); OS software

Periodic MAJOR innovation is essential: everything becomes a commodity eventually – and may even be entirely supplanted.

Hot and proprietary once – now commodities:

- 3M transparent "Scotch" tape.
  Marginal improvements kept it going for decades:
  >>Decorated "gift tape," write-on tape, double-sided tape.

- Aspirin >> Buffered, coated, child-sized, liquid…

Once hot – now entirely gone:

- Battleships, record-players…

"Breakthrough" vs incremental innovation

- A "breakthrough" innovation, as we use the term, is the *first member* of a major new product line in a firm:
  - The first gas-chromatograph (GC)
  - The first masking tape
- "Incremental" innovations are improvements to existing product lines
  - Improved GC
  - Improved masking tape

Why a course on developing breakthroughs?

Because:

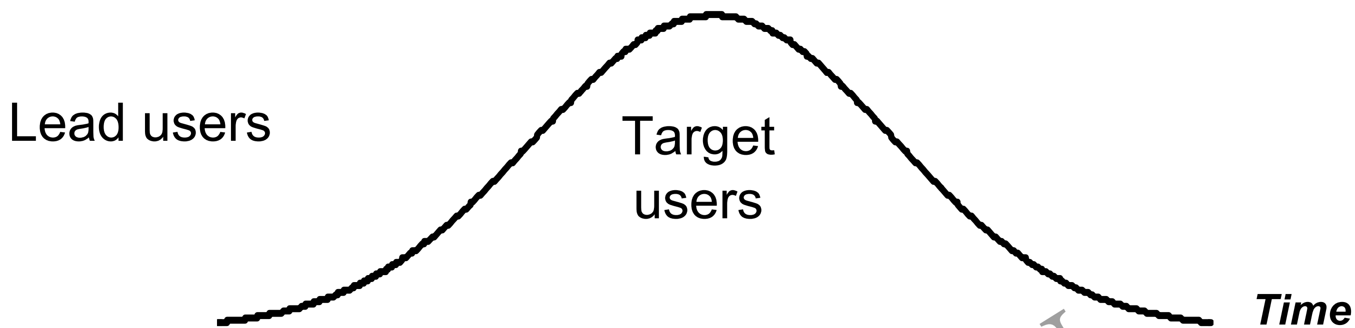
- Periodic breakthroughs are ESSENTIAL to firms
- Firms are (pretty) good at incremental innovation – but they don't know *how* to develop breakthroughs systematically
- Result: major innovations are often very rare and desperately sought by management:
  - In 5 3M Divisions studied less than 1 new product line introduced per Division every 2 years on average

Introducing major innovation is not easy even when you understand the principles: Innovation is both essential and *UNWANTED*

- Change is disruptive – to be avoided if possible
- Change obsoletes corporate expertise and production investments
  - Polaroid produces instant film and cameras – not digital!
  - Kodak produces film – not digital cameras!
- Change devalues personal “intellectual property”
  - I know Cobol – not C++!
  - I know tubes – not transistors!
  - I know manned aircraft – not drones!

Contrasting innovation methods

Need and market life cycle curve



New methods are based on finding / encouraging and commercializing ***solutions*** developed by users themselves

Traditional methods are based on "find a need and fill it" (Target users provide ***needs***; Manufacturer develops solutions)

Essential Definitions

The “functional” source of innovation depends upon the *functional* relationship between innovator and innovation:

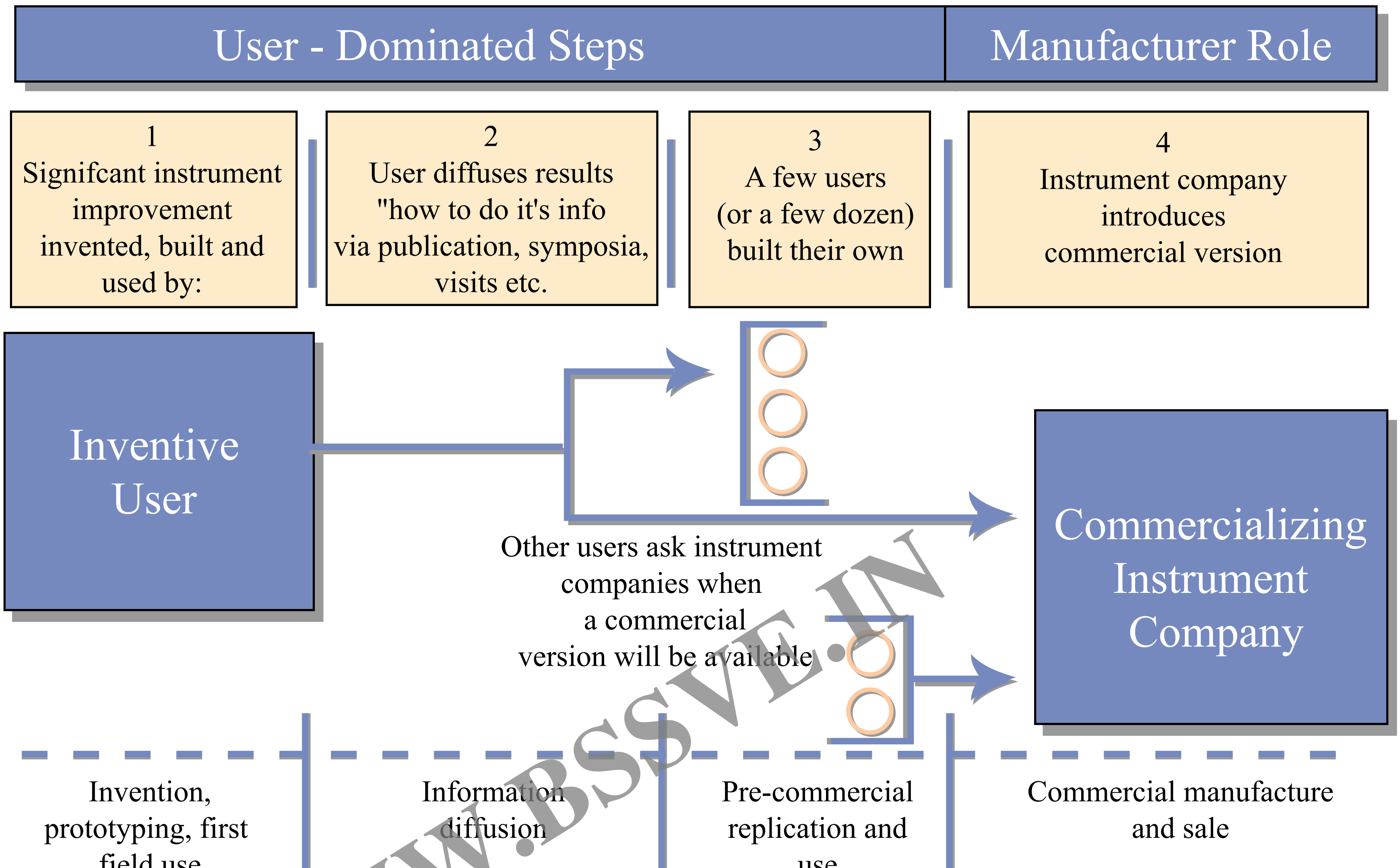
– An **INNOVATION** is anything new that is actually used (“enters the marketplace”) – whether major or minor.

– An innovation is a **USER innovation** when the developer expects to benefit by USING it;

– An innovation is a **MANUFACTURER innovation** when the developer expects to benefit by SELLING it.

How we discovered that users develop many major new products

Innovations Affecting	First Device	Major Improvement	Minor Improvement
Gas Chromatography	1	11	-
Nuclear Magnetic Resonance Spectrometry	1	14	-
Ultraviolet Spectrophotometry	1	5	-
Transmission Electron Microscopy	1	14	63
Total	**4**	**44**	**63**



This diagram is based on: von Hippel, Eric. "The Dominant Role of Users in the Scientific Instrument Innovation Process." *Research Policy* 5, no. 3 (July 1976): 212-39.

First device used in field developed and built by:

Innovations Affecting	% User	User	Mfg.
Gas Chromatography	83%	10	2
Nuclear Magnetic Resonance Spectrometry	80%	12	3
Ultraviolet Spectrophotometry	100%	6	0
Transmission Electron Microscopy	72%	44	17
Total	**77%**	**72**	**22**

Gammaflow:

A Completely Automated Radiommunoassy System

(This image is available in *Science*, Vol. 194, October 1976.)

(Photograph of a Washington state police car with a system of air tubes attached to it. It is a homemade, lead user solution to the problem of volcanic ash damaging its engine.)

- UPI Photo, May 26, 1980.

(Photograph of a unique method of irrigation in Kufra, using a center-pivot system that creates large circular fields.)

(Close-up photographs of the system that supplies water to fields using the center-pivot system.)

The World Wide Web – A User Innovation

"Berners-Lee did not set out to invent a contemporary cultural phenomenon; rather, he says, "it was something I needed in my work." He wanted to simply to solve a problem that was hindering his efforts as a consulting software engineer at CERN.

Berners-Lee's innovation was to apply hypertext to the growing reality of networked computers. He expanded the idea he had developed at CERN and made it available on the Internet in the summer of 1991.

Technology Review, July 1996, p.34

Examples of Important Consumer Product Innovations

Category	Example
Health Products	Gatorade
Personal Care	Protein-base Shampoo Feminine Hygiene
Sports Equipment	Mountain Bike Mountain Climbing-Piton
Apparel	Sports Bra
Food	Chocolate Milk Graham Cracker Crust
Office	White-out Liquid
Computer Application Software	Electronic Mail Desk Top Publishing

Exercise: identify your own examples of user innovation

1. Think of your experiences in a firm.
   - Did a product modification by a **customer** come to your attention?
   - Did your firm modify a product sold to you or develop a new one for in-house use?

2. Think of your experiences as a consumer in a field you really care about (a sport? type of cooking?)
   - Did you ever modify a commercial product you bought?
   - Did you ever use a product in a new way?

History of "AOL Instant Messenger"

Instant Messaging is a User Innovation

- By 1987 MIT Lab for Computer Science had thousands of "Athena" workstations online and difficulties diffusing system admin info rapidly. Developed "Zephyr" instant message system.
- MIT students begin to use for general instant messaging.
- Other universities adopted Zephyr-like programs

First Commercial Product 9 years later

- 1996 Israeli firm Mirabilis put out comml product ICQ
- 1998 Mirabilis acquired by AOL

Source: Rapp, David. "I've Got to Get a Message to You." *Technology Review*, October 2002.

Ongoing evolution of Wi-Fi

User Activities to Date

- Users discover possibilities and begin free sharing of wireless networks
- Users Modify Wi-Fi antennas to greatly increase range
- Widespread implementation occurs – travelers find “hot spots” as they travel, can get Internet access, send e-mail from the highway etc.

Traditional Supplier Responses?

- No one will want it – no network security
- We think this might be service stealing… should stop.

Source: October 2002 *Technology Review*

User and Manufacturer Innovations Differ

Users tend to develop **Functionally Novel** innovations:

- The first sports-nutrition bar
- The first scientific instrument of a new type

Manufacturers tend to develop **Dimension of Merit Improvements:**

- A better-tasting sports-nutrition bar
- Improvements to an existing type of scientific instrument

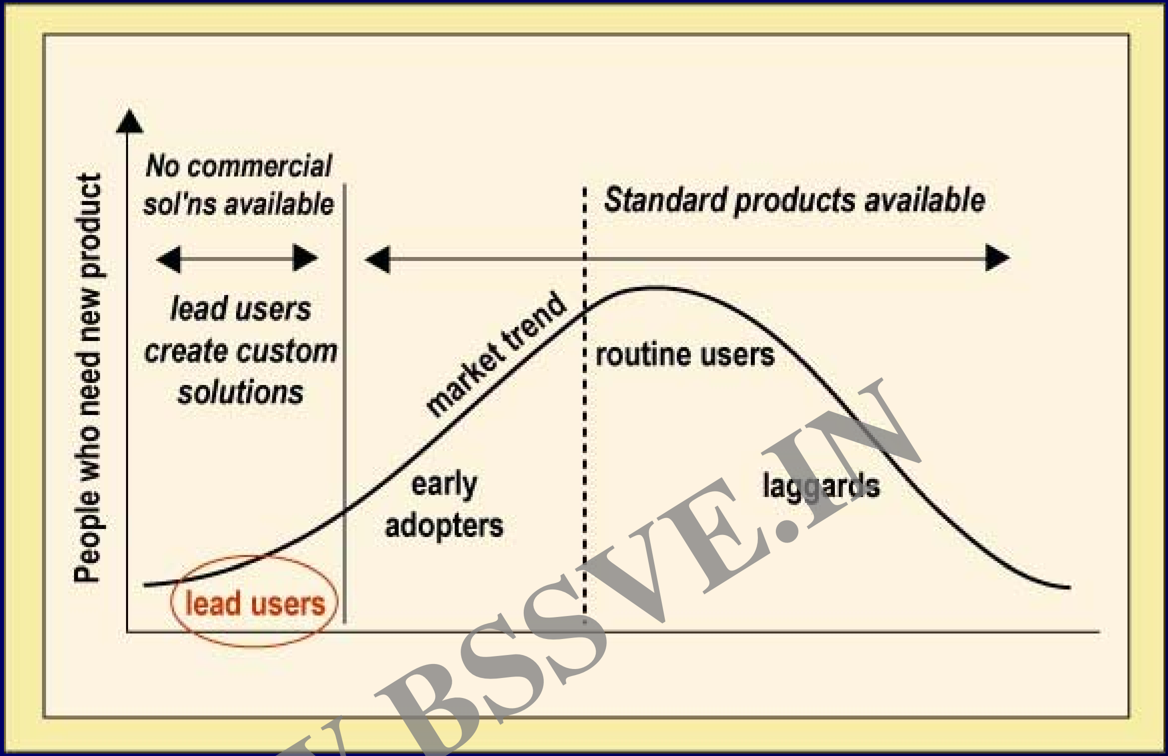
Users innovate when it pays… for them

Only "Lead User" innovations form the basis for new products and services of value to manufacturers.

"Lead Users" are users that:

1. Have needs that ***foreshadow general demand*** in the marketplace;
2. Expect to ***obtain high benefit*** from a solution to their needs. (Such users are more likely to innovate – "Necessity is the mother of invention!")

