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Engineer: The Power Behind Innovation

University of Patras Seminar Series

Presented by:

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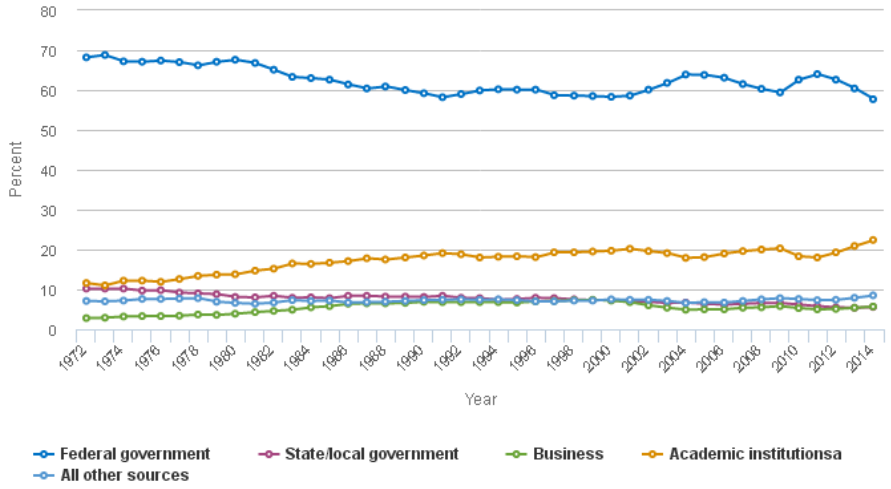
Center for Environmental Systems
May 31, 2017

Trends in Innovation and Entrepreneurship

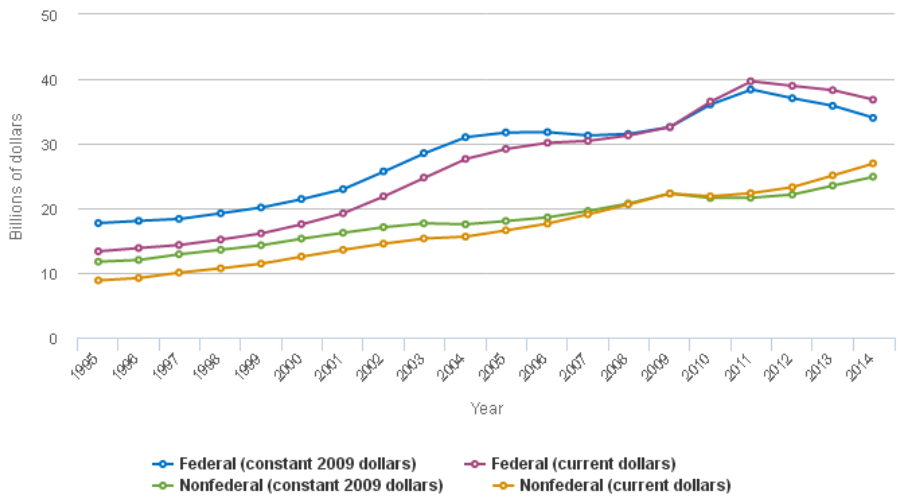
- The contribution of Engineering to Innovation
- The traits of the entrepreneur
- The entrepreneurial ecosystem
- How to build a start-up
- A case-study

Who is funding academic R&D and technology commercialization?

Academic S&E R&D expenditures, by source of funding: FYs 1972–2014



Federal and nonfederal funding of academic S&E R&D expenditures: FYs 1995–2014

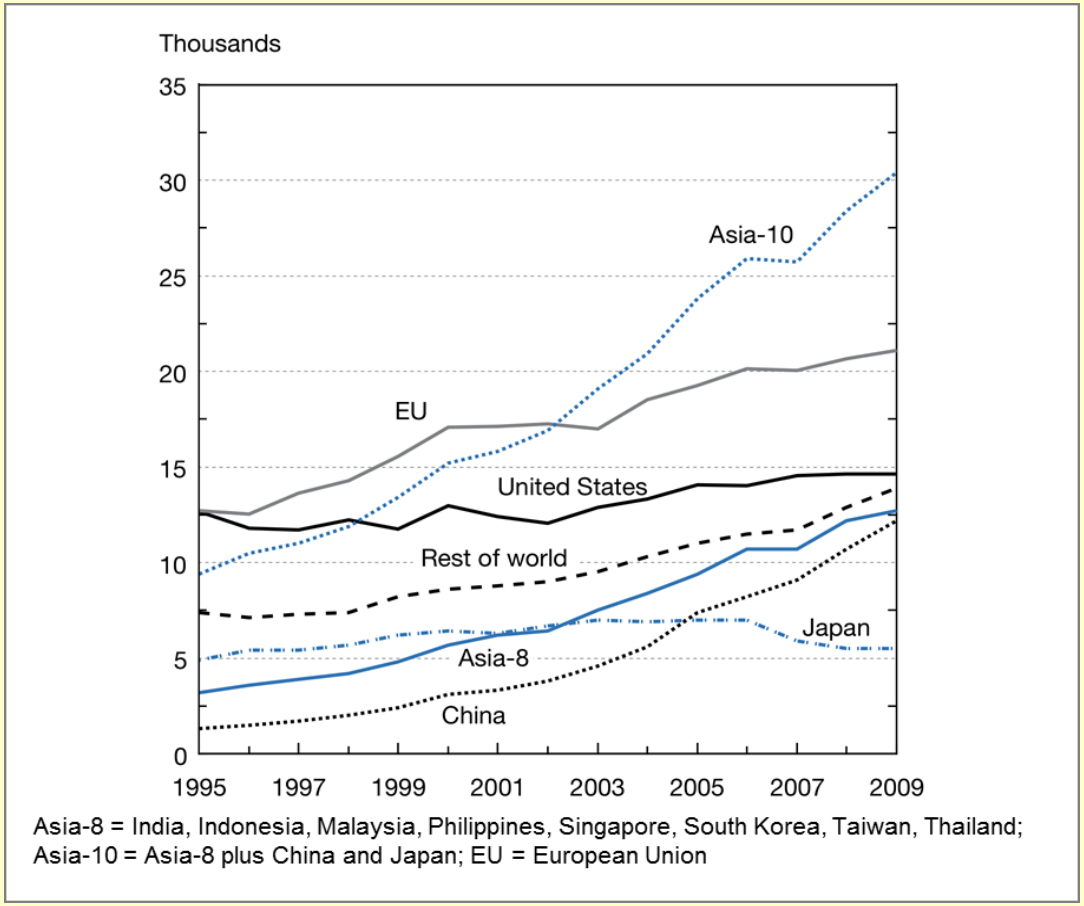


The majority of academic R&D funding in the US is provided by the federal government

Two major sources of new technology-based firms are well established:

1. Industrial firms (corporate spin-offs) and
2. Universities (academic spin-offs), which have been traditionally considered as an important source of new technology

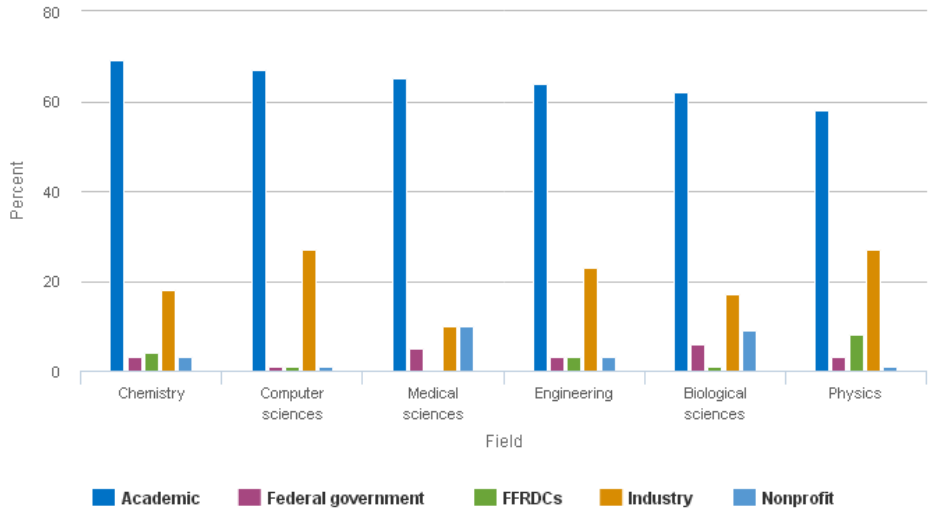
Engineering journal articles produced by selected regions/countries: 1998–2009



Asia-8 = India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand;
Asia-10 = Asia-8 plus China and Japan; EU = European Union

Contribution of Academia to Patents

Figure 5-36
Citation of U.S. S&E articles in U.S. patents, by selected S&E field and article author sector: 2014



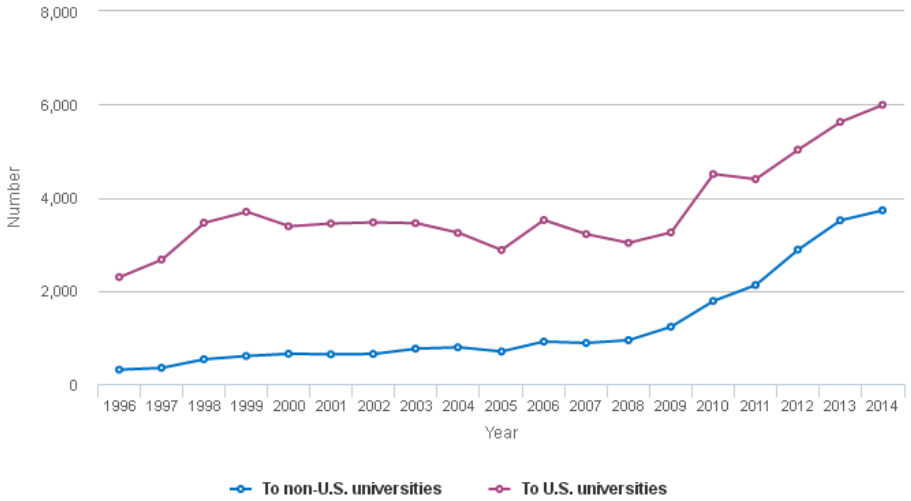
FFRDC = federally funded research and development center.

