STUDY GUIDE · PRINT CRAFT FOR SOFTWARE BUILDERS

The Print Production Craft

The Physical Craft of Print — A Beginner-to-Advanced Study Guide for Software Builders

Prepared 2026-06-21 · Read the sections in order

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How to Use This Guide

Welcome. If you write software for a living and have just been handed a print-shop product to build — orders, products, pricing, file uploads, production tracking — but you have never stood next to a press, smelled the ink, or watched a 2,000-sheet job get folded and stitched, this guide is for you.

You do not need to become a press operator. But you do need to **understand the craft you are modeling**. Print is a real, physical manufacturing process with rules that come from chemistry, paper fibers, ink, and machines — not from your database schema. When your software ignores those rules, it quietly produces wrong quotes, impossible orders, and jobs that jam on the floor. When your software respects them, print-shop owners trust it, and that trust is the whole game.

Who this guide is for

- **Software builders** — engineers, product people, and founders working on print SaaS, web-to-print, or print e-commerce who know code but not the craft.
- **Smart beginners** — you are technical and curious, but new to printing. We start from "what is paper weight" and build to "how do I batch jobs to share make-ready cost."
- **Anyone who must talk to print-shop owners** and not sound like a tourist.

Why the craft makes you a better builder

Every concept here maps to a decision in your product. If you do not know what `bleed` is, your file-upload step will accept files that print with white slivers at the edge. If you do not know that `make-ready` cost is fixed per job, your pricing engine will under-quote small runs and lose the shop money. If you do not know the difference between `offset` and `digital`, you will let a customer order 5 business cards on a press that needs 500 just to break even.

Understanding the craft turns you from a vendor who ships forms into a partner who ships *print software*. That is the difference between a shop tolerating your tool and a shop loving it.

How the chapters build up

The guide moves from the big picture to the practical, then back to your software:

- **Chapters 1–5** teach the printing methods themselves — the big picture, then offset, digital, apparel/specialty, and wide-format/flexo. This is the "how ink gets onto stuff" foundation.
- **Chapters 6–8** cover the things that make or break every job: color and files (prepress), the materials you print on (substrates), and everything that happens after the press (finishing & bindery).
- **Chapters 9–12** zoom out to running a shop: operations and workflow, economics and quoting, supply chain and fulfillment, and sustainability.
- **Chapter 13** brings it all home — how to model print correctly in software, seen through a print-SaaS lens: which fields to capture, which statuses to track, and where naïve data models go wrong.

Read them in order the first time. Later, jump straight to the chapter behind whatever feature you are building.

How to read the callout boxes

The callouts are the heart of the teaching style. Each one does a specific job — learn to spot them:

- **Analogy** — an everyday comparison that makes an unfamiliar print idea click. ("Bleed is like cutting wrapping paper bigger than the box.")
- **Example** — a concrete scenario with real numbers, so the concept stops being abstract.
- **Best practice** — what experienced shops actually do; copy these into your defaults.
- **Common mistake** — the trap beginners (and beginner software) fall into. If you only skim, skim these.
- **Key takeaway** — the one sentence to remember from a section. Most major topics end with one.

You will also see small notes wherever the craft touches **software design** — a field to model, a status to track, a value to capture on an order. Those are your bridge from the press floor back to the codebase.

> **Best practice:** Keep a running list as you read of every print term that maps to a database field, a validation rule, or an order status. By Chapter 13 you will have a draft data model — and a much shorter list of surprises waiting for you in production.

Every term is defined in plain English before it is used, and the Glossary at the back is your quick reference. Take your time, picture the paper moving through the machine, and let's begin.

How Printing Really Works — The Big Picture

If you build software, you have probably "printed" a thousand times: you hit a button, a file leaves your computer, and a sheet slides out of a machine on your desk. It is tempting to picture commercial printing as the same thing, only bigger. It is not. The moment a customer orders 5,000 brochures, you have left the world of software and entered a **physical factory**. A digital file becomes ink (or toner) pressed onto a real material, that material is then cut, folded, and glued by machines, and finally the finished object is boxed and physically carried to a person.

This chapter gives you the mental model that the rest of the guide builds on. If you take away only one idea, take this one: **a print order is not an action — it is a job that flows through a chain of physical stations**, like a part moving down a factory line. Getting that one idea into your software's bones is the difference between a product that quotes, schedules, and tracks real print correctly and one that quietly lies to its users.

