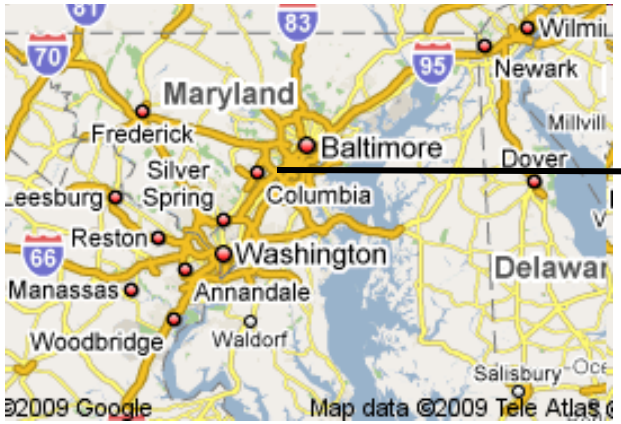
Invention to Product

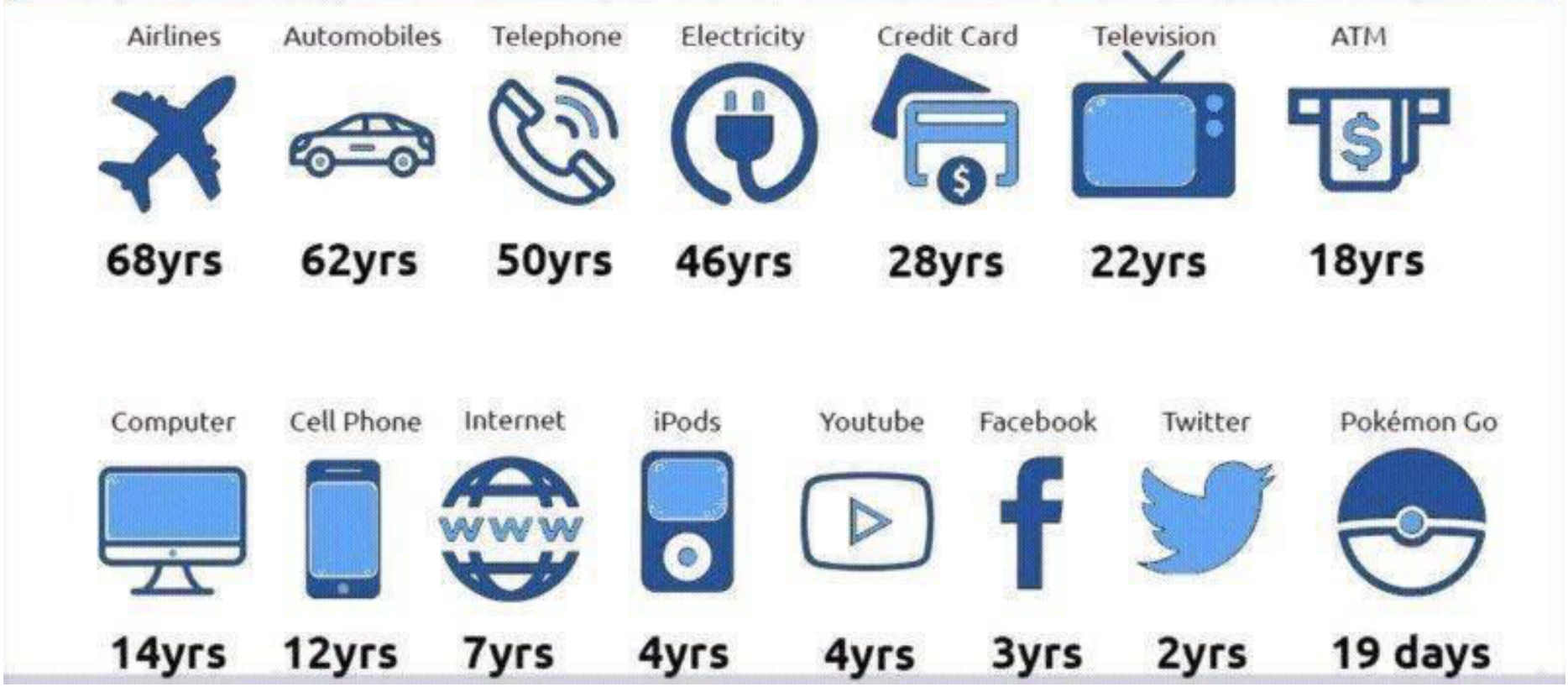
Surya Raghu

Entrepreneurship for Scientists and Engineers

ICTP, Trieste
March 19-23, 2018



NUMBER OF YEARS IT TOOK FOR EACH PRODUCT TO GAIN 50 MILLION USERS:



OUTLINE

1. **Introduction**
2. **Inventions, Technology Development and TRLs**
3. **Invention to Product: Processes (Things To Do) and Timelines**
4. **Examples of Invention to Products**
5. **Pitfalls to commercialization**
6. **Conclusions**

Why do we need inventions and new products?

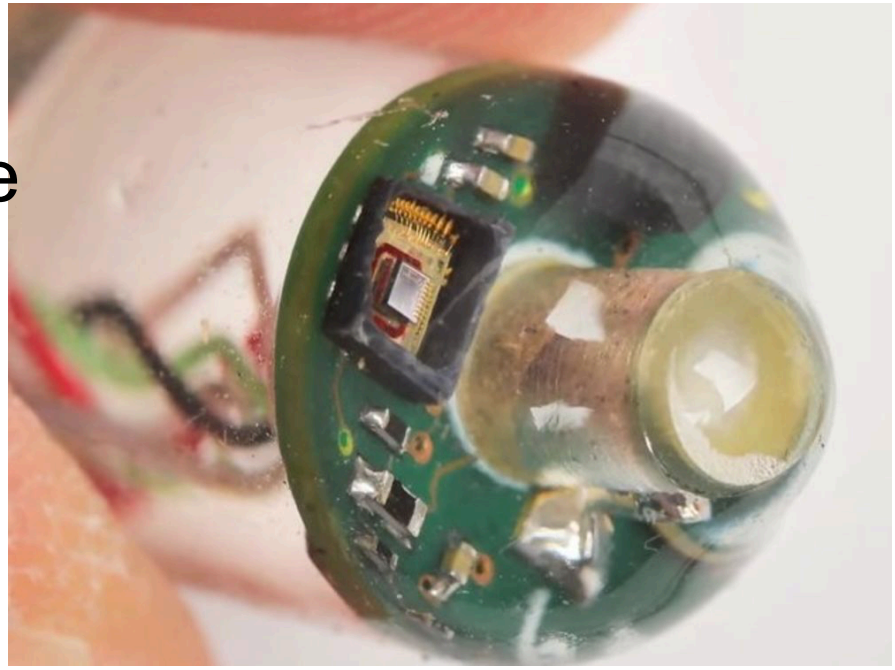
- Improve quality of life – "useful"

(Are all your projects serving the needs of the society?)

- Commercialization for economic benefit while also beneficial to the society – profit, to be more specific.

2016 Popular Science Invention Awards

The EnteroPhone



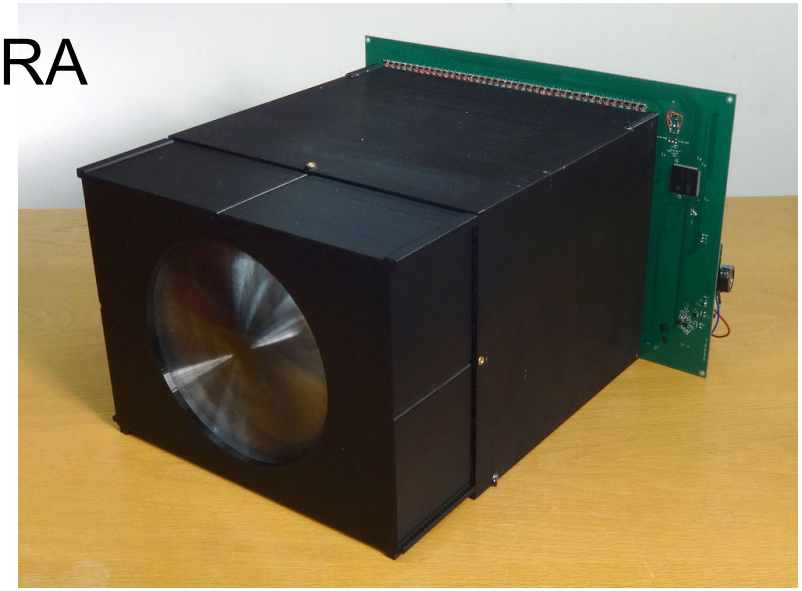
(www.popsci.com)

The EnteroPhone is a pill designed to monitor vital signs from inside the body.