NOTES: Fields with less than 5% in 2014 are omitted. Citations where the sector is unknown sectors are not shown. Citations to state and local government S&E articles are also not shown.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics; SRI International; Science-Metrix; LexisNexis and U.S. Patent and Trademark Office patent data; Elsevier, Scopus abstract and citation database (www.scopus.com). See appendix table 5-65.

Science and Engineering Indicators 2016

Figure 5-37
USPTO patents granted to U.S. and non-U.S. academic institutions: 1996–2014



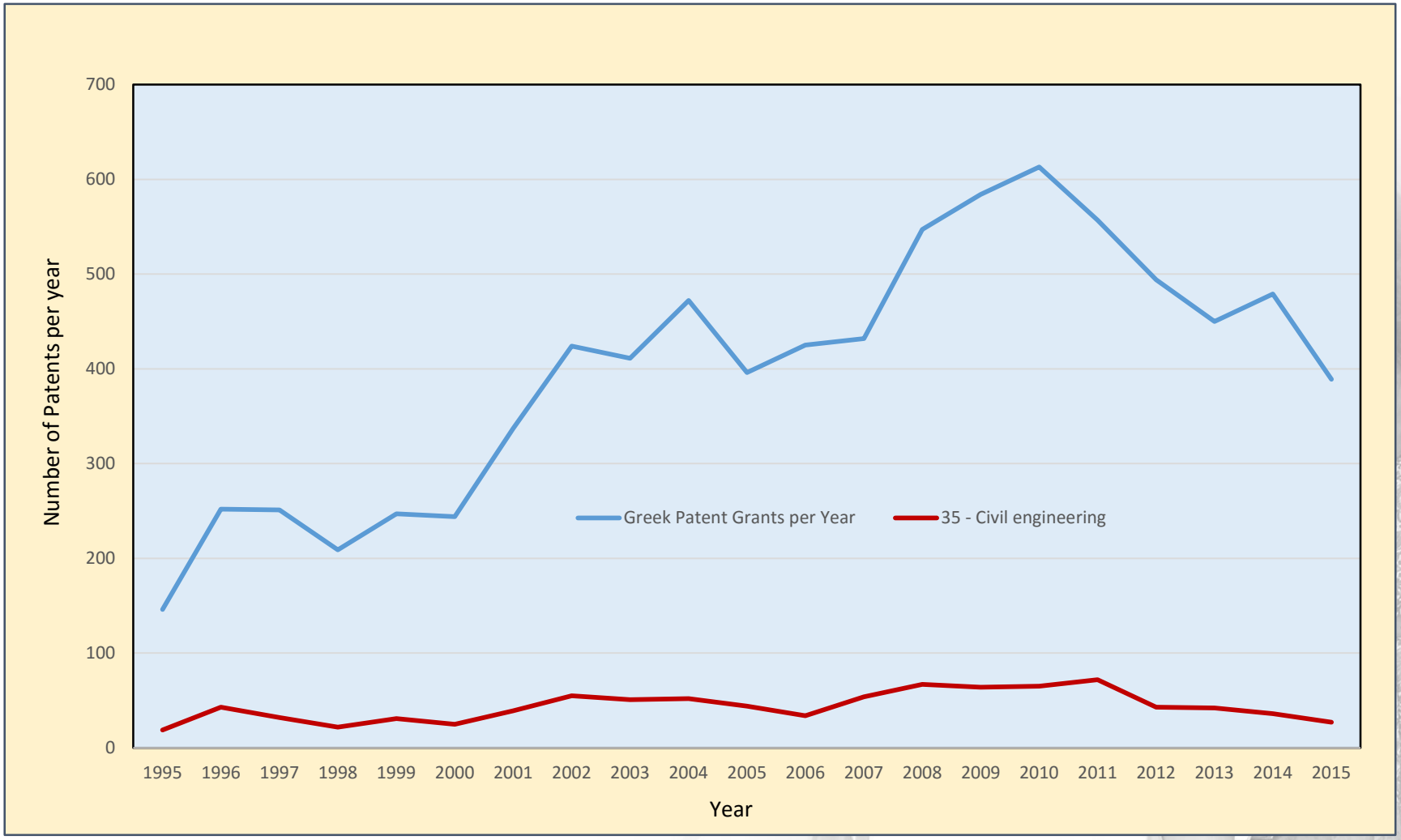
USPTO = U.S. Patent and Trademark Office.

NOTE: Patents are credited on a fractional-count basis (i.e., for articles with collaborating institutions, each institutions receives fractional credit on the basis of the proportion of its participating institutions).

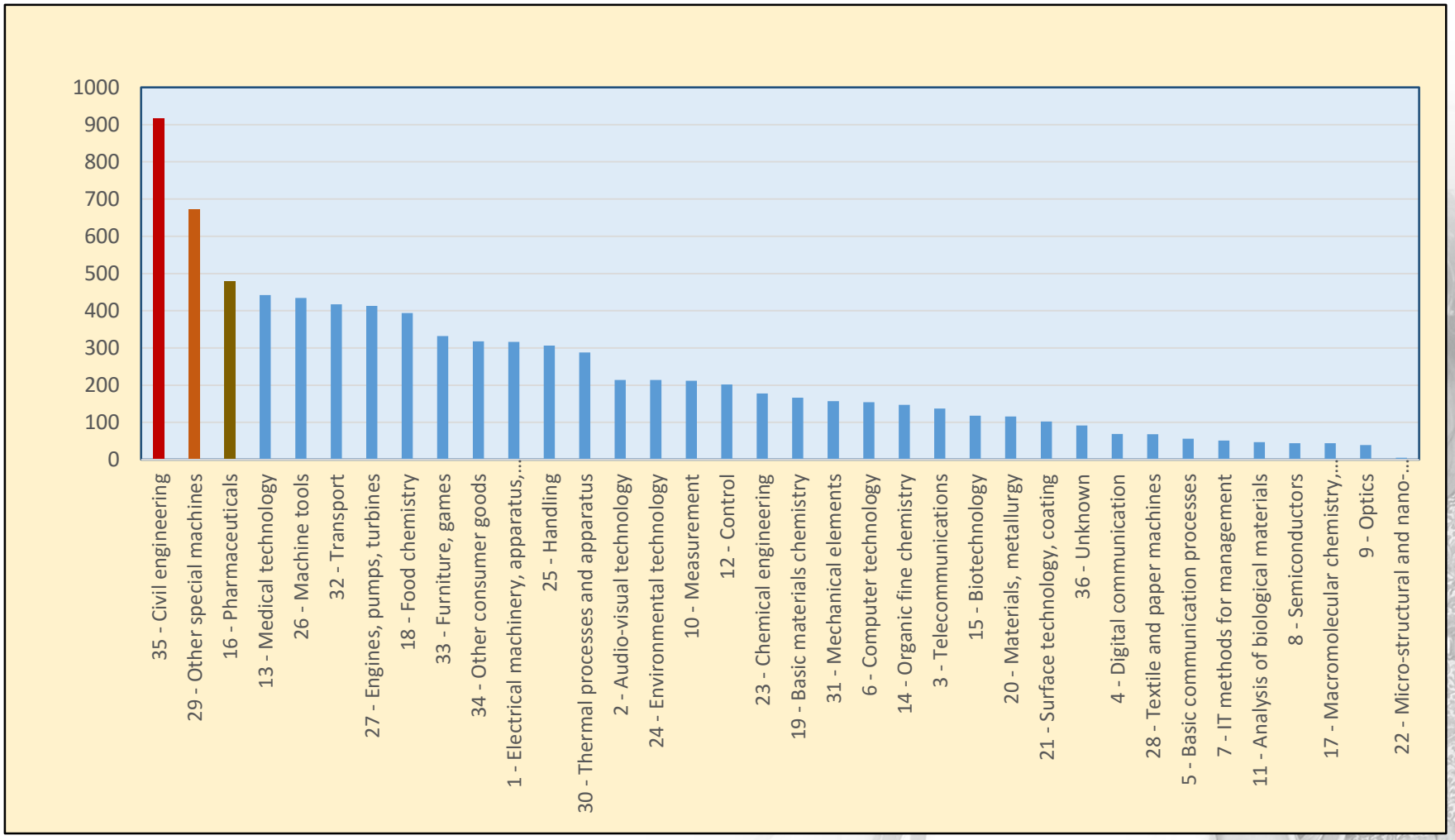
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics; SRI International; Science-Metrix; U.S. Patent and Trademark data.