Lead users at leading edge of curve



Adopter Categorization According to Innovativeness

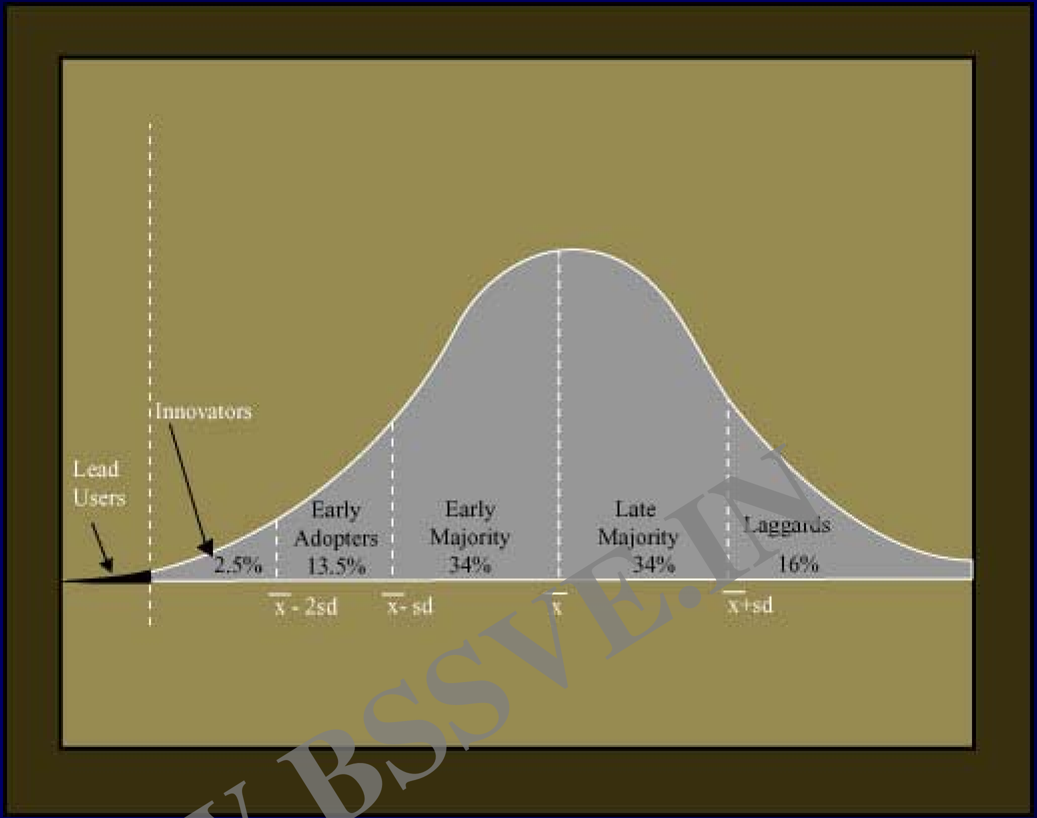


Diagram based on: Rogers, E. M. *Diffusion of Innovations*. New York: Free Press, p. 182.

Course topics

- Where breakthroughs come from and why
- Finding lead users – and their innovations
- Conventional market research – the path to incrementalism
- Brainstorming and creativity
- Build it and they will come (MIT Media Lab)
- Ethnographic methods
- Why users reveal their innovations
- Toolkits for user innovation
- User innovation communities
- Resistance to innovation

Course logistics

- The Wait List
- Grading:
  - Class attendance and participation 50%
  - Two mini-papers (7 pages) 50%
- For each paper:
  1. Choose a topic covered in this class that especially interests you.
  2. Briefly explain topic Devote 1-2 pages to this. No extra reading needed here: derive from class lectures and discussions, assigned readings and other sources of information that you may already have.
  3. Expand in the direction of your interest. Fine to draw in your personal experience and views in addition to findings from extra reading on the topic.

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The Lead User idea generation method

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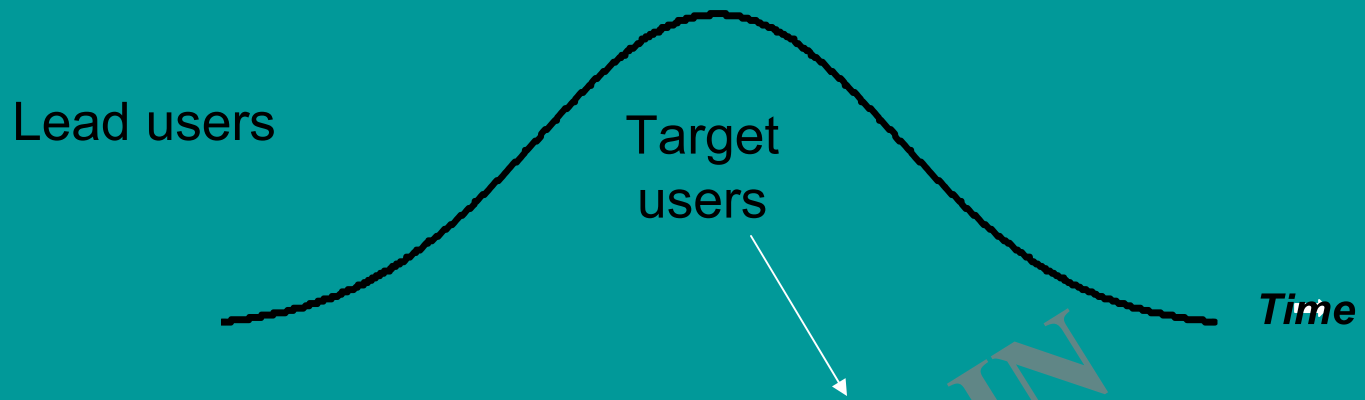

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Many industrial and consumer products have roots in user innovation.

Consumer product examples:

Category	Example
Health Products	Gatorade
Personal Care	Protein-base Shampoo Feminine Hygiene
Sports Equipment	Mountain Bike Mountain Climbing-Piton
Apparel	Sports Bra
Food	Chocolate Milk Graham Cracker Crust
Office	White-out Liquid
Software	Electronic Mail, Desk Top Publishing

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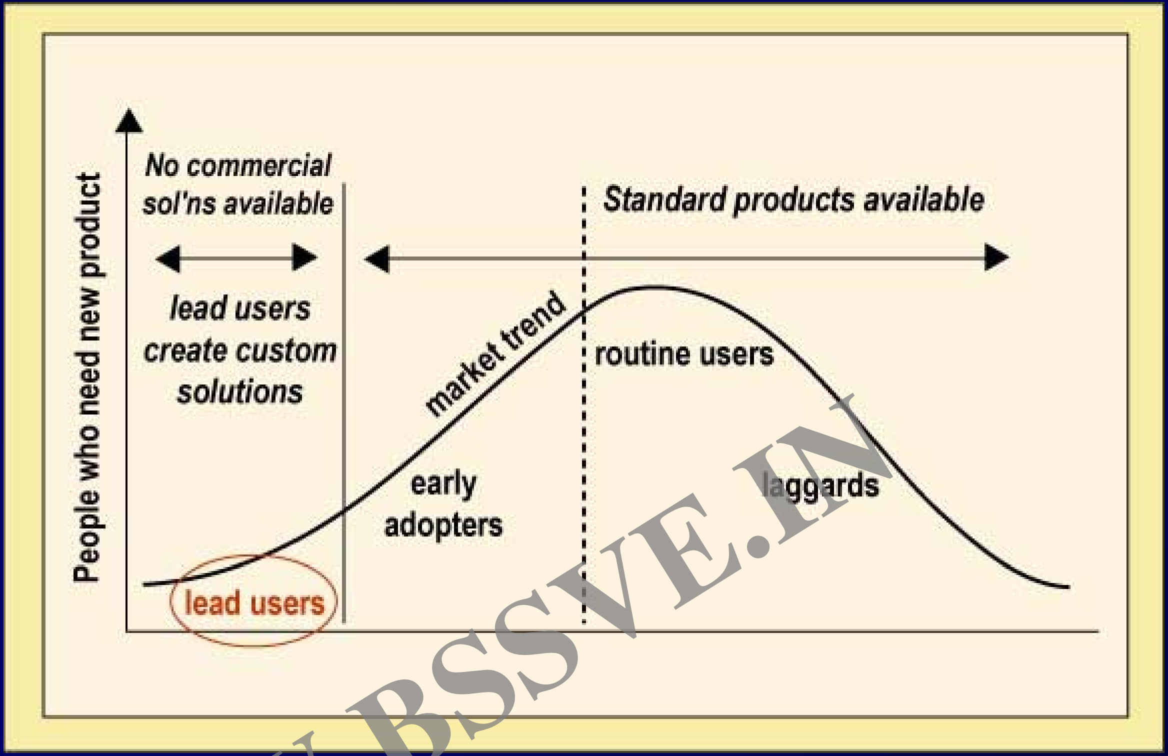
Lead users at leading edge of "need curve"



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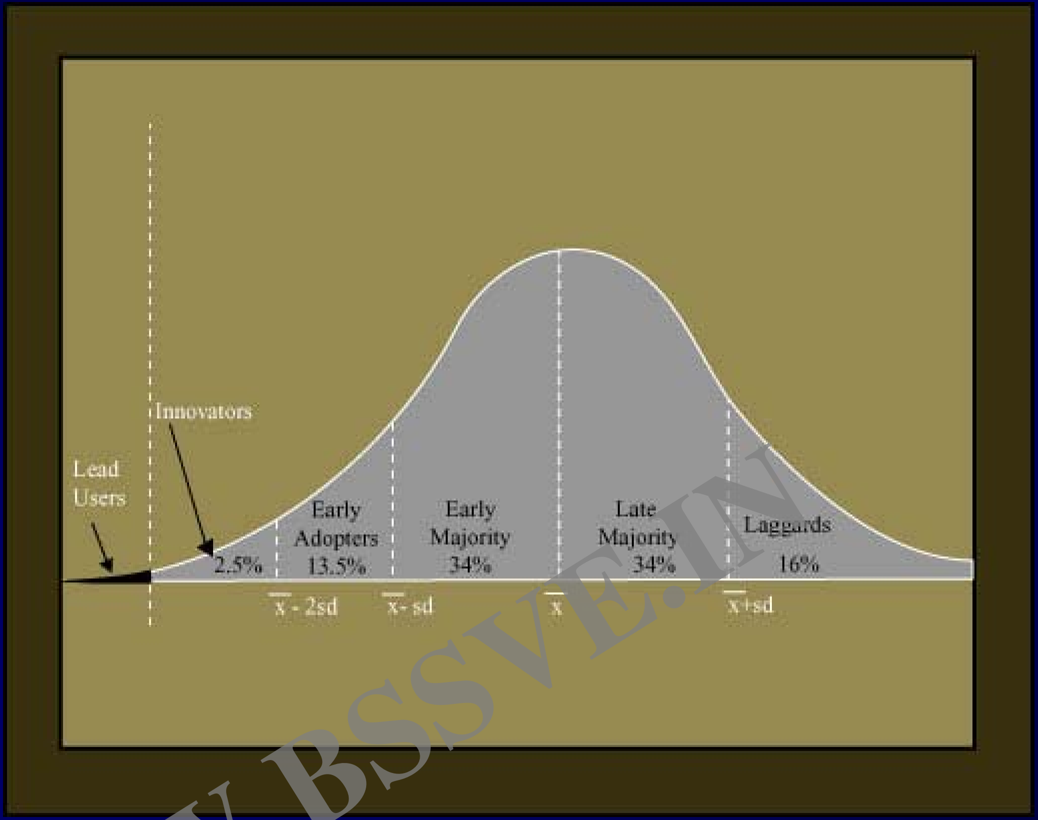
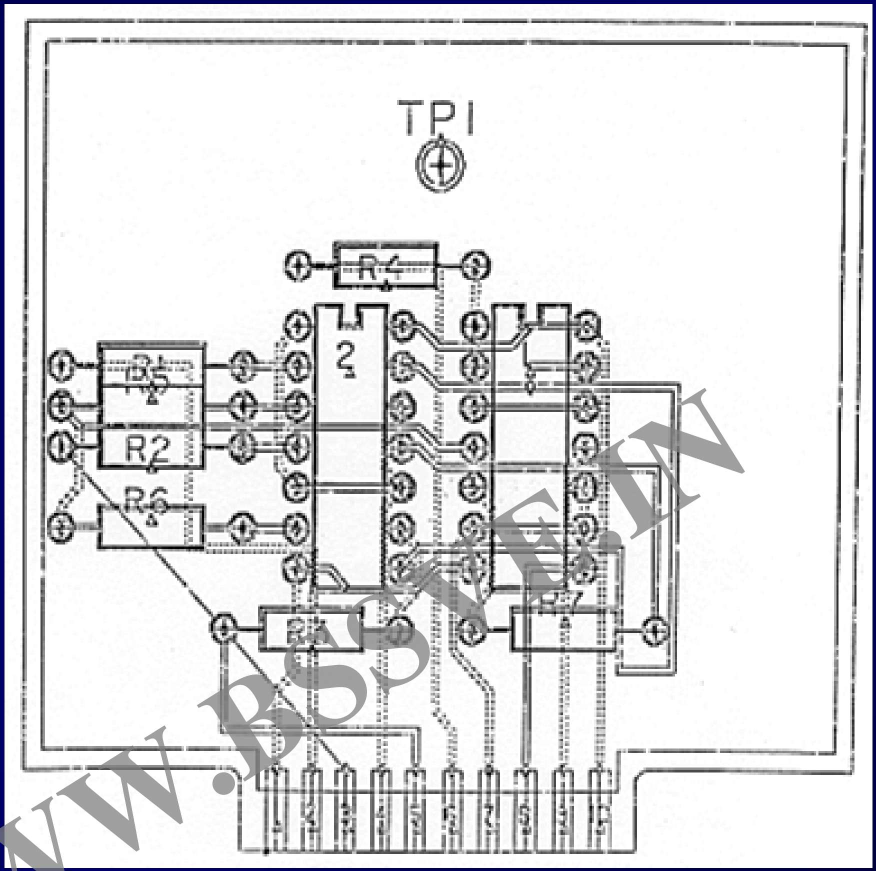


Diagram based on: Rogers, E. M. *Diffusion of Innovations*. New York: Free Press, p. 182.

Product area selected for pilot test of lead user methods:

Computer-Aided-Design systems
Used to lay out printed circuit boards (PCB-CAD)



In PC-CAD Lead Users were innovating - Routine Users were not

Expected Lead User Attribute	Type of Questions We Asked	LEAD Users	Routine Users
At Front of "High Density" Trend?	What are your:		
	• Avg. Number of layers?	6.8	4.1
	• Avg. Line width (mils)? (1988 data)	11	15
High Need For Improved System?	"Are you satisfied with your present PCB CAD system?	No	It's OK
Active In Solving Own Problem?	Did you build own PCB CAD System	82% Yes	1% Yes
Number in Sample		33	99

Based on: Urban, Glen L., and von Hippel, Eric. "Lead User Analyses for the Development of New Industrial Products." *Management Science* 34, no. 5 (May 1988): 569-82.

Consumer product innovators are lead users too

Sports equipment user Characteristics	Innovators	Non-innovators	Difference
Lead User Characteristic (1): Being Ahead of the Trend*			
"I improved or developed new techniques in my sport."	4.29	5.84	**p<0.001**
Lead User Characteristic (2): High Benefit from Innovation*			
"I have new needs which are not satisfied by existing products."	3.27	4.38	**p<0.001**
"I am dissatisfied with the existing equipment."	3.90	5.13	**p<0.001**

Sports equipment study: Franke and Shah (2003)
***7-point rating scale: 1 = very accurate; 7 = not accurate at all**

Based on: Nikolaus Franke & Sonali K. Shah, "How Communities Support Innovative Activities: Assistance and Sharing Among Sports Enthusiasts." Denver, CO: *Academy of Management,* Technology & Innovation Management Division (August 2002): Table 3.

Many lead users innovate

Industrial products	n	% innovating
Printed Circuit CAD	136	24.3%
Pipe Hanger Hardware	74	36%
Library IT Systems	102	26%
Software security features	131	19.1%
Surgical Equipment	262	22%
Consumer products		
Outdoor Products	153	9.8%
"Extreme" sports equipment	197	37.8%
Mountain biking equipment	291	19.2%

Table source: Franke, Nikolaus, and Eric von Hippel. "Finding Commercially Attractive User Innovations: An Exploration and Test of "Lead User" Theory." MIT Sloan School of Management Working Paper No. 4402-03, July 2003. Used with permission.

