Principles of Printing

Introduction to Print

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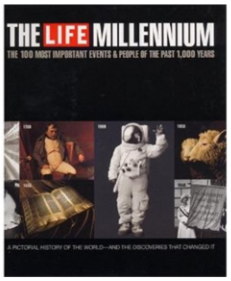
The Last Millennium

- At the turn of the Millennium, LIFE published a list of the 100 most important events of the past 1,000 years.
- LIFE Ranked:
  - Putting a Man On The Moon as No. 33
  - Building the Atomic Bomb as No.16
  - The Discovery of Germs as No. 6
  - Mass Production and the Industrial Revolution as No. 4
  - The Discovery of America as No. 2



- LIFE ranked the Invention of Movable Type Print in the West as No. 1 - the most important event of the Millennium. Why?

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When Time Life published a list of the 100 most important events of the last millennium, mankind's marquee accomplishments ranked in the top third, but not at the top. Instead, the events at the top were the ones that changed the course of human history:

The Discovery of Germs (#6) triggered changes in food processing and medical treatment that eventually doubled the life expectancy of the average person.

The Industrial Revolution (#4) transformed a world filled with subsistence farmers into a world where humanity could channel the majority of its energy into improving the quality of life.

The Discovery of America (#2) created the growth engine for Western Society and eventually produced what is currently the world's most powerful nation.

Yet, in Life's assessment, one event overshadowed all others in its impact on human history.

Time chose the invention of Movable Type Print in the West (where a simple alphabet made rapid adoption practical) as the most important event of the millennium. Why??

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The Most Important Event

- Because movable type Print made it possible for ordinary individuals to present new ideas to large numbers of people quickly and affordably.
- Print enabled an Intellectual Revolution … and a step change in the rate of human progress.


THE
VIRGINIA GAZETTE
Containing the prefent Advices, Foreign and Domeſtick.