Print is manufacturing, not "hit print"

Three things happen to a print order that never happen to a document on your laptop printer:

- **Material is consumed.** Every job eats a specific physical material — and material that gets ruined (a misprinted sheet) is real money thrown in the bin, called **scrap**.
- **Machines must be set up.** Before the "good" copies run, someone has to prepare the machine for this exact job — load the right plates, mix the ink, line up the colors. That setup costs time and wasted material whether you print 100 copies or 100,000.
- **The object moves through stages.** Printing is only the middle. The sheet still has to be cut, maybe folded and bound, maybe coated, then packed and shipped. Each of those is a separate machine, a separate person, a separate point where things can go wrong.

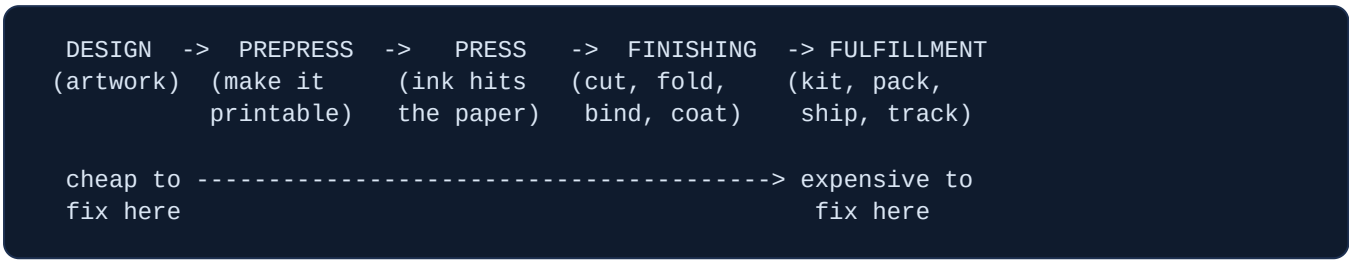
> **Analogy:** Think of a restaurant kitchen, not a vending machine. A vending machine takes your coin and drops out a product in one step. A kitchen takes your order, then it flows past stations — prep, grill, plating, the pass, the runner who carries it to your table. Each station has its own setup, its own queue, its own way of getting an order wrong. Commercial print is the kitchen.

The practical consequence for cost is huge. Because setup is paid once and then spread across the whole run, the **per-unit cost falls as quantity rises**. Printing 100 business cards and printing 5,000 do not cost "50× more" — the setup is the same, so the 5,000 are far cheaper each. This single fact breaks the naive software instinct of `price = unit_price × quantity`. We will return to this many times.

> **Key takeaway:** Print is physical manufacturing. Material is consumed, machines are set up per job, and the object passes through many stations — so cost is non-linear and errors caught late are expensive scrap.

The end-to-end spine: five phases every job flows through

The print industry traditionally names three big stages — **prepress**, **press**, and **post-press**. But for someone building order-and-fulfillment software, it is clearer to think in five practical phases. This is the spine of the entire guide.



Notice the arrow at the bottom. The further down the line a mistake travels, the more it costs to fix. A wrong color caught in prepress is a free edit. The same wrong color caught after 5,000 sheets have been printed is 5,000 ruined sheets plus a reprint. **This is why so much of a print platform's value lives early, at intake and prepress.**

1. Design — creating the artwork

This is where the look is decided: layout, fonts, photos, colors. It is usually done in tools like Adobe Illustrator, InDesign, or Photoshop (or, in your SaaS, an online design studio). Important: a finished-looking design is **not** the same as a print-ready file. Design sets the intent; it has not yet been checked or prepared for a real press.

2. Prepress — turning a design into a manufacturable plan

Prepress means everything that happens between an approved design and a machine that can actually print it. It is the quality gate. Its sub-steps:

- **File prep & preflight** — inspect the file for print problems (we cover this below).
- **Assembly** — **trapping** (tiny color overlaps so gaps don't show) and **imposition** (arranging the pages/copies on a big sheet so they come out right after folding and cutting).
- **Proofing** — producing a sample for sign-off before money is spent.
- **Plate-making** — for offset presses only, burning the image onto metal plates.

3. Press — physically applying ink to the material

The press is where ink or toner meets the material. The machine is set up for this exact job (**make-ready**), the colors are lined up (**registration**), and then the real run prints. The three main methods are offset, digital, and screen — covered later in this chapter.