As innovator LU characteristics go up – so does innovation attractiveness

Figure 1:
Attractiveness of Innovations as a Function of the Lead User Construct

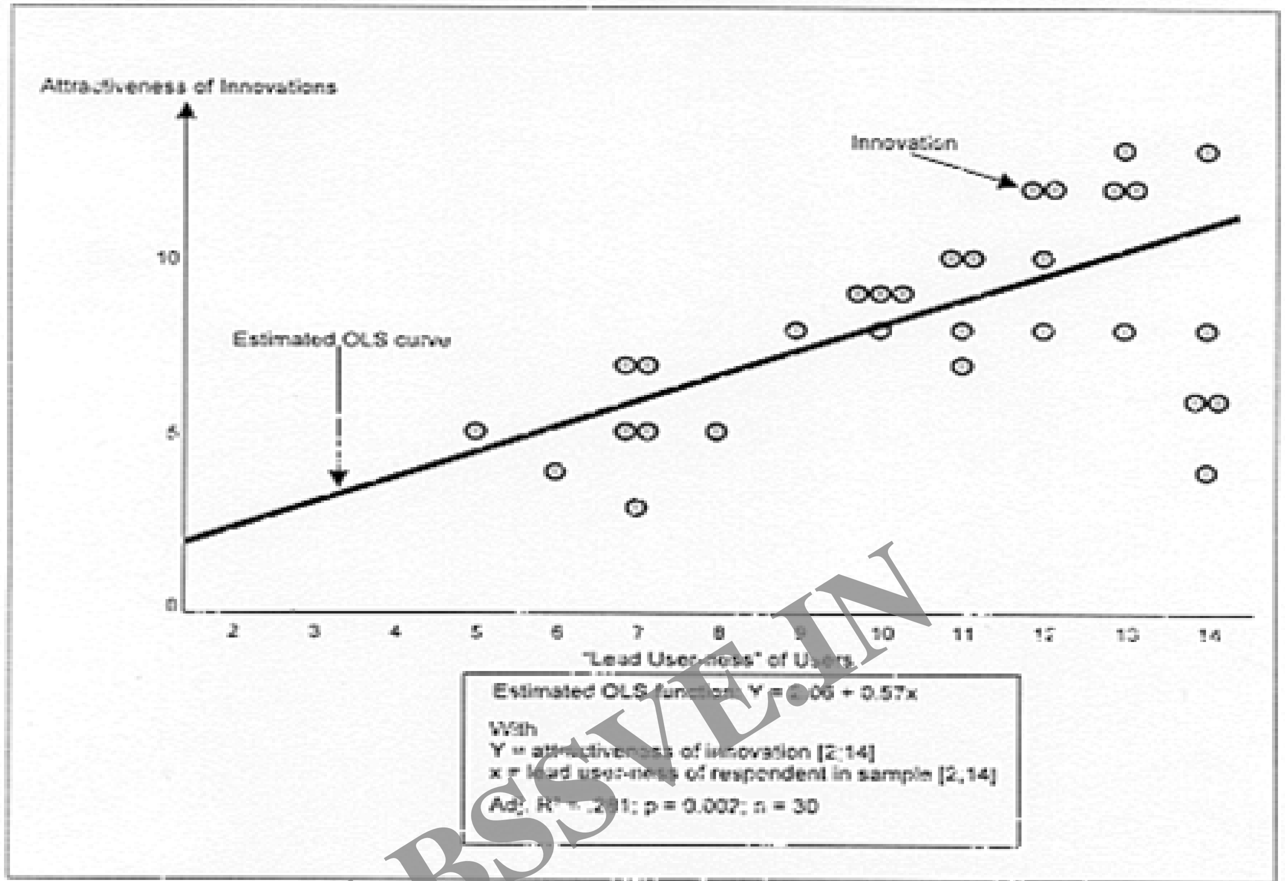


Figure 1 graphically summarizes two important findings. First, the increased concentration of innovations towards the right indicates that the likelihood of innovating is higher for users having higher lead user index values. Second, the rise in average innovation attractiveness as one moves from left to right indicates that innovations developed by lead users tend to be more attractive.

Source: Franke, Nikolaus, and Eric von Hippel. "Finding Commercially Attractive User Innovations: An Exploration and Test of "Lead User" Theory." MIT Sloan School of Management Working Paper No. 4402-03, July 2003. Used with permission.

Performance Assessment of Lead User Research at 3M

Research Team: Prof. Gary Lilien, Penn State University; Prof. Pam Morrison, University of New South Wales; Dr. Kate Searls, ASI Associates, Mary Sonnack, Division Scientist, 3M;

Prof. Eric von Hippel, MIT

(For the complete article and other Lead User Videos and articles: Go to leaduser.com on the Web)

For more information on the following 7 slides, see: Lilien, Gary L., Pamela D. Morrison, Kathleen Searls, Mary Sonnack, Eric von Hippel. "Performance Assessment of the Lead User Idea Generation Process." MIT Sloan School of Management Working Paper No. 4151, January 2001. *Management Science,* forthcoming.

Assessment Results: Lead User vs. Non-Lead User Funded Ideas

	LU Ideas (n=5)	NON-LU Ideas (n=42)	Sig.
"Newness" of Idea			
• Novelty compared to competition	9.6	6.8	0.01
• Newness of needs addressed	8.3	5.3	0.09
Projected Profitability			
• % market share in year 5	68%	33%	0.01
• Estimated sales in year 5	$146m	18m	0.00
Strategic Value			
• Strategic importance	9.6	7.3	0.08
• Fit with Strategic plan	9.8	8.4	9.24
Fit with Business			
• Intellectual prop. protection	7.1	6.7	0.80
• Fit with mfr. Capabilities	7.8	6.7	0.92
• Fit with distribution channels	8.8	8.0	0.61

Note: Items measured on 10 pt. Scale, 10=high, 1=low

Essential Definitions

"Breakthrough:"

- Determines Future Business Growth and Margins
- Major Product line >20% of Division Sales

Incremental improvement:

- Valuable to existing business
- Extension to existing line

	Incremental	Breakthrough
Traditional 3M Method	**41**	**1**
LU Method At 3M	**0**	**5**

Example of a LU innovation on 3M website

“3M's Major Innovations”

Commercialized 2001

- 3M ™ Inflata-Pak™ Air Cushion Packaging. This packaging eliminates the need for peanuts or bubble wrap while protecting fragile items for shipping. Made of tough, durable plastic, it conforms to odd shapes and seals itself.

Lead User concept generation projects cost more than traditional ones

	Person Days	Total Cost
Traditional 3M concept development stage	60	$30,000
Lead User concept development stage At 3M	154	$100,000 (plus coaching)

ACTIVITY: Think about possible Lead Users in *your* markets

Step 1 **Select a specific market & specific *major* trend to think about**

Step 2 **Brainstorm possible lead users *within* that target market**

- Which types of individuals or firms have needs at the leading edge of the trends?
- Which ones have a high incentive & the resources to solve their leading edge needs?

Step 3 **Brainstorm possible lead users *outside* target market**

- Which types of users in other fields & applications are facing a similar need but in a more demanding form?

Step 4 **Specify what you might learn from each type of LU**

Example of searching for lead users *outside* your target market

Medical X-Ray

Instead of a "board of leading radiologists"...

Look for users facing *higher* needs than anyone in target market:

People who need even high resolution than anyone doing medical imaging

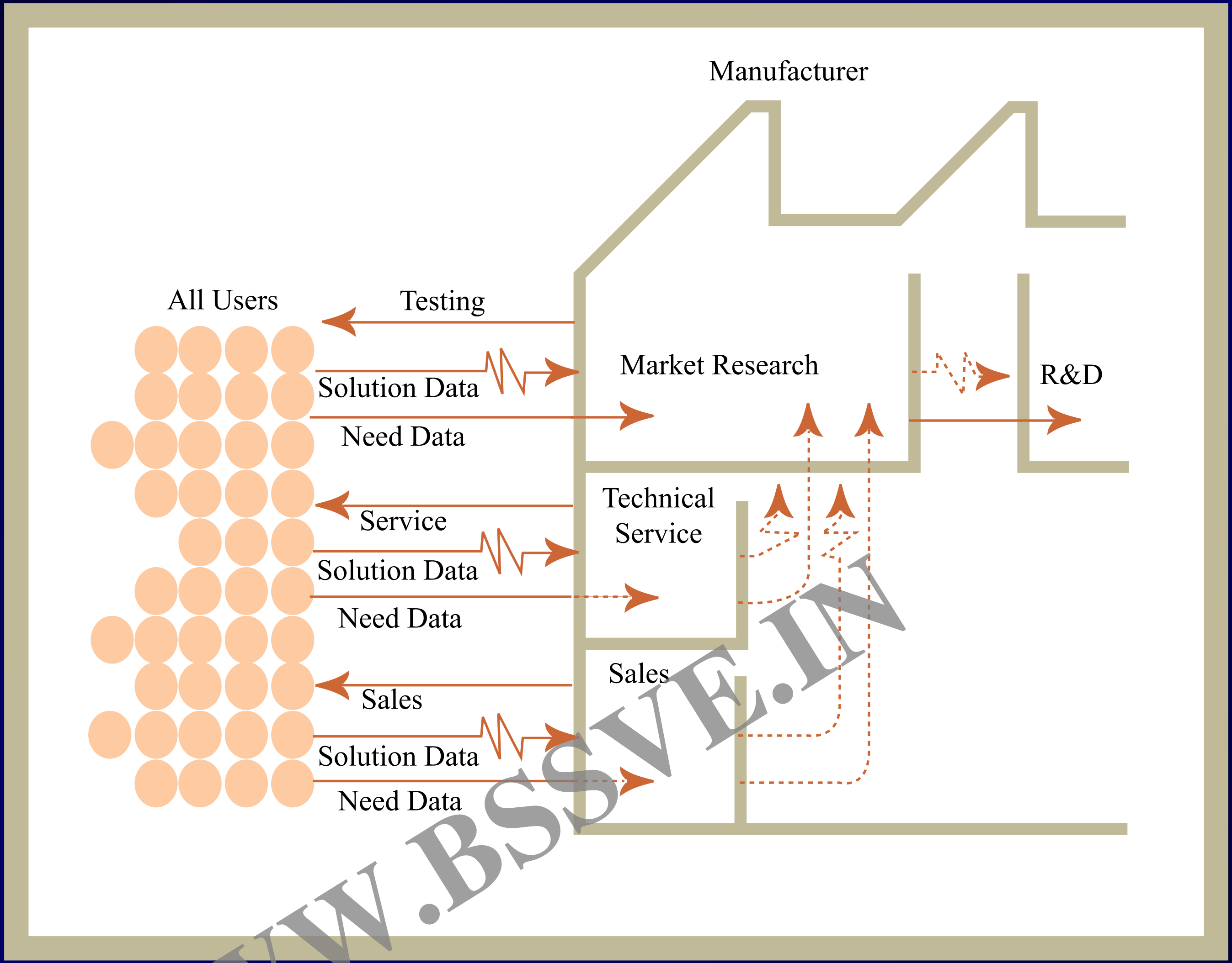
Image enhancement ("pattern recognition") specialists

Examples:

Experts in semiconductor chip imaging

Experts who process photographs from space probes

Organizing to use the LU Method



Finding out what users *really* need: “trial and error” and “sticky information”

Professor Eric von Hippel

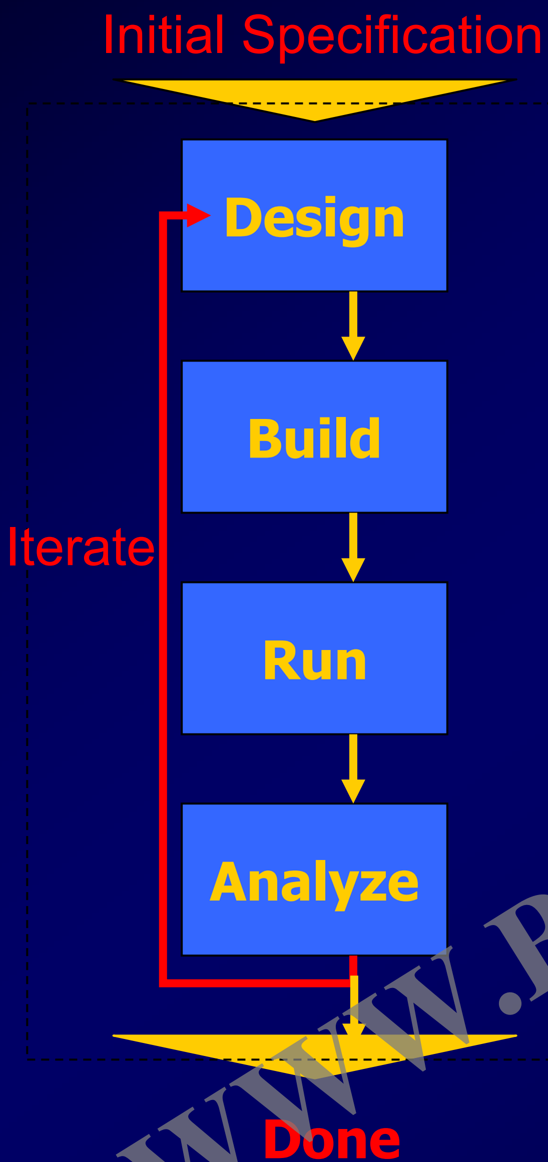
MIT Sloan School of Management

Innovation is:

1. A problem-solving process based upon directed trial-and-error

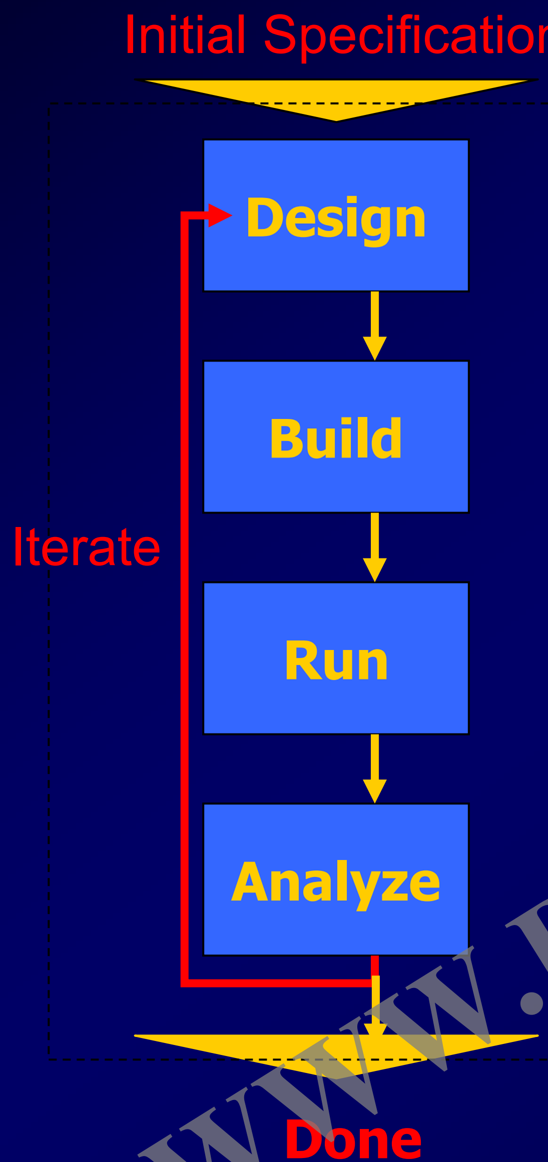
2. Carried out at the site of “sticky information”