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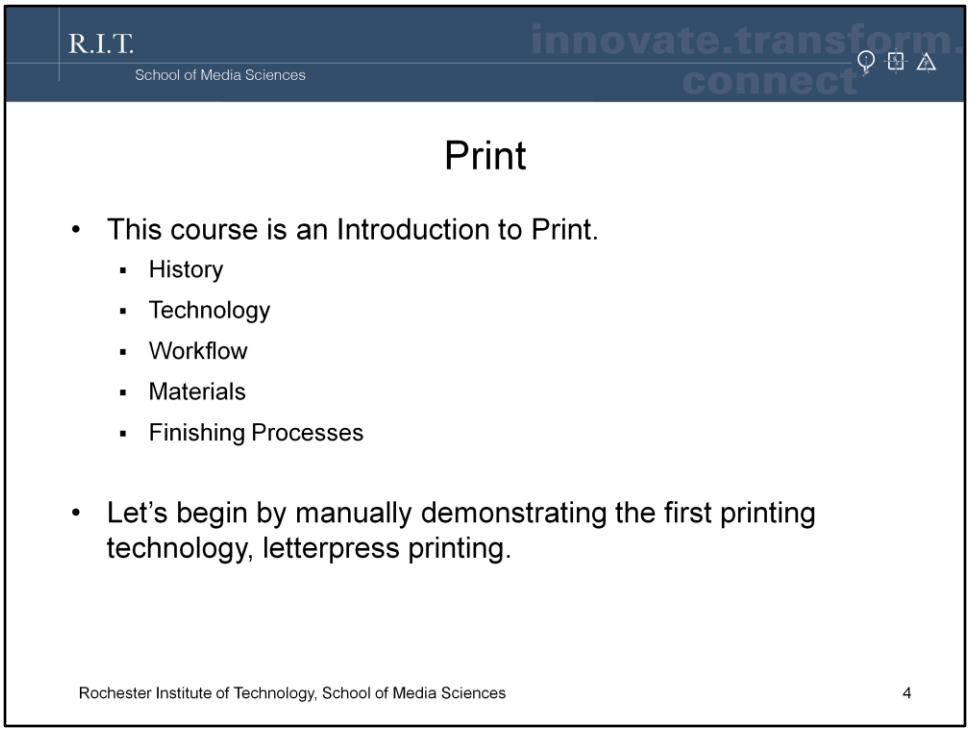
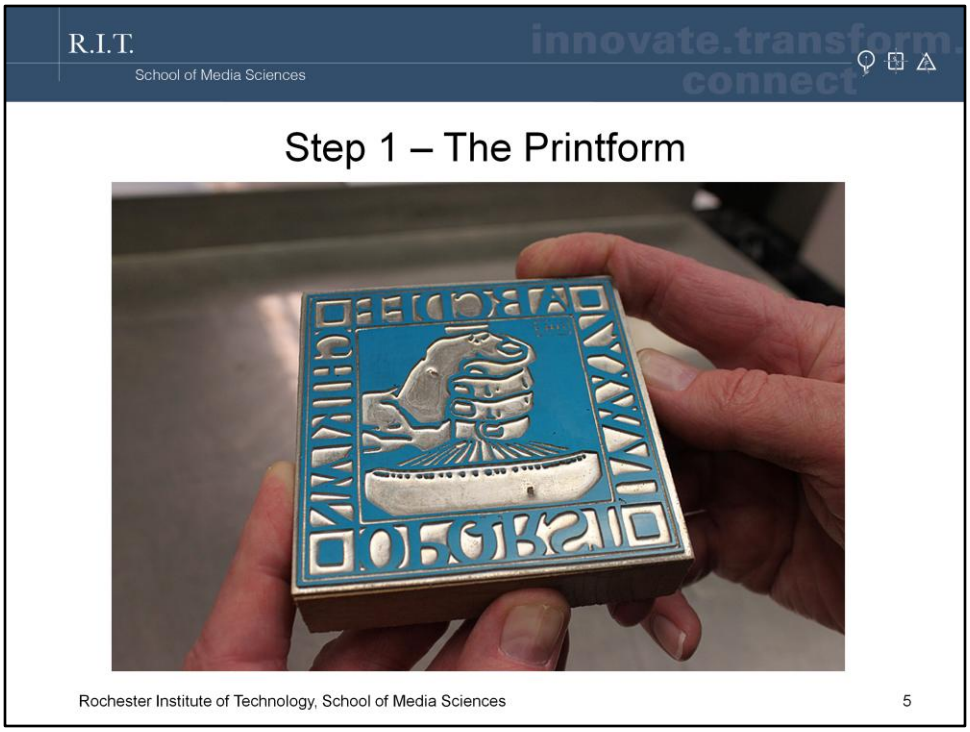
LIFE's answer was that print changed the nature of invention and inventive thinking. Before print, new ideas travelled primarily by word or mouth. The power structures of Church and State had a monopoly on the broad dissemination of ideas, and these institutions censored inventive thinking.

Print changed the way ideas were disseminated, broke the monopoly power of Church and State, led first to the Renaissance and later to the Scientific Revolution. In short, Print enabled an Intellectual Revolution which was the fountainhead for virtually all of the other events that shaped the course of humanity in the past 500 years.