Technology Maturity 1/5

2016 Popular Science Invention Awards

A SELF-POWERED CAMERA



(www.popsci.com)

Technology Maturity: 3/5

2016 Popular Science Invention Awards

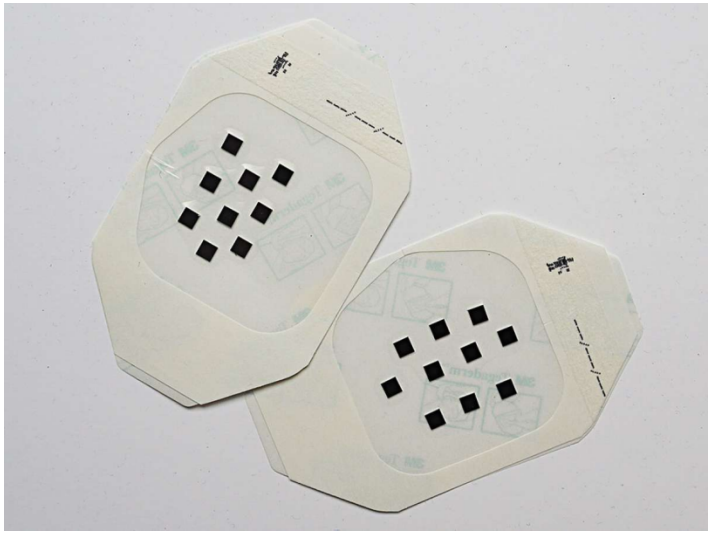
eora 3D

PRECISE 3D SCANNING ON THE GO

(www.popsci.com)

Technology Maturity: 5/5

2015 Popular Science Invention Awards



http://www.popsci.com/2015-invention-awards

Invention Awards

MEDICINE

Needle-Free Vaccination

Vaccines save lives, but most of them are delivered by needle. That's a problem for people without access to refrigerated solution, clean syringes, and safe ways to dispose of medical waste. Biomedical engineer Kasia Sawicka invented a painless alternative: a patch, called ImmunoMatrix, that can vaccinate patients without breaking the skin. "This technology can affect how vaccines are delivered, especially during pandemics," Sawicka says.

The skin doesn't absorb large molecules easily, which meant Sawick had to find another way to get vaccines across that barrier. As an undergraduate at Stony Brook

Inventor: Katarzyna "Kasia" Sawicka

Company: ImmunoMatrix LLC

Invention: ImmunoMatrix

Development cost to date: $100,000–200,000

Maturity

2015 Popular Science Invention Awards

Inventors:
Kevin R. Hart and Laura Moe

Company:
TZOA Wearables

Invention:
TZOA

Development cost to date:
Undisclosed

Maturity:

http://www.popsci.com/2015-invention-awards

2015 Popular Science Invention Awards

HEALTH

Medical Lab in a Music Box

1 selects a punch given reaction a it past gears wit

2 As one tooth slides into a punched hole, another squeezes a fluid channel to pump a chemical through a removable microfluidic chip.

One night in 2011, as Manu Prakash turned the handle on a music box, he realized the simple mechanism—a crank rotating gears—could also run a programmable chemistry set. Most "lab-on-a-chip" devices require computers, technicians, and expensive laboratories to pump precise amounts of liquid through a microfluidic chip. But a hand-cranked mechanism could eliminate all that; Prakash's idea wouldn't even need power. "What we're doing here is steampunk chemistry," he says.

Prakash, who heads a Stanford University research lab, recruited graduate student George Korir to help create a sophisticated scientific device that works li First, the duo had t paper punched wit holes—each keyed chemical reaction— tiny mechanical pu to generate nanolit Twenty-some proto they're preparing t nvention, Punchca

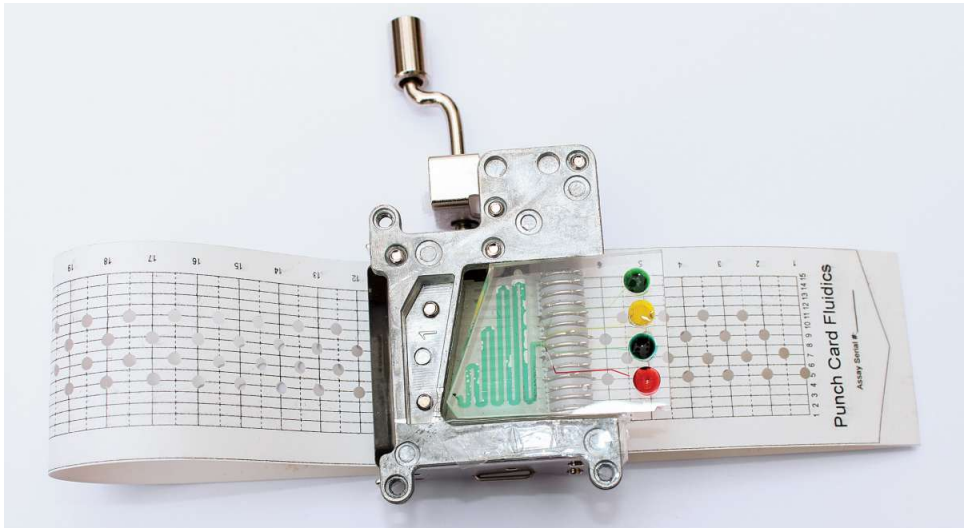
Inventors: Manu Prakash and George Korir

Affiliation: Stanford University

Invention: Punchcard Programmable Microfluidics

Development cost to date: $50,000

Maturity:



http://www.popsci.com/2015-invention-awards

An idea is not an invention

An invention is not a product

Not done before $\neq$ Necessarily useful invention!

Useful Invention = Successful Product *only* if marketed well

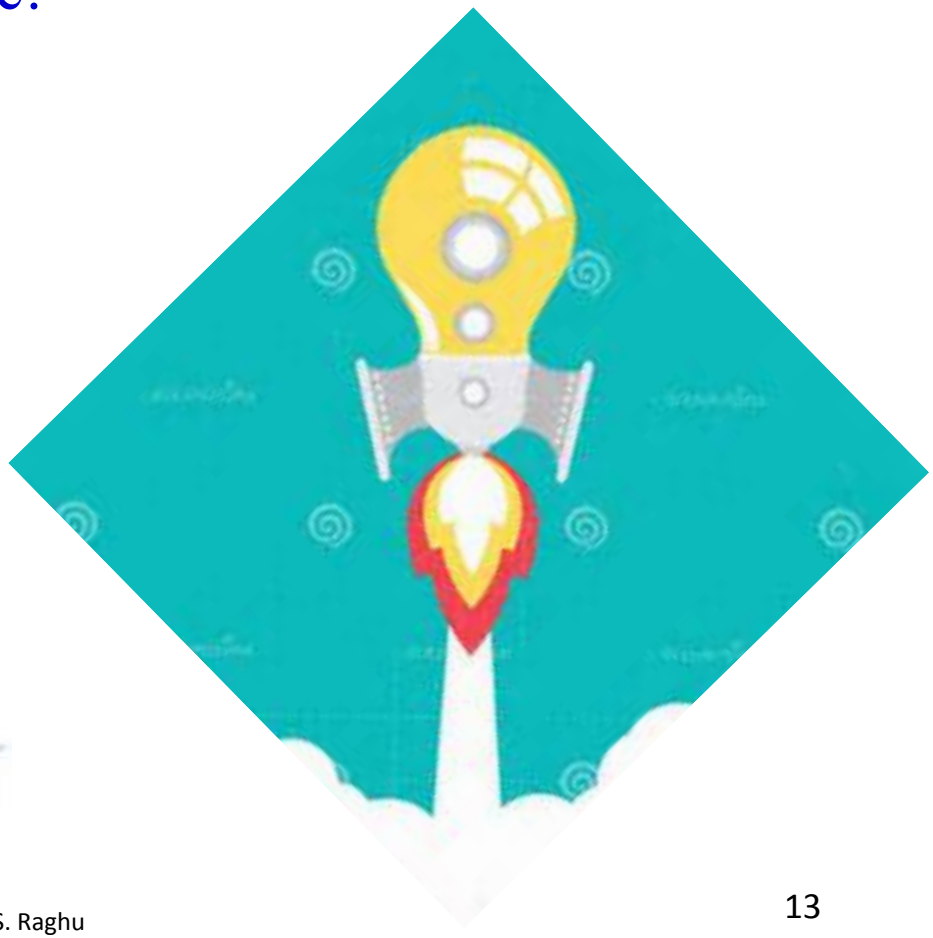
The path from invention to a product

6 aspects of taking an invention to a product

1. Technology Development
2. Securing Intellectual Property
3. Manufacturing Process development
4. Financials
5. Business Development
6. Company set-up and management

The path from invention to a product

It is important to understand that there are **quite a few things to be done** in taking an invention to a product – and **it takes some time** to accomplish all these!