Trial and error is THE fundamental problem-solving process



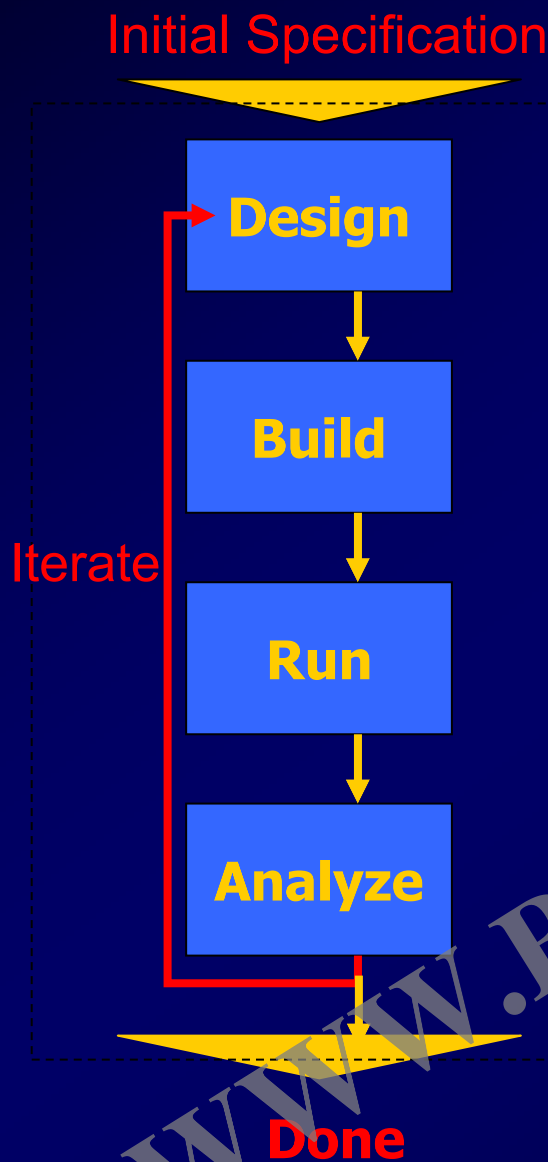
- Start by designing what you THINK will work (*directed* T&E)
- Develop a thought experiment, a simulation or a prototype
- Test your design in a real or simulated use environment
- Analyze what happened, revise your design, try again till satisfied

Directed trial and error is THE fundamental problem-solving process



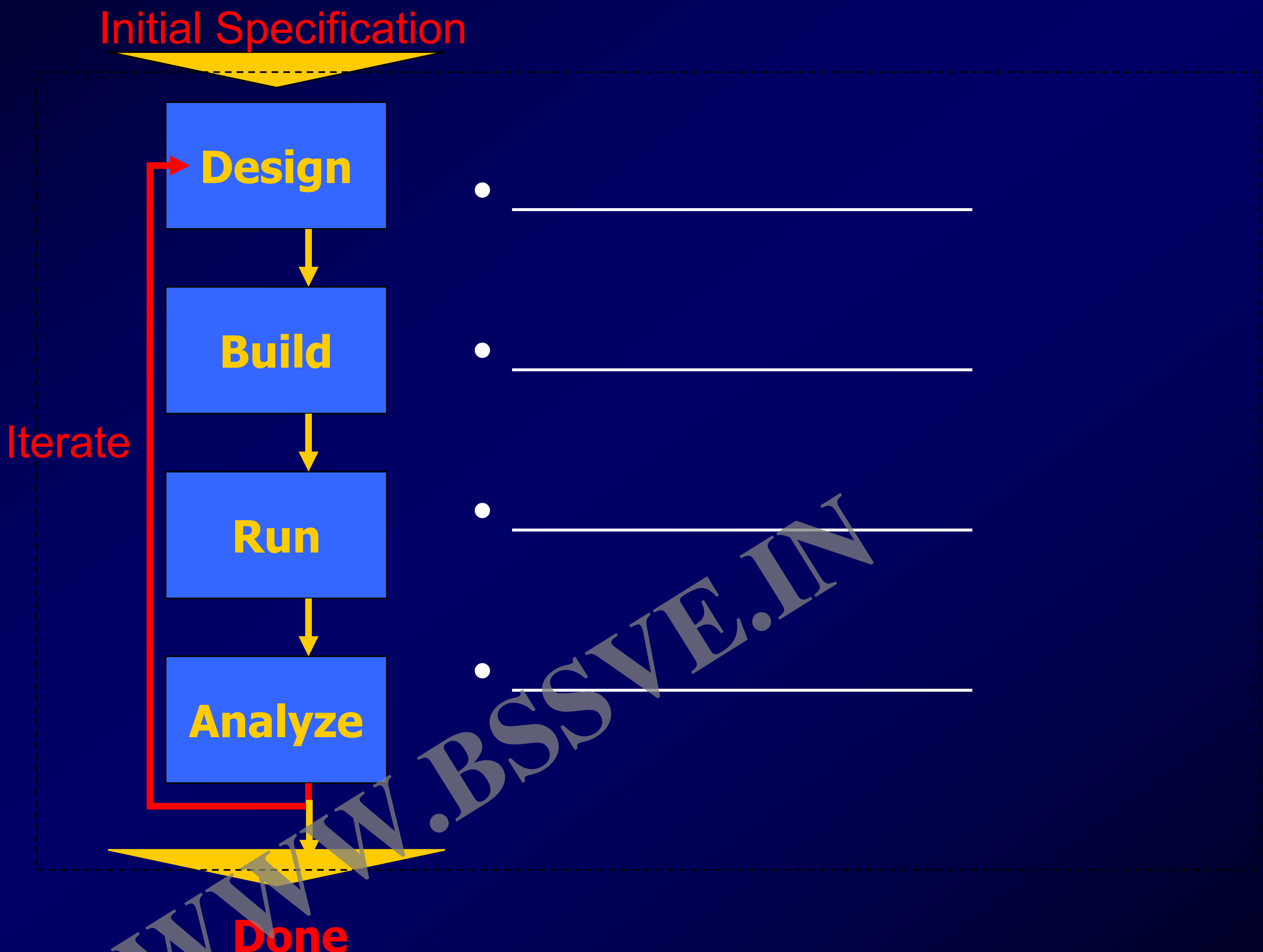
- I will outline a paper about X
- I will write a draft
- I will see if my room-mate likes it
- I will learn from the comments and revise the paper

Directed trial and error is THE fundamental problem-solving process



- I will design a rocket
- I will build it
- I will flight test it
- It crashed: I will analyze what went wrong so I can redesign

TRY YOUR OWN EXAMPLE



Innovators / problem-solvers require information about both a need and a solution approach

- **Need** information is usually found at user sites.
- **Solution** information is usually found at manufacturer sites.

Product Manufacturer

Solution Information

Product User

Need Information

But bringing full and accurate need and solution information together is often *VERY* difficult

Why? Because information is often "sticky" - very costly to transfer from place to place

- Information needed by developers may be ***tacit***
  - Can you tell your child how to ride a bike?
- A ***lot*** of information is often needed by developers
  - "You didn't tell me you were going to use the product *that* way!"

A result: user and manufacturer innovations differ in *kind*

Users tend to develop **Functionally Novel** innovations:

- The first sports-nutrition bar
- The first scientific instrument of a new type

Manufacturers tend to develop **Dimension of Merit Improvements:**

- A better-tasting sports-nutrition bar
- Improvements to an existing type of scientific instrument

Example of the impact of sticky information on the locus of innovation:

Fifty percent of all prescriptions written in the U.S. are written for “off-label” uses of prescription drugs

- **New prescription drugs are generally developed in the labs of pharmaceutical firms** – sites where much specialized information about drug development has been build up over the years.
- **Off-label applications are generally found by patients and physicians.** They apply the drugs many times under widely varying field conditions – and discover unanticipated positive (or negative) effects thereby. (“Doctor: this blood pressure medication you gave me is causing my hair to regrow!”)

Studies show this effect clearly

Sample of 24 inventory control system innovations by 7-11 Japan and NEC

(For this diagram, see:

Ogawa, Susumu. *Does sticky information affect the locus of innovation? Evidence from the Japanese convenience-store industry*. *Research Policy* 26, 7-8, April 1998. Figure 1, p. 78.)

Product or service design tends to move to the site of the crucial sticky information

Manufacturer-Based Design (DOM products)

Manufacturer design tasks

- Have solution information
- Acquire *need info* from user
- Design product

User design task

Need Info Source

User-Based Design (Functionally novel products)

Manufacturer design task

Solution Info Source

User design tasks

- Have need information
- Acquire solution information
- Design product

Product or service design tends to move to the site of the crucial sticky information : EXAMPLE

Manufacturer-Based Design (DOM products)

Manufacturer design tasks | **User design task**

Video Game Engine ← Need Info Source

User-Based Design (Functionally novel products)

Manufacturer design task | **User design tasks**

Engine Interfaces → Video game mods

Product or service design tends to move to the site of the crucial sticky information : EXAMPLE

Manufacturer-Based Design (DOM products)

Manufacturer design tasks | **User design task**

DOM: Smoother-running skateboard wheels ← Need Info Source

User-Based Design (Functionally novel products)

Manufacturer design task | **User design tasks**

Tools and materials → The Skateboard

Sticky information and the (failed) "waterfall" innovation process

Manufacturer to user: "Specify what you want –
We will negotiate a contract to deliver exactly that!

The manufacturer labors to meet the specification. Delivers the completed product!

User to manufacturer: "Now that I try it out,
I find that this is NOT what I want!"
Manufacturer to user: "It IS what you contracted for!"

The problem: Due to sticky information the agreed-on specification *was not* complete and accurate

"Rapid prototyping" innovation processes as a solution

MFR ACTIVITY	USER ACTIVITY
	User provides initial specification
Manufacturer develops prototype	
	User evaluates and improves /changes specifications
Manufacturer incorporates changes	
	User iterates until satisfied

Learning by doing

Users have the advantage of problem-solving in their *own use environments* as they "do" a desired activity – they are "learning by doing."

Examples:

- Airlines learn how to maintain their planes more efficiently as they do that work – they "go down the learning curve."
- Skateboarders learn to do new things on their boards *as they skate.* They don't go into the lab and do R&D – they are learning by doing

Learning by doing can be incredibly cheap for users *within* their own narrow niche of "doing"

(Photograph of windsurfers.)

Photograph courtesy of Lisa A. Devlin. Used with permission, http://www.windwardskies.com/

Learning by doing can be incredibly cheap for users *within* their own narrow niche of "doing"

Mountain bike innovation

- "When I do tricks that require me to take my feet off the bike pedals in mid-air, the pedals often spin, making it hard to put my feet back onto them accurately before landing."

  I added a foam ring around the pedal axle near the crank. This adds friction, and prevents the pedals from free-spinning when my feet are off."

Development of instant messaging at MIT

In 1987 MIT Lab for Computer Science had thousands of Athena workstations online and difficulties diffusing system administration information rapidly.

On-site programmers programmed the "Zephyr" instant message system. MIT students quickly begin to use Zephyr for general instant messaging.

Learning by doing can be incredibly cheap for users *within* their narrow niche of "doing"

Example: "I'm a mountain biker and a human movement scientist working in ergonomics and biomechanics. I used my medical experience to improve my mountain bike.

(Consider the cost if that person had not been a biker and had to learn the sport to innovate – or did not have medical training and tools "in stock.")

Exercise: think of your own instances of learning by doing

Example:

I worked out the quickest route from home to school.

1. Think about the process you used to determine the quickest route.
2. Notice the low incremental cost to you. For example, since your trip from home to school was a trip you took "anyway," the cost of each experiment was minimal. (It would cost much more to hire someone to do this experiment who did not have to take that trip "anyway.")

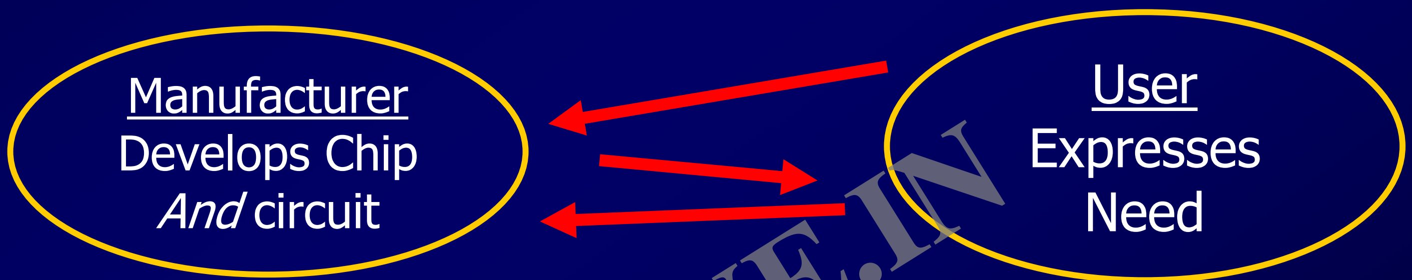
How can you reduce iteration?

Repeated shifts of problem-solving sites during product development can be very costly – what can you do to reduce the need for it?

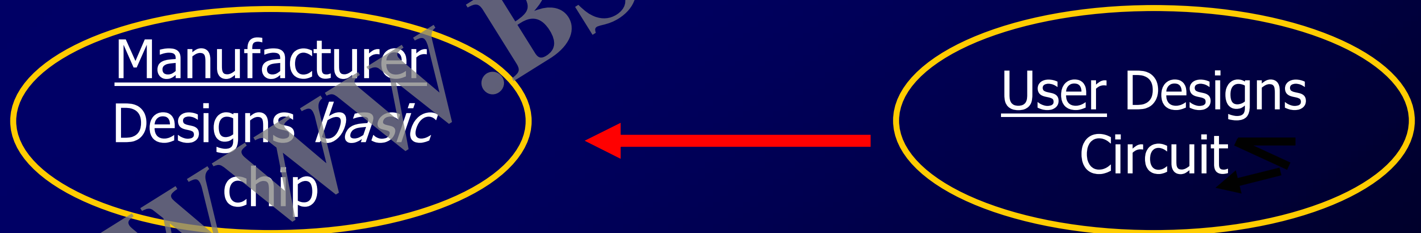
3. Reframe the initial product or service design problem which draws on two sticky information sites into sub-problems – each of which draws on sticky information location at only one site

Example: Custom Integrated Circuit Design

"Full custom" chip development procedure

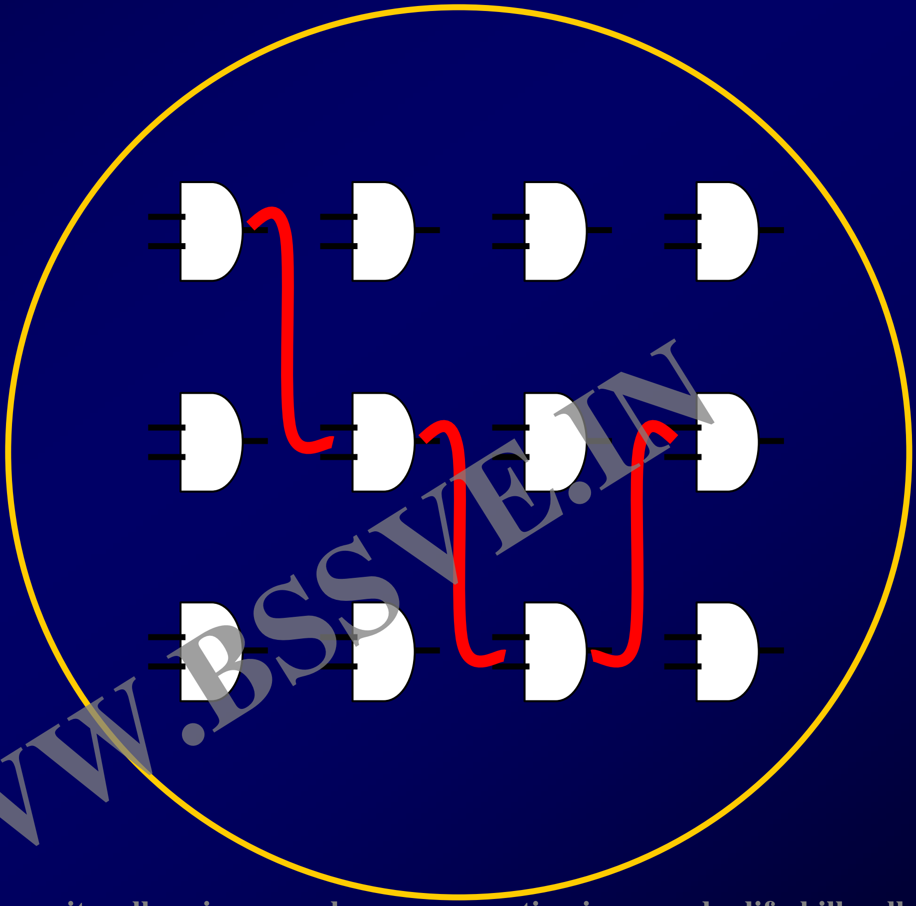


ASIC custom chip development procedure



Example

"Full-custom" IC Design vs "Gate Array IC Designs"