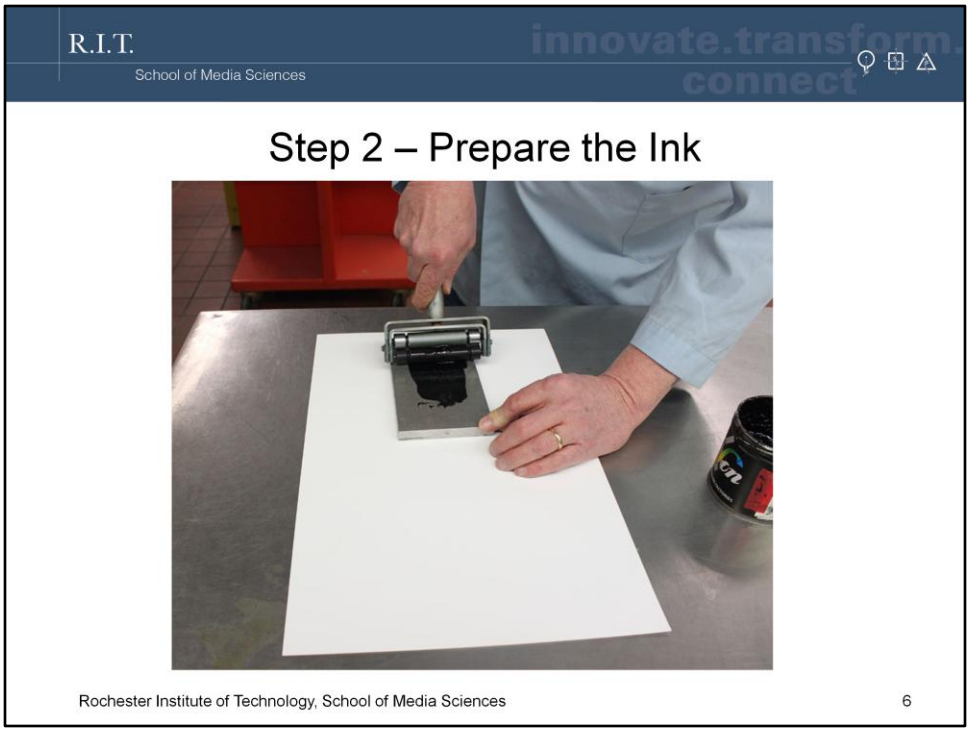


The objective of this course is for you to develop a deep understanding of Print. Understanding print means several things. First, it means understanding the convergence of technologies that made the invention of print possible. It also means understanding the many printing technologies that have evolved over the past 500 years. Next, it means understanding the printing workflow that connects the creation of a design with its reproduction using one of these printing technologies. Finally, it means understanding the inks, papers, films, and finishing processes that go into creating a printed products.

The printing technology that Gutenberg invented is called letterpress, printing on a press that uses a raised metal printform. A good way to introduce print is to strip away the press and demonstrate how this technology works when an image is printed by hand.



Before the era of digital printing all printing technologies depended on a physical image carrier which was called a printform. In letterpress, this form is made of metal. The non-print area is recessed (silver in this image) and the print area is raised (blue in this image). In movable type print, each character is a separate printform and the page is composed by setting these characters in a frame. For this demonstration, the type is not movable and the printform is a single piece of metal (mounted on a wooden block so we have something to hold onto).



Letterpress uses a thick paste ink which will adhere to the slippery metal printform even when the printform is turned upside down. The ink is transferred to the plate using a roller (technically called a brayer). In this step, the paste ink is rolled out and transferred to the brayer for subsequent application to the printform.

Next, the printform is inked. Notice that some areas of the plate were not inked in the first pass with the brayer. While the printer can make additional passes to insure the printform is fully inked for our manual demonstration, a commercial printing press must ink the plate in one pass to achieve acceptable levels of cost and productivity. This problem is typical of all printing processes. Many of the basic techniques (e.g. inking a plate with a roller) are so simple as to be elementary. The real challenge is to perform these elementary processes faultlessly at high speed in a commercial printing environment.