Science and Engineering Indicators 2016

Total number of patents issued per year in Greece



Total number of patents awarded by industry sector in Greece 1995 to 2000



The Innovation Engineer

Author Stephen Armstrong and professor of innovation at the University of Toronto writes:

- A new kind of 'innovation engineer' that will serve society at the strategic and humanitarian level as well as the technical and operational level is needed
- The role and future work skills is about necessity – 50 per cent of the new engineer role is managing change.
- Engineers as currently educated aren't capable of doing this – they are weak at 'engineering' social and cultural change – their education is deep but in very narrow technical domains – add-on business or humanities courses are not enough;
- Engineering is not a scientific activity – science enables engineering – not the other way around – without engineering science is just philosophy;
- Engineering is art, science and above all practice.

Can entrepreneurship be taught?

Yes!

How?

- By a variety of pedagogical methods

Traditional training

- Courses, Senior Design etc.
- Business plan competitions
- Summer internships
- Seminars, modules
- Entrepreneurship minor

Experiential learning

- Apprenticeships
- Internships in start-ups
- Entrepreneurship practicum
- Interviews with entrepreneurs
- Computer simulations

Entrepreneurship is a State of Mind

Entrepreneurial characteristics / traits

Entrepreneur: An **entrepreneur** is a person who starts a new business venture, a startup (**Νεοφυής επιχείρηση**). We tend to think of entrepreneurs as people who have a talent for seeing opportunities and the abilities to develop those opportunities into profit-making businesses

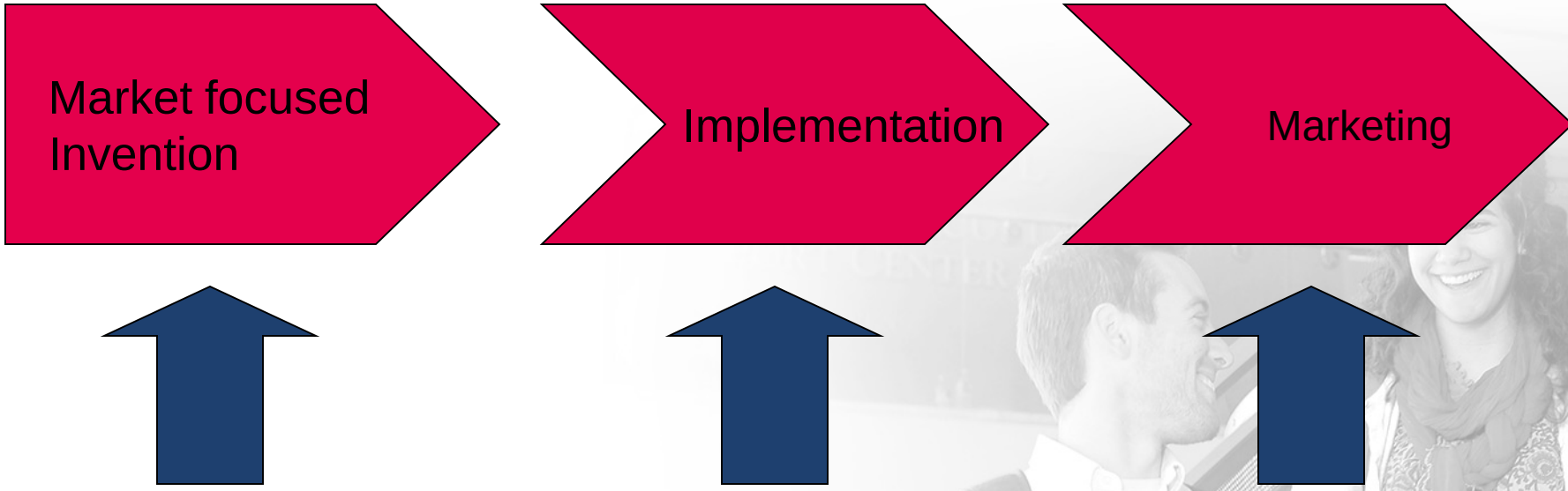
- Imagination - Φαντασία
- Goal-Setter
- Self-Confidence -Αυτοπεποίθηση
- Knowing Your Strengths and Weaknesses
- Maximizing Opportunities
- Intuition - Διαίσθηση
- Strong positive attitude
- Integrity-peole invest in people- Ακεραιότητα

- Successful Entrepreneurs Never Give Up - Επιμονή
- Know Your Business/Know Your Competition
- Hard Work - Εργατικότητα
- Effectively Manage Budgets and Finances
- Passion - Πάθος
- Enjoy your Business
- Willingness to try new things and fail – Τόλμη

Do not Fear Failure

- What you don't do matters as much as what you do.
- Failing in one area may mean winning in another
- Failure Is Not the End. It's an Opportunity to Learn.
- Failure forces you to think differently

The Simplified Innovation Process



- Problem Definition
- Idea Generation
- Idea Evaluation

- Prototype development
- Fabrication and Testing
- Pilot Application

- Production
- Market Launch and penetration

The Entrepreneurship Ecosystem
Integrating Key Stakeholders – An Example

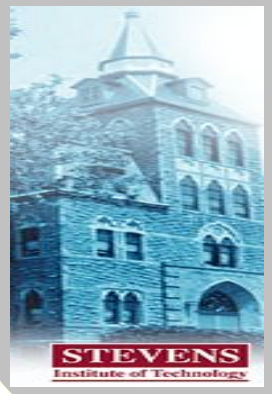
Investors

Government Agencies

Students

Admin.

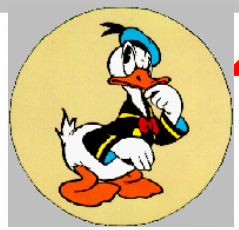
Faculty



Stevens

Innovation

New Ventures



Industry

Entrepreneurs

Startup Legal Advise and Support

1. The legal creation of the company typically as via a Limiting Liability Company, LLC
   - ❑ Ίδρυση – Σύσταση Ατομικής Επιχείρησης – Fast and low cost but business risk is passed to the owner who is personally responsible for all potential liabilities of the company
   - ❑ Μειονέκτημα: ανάληψη του επιχειρηματικού κινδύνου εξ ολοκλήρου από τον επιχειρηματία
2. Trademarks -Η εμπορική ταυτότητα της επιχείρισης: κατοχύρωση και προστασία του εμπορικού σήματος
3. Non-disclosure agreements, (Συμφωνητικό Εχεμυθείας) or non-compete (Συμφωνητικό μη Ανταγωνισμού)
4. Intellectual property (IP) protection – The IP fence is critical to fund raising
   1. Patents - Ευρεσιτεχνία
   2. Copyrights
5. Other transaction (negation of licensing agreements, partnerships, etc.)

10 Ways to Fund Your Starup

1. Fund your startup yourself - Bootstrapping (maximize use of resources and work hard – sweat equity)
2. Pitch your needs to friends and family.
3. Apply for a small-business grant (USA: SBIR/STTR- EE: Συμμετοχή σε αναπτυξιακά προγράμματα και επιχορηγήσεις)
4. Start a crowdfunding campaign online.
   - Kickstarter videos Multi Sip: MGT 103 Student Video - 108 backers pledged $10,416 to help bring this project to life.
5. Apply to local angel-investor groups.
6. Solicit venture-capital investors.
7. Join a startup incubator or accelerator.
8. Negotiate an advance from a strategic partner or customer
9. Trade equity or services for startup help.
10. Seek a bank loan or credit-card line of credit.