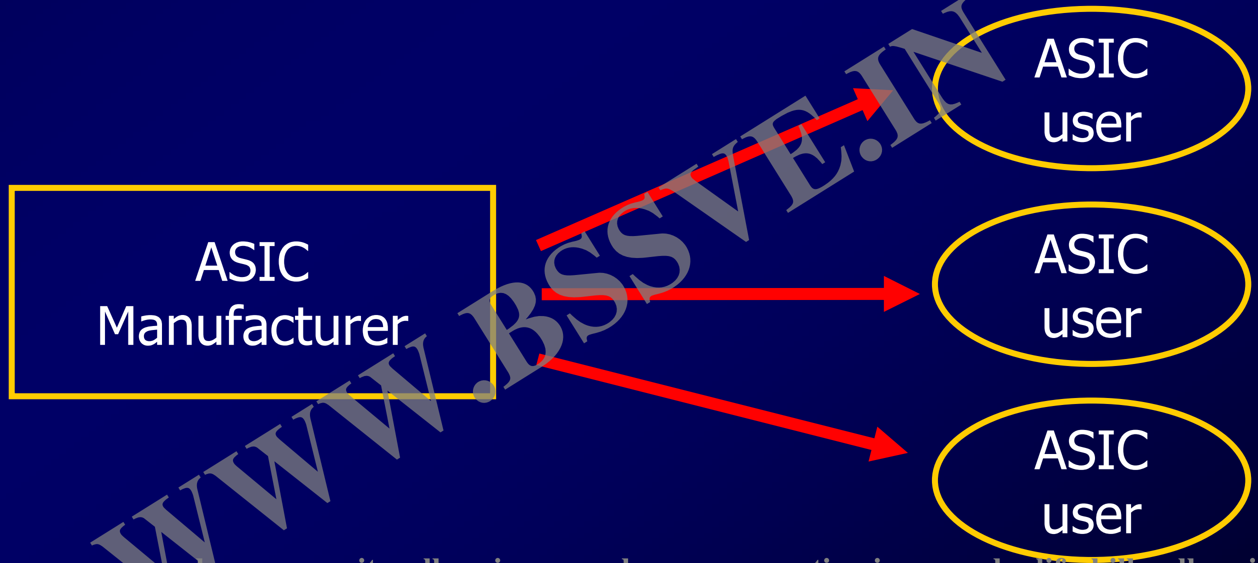


Shifting innovation to users

Economics of sticky information tends to shift the locus of problem-solving to users. For custom design projects, manufacturer information is standard from project to project but user need differs

Example:

Each ASIC design may require the same information from the ASIC manufacturer, but unique information from the ASIC user.



Quantitative market research for incremental improvement innovations

Professor Eric von Hippel

MIT Sloan School of Management

Incremental innovation is important. Quantitative market research can identify needs for incremental change

Major new product lines are rare – incremental improvements are by far the most common type of project in product and service development. So it is important to learn to do incremental innovation well.

Examples:

- *Many* incremental improvements to 3M transparent "Scotch" tape over the years. Convenient tape dispenser, decorated "gift wrap tape," write-on tape, double-sided tape.
- *Many* incremental improvements to aspirin over the years. Buffered aspirin, coated, child-sized tablets, liquid formulation, time release capsules…

There are several ways to generate ideas for incremental product and service improvements

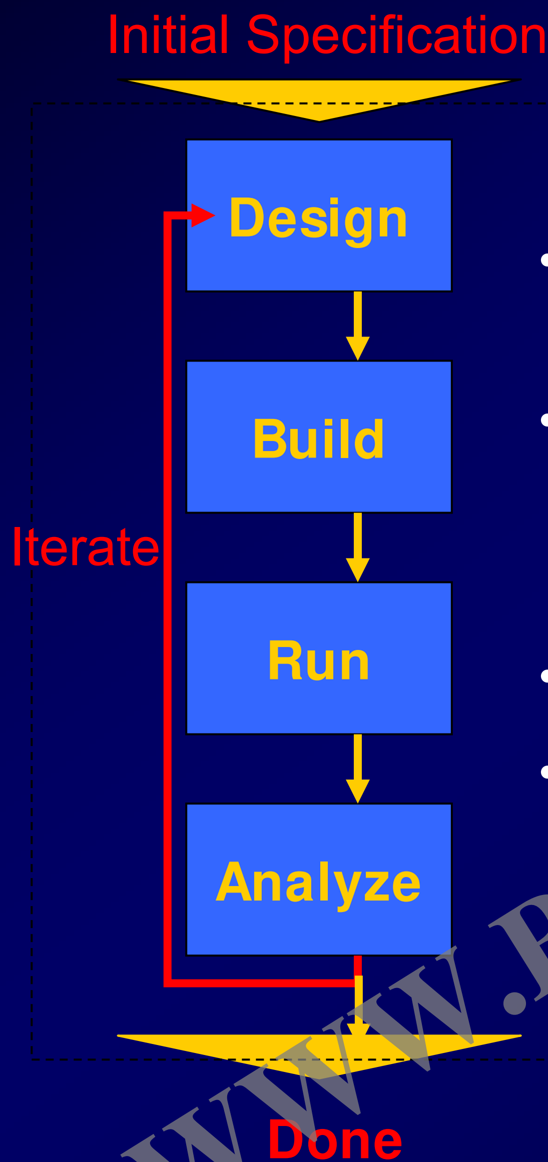
- Observation of users: “Many users are using / modifying our products *this* way – let’s add that feature for them.”
- Sales channel inputs: “My customers are asking for masks in pediatric sizes – I said we could do that for them.”
- “Me too / me better: “Competitors are getting good sales with their pancake mix with fruit added – lets do fruit *and* nuts!”
- Traditional quantitative marketing research.

Traditional quantitative marketing research is *designed* to identify only incremental needs (but not always understood to have that in-built bias).

Traditional market research focuses on ***target*** market customers

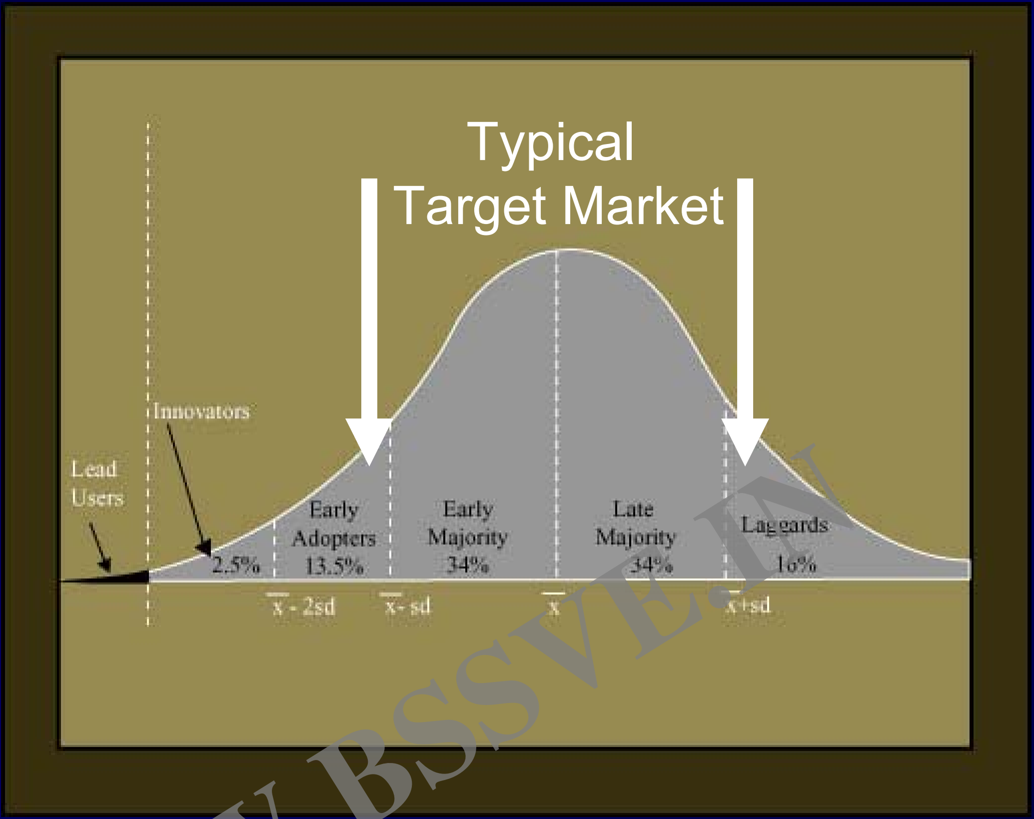
1. What need information do target market customers have?
2. How do you get information from them?
3. How do you analyze their information?

In traditional market research trial and error is being done – but manufacturers rather than users are doing it



- Mfr-based designers design a product based on user need
- Mfr builds a prototype
- Does market tests
- Analyzes – finds areas for improvement.

A typical target market



Target market users have need but not solution information. Example: PCB-CAD study

Target market customers have *need information* - *not solution information* to offer market researchers

For more information on this study, see:

Urban, Glen L., and von Hippel, Eric. *Lead User Analyses for the Development of New Industrial Products*. *Management Science* 34, no. 5, May 1988: pp. 569-82.

The needs of target market customers are "fixed" on the "middle of the road"

"Functional fixedness" says that people don't stray much from the needs and solutions they *directly* experience.

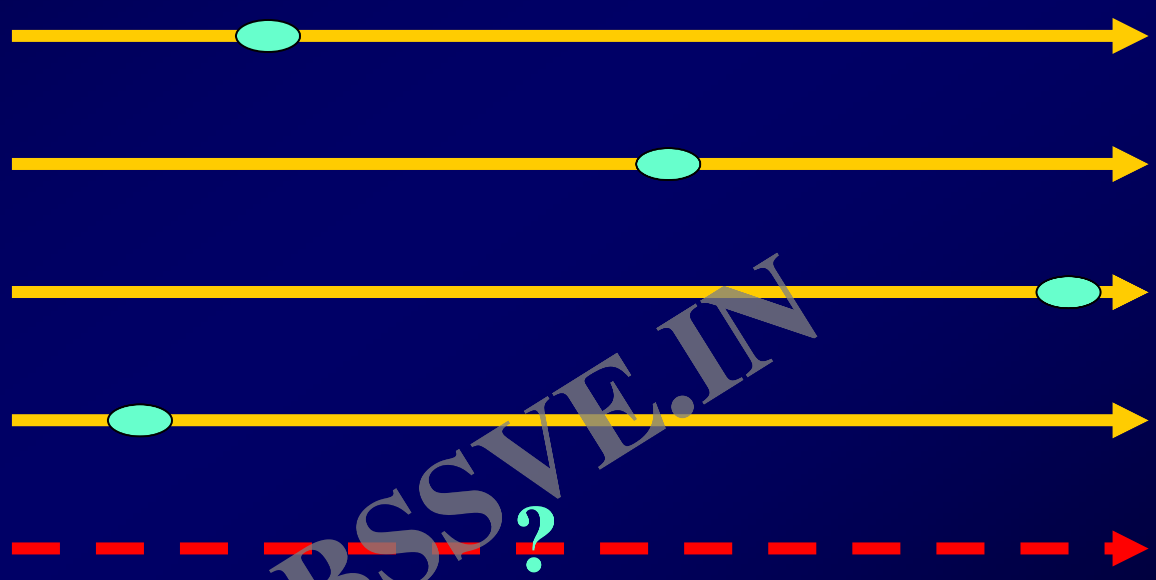
How quantitative market research gets information on needs from target market customers

- The process starts by identifying 10-30 product attributes target market customers think are important for a type of product (say, a cell phone). Usually, a focus group is used to identify these.
- This procedure creates a barrier to out-of-the-box innovation. If an attribute is not listed by ordinary users – it cannot enter into later analytical steps. For example, if camera functionality is not listed as a cell-phone attribute – it is gone!

Analysis centers on product attributes that *many* target users describe as important

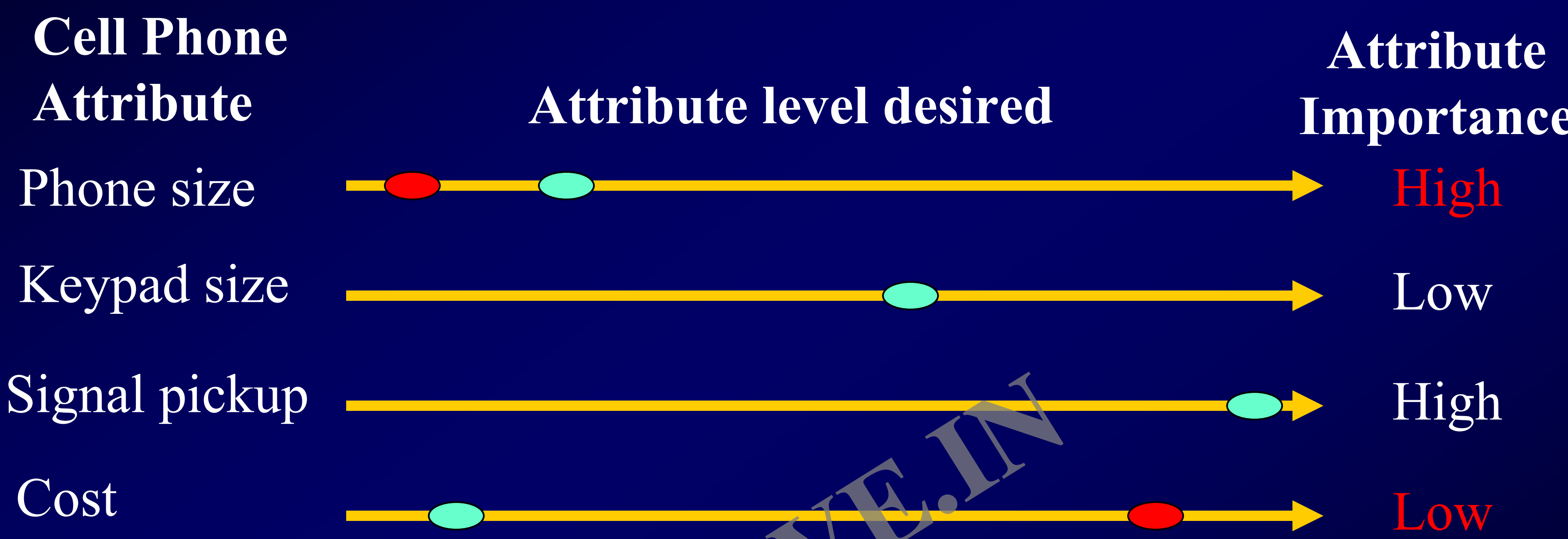
(Rarely mentioned attributes are dropped as outliers)

Cell Phone Attribute	Attribute level desired	Attribute Importance
Phone size		Medium
Keypad size		Low
Signal pickup		High
Cost		High
(Camera?)		