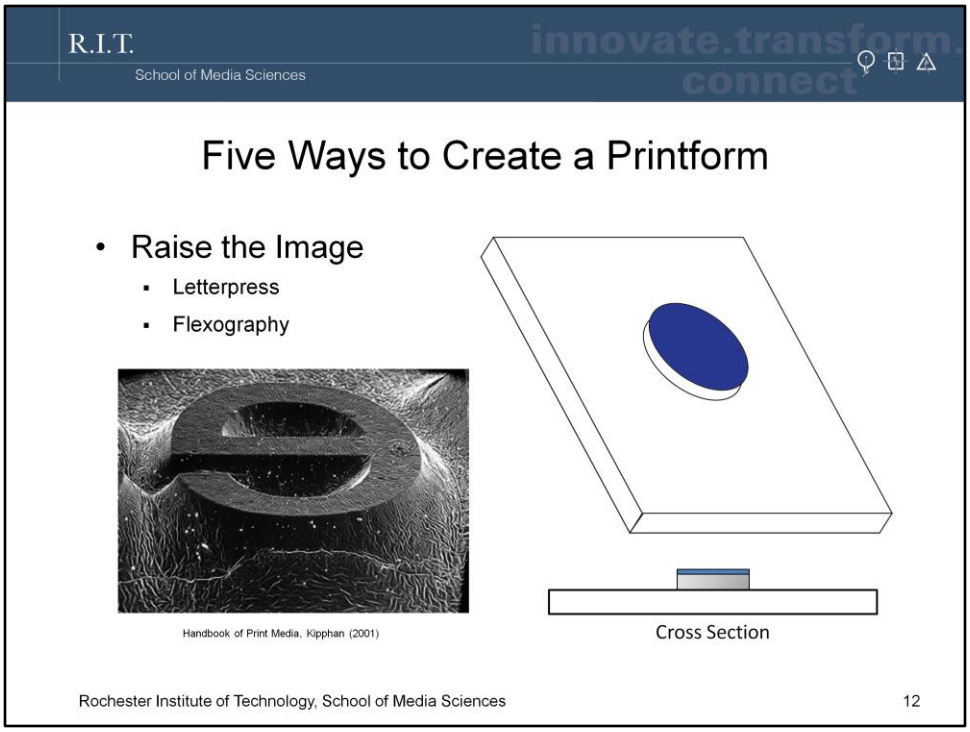
After three passes, the printer has successfully inked the printform. The raised blue print areas are covered with black ink, while the silver recessed areas are ink free.

Once the printform is properly inked, we are ready to transfer the image to the paper.

Transferring the image to the paper occurs through a process called ink splitting. Pressure is applied to bring the ink into intimate contact with the paper. Because paper is an interpenetrating matrix of fibers, this means forcing the ink and fibers to make contact thus creating an adhesive force. If the adhesive force between the ink and paper is greater than the cohesive force holding the ink together, then the ink layer splits in two when the printform is lifted from the paper. The bottom of the ink layer adheres to the paper and produces the print.

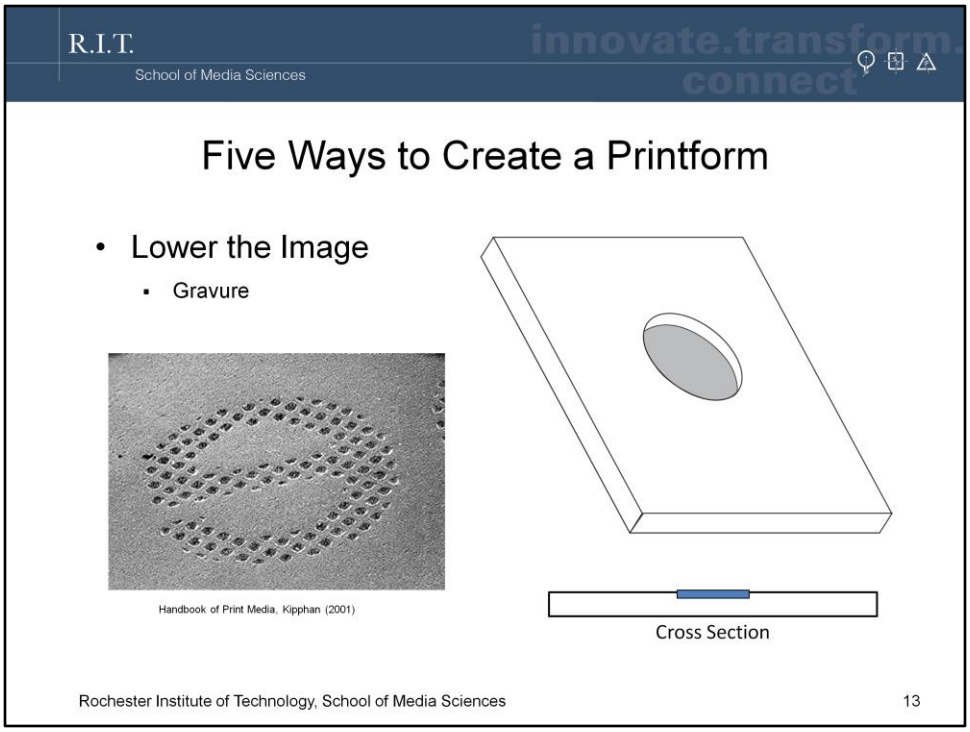
It takes a great deal of pressure to bring ink on a rigid plate into intimate contact with individual paper fibers, which is why the printing process has traditionally been associated with the use of a press. For this demo, a 240 pound printer is taking the place of the press. The next slide shows how well he did.