4. Finishing (also called post-press or bindery) — shaping the printed sheet

A printed sheet is rarely the final product. Finishing does the mechanical transformation: trimming to size, folding, scoring (a crease so a fold is clean), binding pages into a booklet, and decorative work like

lamination, foil, embossing, or die-cutting (cutting custom shapes). Each finishing option is its own machine with its own setup and lead time.

5. Fulfillment — getting it to the customer

Finally the physical object has to reach a human: assembling pieces into a package (**kitting**), storing them (**warehousing**), picking and packing the order, shipping or mailing, and tracking delivery. For software, this is a first-class part of the job, not an afterthought.

Example: Order: **5,000 business cards**. *Design*: customer uploads artwork. *Prepress*: preflight flags an RGB logo and no bleed → fixed to CMYK with 3 mm bleed → imposed many-up on a large sheet and ganged with other card jobs → four CMYK plates made. *Press*: make-ready (line up colors, match color, a few waste sheets) → run 5,000. *Finishing*: cut to final size → optional matte lamination (a separate setup). *Fulfillment*: boxed, picked, packed, shipped. Per-card cost is low because that one make-ready is spread across 5,000 cards.

Key takeaway: Every job flows design → prepress → press → finishing → fulfillment. Mistakes get exponentially more expensive the later they are caught, so your software earns its keep early — at intake and prepress.

The core vocabulary primer

Before going deeper you need the words. Print people use these constantly, and your data model will need most of them as fields. Plain definitions first:

Term	Plain meaning
Substrate	The physical thing you print on — paper, card, vinyl, plastic, fabric, metal. The most general word; covers non-paper too.
Stock	The specific paper/material spec: its weight, finish, color, texture, thickness. "Substrate" = any printable surface; "stock" = the particular paper you chose.
Run length	How many copies the job produces. The single biggest driver of which method to use and what it costs.
Impression	One contact of the press to one side of one sheet. Press speed is measured in **impressions per hour (IPH)**.
Make-ready	All the setup to prepare a machine for a specific job before the good run starts (mount plates, ink up, line up colors). Fixed cost + setup waste, the same regardless of run length.
Prepress	Everything between an approved design and a machine that can print it.
Finishing / bindery	The post-print department: folding, trimming, binding, packaging, plus decoration.
Proof	A representation of the final piece for sign-off. A *soft proof* is on-screen/PDF; a *hard proof* is a physical sample for color-critical jobs.
Imposition	Arranging many pages/copies on one big press sheet so that after folding and cutting they end up in the right order and size.
Preflight	Checking a file for print problems (missing fonts, low resolution, wrong colors, no bleed) before it goes further.
Bleed	Color/image extended about 3 mm (0.125 in) past the cut line, so there is no white edge after trimming.
Gang run / ganging	Putting many different jobs on one sheet so they share a single make-ready and waste less material.
CMYK	The four process inks — Cyan, Magenta, Yellow, and Black ("Key") — that mix to make full color in print (screens use RGB instead).
Plate	The imaged metal carrier in offset that holds one color's image; a full-color job needs four (one per CMYK color).
Job ticket / docket	The traveling instruction sheet (today often digital/barcoded) that follows the job through every station, listing every spec and decision.

Best practice: Many of these words map straight onto fields in your software. `substrate` / `stock` and finishing choices become priced product options; `run_length` drives method and price tiers; the `job ticket` becomes the order/job record that aggregates everything and stays visible to staff and the customer.

Two ways paper goes through a press: sheet-fed vs web-fed

Presses feed material in one of two ways, and the choice is driven almost entirely by run length. You do not need to operate one, but you must understand why it changes cost and turnaround.

- **Sheet-fed** presses take individual **cut sheets**, one at a time. Agile, precise, great color control. Best for short-to-medium runs and premium work.
- **Web-fed** presses pull paper from a giant continuous **roll** (the "web"), printing at very high speed and often cutting and folding in-line. Best for long runs.