This type of analysis leads directly to DOM improvements along Commonly-understood attributes = incremental innovation

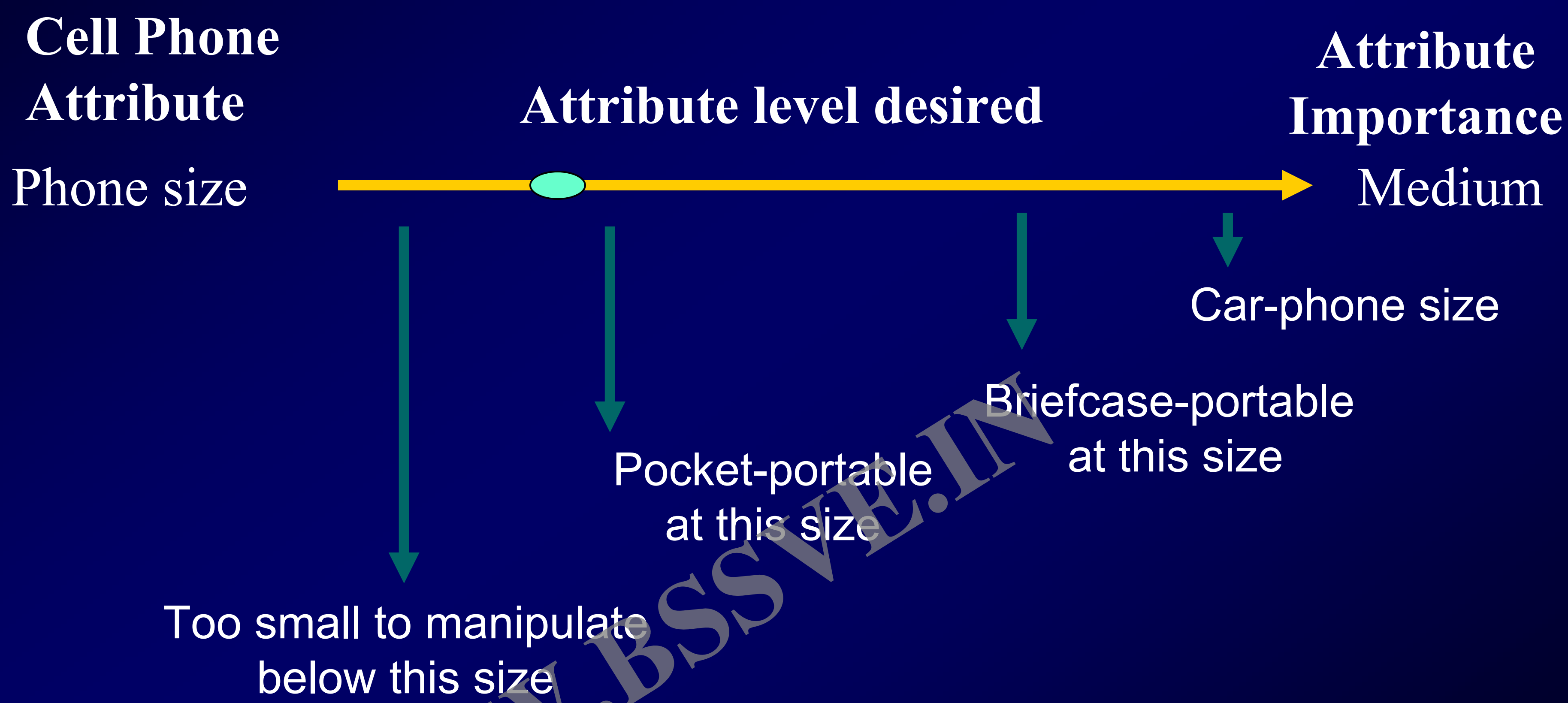
A few market segments with *common* weightings are identified – mass manufacturers want to “build for the masses.”



Cost-conscious segment

Luxury segment

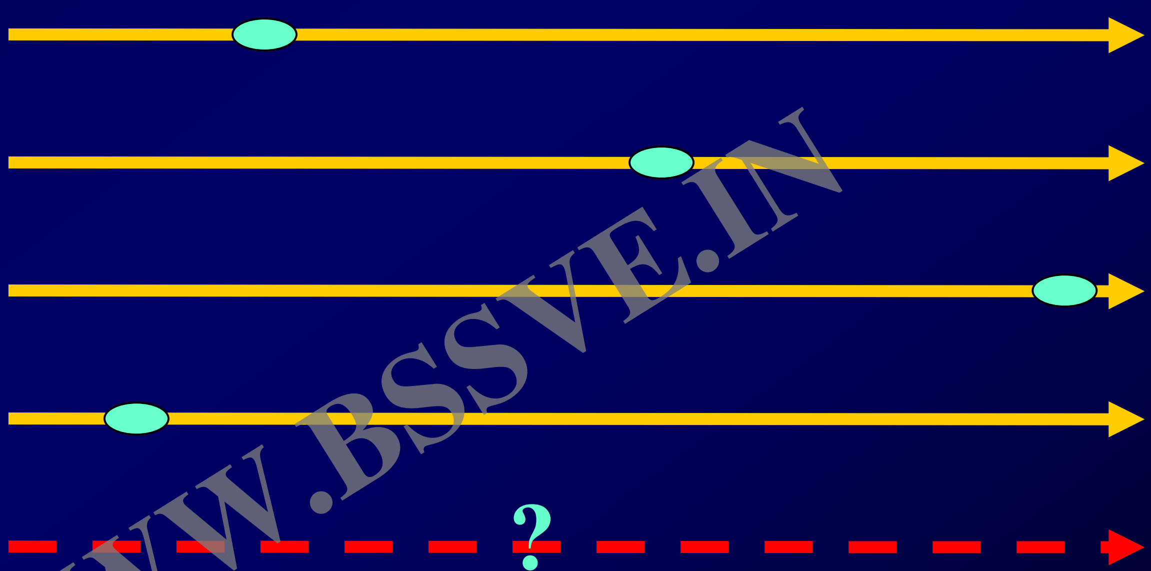
Even for incremental products quantitative analyses can mislead. Example: it is assumed that preferences for each factor vary linearly - often not true!



What happens when these methods are used to quantify *existing demand for* familiar vs unfamiliar ideas *after* they have been developed?

How would "functionally fixated" consumers assess cell phone cameras?

Cell Phone Attribute	Attribute level desired	Attribute Importance
Phone size		Medium
Keypad size		Low
Signal pickup		High
Cost		High
(Camera?)	?	?



In sum: aspects of traditional methods that create a focus on *incremental* improvements

Focus on:

- "Center of the market" customers
- Improvements only along attributes *known to be important* by target market customers for a product category

Possible question for a paper:

- Can quantitative methods be modified in some way to enable the generation of major new innovations?

Firms organize around the way they ***think*** idea generation works

(For this diagram, see: von Hippel, Eric. *Users as Innovators*. Cambrdige, MA: *Technology Review* 80, no. 3, January 1978, pp. 31-39.)

Contrasting innovation methods

Need and market life cycle curve

New methods are based on finding ***emerging needs*** among lead users. These lead users may also develop *solutions*.

Traditional methods are based on finding ***needs*** among target market Users.
Manufacturers then develop solutions

15.356 Trading and revealing information

Professor Eric von Hippel

MIT Sloan School of Management

Agenda

1. Why people freely reveal their innovations to manufacturers – and other users
2. Informal information *trading*

Know-How Trading Patterns Among Steel Minimills

For more information on this study and its results, see:

von Hippel, Eric. *Cooperation Between Rivals: Informal Know-How Trading*. *Research Policy* 16, 1987, pp. 291-302.

Steel minimills are far from mini in size and effect!

For more information, see:

Christensen, Clayton. *The Innovator's Dilemma*. HaperBusiness, 2000.

Firms can increase the amount of information they possess by trading:

	Situation Pre-Trade	Situation Post-Trade
Firm A	Unit A	Unit B + Unit A
Firm B	Unit B	Unit A + Unit B

Information trading can pay under SOME conditions

Consider the Total Profit (also sometimes called "rent") that a proprietary "unit" of know-how yields to a firm exclusively possessing it as made up of two parts:

Total Profit = Profit + Δ Profit

Profit = the portion of Total **Profit** which a firm expects after trading the unit of knowhow to another firm. (Both firms then possess the traded knowhow.)

Δ **Profit** is the extra **Profit** which a firm expects if it possesses the knowhow unit exclusively.

Example: ASSUME TWO FIRMS START WITH KNOW-HOW UNITS OF DIFFERENT CONTENT BUT EQUAL VALUE:

Before trade each firm has: **Total Profit = Profit + Δ Profit**

After trade each firm has: **Total Profit = 2 (Profit)**

Therefore trading pays only when **Profit > Δ Profit**

KNOW-HOW TRADING AS A "PRISONER'S DILEMMA"

Assume as before that two firms have one unit of unique proprietary know-how each. Assume also that each firm's unit, although different, has an identical **Profit** and Δ **Profit** associated with it.

Then, pre trade, each firm has: Total Profit = **Profit + Δ Profit.**
After a cooperative trade, **R**, each firm has: **R = 2 Profit**

All four possible outcomes of a single play of this game are:

T = 2 Profit + Δ Profit **R = 2 Profit**
P = Profit + Δ Profit **S = Profit**.

A Prisoner's Dilemma exists if **T > R > P > S and 2R > T+S** (A strategy of continuing cooperation has been shown empirically to pay best over many plays of a Prisoner's Dilemma game.)

Therefore, know-how trading pays
(conditions for a Prisoner's Dilemma are met)
if ***Profit > Δ Profit*** *but not if* ***Profit < Δ Profit***

FIRMS THAT DO TRADE HAVE AN ADVANTAGE OVER NON-TRADERS

Assume firms A and B trade $ research results with low competitive value but that Firm C does not trade

	Situation Pre-Trade	Situation Post-Trade
Firm A	low unit + high unit	low + low + high
Firm B	low unit + high unit	low + low + high
Firm C (non-trader)	low unit + high unit	low + high

Information trading examples

(1) Oil Geologists trade easily reproducible know-how;

Profit > Δ Profit

Unless it involves an upcoming oil leasing competition;

Profit < Δ Profit

(2) Aerospace engineers trade easily reproducible know-how;

Profit > Δ Profit

Unless it bears on a competition for an important contract;

Profit < Δ Profit

How Frequent is Know-how Trading?

Minimill Personnel Sample:

The results of this study can be found in:

Schrader, Stephan. *Informal technology transfer between firms: Cooperation through information trading*. *Research Policy* 20, 1991, pp. 153-170.

Oil Scouts Trade "Black Box" Information Only

Firm A	Type of Information	Firm B
Geologist	**Data Analysis Know-how**	**Geologist**
Scout	**Oil Well Logs Oil Well Cores Seismic Data**	**Scout**

When Scouts can be used, Oil Companies tend to force their use. Hypothesized advantages:

- Specialists have better networks, are better traders;
- Collects IOU's in one place, minimizing # outstanding, and time they are outstanding.

Some Rules of Oil Scout Behavior

(As per Scouting Association codes of ethics)

- "A scout must represent only one company...".

- "The information a scout obtains should be invariably first transmitted to the employer."

- "A member may not dispose of information without the consent of the employer."

- "Scouts should never knowingly dispense information of an untrue or doubtful character".

Source: 1988 Houston Oil Scouts Association Code of Ethics

Shifting Innovation to Your Customers via Toolkits for User Innovation

Professor Eric von Hippel

MIT Sloan School of Management

To develop a product or service, information about needs and about solutions must be brought together at a single site.

- **Need** information is usually found at user sites.
- **Solution** information is usually found at manufacturer sites.

Information is often "sticky"

But need and/or solution information can be very costly to transfer from site to site – is often very "sticky."

Some reasons:

- Information needed by developers may be ***tacit***
  - Can you tell your child how to ride a bike?
- A ***lot*** of information is often needed by developers
  - "You didn't tell me you were going to use the product *that* way!"

Impact of sticky information #1

1. Product or service design should move to the site of sticky information, "other things being equal."

That is:

- If need information is very sticky, and solution information is not, product design should be done at the user site;
- If solution information is very sticky, and need information is not, product design should be done at the manufacturer site (The traditional pattern).

Problem-solving *does* move to sticky information sites

Sample of 24 inventory control system innovations by Seven-Eleven Japan and NEC

(For this diagram, see:

Ogawa, Susumu. *Does sticky information affect the locus of innovation? Evidence from the Japanese convenience-store industry*. *Research Policy* 26, 7-8, April 1998. Figure 1, p. 78.)

Manufacturer-Based Design

Manufacturer design tasks

- Have solution information
- Acquire *need info* from user
- Design product

User design task

Need Info Source

User-Based Design

Manufacturer design task

Solution Info Source

User design tasks

- Have need information
- Acquire solution information
- Design product

Example of the impact of sticky information on the locus of innovation:

Fifty percent of all prescriptions written in the U.S. are written for "off-label" uses of prescription drugs

- **New prescription drugs are generally developed in the labs of pharmaceutical firms** – sites where much specialized information about drug development has been build up over the years.
- **Off-label applications are generally found by patients and physicians.** They apply the drugs many times under widely varying field conditions – and discover unanticipated positive (or negative) effects thereby. ("Doctor: this blood pressure medication you gave me is causing my hair to regrow!")

Impact of sticky information #2

2. If both need and solution information are sticky, problem-solving activity will tend to ***iterate*** between user and manufacturer sites, as information from each site is drawn upon for problem-solving

MFR ACTIVITY	**USER ACTIVITY**
	User provides initial specification
Manufacturer develops prototype	
	User evaluates and improves /changes specifications
Manufacturer incorporates changes	
	User iterates until satisfied

Evidence for repeated site shifts during problem solving

(For this chart, see:

von Hippel, Eric and Marcie J. Tyre. *How Learning by Doing Is Done: Problem Identification in Novel Process Equipment. Research Policy*. 1994.)

How can you reduce iteration?

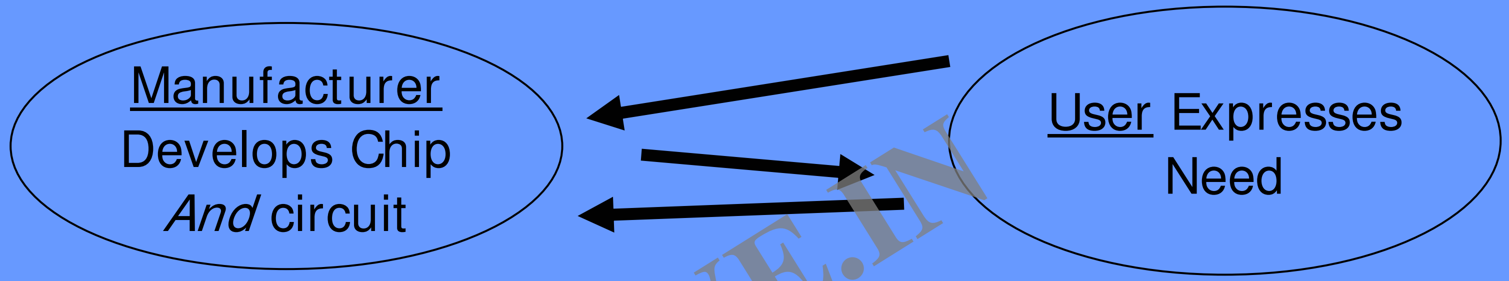
Repeated shifts of problem-solving sites during product development can be very costly – what can you do to reduce the need for it?