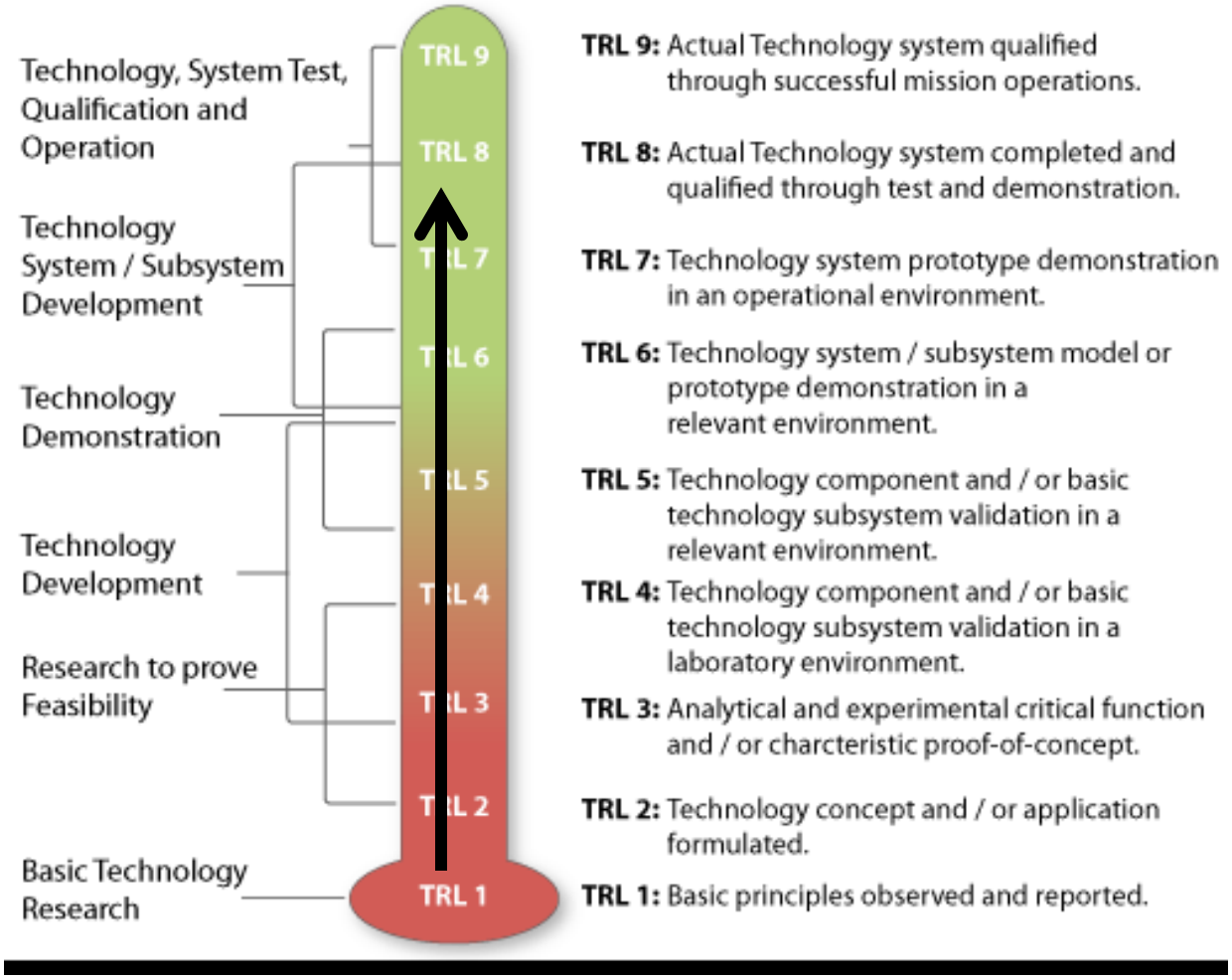
Technology Development and Technology Readiness Levels (TRL)

TRL Table: Developed by NASA and commonly used in the US (and more recently in Europe) for technology development programs to measure the maturity of a technology. Also important in the valuation of the product/company.

9 Stages of Technology Readiness Levels – TRL 1-9

(Ref: John C. Mankins (1995), http://www.hq.nasa.gov/office/codeq/trl/trl.pdf)

Technology Readiness Levels (TRL)



http://www.aof.mod.uk/aofcontent/tactical/techman/content/trl_applying.htm

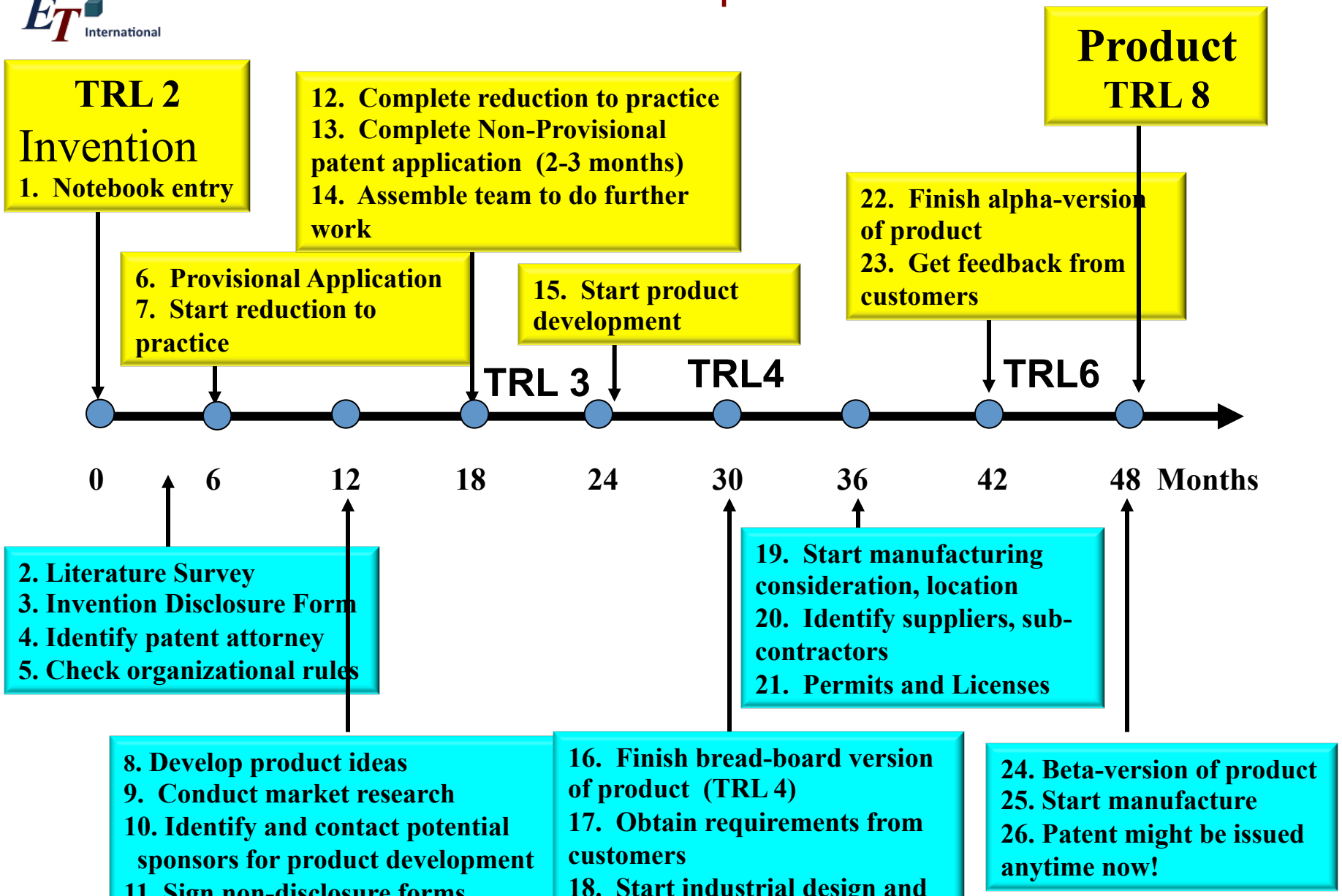
Some points about TRL

No official certification/approval process of TRLs

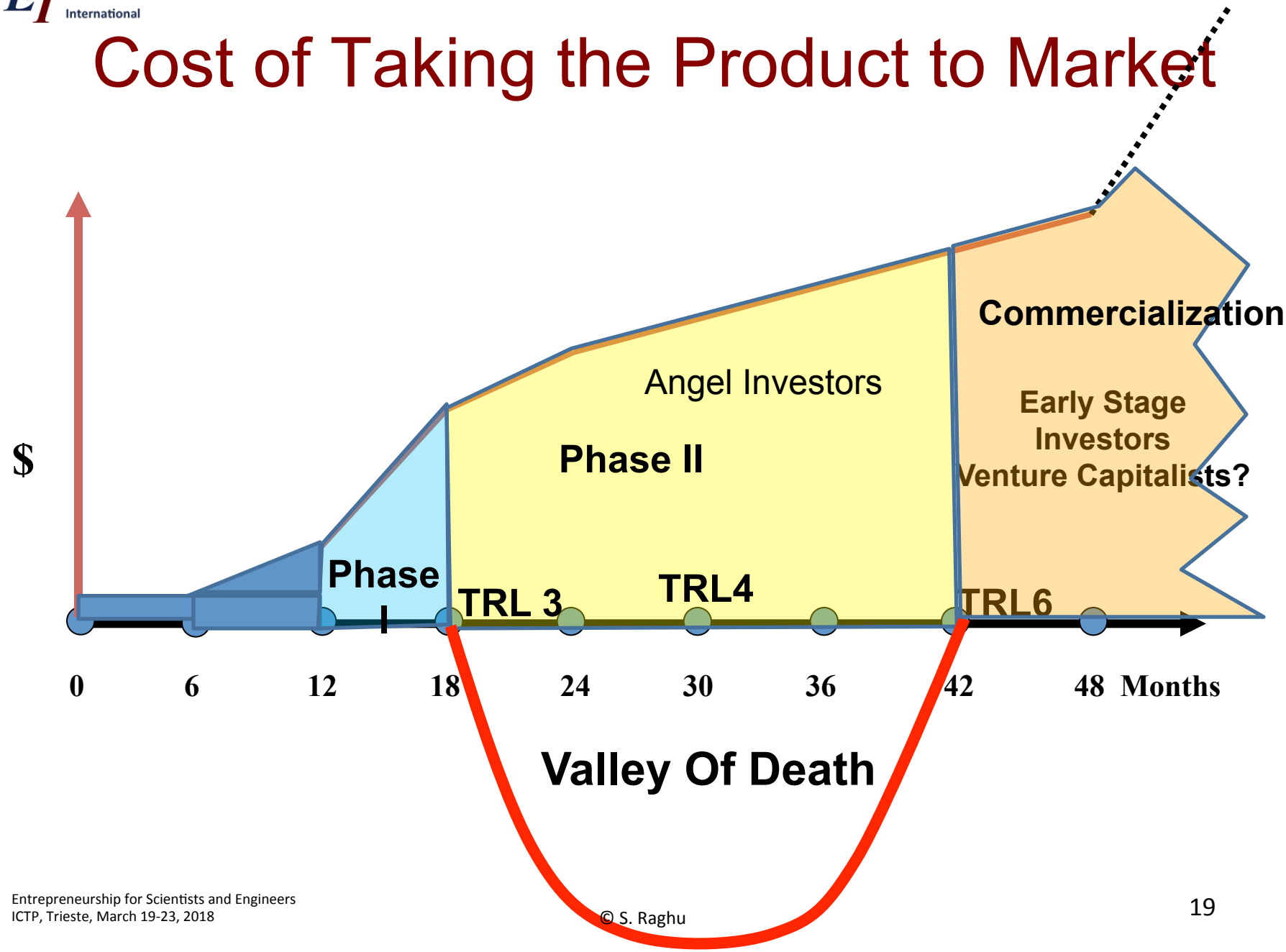
Multiple technologies in a single product?