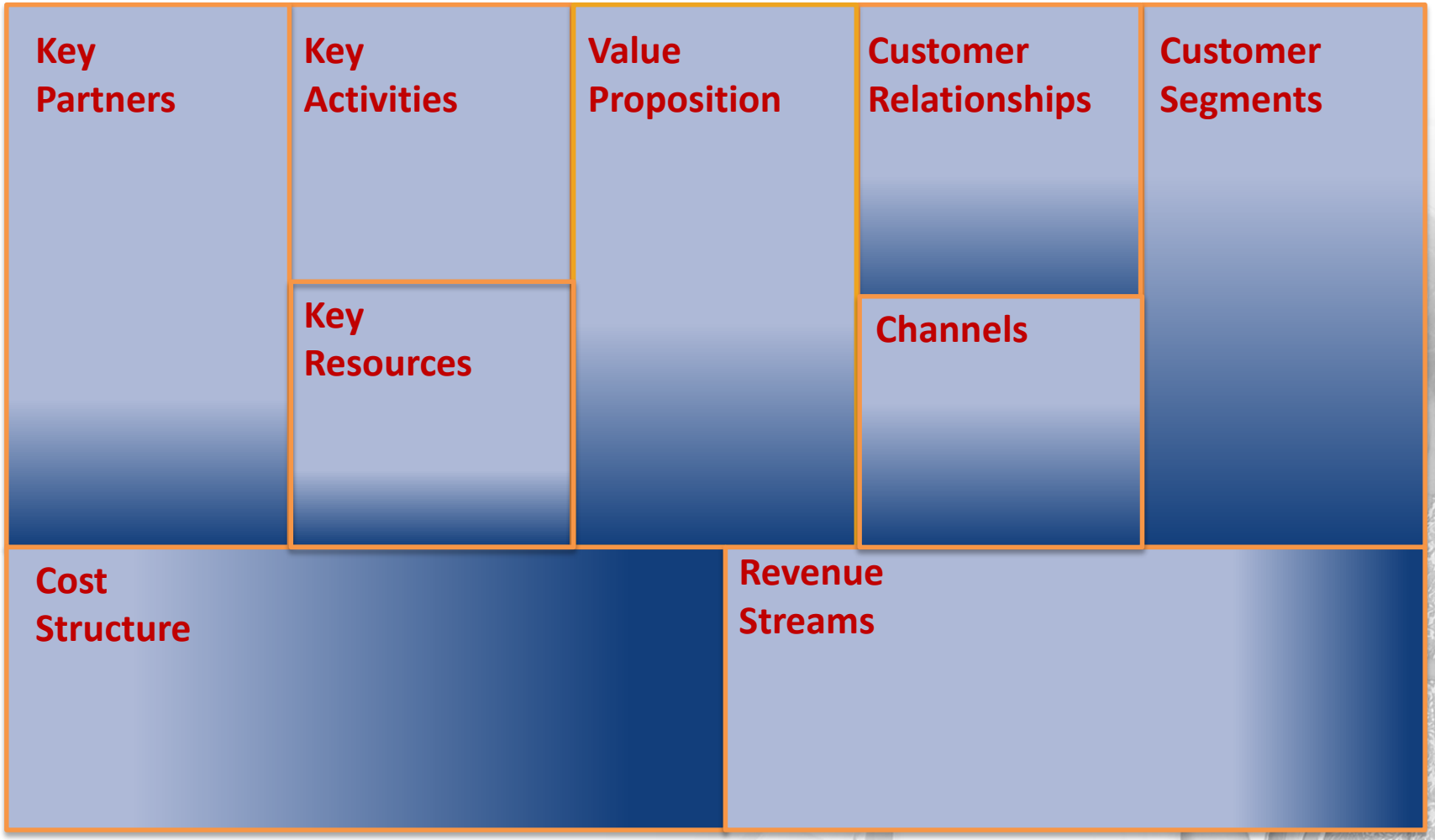
The Lean Startup Methodology

A cost-effective methodology for developing businesses and products. A Customer-Centric approach to building a successful startup

- It aims to shorten the product development cycles.
- It's an iterative process that relies on costumer feedback to improve a **minimum viable product (MVP) – Ελάχιστο Βιώσιμο Προϊόν** for early release.
- **The MVP** is a product with just enough features to satisfy early customers, and to provide feedback for future development

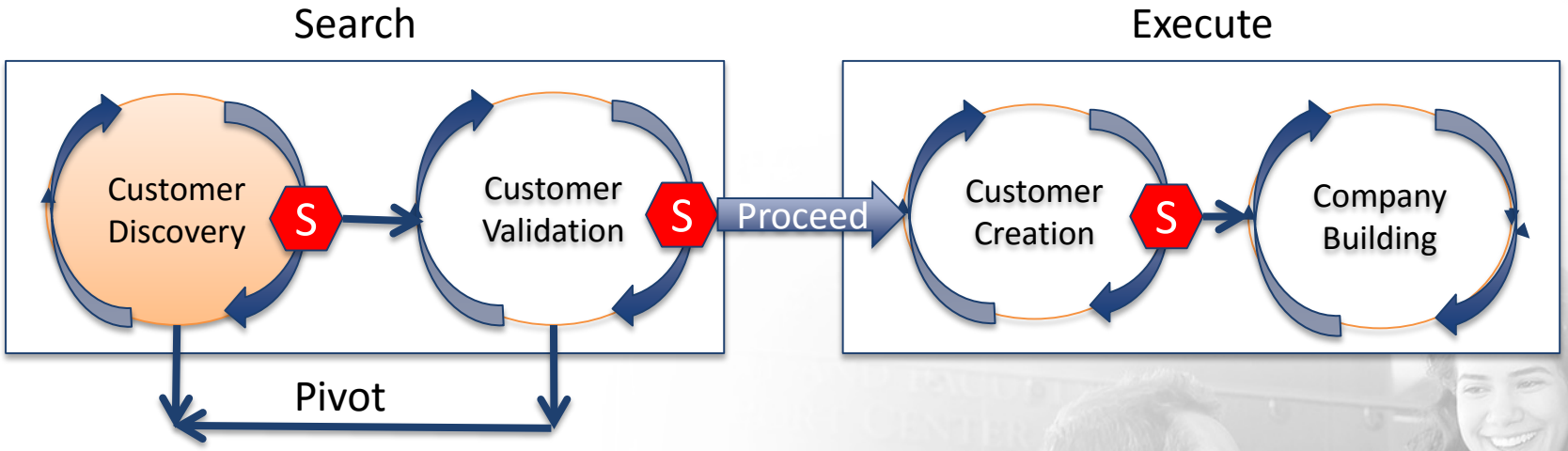
Focus on Business Building

The Business Model Canvas*



*Alexander Osterwalder's

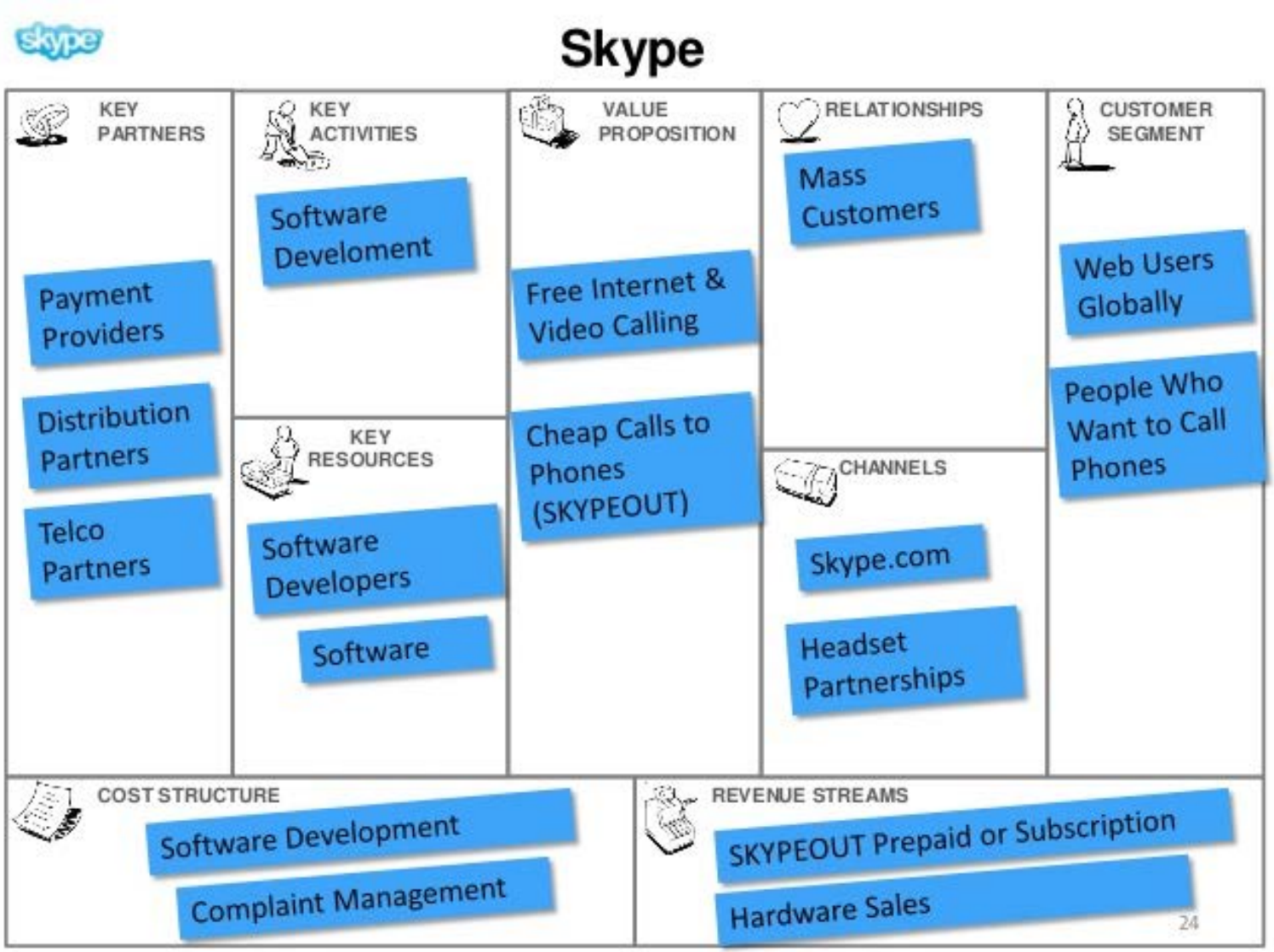
A Customer Development Process



Get out of the building and talk to you customers -Interview 100 customers

- *Customer discovery* captures vison and turns it into a series of business model hypotheses
- *Customer validation* tests the repeatability and scalability of the business model. If not, go back to customer discovery
- *Customer creation* builds end-user and drives it to sales channels
- *Company-building* transitions the startup into a company focused on exection of a validated model