3. Reframe the initial product or service design problem which draws on two sticky information sites into sub-problems – each of which draws on sticky information location at only one site

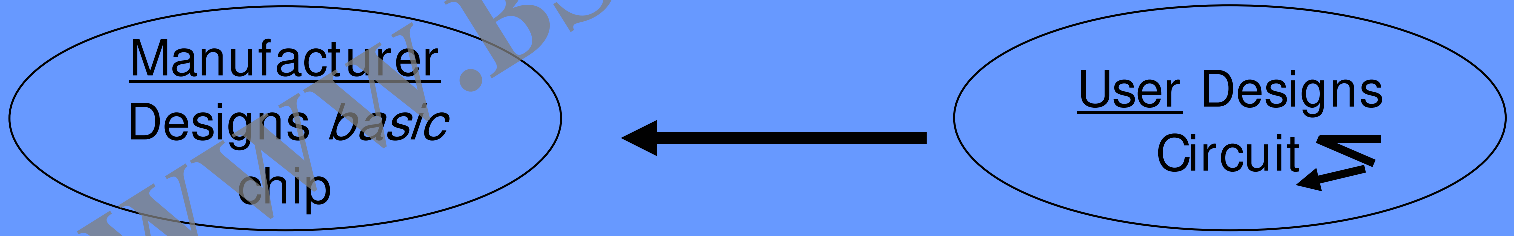
Example: Custom Integrated Circuit Design

"Full Custom" IC design vs ASIC / FPLD Design

"Full custom" chip development procedure



ASIC custom chip development procedure



Example

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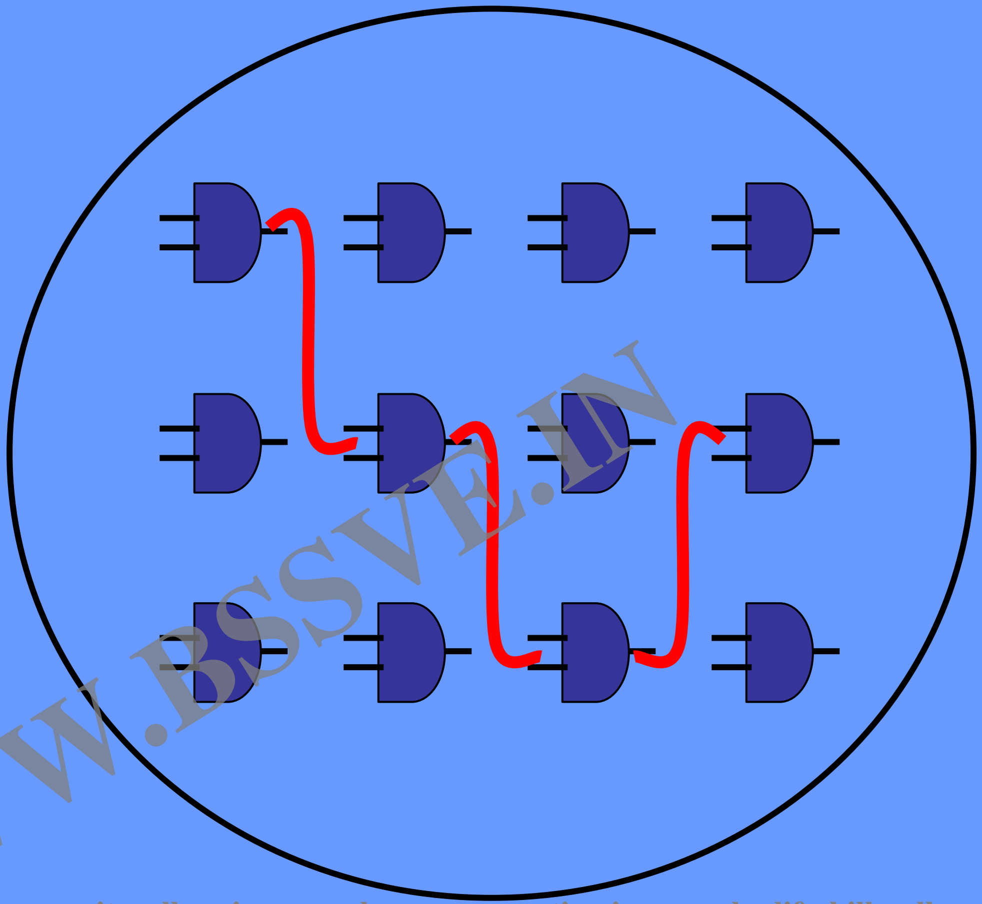
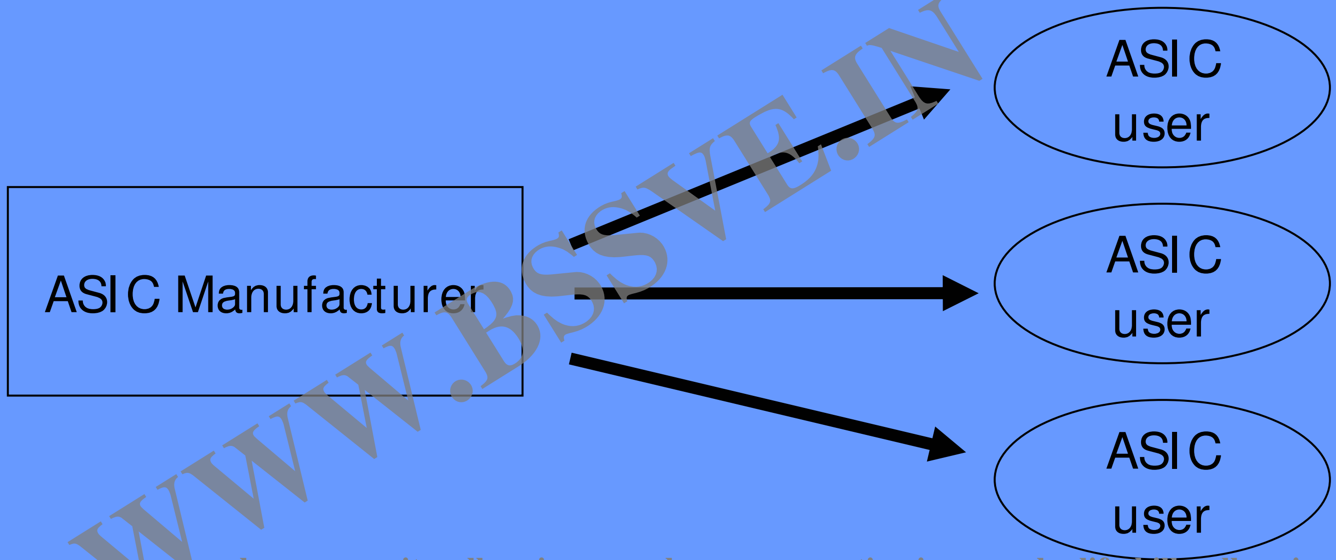


Why all this leads to toolkits

Economics of sticky information tends to shift the locus of problem-solving to users. For custom design projects, manufacturer information is standard from project to project but user need differs

Example:

Each ASIC design may require the <u>same</u> information from the ASIC manufacturer, but <u>unique</u> information from the ASIC user.



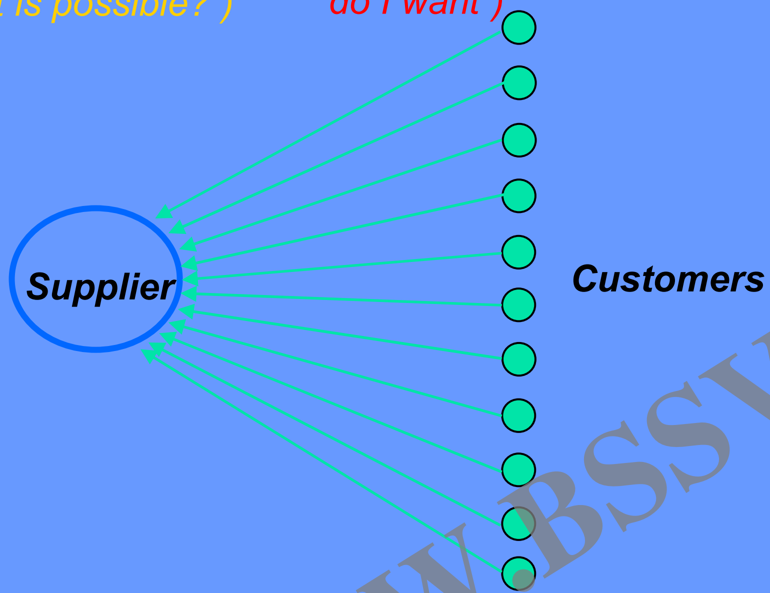
With toolkits customers – not manufacturers - need to "understand customer need"

<u>"Find a need and fill it" model</u>

<u>Toolkits model reverses information flow</u>

Solution Information *("What is possible?")*

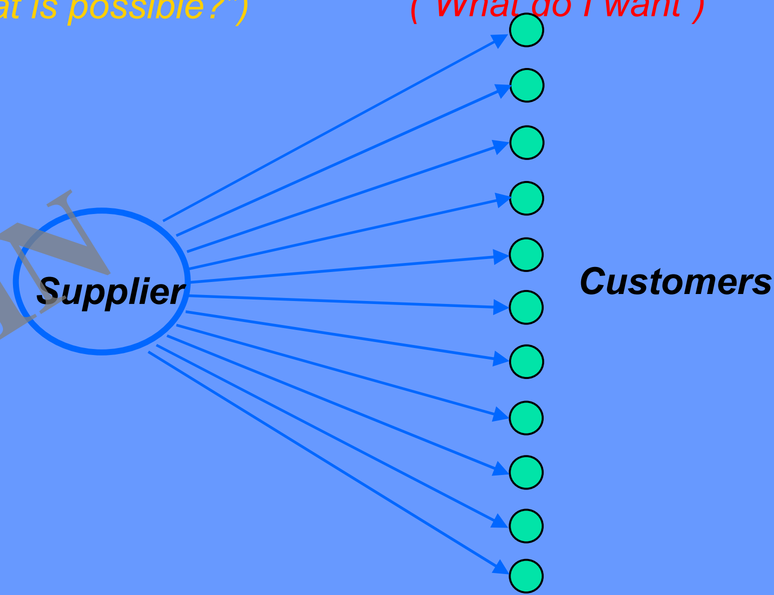
Need Information *("What do I want")*



"Market Research"

Solution Information *("What is possible?")*

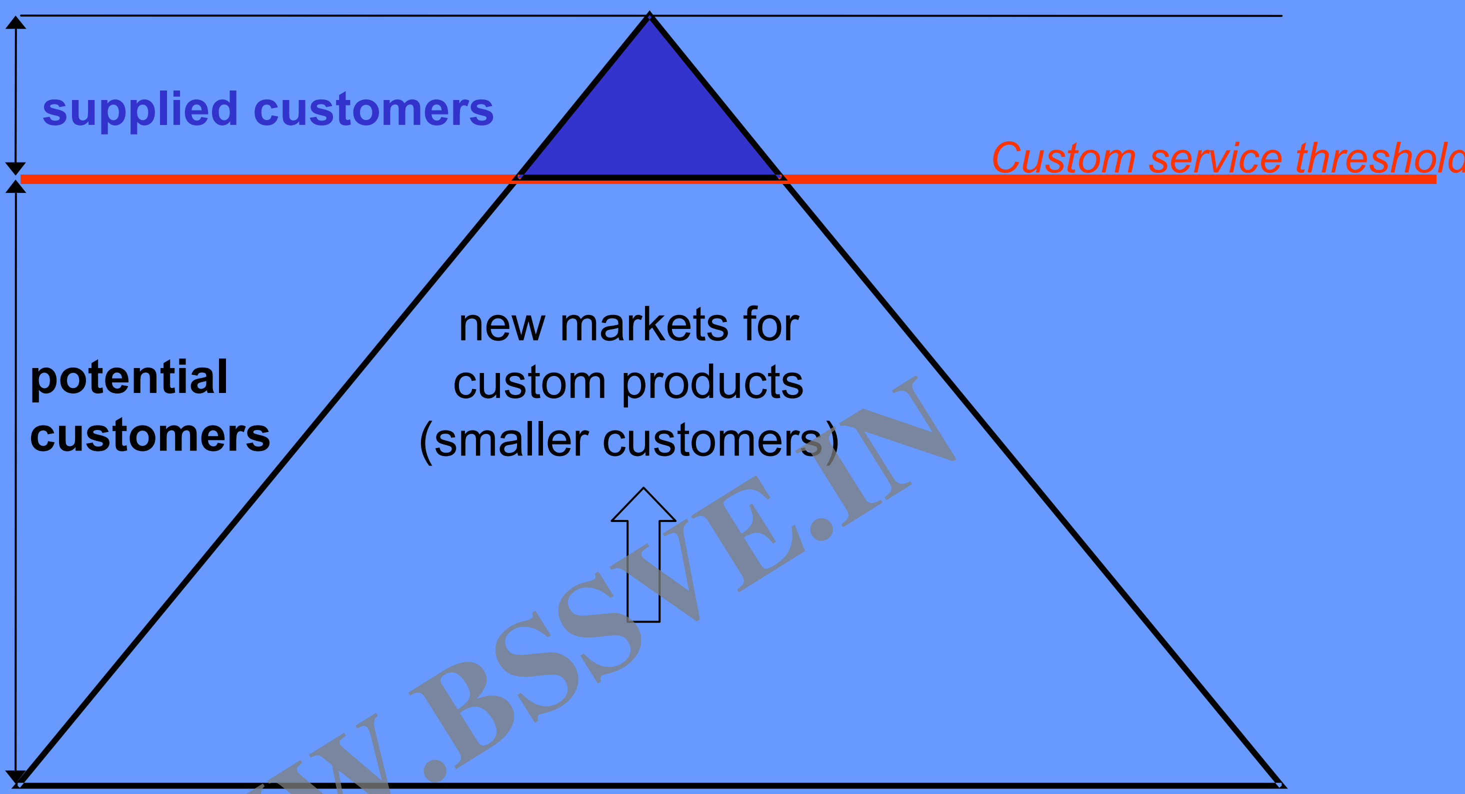
Need Information *("What do I want")*



"Innovation Toolkits"