Dimension	Sheet-fed	Web-fed
How paper feeds	Individual cut sheets, one at a time	Continuous roll ("web")
Typical speed	~12,000–18,000 impressions/hour	2–3× faster; tens of thousands of cut-offs/hour
Setup / make-ready	Shorter per job; nimble	Longer (thread the web, calibrate in-line finishing) but blazing once running
Best run length	Short-to-medium	Long runs, often >10,000–20,000 impressions
Strengths	High resolution, precise color, flexible	High volume, both sides + fold/cut in-line
Typical products	Brochures, business cards, posters, premium short runs	Newspapers, magazines, catalogs, books, direct mail

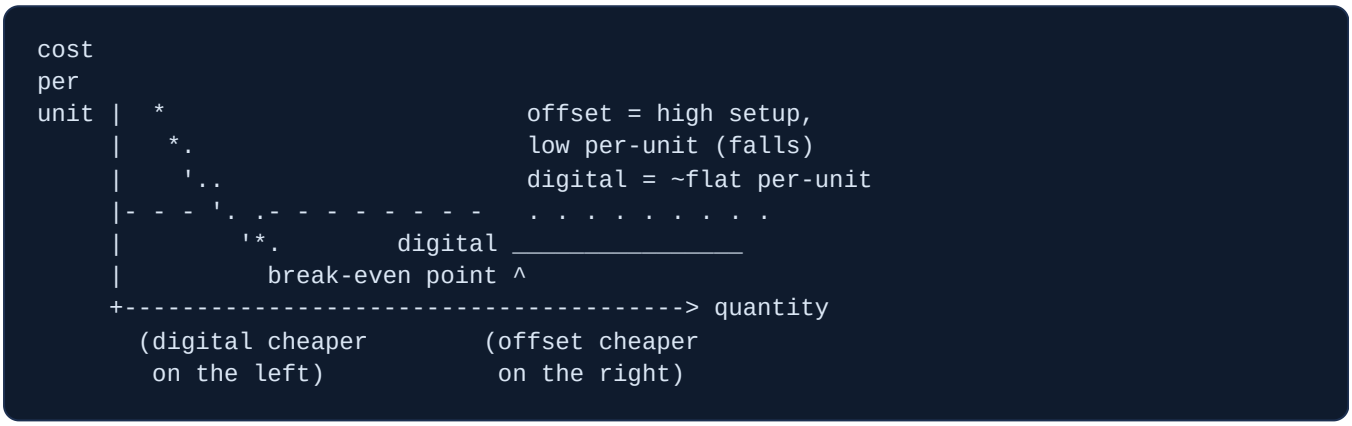
Example: A run of **50,000 catalogs** on a web press flows off the roll, prints both sides, and folds in-line at tens of thousands per hour; the long make-ready is spread thin over 50,000 copies. The same job on a sheet-fed press, one sheet at a time, would be uneconomical. Flip it around: 250 premium brochures belong on sheet-fed — a web press's long setup would dwarf such a tiny run.

Key takeaway: Press type follows run length. A product configurator that ignores quantity cannot pick the right method, so it cannot price the job or promise turnaround correctly.

The economic break-even: offset vs digital

Within these presses, the two dominant print *methods* have opposite cost shapes. Understanding the crossover is essential, because it is the clearest proof that print pricing must be non-linear.

- **Offset** printing transfers ink from plates onto a rubber blanket and then onto the paper. It has a **high fixed cost** (making plates + make-ready) but a **low cost per copy**. The per-unit price keeps falling as the run grows.
- **Digital** printing (toner or inkjet, like a giant office printer) has **almost no setup** but a **higher, flat cost per copy**. It wins on short runs, on-demand jobs, and personalization.
- **Screen printing** is a third method for apparel, large-format, and specialty goods: a stencil ("screen") per color, with per-color setup — cheap at volume, per color.



The crossover is the **break-even quantity**. A simple way to find it:

```
break_even_qty = offset_setup_cost / (digital_cost_per_unit - offset_cost_per_unit)
```

Example: Offset setup is $700, digital costs $0.22 per unit, offset costs $0.11 per unit. Break-even = 700 / (0.22 − 0.11) = **≈ 6,364 units**. Below that, digital is cheaper; above it, offset wins. As a rough industry rule, under ~1,000 copies digital almost always wins, and over ~2,000–3,000 offset usually does — but it varies a lot by job (some standard CMYK jobs cross around a few thousand, others much higher).

Common mistake: Pricing print as a flat `unit_price × quantity`. That model is structurally wrong: it mis-quotes small orders (it forgets the fixed setup) and mis-quotes large orders (it never lets the per-unit cost fall). Real print pricing is a **fixed setup line + a tiered/quantity curve**, with the method itself chosen by run length.