Not too bad, but right side of the image (from our point of view) transferred incompletely (look at the “W” and solid black printing beside it). Notice also that the ink has split between the printform and paper. If all of the ink had transferred from the printform to the paper, we would see the blue color of the raised print area. Instead we see black. The ink layer split in the middle with some ink sticking to the printform and the rest sticking to the paper.

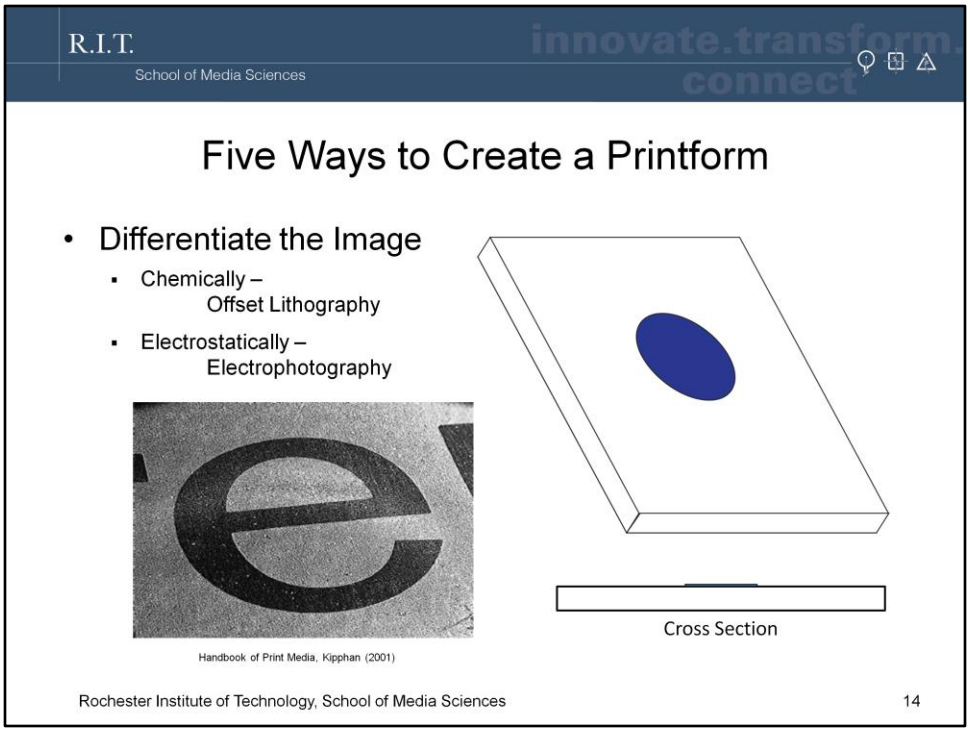


The key to creating a printed image is to be able to distinguish the ink laden print area from the ink free non-print area. Letterpress creates this distinction by raising the print area above the non-print area.