How long does it take to get from TRL1 to TRL9?
(what is your estimate?)

Invention to Product: Steps and Time-Line



Cost of Taking the Product to Market



IRL and TRL??

Investor Readiness Level (IRL)

Examples of Timelines for Products

The Issued Patent

US006253782B1

(12) **United States Patent**
Raghu

(10) **Patent No.: US 6,253,782 B1**
(45) **Date of Patent: Jul. 3, 2001**

(54) **FEEDBACK-FREE FLUIDIC OSCILLATOR AND METHOD**

(75) Inventor: **Surya Raghu**, Ellicott City, MD (US)

(73) Assignee: **Bowles Fluidics Corporation**, Columbia, MD (US)

(*) Notice: Subject to any disclaimer, the term of this

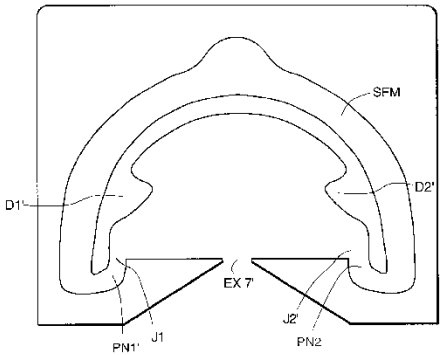
5,213,270		5/1993	Stouffer et al.	239/589.1
5,396,808	*	3/1995	Huang et al.	73/861.19
5,638,867	*	6/1997	Huang	137/826

FOREIGN PATENT DOCUMENTS

1550510	*	3/1970	(DE)	137/812

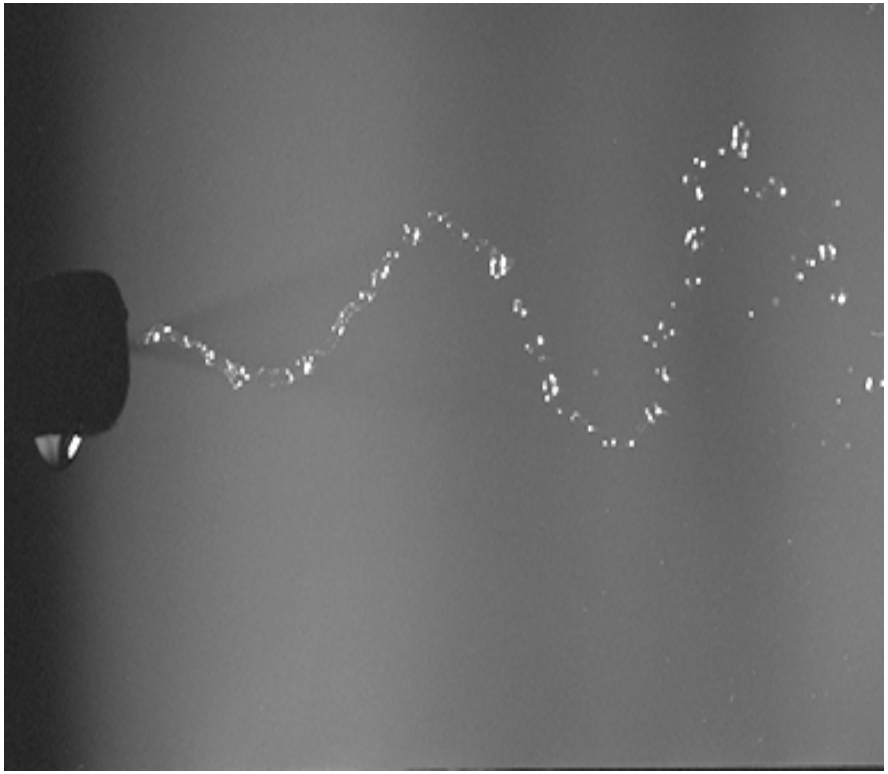
* cited by examiner

Primary Examiner—A. Michael Chambers



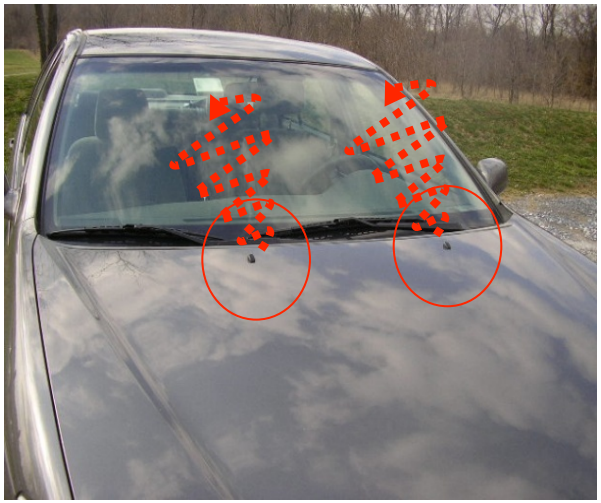
Where can I use this?

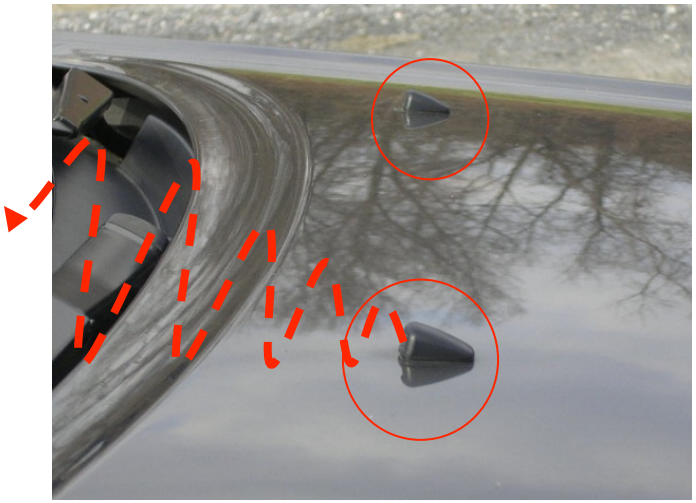
Oscillating jet (spray) generated by the device



Can I patent this idea?

Windshield Washer Nozzle





Example: Windshield washer nozzles based on hydrodynamic instabilities (market pull)

Inventor: Surya Raghu, USA

Invention process: August-October 1998

US Provisional application: October 1998

Non-Provisional Application: October 1999

Patent issued: July 2001

Development:

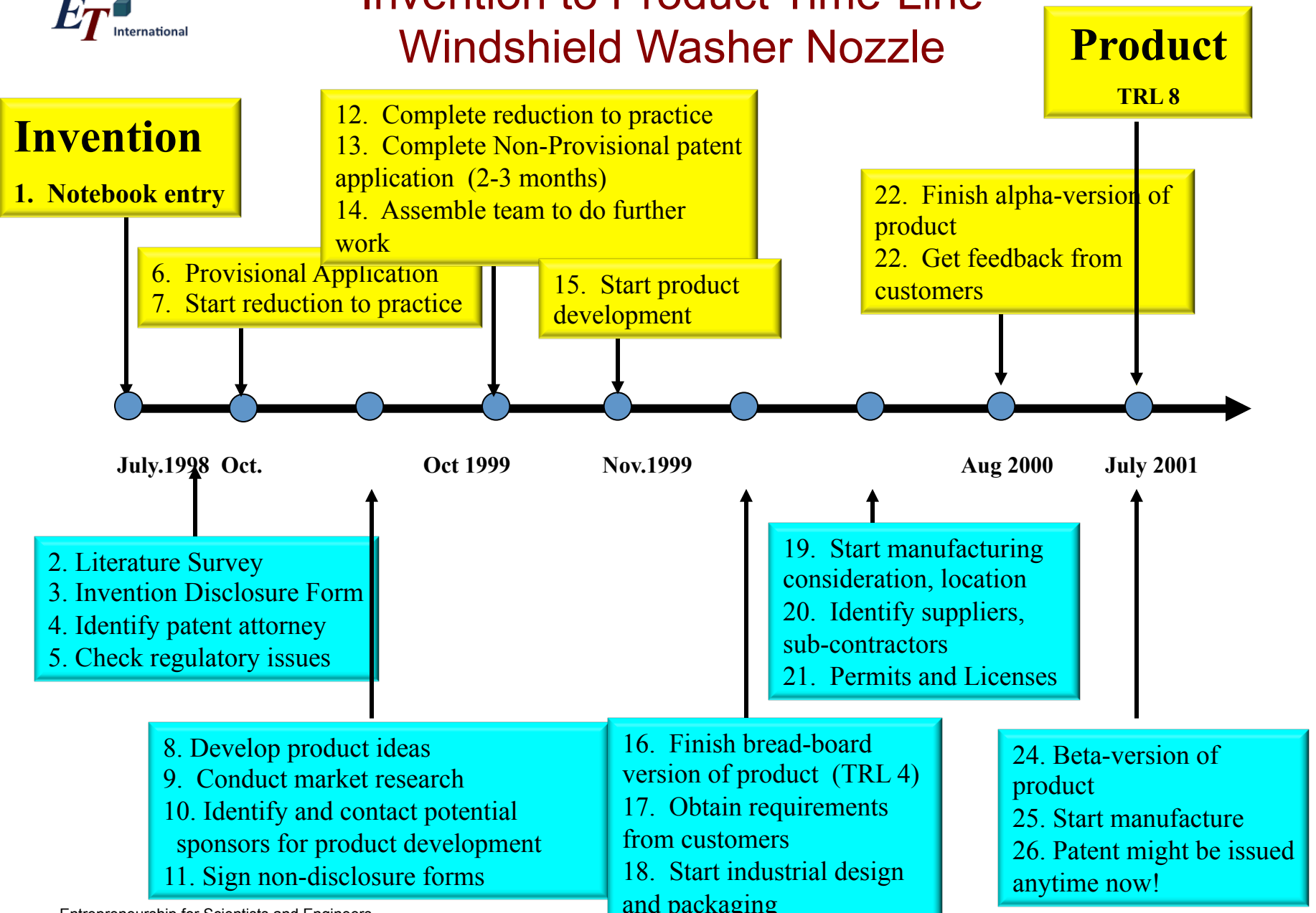
Currently an automotive product in use from 2001

The Final Product: Windshield Washer Nozzle (Manufactured in Zacatecas)

40 million nozzles/year

Used in GM,Ford, Chrysler, Volkswagon, Mercedes Saab, Jaguar Toyota, Honda

Invention to Product Time-Line
Windshield Washer Nozzle



Example: Wireless Corrosion Health Monitor

Inventors: Guy Davis, Chester Dacres and Lorrie Krebs (DaccoSci Inc)

Date Applied for patent: August 1999

Date Issued: Dec. 2001

Date product development began: Oct. 2005 (DaccoSci, Advanced Fluidics and Virginia Technologies)

Current status: Marketed by Electrawatch

The Issued Patent

US006328878B1

(12) **United States Patent**
Davis et al.

(10) **Patent No.: US 6,328,878 B1**
(45) **Date of Patent: Dec. 11, 2001**

(54) **ADHESIVE TAPE SENSOR FOR DETECTING AND EVALUATING COATING AND SUBSTRATE DEGRADATION UTILIZING ELECTROCHEMICAL PROCESSES**

(75) Inventors: **Guy D. Davis**, Baltimore; **Chester M. Dacres**, Columbia; **Lorrie A. Krebs**, Baltimore, all of MD (US)

(73) Assignee: **Daceo Sci, Inc.**, Columbia, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/372,074**

(22) Filed: **Aug. 11, 1999**

(51) **Int. Cl.**[7] **G01N 17/04**; G01R 27/02

(52) **U.S. Cl.** **205/776.5**; 205/791.5; 324/71.2; 324/693; 324/700; 204/404

(58) **Field of Search** 324/693, 700, 324/707, 713, 722, 71.2; 205/776.5, 777, 791.5; 204/404; 422/53

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,806,849	*	2/1989	Kihara et al.	204/404
4,890,622	*	1/1990	Ferrari	128/640
4,899,754	*	2/1990	Fily et al.	128/640
5,069,771	*	12/1991	Hlavky et al.	204/404
5,306,414	*	4/1994	Glass et al.	204/404
5,438,988	*	8/1995	Duan et al.	128/640
5,859,537	*	1/1999	Davis et al.	324/693
6,054,038	*	4/2000	Davis et al.	205/776.5

OTHER PUBLICATIONS

Simpson et al "Evaluation of the effects of acidic deposition on coated steel substrates", Prog. Org. Coatings. 20 pp. 199–216, month unavail. 1992.*

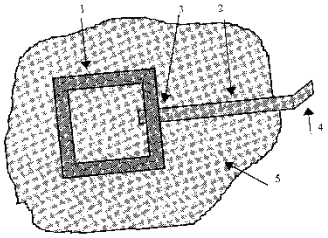
* cited by examiner

Primary Examiner—Robert J. Warden, Sr.
Assistant Examiner—Kaj K. Olsen

(57) **ABSTRACT**

A portable and nondestructive adhesive tape corrosion sensor which is utilized under actual field or laboratory conditions in detecting coating and substrate degradation using Electrochemical Impedance Spectroscopy (EIS) of coated or uncoated metal structures has been developed. The invention allows for broad applicability, flexibility in utilizing the sensor in various environments without structural compromise and the ability to inspect and evaluate corrosion of the actual structure, regardless of the size, shape, composition, or orientation of the structure. The electrodes may be removed once a measurement is made or remain in the original fixed position so that subsequent measurements may be made with the same electrode. The nondestructive sensor apparatus is comprised of a pressure-sensitive adhesive tape that consists of a conductive film or foil and conductive adhesive overlapping another pressure-sensitive adhesive tape that consists of a conductive film or foil and non-conductive adhesive. The conductive tape serves as the sensing element or device. The non-conductive tape serves as the lead between the sensing element and the point of measurement. In an alternative configuration, the tape with the conductive adhesive may be used alone, acting as both sensor electrodes and the lead to the point of measurement. The metal structure or other substrate being sensed or evaluated for degradation serves as the working electrode. This two electrode sensing device is responsive to water uptake, incubation, and corrosion by measuring differences in impedance spectra. The invention can readily detect, quantify and monitor coating and metal degradation from its earliest stages, well before any visual indication of corrosion appears, under both laboratory and field conditions.

2 Claims, 2 Drawing Sheets



Corrosion Health Monitor

Product (2008)

www.electrawatch.com

(2007)

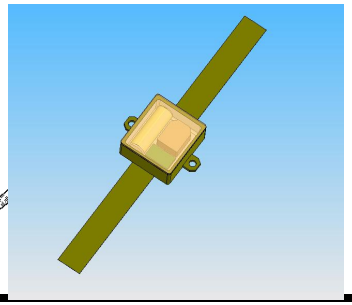
Prototype 1

"mock-up"

(2006)

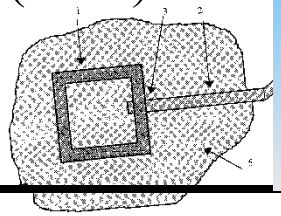
Product concept

(2005)



Patent

(2001)



TRL 8

TRL 6

TRL 3

TRL 1

ATRIAL FIBRILLATION MONITOR

UK: MELYS DIAGNOSTICS

USA: ADVANCED FLUIDICS

ATRIAL FIBRILLATION MONITOR

Inventor: Dr. Dawood Parker, UK

Invention process: 2003-2006

European Patent application: May 2006

Complete Specification: May 2007

Patent issued (date): To be issued

Development:

1. Proof of concept

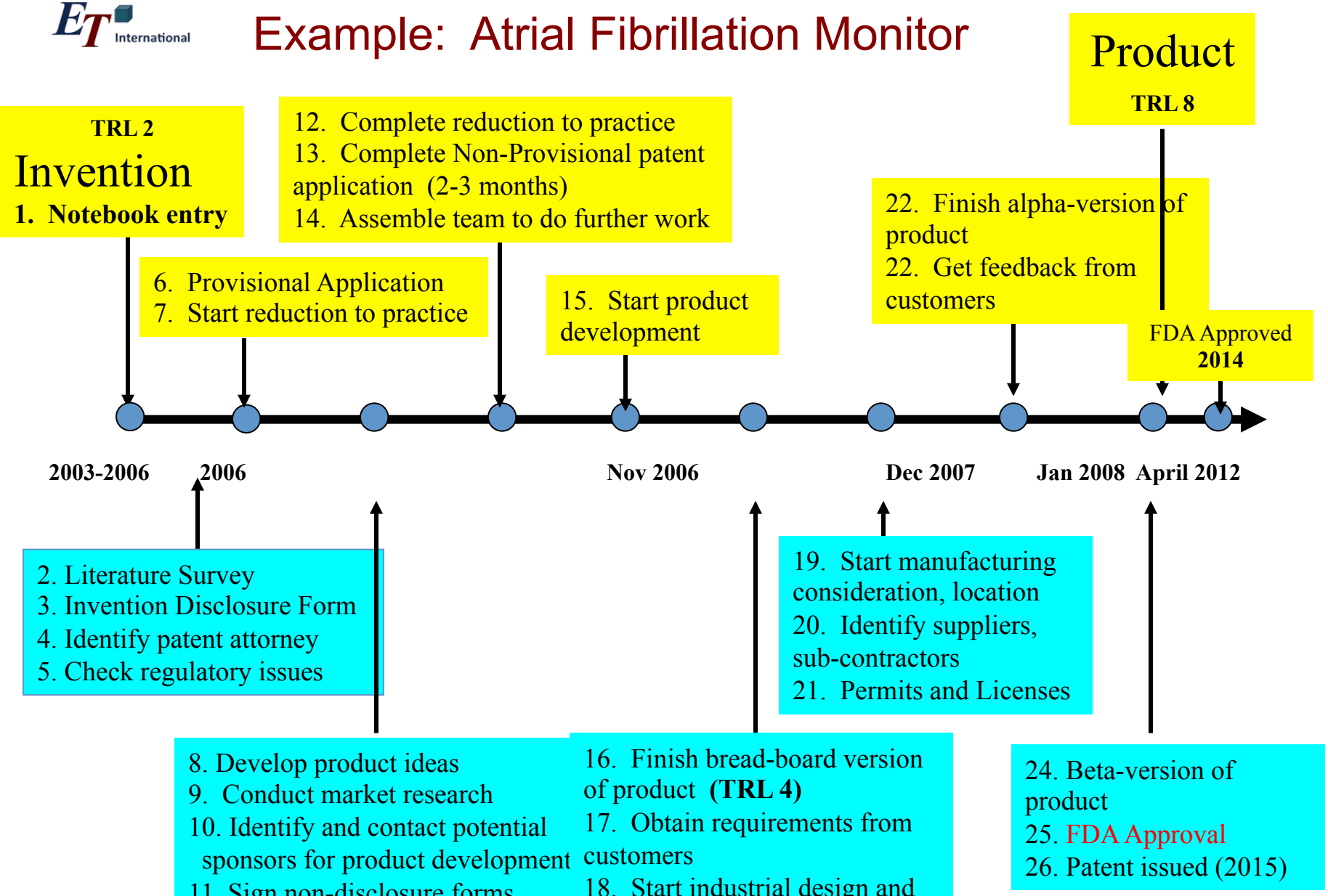
2. Validation with EKG (UK &US)

3. Pre-production (Alpha) Prototype ready in November 2007

4. Manufacturing prototype Version 1 2008

5. FDA Approval Process and Redesign for Manufacture (2009)

Example: Atrial Fibrillation Monitor



Airplanes

Green Aviation

April 22, 2015

NASA Tail Technology Could Someday Reduce Airplane Fuel Use

http://www.nasa.gov/image-feature/nasa-tail-technology-could-someday-reduce-airplane-fuel-use

NEWS
News, features & press releases

MISSIONS
Current, future, past missions & launch dates

MULTIMEDIA
Images, videos, NASA TV & more

CONNECT
Social media channels & NASA apps

ABOUT NASA
Leadership, organization, budget, careers & more

Search

For Public | For Educators | For Students | For Media

Send Share

News & Features

Text Size

News Topics

Nov. 14, 2013

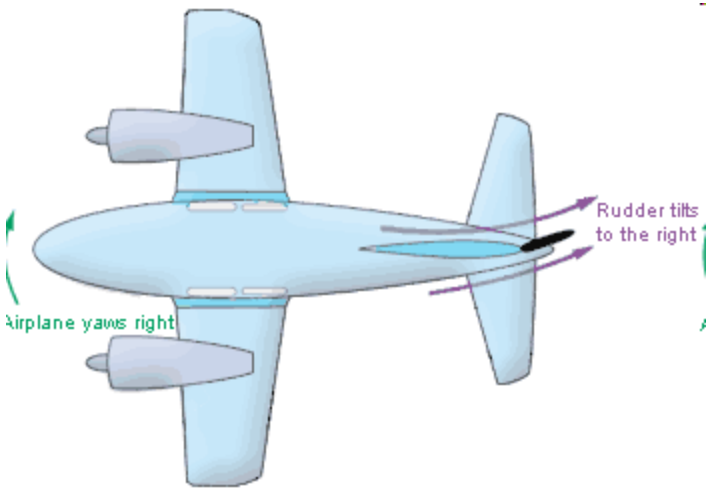
RELEASE 13-340
NASA, Boeing Finish Tests of 757 Vertical Tail With Advanced Technology

"The flow control on the 757 vertical tail model comes from **sweeping jet actuators**, which are devices that essentially blow air in a sweeping motion along the span of the tail"

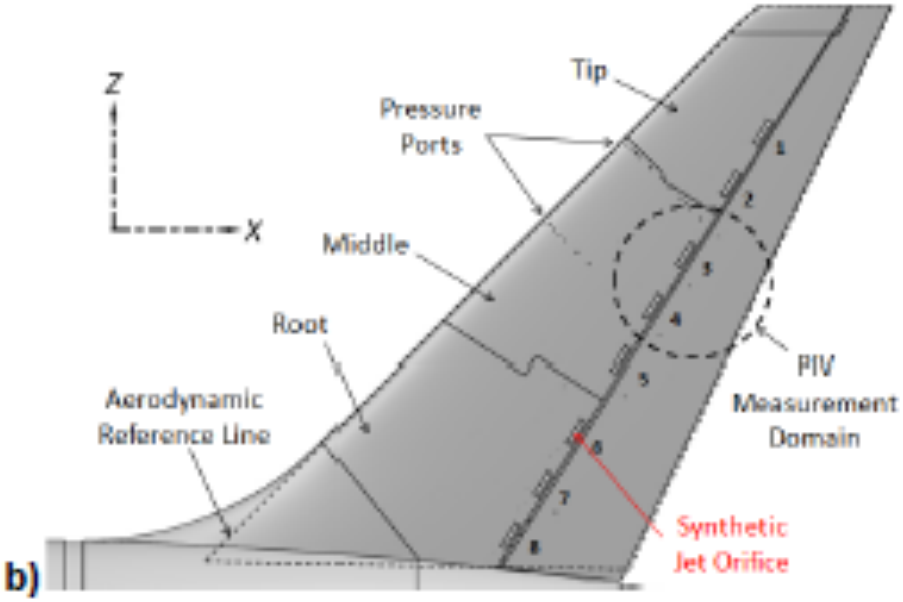
"NASA's goal for the AFC project is to increase sideforce 20% on demand, and shrink the vertical tail by 17% to reduce aircraft fuel burn by 1-2%."

http://aviationweek.com/awin-featured-story/boeing-nasa-test-active-flow-control-tail

Aerodynamic Flow Control Devices for Future Airplanes



http://wingsovermars.arc.nasa.gov/surfaces.html



Rathay et al, AIAA 2012-0071

Aerodynamic Flow Control Devices for Future Airplanes

Idea: 2006:

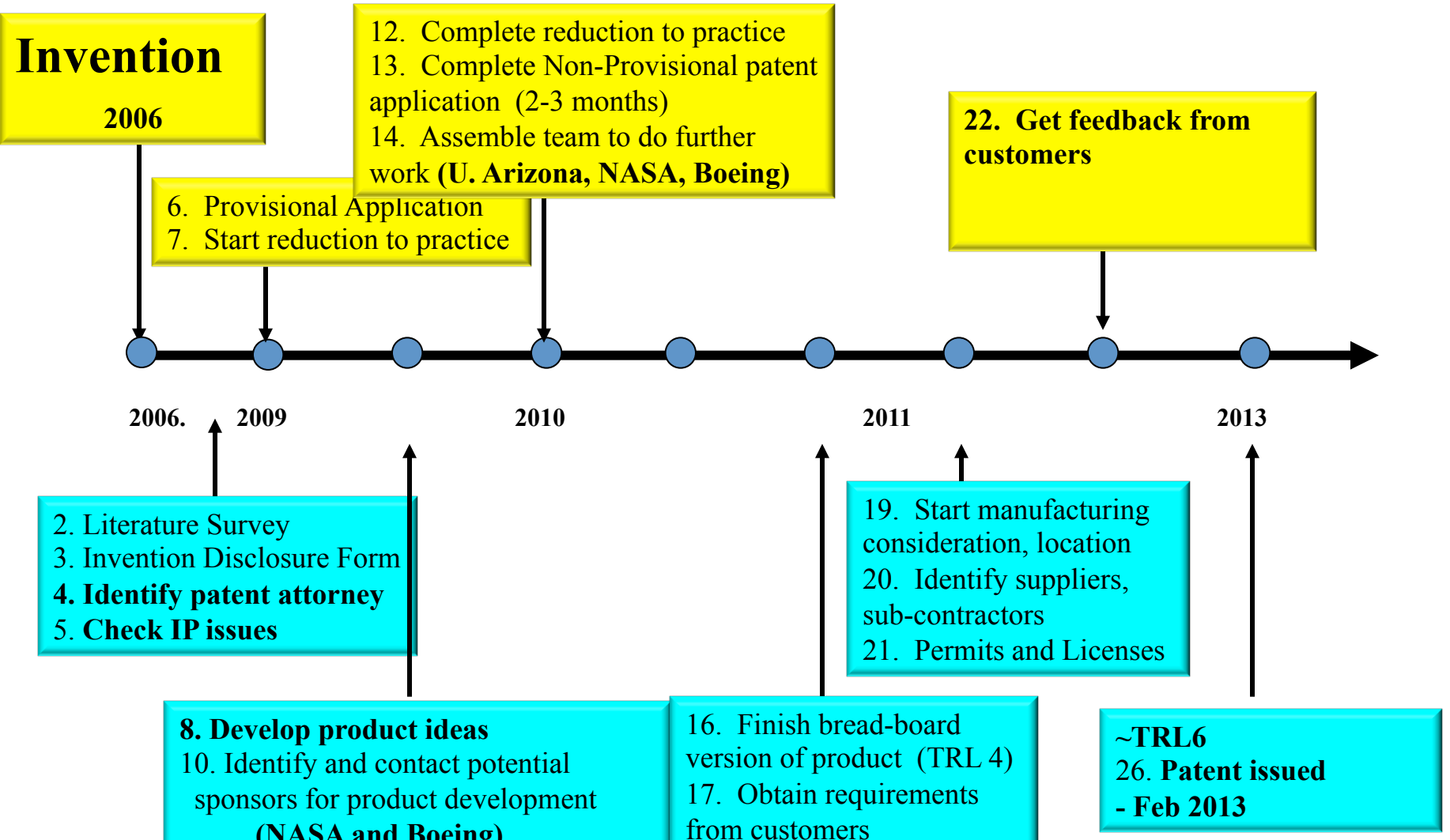
Started working in 2008 (Invention)
Provisional Patent application – July 2009
Full US Patent Application in July 2010
Patents Issued February 2013