Key takeaway: Offset = high setup, low per-unit; digital = no setup, flat per-unit; they cross at a break-even quantity. Your pricing engine must be tiered and setup-aware, never linear.

Prepress and preflight: where defects (and software value) live

Most expensive print failures are not press failures — they are **file failures that should have been caught at intake**. This is exactly where good software pays for itself, because it can validate a file the moment a customer uploads it.

Preflight is the inspection. The most common reasons a file gets rejected:

Problem	What goes wrong	The fix
Wrong color space	File is in RGB (screen colors); colors shift when forced to print inks	Convert to **CMYK** (or define spot/Pantone colors)
Low resolution	Web images at 72–96 dpi print blurry/pixelated	Use **300 dpi at final print size**
No bleed	Color stops at the edge → white slivers appear after the cut	Extend art **~3 mm past the trim line**
Overprint/knockout errors	White set to overprint vanishes; black without overprint shows halos when colors misalign	Set black text to overprint; verify overprint settings
Missing fonts	Text reflows or substitutes the wrong font	Embed or outline all fonts

The industry's answer is a contract file format: export as **PDF/X-1a** or **PDF/X-4**. These enforce CMYK/spot colors, embedded fonts, defined bleed, and crop marks — a PDF/X file is the agreed-upon "this is printable" handshake. After preflight comes **assembly** (trapping + imposition) and, for offset, plate-making.

Common mistake: Letting customers submit files with no preflight. The defects are silent — everything looks fine on screen — and only surface *after* printing, as scrap and an angry reprint. Validate color space, resolution, bleed, fonts, and PDF/X conformance at upload, and return **plain-language fixes** ("Your logo is in screen colors — we'll convert it, which may shift the blues"), never a raw error code.

Key takeaway: Prepress is the quality gate, and preflight is where you stop expensive mistakes for free. Building real file validation (plus a proof-and-approve step before press) is the highest-leverage thing print software does.

Press, finishing, and fulfillment — the rest of the line

A few more realities round out the picture:

- **Press:** after mounting plates and inking up, the operator dials in **registration** — lining up the four CMYK layers precisely. Misregistration or a color shift can ruin an entire run, and the few **make-ready waste sheets** at the start are normal and counted as cost.
- **Finishing/bindery:** trimming, folding, scoring, perforating, collating, and binding. Binding styles include **saddle-stitch** (staples through the fold), **perfect bound** (glued spine, like a paperback),

spiral/wire-O, and **case/hardcover**. Decoration adds lamination, UV/spot varnish, embossing, die-cutting, and foil stamping — each with its own setup (a custom die, a foil plate) and its own lead time.

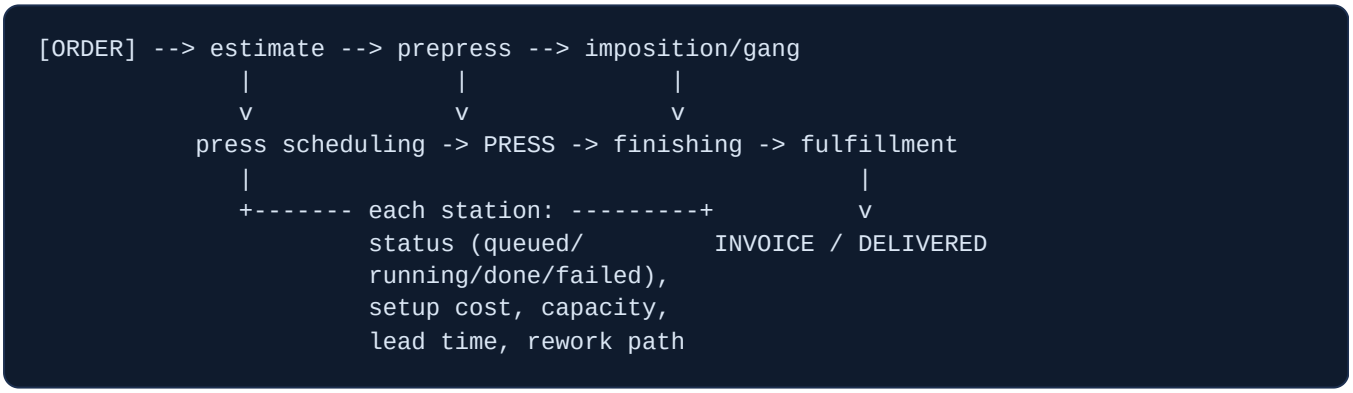
- **Fulfillment:** kitting, warehousing, pick-and-pack, shipping/mailing, and tracking. A key concept here is **Variable Data Printing (VDP)** — personalizing each piece (name, address, offer) within one run, the backbone of direct mail and personalized print-on-demand.