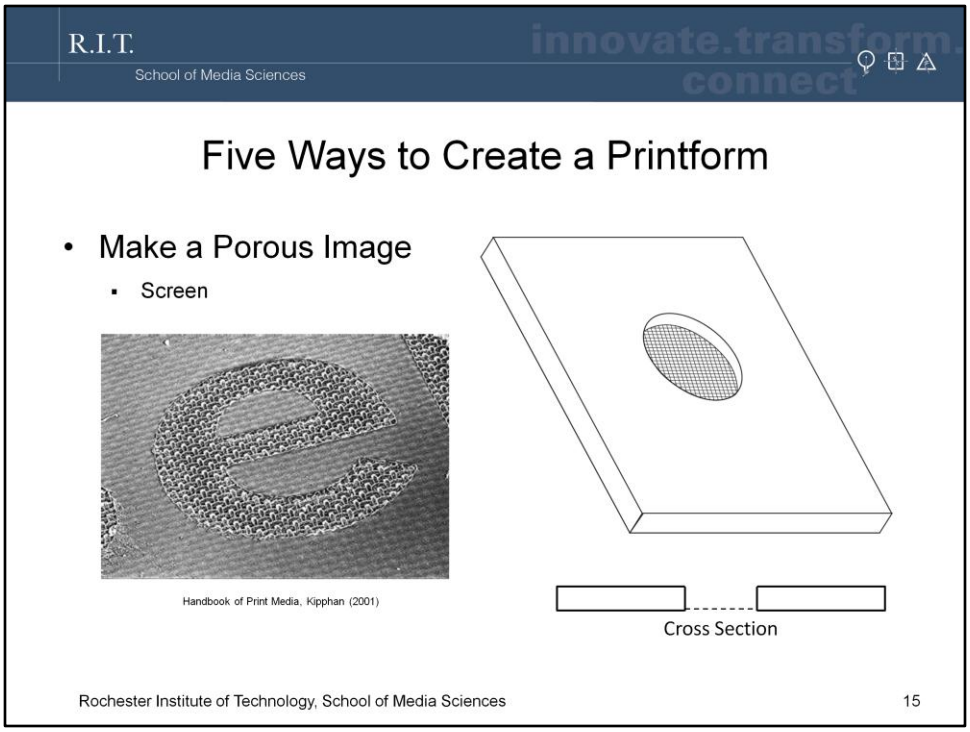
Over time, letterpress has been replaced by more modern printing technologies including Flexography. In Flexography, the image area is still raised, but the printform is no longer made of metal. Instead, as the name suggests, the print form is made from a flexible polymer.



Printforms can also be created by lowering the print area below the non-image area. In this case, the print area consists of tiny buckets of ink which are subsequently transferred to the paper through a combination or pressure and wicking action. Surface tension holds the ink in the bucket until we're ready to transfer it. Cells are typically a few thousandths of an inch across (30 to 350 microns) and a single printform might require more than 10,000,000 cells. Individual cells are engraved using a diamond stylus or a laser beam. Because the image area is engraved, this printing technology is called Gravure Printing.



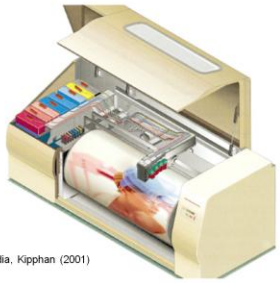
A third option for creating a print form is to differentiate the print and non-print areas on a flat surface. In this case, the print area is treated to attract ink while the non-print area is treated to repel ink. In Offset Lithography, this differentiation is accomplished chemically. Non-print areas are hydrophilic (water loving) and are covered with water prior to exposing the plate to ink. Print areas are hydrophobic (water repelling) and remain dry. When the plate is exposed to an oil based ink, the ink sticks to the dry image areas, but is repelled by the water covered non-image areas. Electrophotography uses the same principle, but differentiates print and non-print areas through the use of electrostatic charges to attract or repel toner.