Team: Advanced Fluidics + NASA + U. of Arizona + Boeing

The development cycle is much longer because of system level requirements and testing

TRL ~ 5 Competition begins!

Aerodynamic Flow Control Devices



Minimize “Time to Market”

Cost

Competition

Window of Opportunity

New Trends in Product Development

1. Plan for future functionality in present product design

2. Consumers are demanding responsibility in product design

3. 3D printing plays a crucial role in any product design

4. Outsourcing is a viable for product design

5. Knowledge base with documentations for customers

6. Globalization vs. Customization

New Trends in Product Development (contd)

7. Smart Products – Hardware + Software

8. Connectivity with customers

"PITFALLS IN COMMERCIALIZATION"

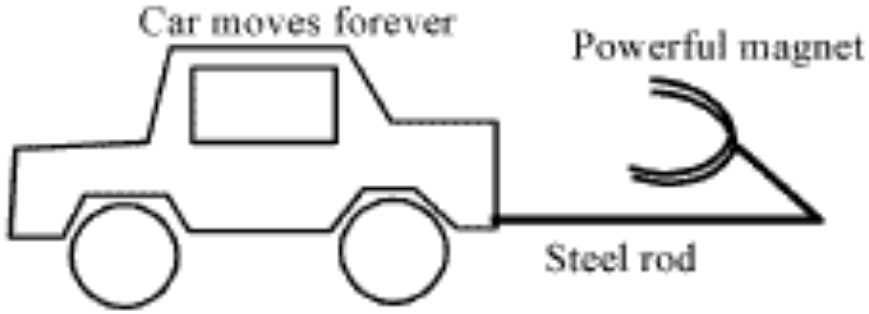
1. Reinventing the wheel

"PITFALLS IN COMMERCIALIZATION"

2. Ideas that did not work in reality – not really an invention

   - Do not stand the test of science!

Example: Perpetual Motion Machines



http://www.lhup.edu/~dsimanek/museum/patents.htm

"PITFALLS IN COMMERCIALIZATION"

Ideas worked and ***even patented*** but limited or no applications (no products)

More Inventions

What not to do? ("less-useful" patents)

http://www.freepatentsonline.com/crazy.html

"PITFALLS IN COMMERCIALIZATION"

Products successful only for a while or technology outdated

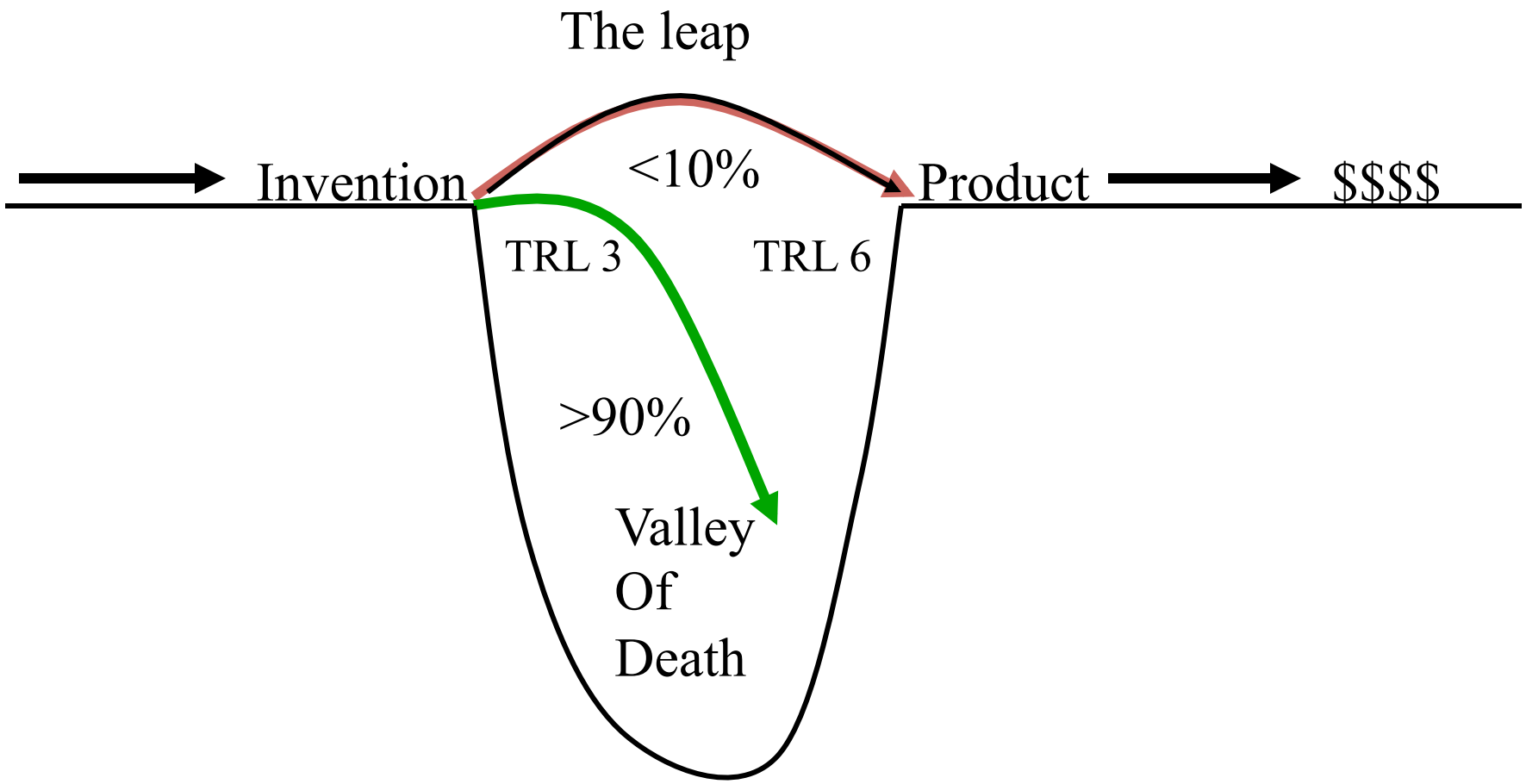
Fountain Pens
Typewriters
Pay Phones
Landline phones
Carburetors
Internal Combustion Engines?

CONCLUSIONS

Invention to a Product involves quite a few steps and processes

Technology Readiness Levels (TRL) is a good metric for determining the stage of the product.

CONCLUSIONS



CONCLUSIONS

Watch out for pitfalls!

ET International

THANK YOU

Challenges for Inventors and Entrepreneurship in Developing Countries

1. Poor physical infrastructure and no financial support
2. Lack of government and institutional support
3. Lack of planning and metrics for progress
4. Economic, cultural and moral factors on inventions
5. Societal and cultural taboos on failure

Opportunities

You have to make them yourselves!

Grand Challenges (National Academy of Engineering, USA)

[http://www.engineeringchallenges.org]

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

How do we promote inventions and innovation in scientific and educational institutions?

1. University-Industry interaction.

   Example: Presentation of Industrial R&D needs to Universities so that researchers will see the market needs.

2. Industry sponsored projects to students and faculty

3. Industrial internships for students and faculty

4. Encouragement – it is OK to fail!

5. Patents are not substitutes for papers – too expensive!

Some Useful References:

1. www.uspto.gov
2. Patent It Yourself --A complete inventor's guide. (11th ed. Spring 2005) By David Pressman, Patent Lawyer, San Francisco
3. http://www.wipo.int/portal/en/resources_innovators.html
4. http://www.wipo.int/patentscope/en/data/developing_countries.html#P11_68
5. http://www.engineeringchallenges.org

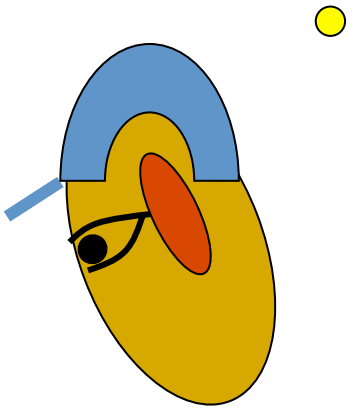
Beginning steps

1. **Think of *products*** that can be developed using the invention. Your invention/product can stand on its own or be a part of others' product or system. ….