You can't afford to understand the needs of smaller customers

Companies cannot afford to design custom solutions for smaller customers



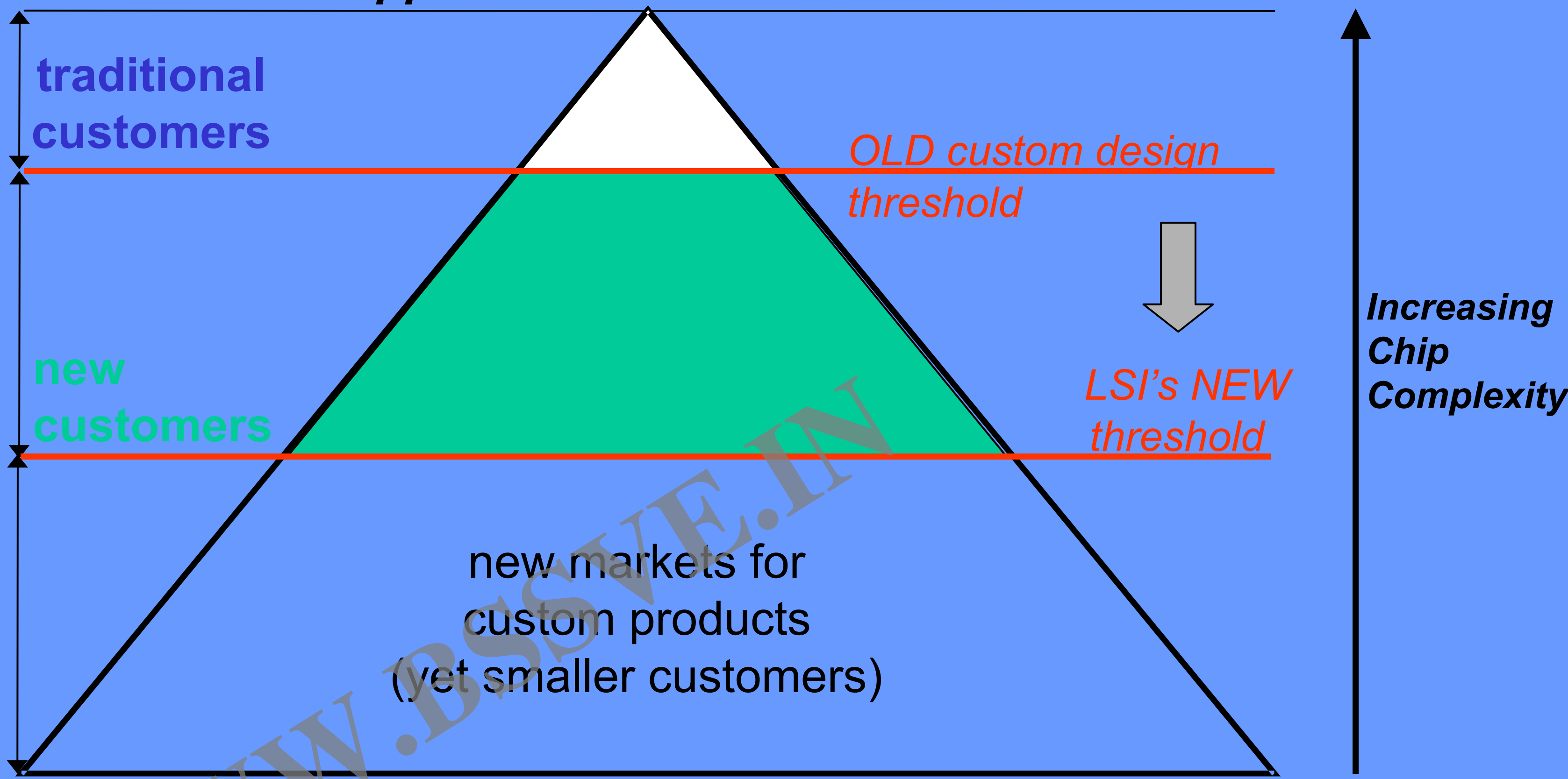
The Solution: LSI's Development Toolkit

- Customers design chips that are produced by LSI
- User-friendly and integrated toolkit (using simulation and CAD technology)
- Traditional suppliers were reluctant to make tools available to markets (intellectual property)
- Fujitsu even refused to share its tools with US division

(Image of an advertisement by LSI Logic Corporation with the headline, "Design Our Gate Arrays On Your Workstation".)

Innovation toolkits made many more customers accessible to LSI

LSI toolkits tapped into customers that had not been served



The Pattern is Repeated: The Rise of Field Programmable Technologies

Customers Increasingly Using Toolkits and Designing their Own Custom ICs

(For this World Semiconductor Trade Statistics chart, see:

Thomke, Stefan, and Eric von Hippel. *Customers as Innovators: A New Way to Create Value*. Harvard Business Review, April 2002. Reprint No. R0204F.)

2 major tasks for toolkit development

A. Separate out development tasks that are custom "need-information –intensive" and assign those to users.

Impact on Product architecture can be major

- Custom cake vs custom pizza;
- "Full-custom" IC vs custom ASIC

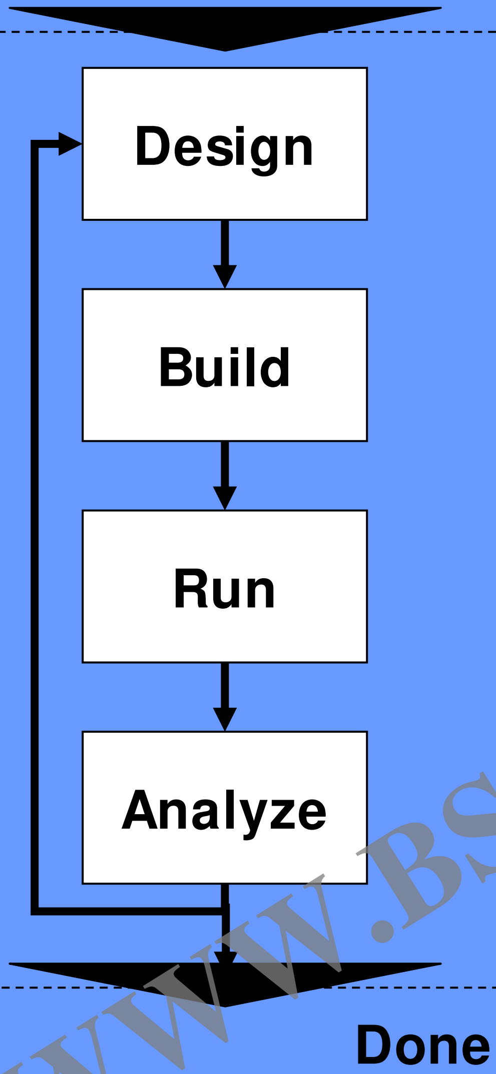
B. Develop the tools users need to carry out the need-intensive tasks assigned to them.

(B) Toolkits for users contain:

Tools to carry out trial-and-error design:

1. That are "user-friendly"
2. That offer the right "solution space"
3. That offer libraries of pre-designed modules
4. That can translate from user-language to producer language without error

Toolkits should help users to do the trial-and-error work of problem-solving in design



- Design a possible solution
- Develop models prototypes
- Test model/prototype In real or simulated use environment
- Analyze findings previous step

Tools to enable user to carry out design by trial-and-error

Four steps in trial-and-error-process:

	ASICs example
Design	Design custom circuit
Build	Create functioning prototype
Test	Take prototype for a "test drive"
Analyze	Compare expected and actual results. If needed, do trial-and-error cycle again. ("Iterate")

(1) Offer "user-friendly" tools

"User-friendly" means that the user does not have to learn a new design language.

Examples:

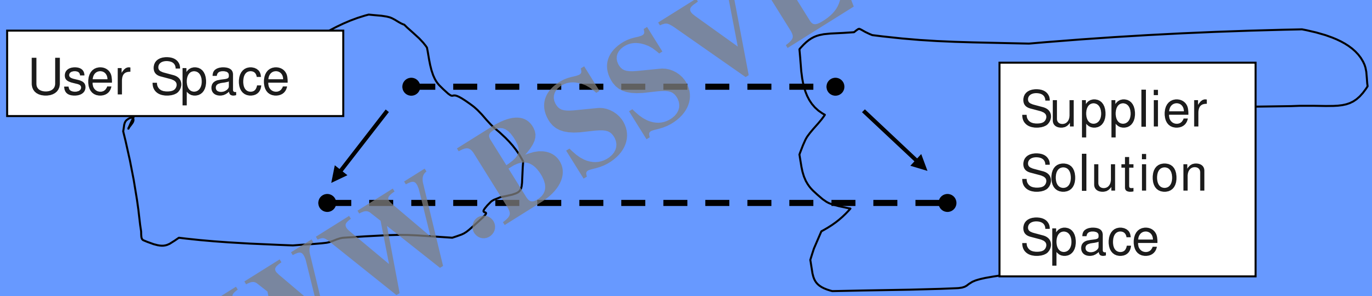
- Allow integrated circuit designers to use their customary design language: Boolean algebra
- Allow hair styling customers to use (virtual) mirror, comb and brush.

Creating user-friendly design systems

Identify the independent design dimensions that are important to the user.

Give each design dimension a familiar, functional name (e.g., "thickener" instead of xanthan gum"

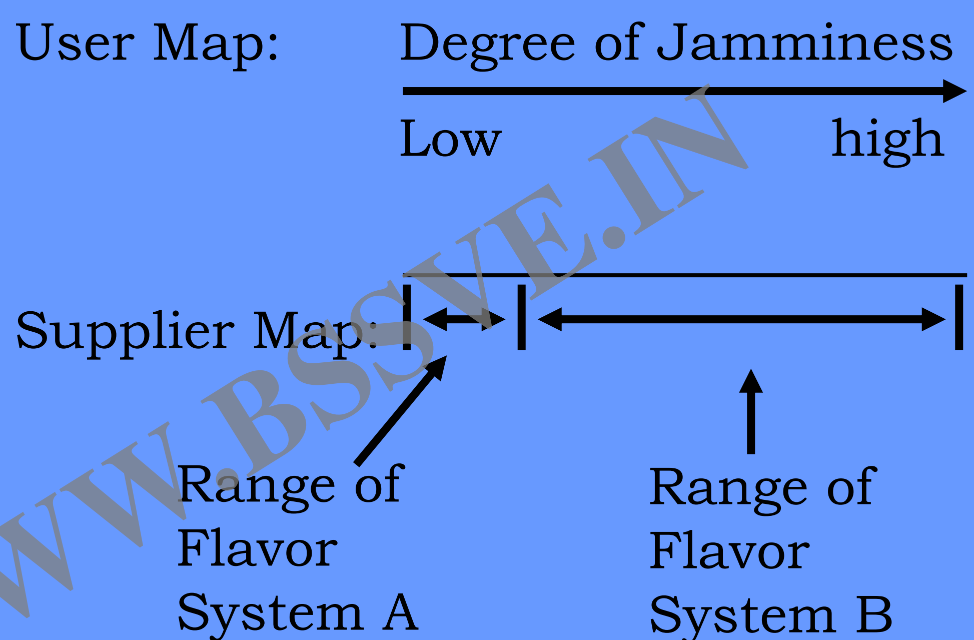
Create a translator – hidden from the user – that translates each move by a user-designer in user solution space to a move in manufacturer solution space. (Flag the user when a user move can't be done in manufacturer solution space.)



Translations can be "bumpy" – but must be error-free

Smooth movement across user solution space may involve bumpy translations on supplier map

Example: "Jammy" flavor note



(2) Offer the right "solution space"

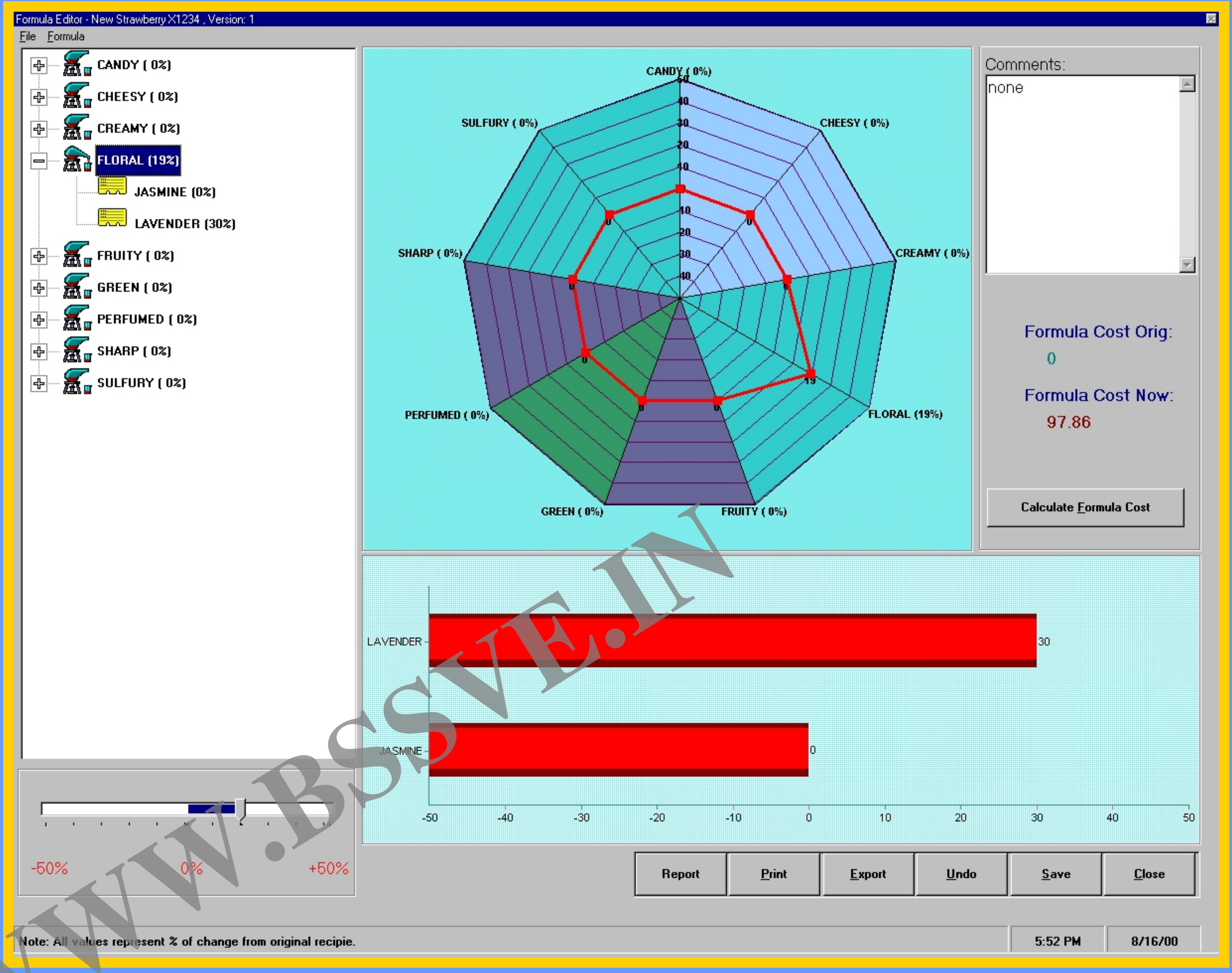
Toolkits must offer users a "solution space" that contains all the design variables and tools they need to create a design.

Example: Hairstyling toolkits:

Design variables offered: hair position, length, color, waviness;

Tools offered: virtual scissors, comb, colorants, curlers, straighteners.

Flavor Design Toolbox for Users



Screenshot of Flavor Design Toolbox software courtesy of John Wright, International Flavors and Fragrances. Used with permission.

(3) Offer pre-designed modules

Custom designs are typically not totally unique. Toolkit libraries should contain pre-designed modules and modifiable "default designs" – so that users can concentrate their design work on the novel features of their designs.

Examples:

- "Macrocells" for custom IC designs: microprocessor
- Modifiable "default designs" for hairstyles or for houses.

Modules should make "design sense" to a user-designer. (e.g., not "half a roof plus front door" for house designers, or "sautéed garlic plus onions" for chefs)

(4) Toolkits must enable "first-time," error-free production of user designs

User design language provided by toolkit must translate to production language without error:

Sometimes this is easy:

Translation from circuit design language (Boolean algebra) to IC producer's digital device fabrication language.

Sometimes this is hard:

Nestle Mexican Sauces toolkit

Creating Value with Toolkits: Experiences at GE Plastics

- 30 years of in-house expertise on website (tools): $5 mill. cost
- Potential customers can solve their own design problems
  - Helpline calls dropped >50%
  - 400 e-seminar for 8,000 potential customers per year
- About one million visitors p.a.
  - Automatic screening and tracking of potential customers
  - One third of new customers
- Sales threshold dropped by more than 60%

Profiting from toolkits

Users will benefit from toolkits in your industry if user needs are heterogeneous.

If users will benefit, you must offer toolkits – or someone else will and get first mover advantage.

Your business model may change when you offer toolkits – for better or for worse.

Example: ASIC foundries profited from a toolkit approach for the first 15 years – and then began to lose profit to specialist toolkit suppliers.

How to start developing a toolkit

- It's OK to start with something rough as long as it offers sufficient value to entice user experimentation. Simple release of in-house design tools is sometimes a sufficient for a start.
- Work with lead customers that **really** need your toolkit and so will be willing to work with you as you refine it.
- You don't need superhuman insight to design and update toolkits – lead users will bump up against the edges of the solution space your toolkit offers and ask for more – or design toolkit improvements for themselves.