A Business Canvas Example



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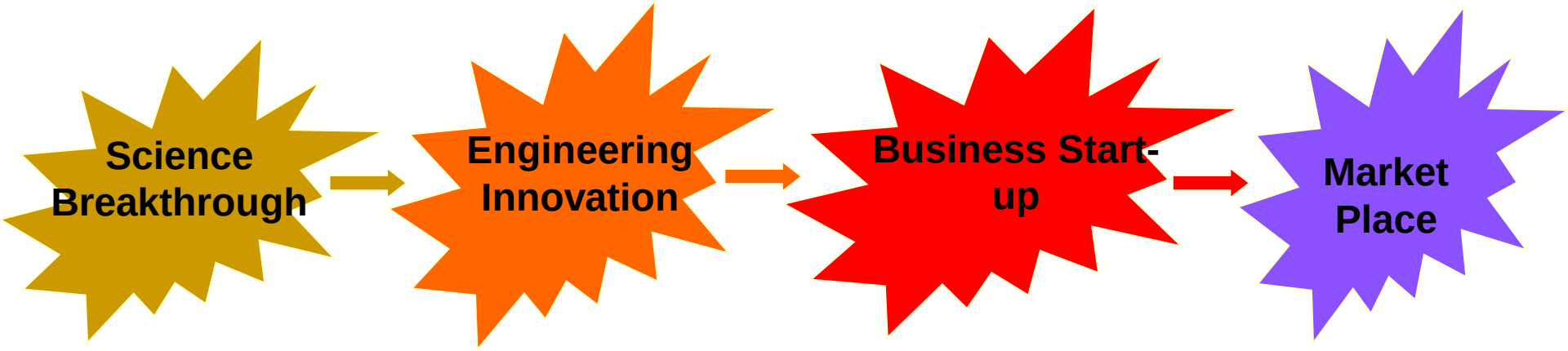
Plasmasol: Converting Technology into a Company

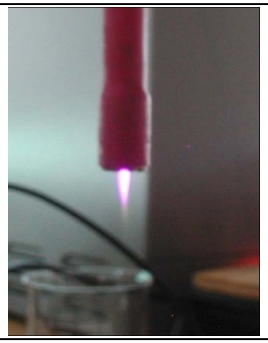
A case Study

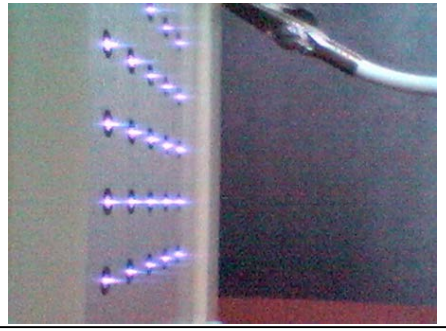
Christos Christodoulatos, Ph.D., Director
Center for Environmental Systems

Science-Driven Disruptive Technology Development and Marketplace Realization - The PlasmaSol's Time(Life)line



Physics	Microplasmas	PlasmaSol	Stryker





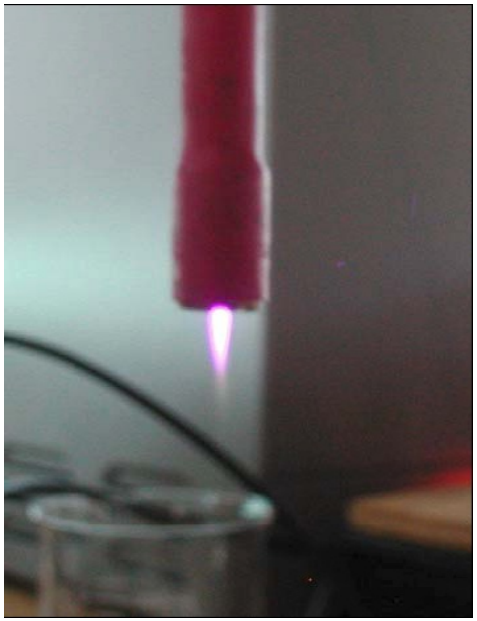
1994	1997	1999	2005

What is a Plasma?

- Electrical discharge with a unique chemistry that glows in a vacuum
- Before 1995, a vacuum was required.
- Plasmas could not easily be generated in gas or liquid environments.
- Plasmas can be tuned by changing electrode material and geometry

Applications of Plasma-GenerateTechnology Breakthrough - d Reactive Species into Liquids

- Technology: Generation of glow discharges in water and air. Reactive species include ozone and peroxide
- Potential applications: water, wastewater treatment, disinfection and sterilization, destroy airborne particles
- Modify automotive exhausts: nitrogen oxide, sulfur oxides, greenhouse gasses



Operating in open air

Operating in liquid

Key Themes in the PlasmaSol Case

- ✓ De-Risking the Technology – using grants and other publicly available funds to get closer to a commercial product
- ✓ Searching for the Right Market and Application
- ✓ The Team – *Investors Invest in People*
- ✓ University Support for Academic Entrepreneurship

The Genesis of PlasmaSol

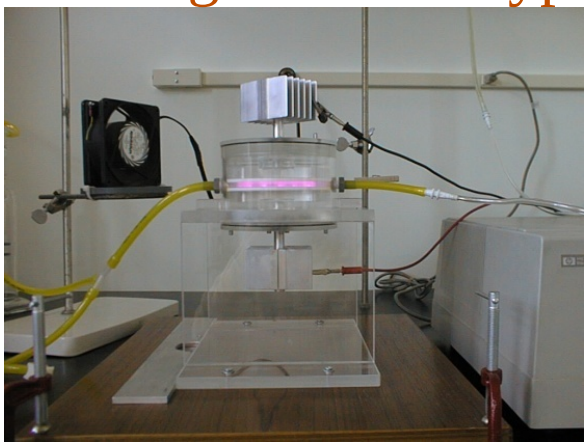
- Inventors find collaborators in the Center for Environmental Engineering (George Korfiatis and Christos Christodoulatos)
- Inventors need to acquire market intelligence
- Engage MTM Students from Professor Gary Lynn to perform Market Opportunity Analysis
- Negotiated License Agreement with Stevens Institute
- University provides Incubation Space

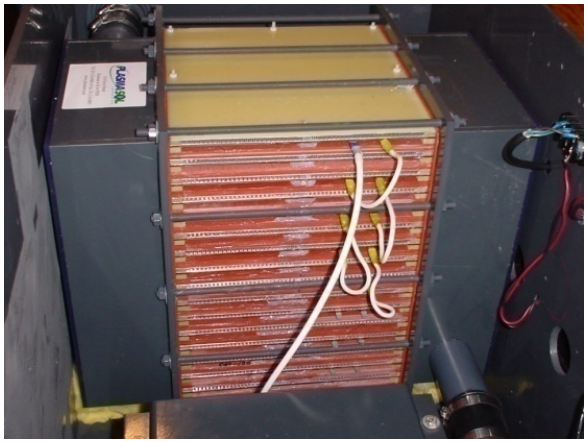
The PlasmaSol Team

- **Students**
  - Kurt Kovach – Eventually becomes CEO
  - Jack Levitt -- Eventually becomes CFO
  - Seth Tropper– Eventually becomes COO
  - Richard Crowe -- CTO
- **Scientists/Entrepreneurs**
  - Christos Christodoulatos
  - George Korfiatis
  - Erich Kunhardt
  - Evo Gallimberti
- **Team Members Receive 6.25% Share**

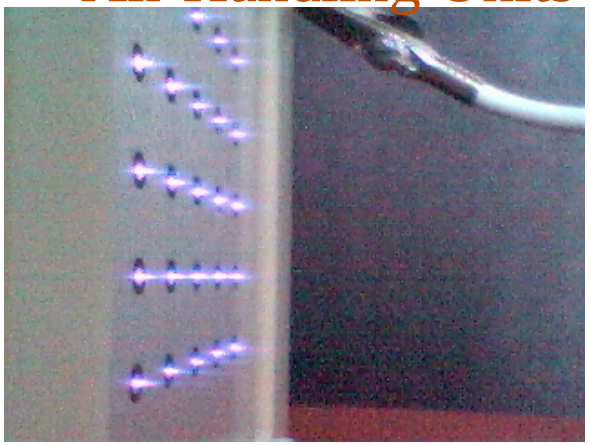
PlasmaSol Develops Products and Hires Employees

Working Lab Prototype





Air Handling Units



What Are the Target Markets? How Big is the Addressable Market?