2. **Connect yourself** to the markets in the field of invention and possibly other related areas.

3. **Document your invention** - this is important for patent filing

Inventions and Technology Readiness Levels (TRL 1-9)



TRL1

Lowest level of technology readiness. Research begins to be translated into applied research and development. Examples might include

a) Paper studies of a technology's basic properties (at the level of a proposal to a funding agency)

b) An exploratory idea that could potentially generate a new product/technology

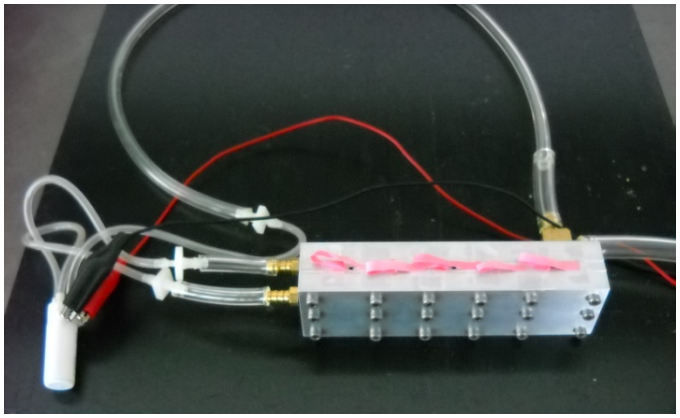
TRL 2

Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.

TRL 3

Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology.

Examples include components that are not yet integrated or representative – bench-top or "warm-feeling" experiments.

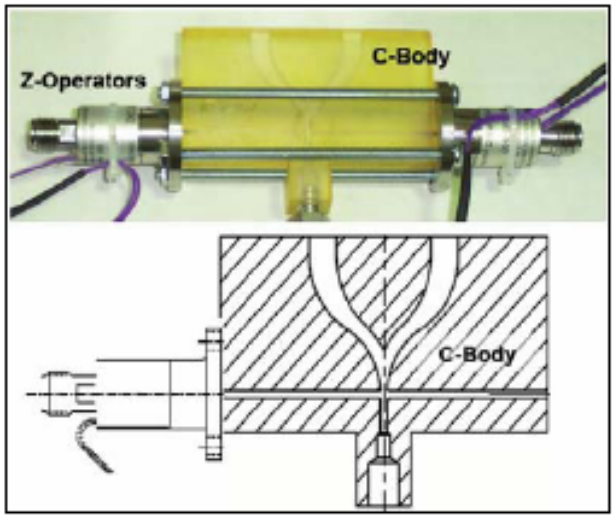


TRL 4

Basic technological components in the intersect areas are ***integrated in a similar fashion*** to establish that they will work together. This is relatively "low fidelity" compared to the eventual system.

Examples include integration of "ad hoc" hardware in the laboratory.

Device fabricated in the lab and either glued or attached with fasteners.



(Dennis Culley, NASA/TM—2006-214396)

TRL 5

Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.

Examples include "high fidelity" laboratory integration of components.

TRL 6

Similar but not necessarily the same system, which is well beyond that of TRL5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness.

Examples include reliability and satisfactory performance characteristics in a high fidelity laboratory environment or in simulated operational environment (operating range of temperature, humidity, pressure, etc.)

Reduces

- Product liability
- Product recalls

Corrosion Sensor

TRL 7

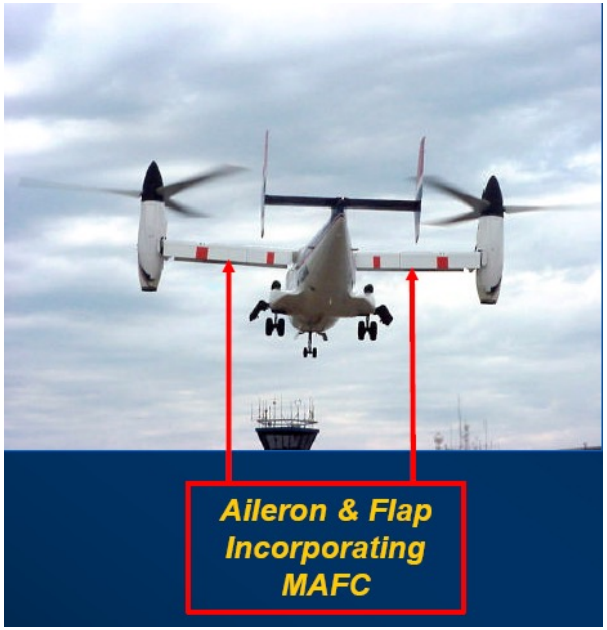
Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment.

Examples include testing the prototype in a mock-up of the final product.

TRL 8

Technology/product proven to work in its final form and under expected conditions. In most cases, this TRL represents the end of true system development.

Examples include developmental test and evaluation of the system in its intended environment to determine if it meets specifications.



(DARPA MAFC Briefing 2003)

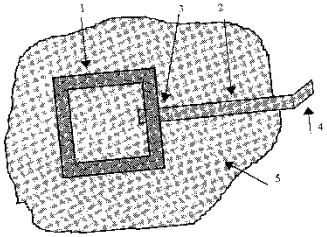
TRL 9

Actual application of the technology or product in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

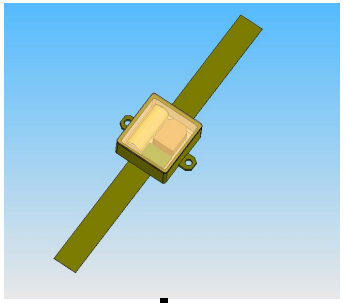
http://serkanbolat.com/2016/02/17/technology-readiness-level-trl-put-into-practice/

Invention to Product: Corrosion Health Monitor

INVENTION → Patent (2001)



Product concept (2005)



"mock-up" (2006)

Prototype 1

TRL 7 (2007)

Product (2008)

www.electrawatch.com

What are you inventing?

New Technology? (Method and Apparatus or Process)

"Technology is a capability that can be used in a product."

Example: Laser – Ted Maiman (1960)

"a solution looking for a problem?"

(http://spie.org/x39920.xml)

OR

A New Product? (Apparatus)

"makes use of existing or new technologies"

Optical readers, scanners, laser pointer, laser-based eye surgery systems, golf trainer, laser machining, …….

A new product has a customer and a market in mind

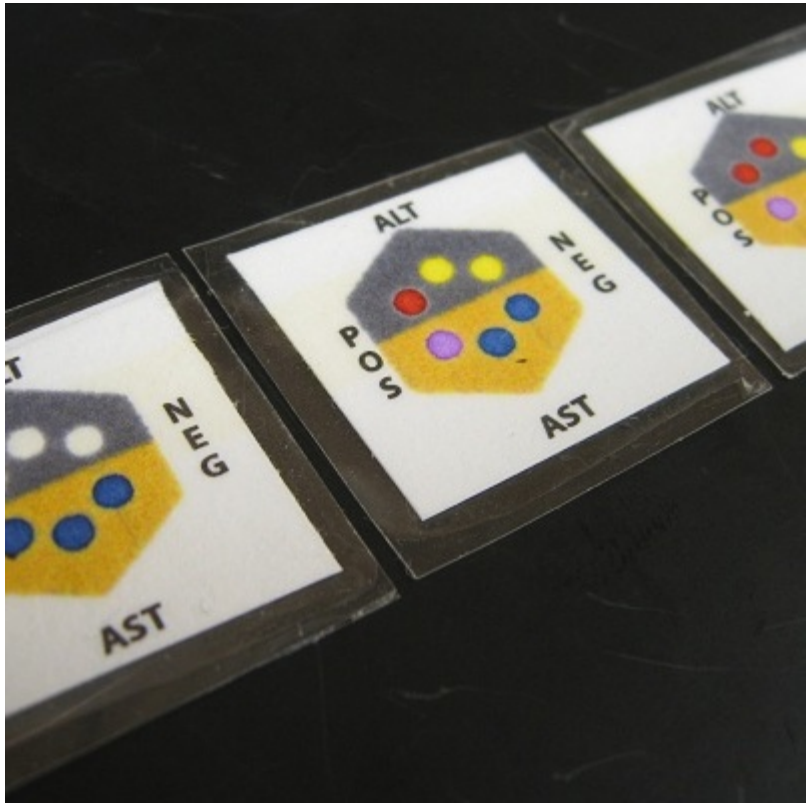
Products from Developing Countries

Waterwheel
https://vimeo.com/31340548

http://www.wellowater.org/

Products from Developing Countries

DFA's Paper-Based Liver Function Tests



http://www.engineeringforchange.org/the-years-promising-prototypes/

Products from Developing Countries

Portable Infant Warmer

http://www.embraceinnovations.com/

Motorized Ice-cream cone

TRL – Science to Wealth