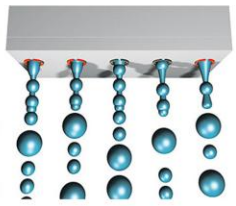
Up to now, we've described technologies that transfer ink from the top of a solid print surface to a sheet of print stock. The fourth approach to creating a print form is to replace the solid print surface with a porous screen and push the ink through it. This technology is called Screen Printing.

Five Ways to Create a Printform

- Non-Contact Ink Transfer
  - Inkjet
  - Other Noncontact (Dye Sublimation)



Handbook of Print Media, Kipphan (2001)



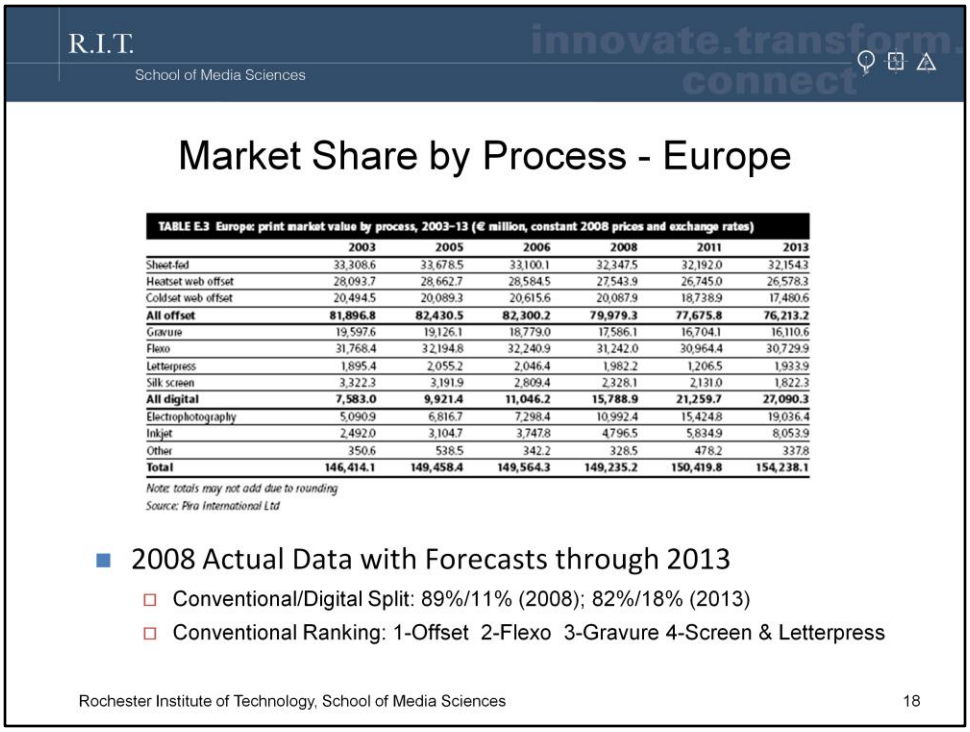
Kodak Stream Inkjet Nozzles

Finally, we can eliminate the need for a physical printform by propelling tiny droplets of liquid ink (or tiny clouds of ink vapor) onto the substrate. Since the print head is no longer required to touch the substrate, these technologies are collectively called noncontact printing technologies. Inkjet is by far the most common noncontact printing technology.