- Combustion Engine Market: $3.5B annually
- VOC Remediation: $1.4B annually
- Surface Cleaning: >$1B annually
- Industrial Stacks: $700M annually
- Sterilization of Medical Implants: Market Size ?

Sources of Funding

- **The Team**
  - Each founder puts up $4,000
- **Government Grants**
  - National Aeronautics and Space Administration
  - Memorial Institute for the Prevention of Terrorism
  - DARPA
  - Environmental Protection Agency
  - National Science Foundation
  - Office of Naval Research
- **Angel Investor**
  - Wilt Hawkins invests $1M
- **Venture Capital –never obtained**

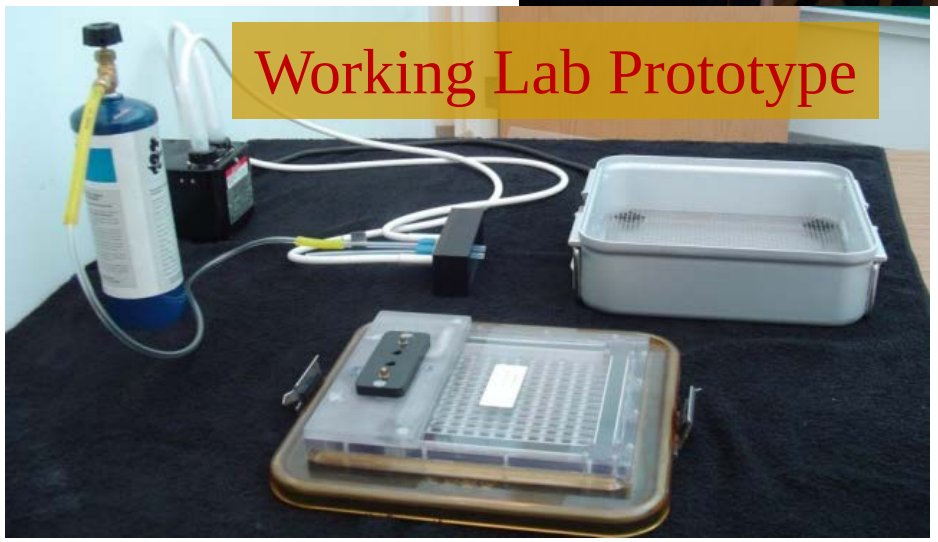
Funding is a Mixed Blessing

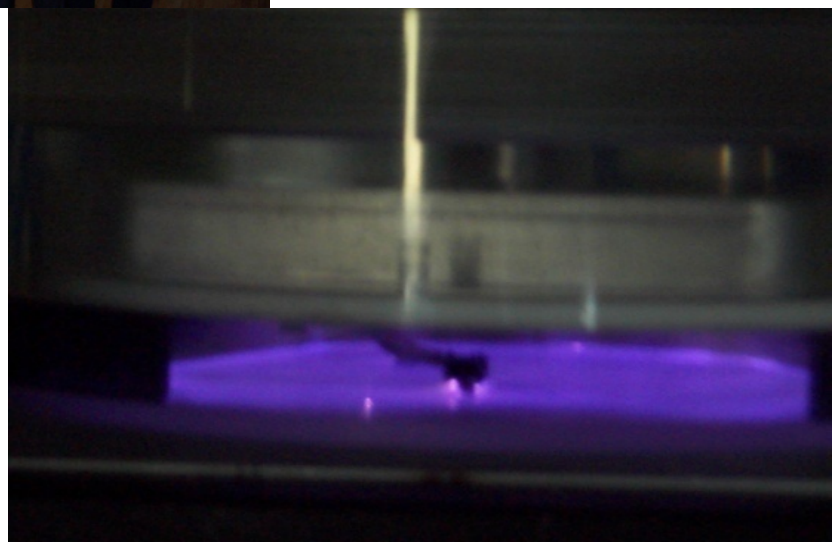
- Government Grants lead the research in divergent directions.
- Market Direction recommended by Business Leaders conflicts with funders Priorities.
- Angel Investor is disappointed.
- Company flounders for lack of single direction.

The Team Struggles and Recovers

- Students Kurt Kovach and Jack Levitt leave the company
- Investors insist on adding professional management
- Company hires Frank Shinneman as President and CEO
- Company also acquires industry expertise in Medical Instruments in 2004: Mike Orrico

PlasmaSol Changes Management and Business Direction





Stryker-PlasmaSol Joint Development & Acquisition Timeline

December 2004:

- Agree to Joint Development program with Stryker division

February 2005

- Stryker Instruments starts funding JD program

March – August 2005

- Monthly research updates
- Stryker feels out PlasmaSol on possible acquisition

Fall 2005

- Due Diligence
- Board members Visit
- Division management sells idea to Corporate

Dec. 28, 2005: Deal Done!

At Time of Sale (2005)

- Stage: Development, Pre-Revenue
- Technology: Sterilization for Medical Instruments and Air
- Employees: 8
- Funding: $1^{+}M/yr. Gov't Contract
- IP: 4 US Patents +14 US Applications
- Sale Price: $17M

The “PlasmaSol Story”

– Concept to Commercialization to Exit
– 6 years
– $2.5M equity financing
– $7M R&D funding (via gov’t)
– $17M sale of company

Approach

•Leverage government R&D contracts toward commercialization

•Collaboration / strategic partnerships

The AUTM's Technology Transfer and Commercialization Index

25	University of Pittsburgh	78.31	91.48	87.84	71.37	87.84
26	North Carolina State University	74.56	86.10	86.54	76.29	87.73
27	Harvard University	83.74	75.74	88.14	75.14	87.71
28	University of New Mexico/Sci. & Tech. Corp.	82.59	68.46	82.53	83.19	87.27
29	University of Southern California	85.02	71.09	85.28	76.81	86.71
30	Stevens Institute of Technology	70.71	54.23	79.90	95.08	86.54
31	The General Hospital dba Massachusetts General Hospital	83.05	86.43	93.33	61.06	85.97
32	Georgia Institute of Technology	84.22	77.48	80.86	76.83	85.95
33	Johns Hopkins University	79.27	84.61	87.41	69.27	85.93

Stevens Ranked 30th out of 225 Universities and Reseacrh Centers

References

1. *The startup Owner's Manual – The step by Step Guide to Building a Great Company* by Steve Blank and Bob Dorf. K&S Ranch, Inc. Publishers, 2012. ICSB -10:0984999302 and ICSB-13:97-0-9849993-0-9
2. *Business Model Generation* by Alexander Osterwalder and Yves Pigneur. John Wiley & Sons Inc. Hoboken, New Jersey 2010. ISBN: 978-0470-87641-1
3. *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses* by Eric Ries, Crown Publishing Group, New York 2011. ICSB: 978-0-307-88789-4

Questions?

Back-up Slides

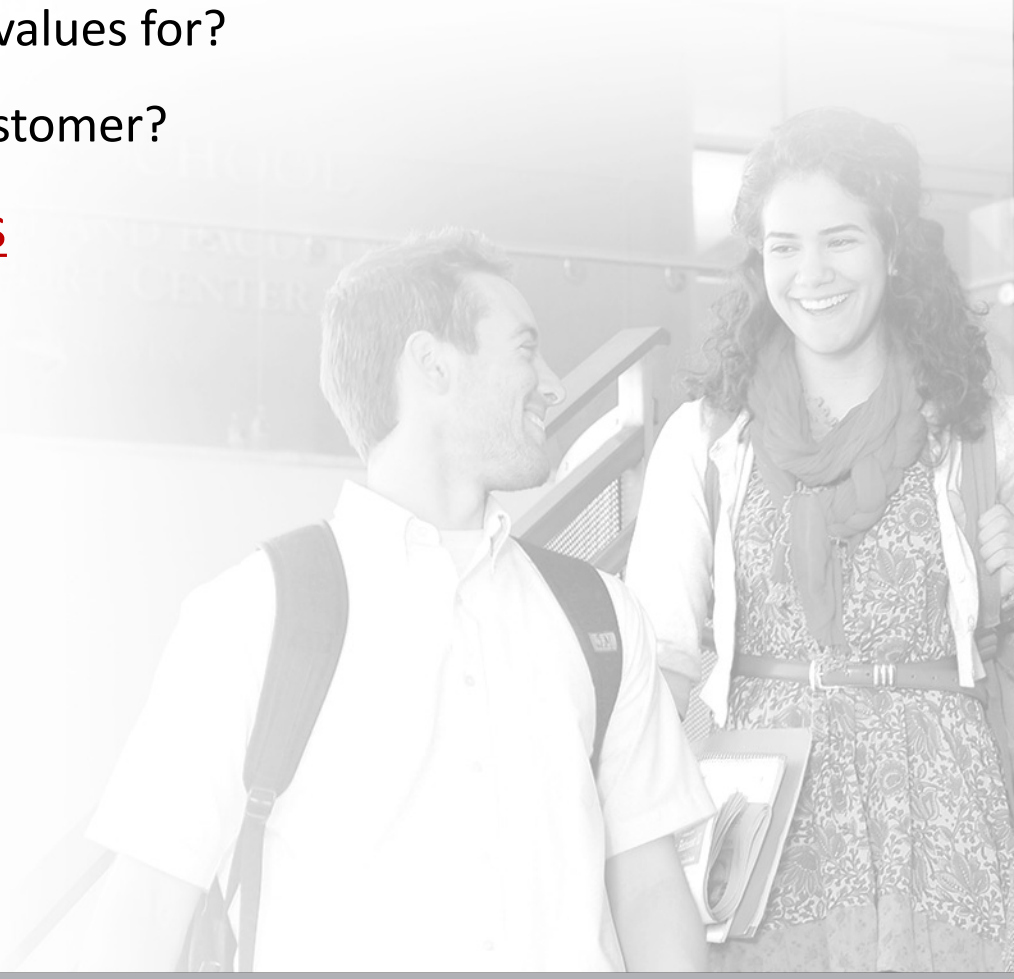
1. Customer Segments

An organization serves one or several Customer Segments

- Which classes are you creating values for?
- Who is your most important customer?

Types of Customer Segments

- Mass market
- Niche Market
- Segmented
- Diversified



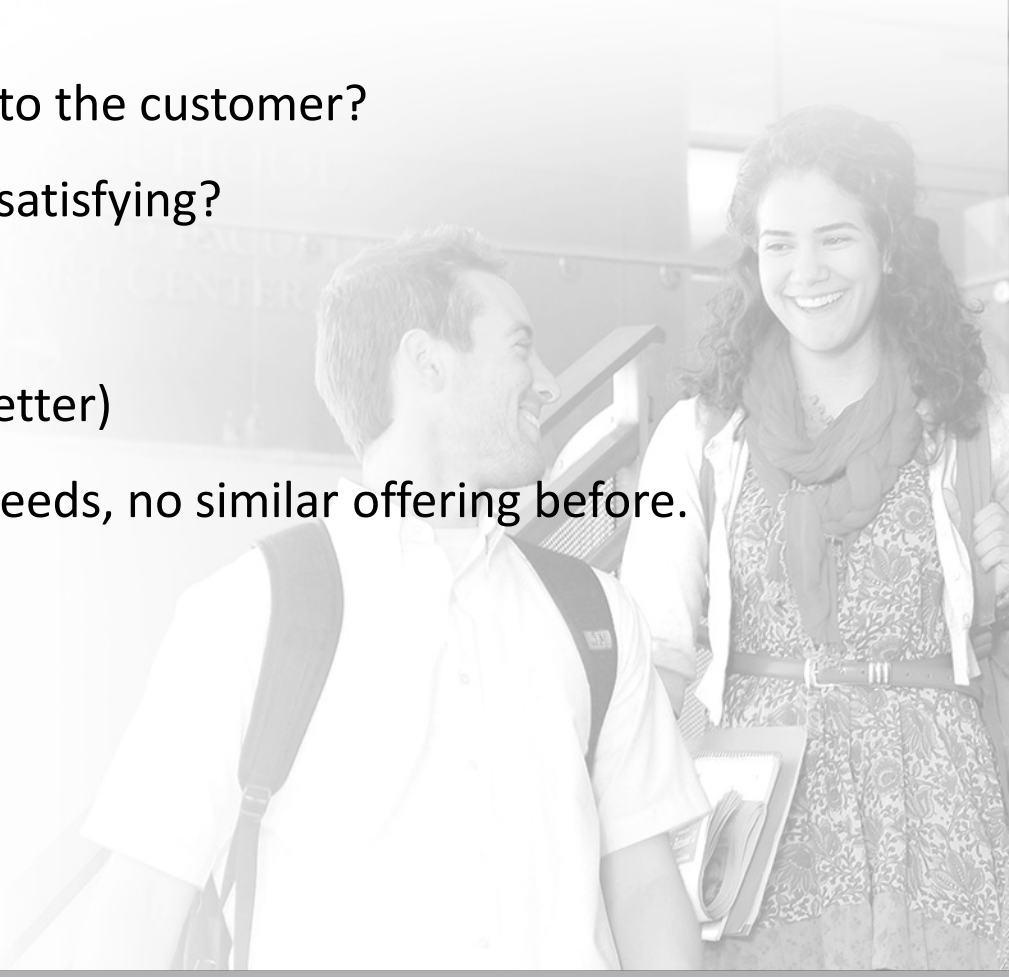
2. Value Propositions

It seeks to solve customer problems and satisfy customer needs with value proposition.

- What core value do you deliver to the customer?
- Which customer needs are you satisfying?

Types of Values

- Performance (cheaper, faster, better)
- Newness (satisfies new set of needs, no similar offering before. Example: Cell phone)
- Customization
- Risk reduction



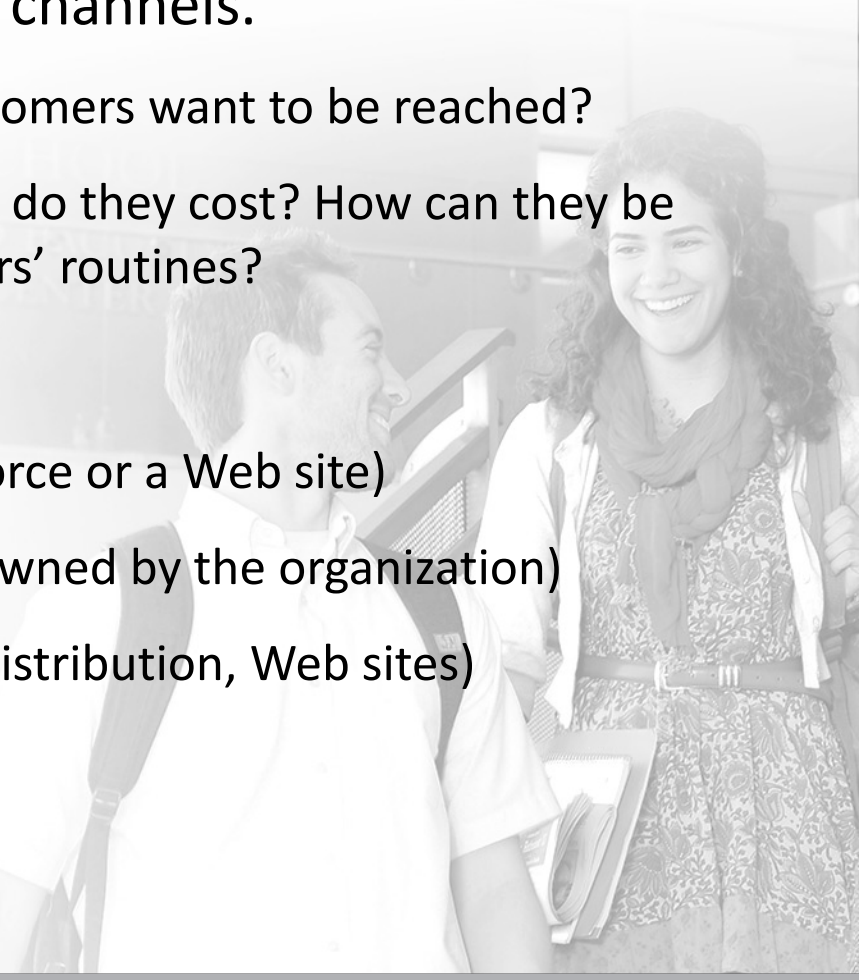
3. Channels

Value propositions are delivered to customers through communication, distribution and sales channels.

- Through which channels that your customers want to be reached?
- Which channels work best? How much do they cost? How can they be integrated into your and your customers' routines?