The Printing Processes

Printing Processes		
Process	**Printform Image**	**Printform Composition**
Letterpress	Raised	Hard (e.g. Metal)
Flexography	Raised	Soft (e.g. Soft Polymer)
Gravure	Lowered	Soft Metal on Hard Cylinder
Lithography	Flush	Chemically Differentiated
Electrophotography	Flush	Electrically Differentiated
Screen	Stencil on Screen	Mesh
Inkjet	Noncontact	Digital Signals

Here's a summary of the printing technologies we just discussed and will study more deeply in this course.

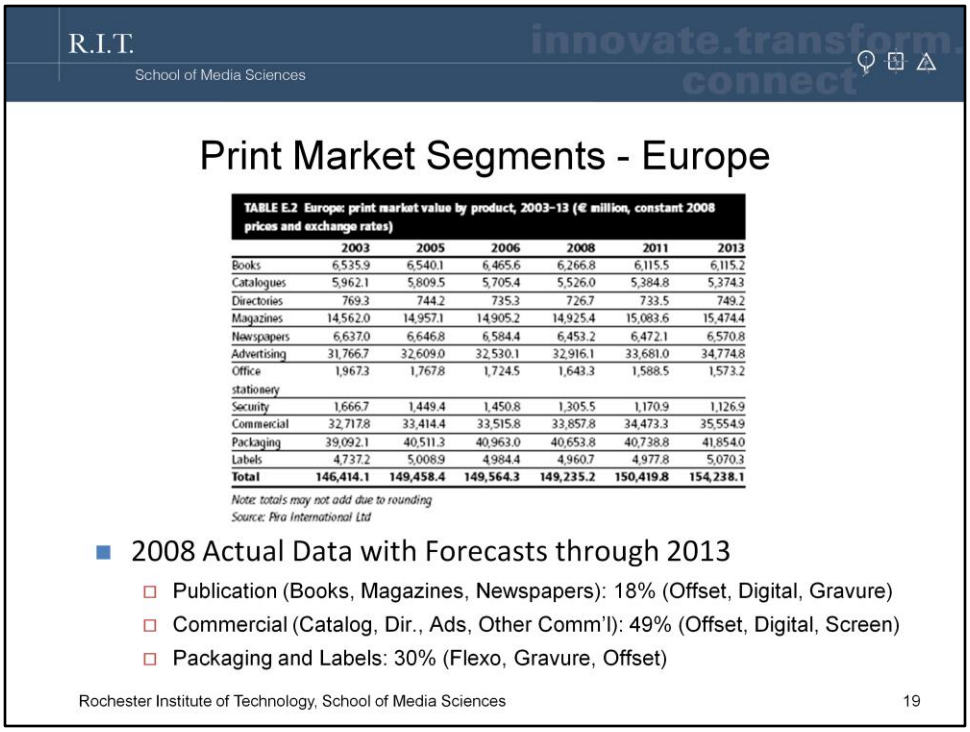


Here's how the technologies compare in terms of market share. Europe was selected for this comparison because (1) relatively recent data is publically available, (2) data for Europe and North America are more reliable than data for the rest of the world, and (3) Europe is a mix of developed (Western Europe) and developing (Eastern Europe) economies.

The big ideas are:

- The overall print market is still growing (by 0.7% per year in this period).
- Digital printing technologies are taking market share at the expense of conventional printing technologies.
- Offset Lithography is the leading output technology with approximately 50% share of market.
- Flexography is the second most popular output technology with approximately 20% share of market.

While the overall digital/conventional trend is highly forecastable, the split between electrophotography and inkjet is less so.



Here are the market segments where printing technologies are used.

Below the chart I've summarized the data into three groupings that cover 97% of all printed materials. Beside each group, I've listed the dominant technologies used in Europe.

Finally, it's important to remember that small quantities of specialty items are printed using other technologies in each market. For example, there is a small segment of the commercial printing market that uses Letterpress for aesthetic reasons. Printing is incredibly diverse … this slide gives the general trends.

You'll find more detail concerning the European print market in "1 Pira Future of Print 2013" which you'll find in this week's reading assignment.