Types of Channels

- Direct Own Channels (in-house sales force or a Web site)
- Indirect Own Channels (retails stores owned by the organization)
- Indirect Partner Channels (wholesale distribution, Web sites)



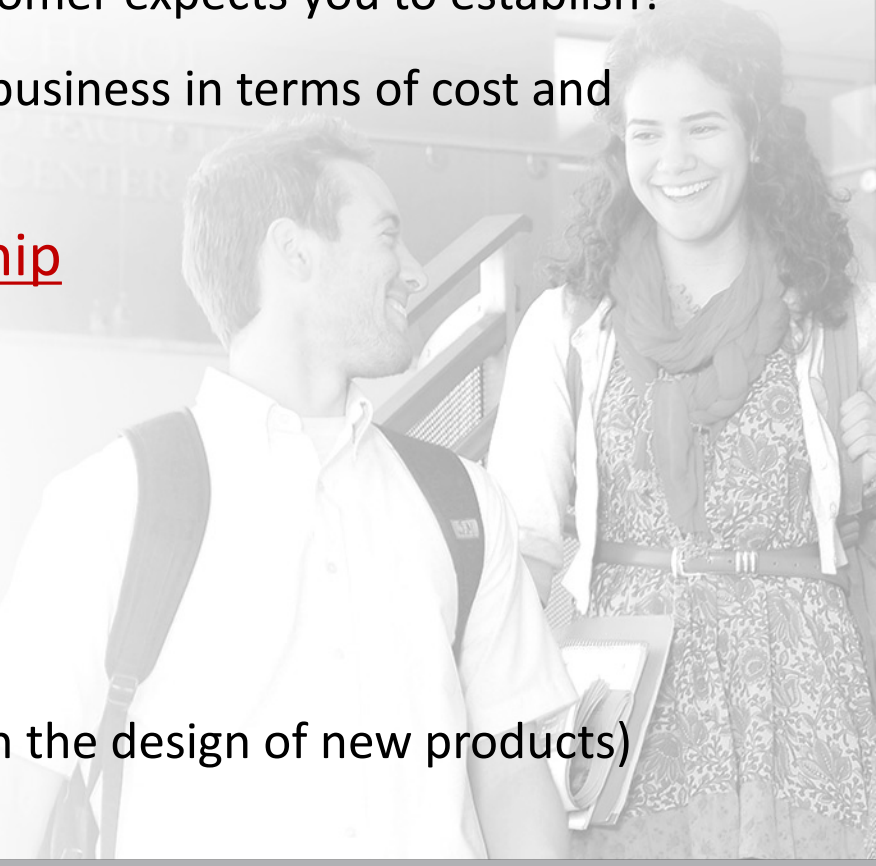
4. Customer Relationships

Customer relationships are established and maintained with each Customer Segment

- What relationship that the target customer expects you to establish?
- How can you integrate that into your business in terms of cost and format?

Categories of Customer Relationship

- Personal Assistance
- Self-Service
- Automated Services
- Communities of Users
- Co-creation (customers are engaged in the design of new products)



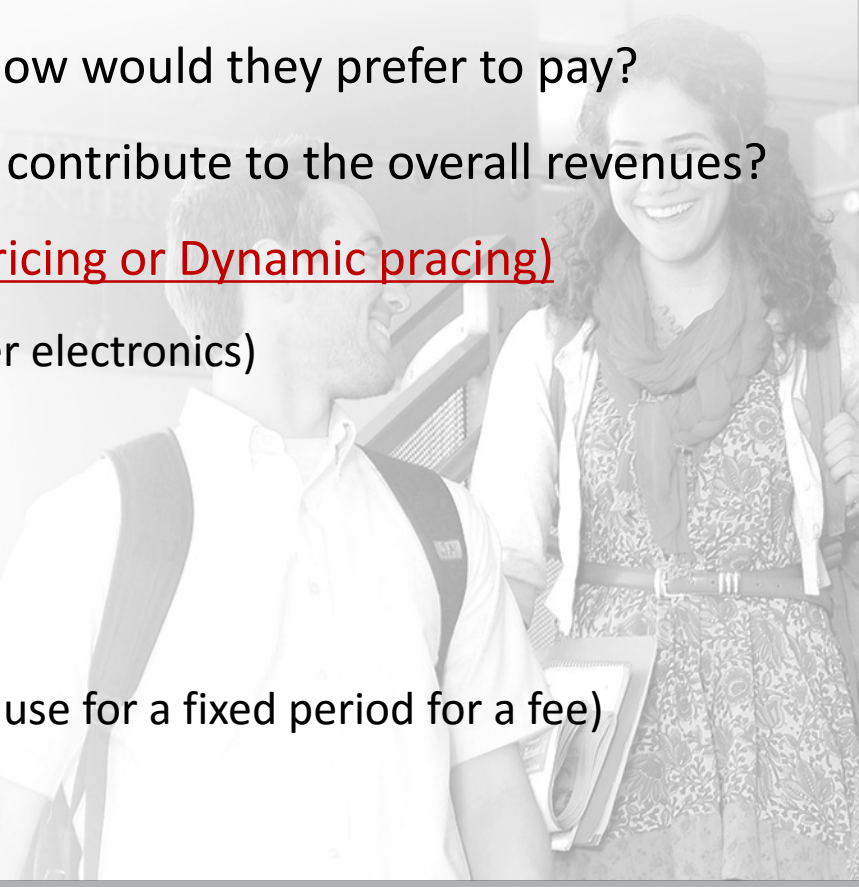
5. Revenue Streams

Revenue streams result from value propositions successfully offered to customers

- What value are your customers willing to pay?
- What and how do they recently pay? How would they prefer to pay?
- How much does every revenue stream contribute to the overall revenues?

Types of Revenue Streams (Fixed menu pricing or Dynamic pracing)

- Asset Sale (Fiat sells automobiles, consumer electronics)
- Licensing (intellectual property)
- Usage fee
- Subscription fees
- Lending/Renting/Leasing (granting right to use for a fixed period for a fee)



6. Key Resources

Key resources are the assets required to offer and deliver the previously described elements…….

- What key resources does your value proposition require?
- What resources are important the most in distribution channels, customer relationships, revenue streams?

Categories

- Physical (manufacturing facilities, vehicles, Machines, distribution networks)
- Intellectual (brands, patents and copyrights, partnerships)
- Human (human capital)
- Financial (lines of credits, stock option pools for hiring key employees)

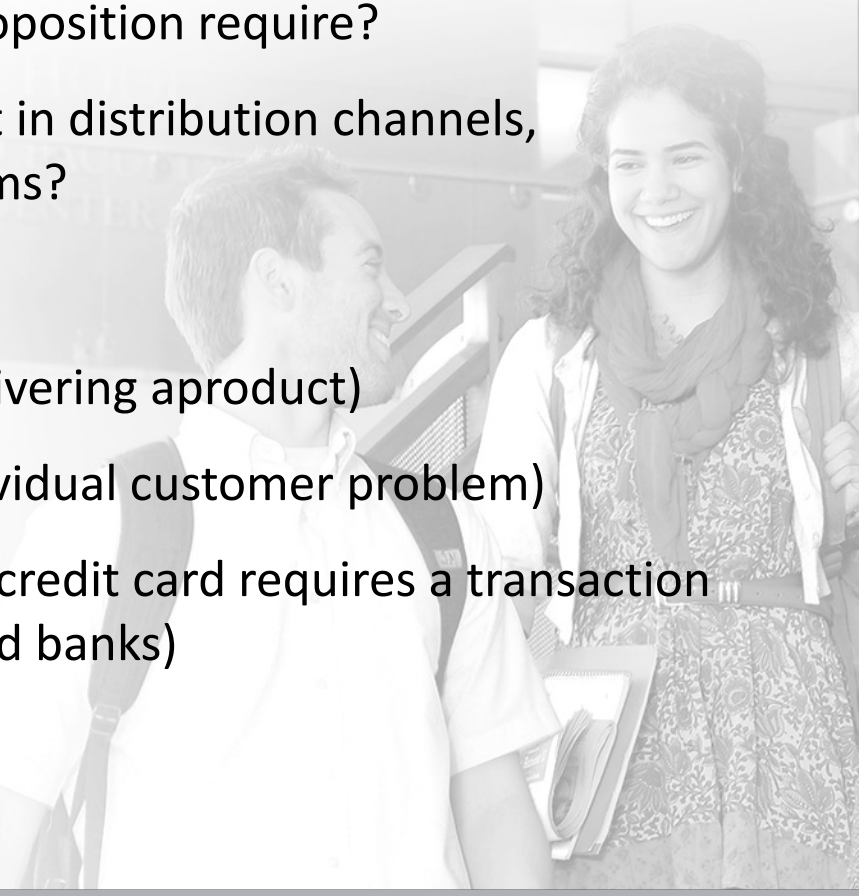
7. Key Activities

Key Activities are the most important actions a company must take to operate successfully.

- What key activities does your value proposition require?
- What activities are important the most in distribution channels, customer relationships, revenue streams?

Types of Activities

- Production (designing, making and delivering aproduct)
- Problem solving (new solutions to individual customer problem)
- Platform/Network (software, e.g. Visa credit card requires a transaction platform for merchants, customers, and banks)



Key Partnerships

Some activities are outsourced and some resources are acquired outside the enterprise

- Who are your key partners/suppliers?
- Which key resources do we acquire from partners, and which key activities do they perform?

Motivations for the partnerships

- Optimization and economy of scale (cost reduction by outsourcing and sharing infrastructure)
- Reduction of risk and uncertainty (competitors may form an alliance. Development of Blu-ray format by a group of consumer electronic manufacturers)
- Acquisition of specific resources and activities (for instance a mobile phone manufacturer may license an operating systems than develop one in-house)

Cost Structure

The Business model elements result in the cost structure that describes all costs incurred to operate a business model

- What are the most important cost in our business?
- Which key resources/ activities are most expensive?

Two broad classes of cost structures

- Cost-driven (focus on minimizing cost)
- Value-driven (focus on value creation, i.e. personalized services)

Cost structures can have the following characreristics

- Fixed costs (salaries, rents, etc.)
- Variable costs (costs vary proportionally with volume of goods produced)
- Economies of scale (large companies benefit from bulk purchasing)
- Economies of scope (same marketing activities or Channels may support multiple products)