> **Best practice:** Treat finishing and decoration as **separately-priced add-ons with their own setup cost and lead time**, never free toggles. A "foil logo" checkbox that adds nothing to price or turnaround is a quote that will lose the shop money.

The mental model for the rest of this guide

Now pull it together. Mature print shops run on a **Print MIS** (Management Information System) — software built specifically for print that understands jobs, dockets, gang-run scheduling, prepress handoff, and method-specific costing. Its central object is the **job ticket**: a record that travels with the job, is often barcoded, and is scanned at each station so everyone can see exactly where the job is.

That is the model you should carry through every later chapter:



What this means for the way you build:

- **Model the order as a routing through stations**, each with its own status and the ability to pass, fail, or send the job back for rework — not a single boolean "printed."
- **Price with setup + tiered volume curves**, and let the method (offset/digital/screen) follow the run length. Linear pricing is wrong.
- **Validate files at intake** (color space, resolution, bleed, fonts) and require a **proof-and-approval gate** before anything reaches the press.
- **Make substrate/stock, finishing, and decoration configurable, separately-costed options** with their own setup and lead time.
- **Snapshot the specs** onto the job/order so that if a product or option is later renamed or deleted, the placed job still shows what was actually ordered.

- **Treat fulfillment** — kitting, pick-pack, ship, track — and personalization (VDP) as first-class downstream stations with their own statuses and customer-facing visibility.

Key takeaway: A print order is a job that flows through physical stations, each consuming time, money, and material. Model it as a lifecycle through work centers with tiered pricing, real file validation, a proof gate, and visible per-station status — and the rest of this guide will keep filling in what happens at each station.

Offset Lithography — The Workhorse of Commercial Print

If you have ever held a glossy magazine, a thick mail-order catalog, a paperback novel, a cereal box, or a stack of full-color brochures, you have almost certainly held something made by **offset lithography**. It is the quiet giant of the printing world. Most printed matter you touch in a day was made this way. People in the trade call it the "workhorse" because it does the heavy lifting of commercial print — high volume, dependable quality, low cost per copy.

This chapter teaches offset from the ground up. We will start with the simplest possible idea (oil and water don't mix), build up the machine piece by piece, then arrive at the one economic idea you must understand if you build print-shop software: **offset is expensive to start but cheap to repeat**, and there is a specific quantity — the **crossover point** — where it overtakes digital printing on price. Let's begin.

What "offset lithography" actually means

The name has two parts, and each part describes one idea. Let's define both in plain words before we use them again.

Lithography means printing from a *flat* surface. On the printing plate, the parts that carry the image and the parts that stay blank are on the **same level** — there are no raised letters (like a rubber stamp) and no carved-out grooves (like an engraving). The image and the blank areas are separated **by chemistry, not by shape**. That is the whole trick, and we will explain the chemistry in a moment. The word comes from the Greek for "stone writing" — it was invented in 1796 by Alois Senefelder, who drew on flat slabs of limestone. Modern plates are thin metal, but the principle has not changed in over 200 years.

Offset means the ink does *not* jump straight from the plate onto the paper. Instead it makes a stopover. The plate first hands its inked image to a soft rubber sheet (called a **blanket**), and the blanket then presses the image onto the paper. The image is "offset" — set off onto a middle surface — before it reaches the page.

Analogy: Think of a rubber stamp you ink and press directly onto paper — that is *direct* printing. Now imagine you instead press the inked stamp onto a soft rubber pad, and then press that pad onto the paper. That extra rubber middle-step is "offset." The rubber squishes to match the paper's texture, so the ink lays down evenly, the image is crisper, and the delicate plate never rubs against gritty paper (which would wear it out fast).

The oil-and-water principle (the chemistry, from scratch)

Here is the foundation everything else sits on: **grease and water repel each other**. Pour oil into a glass of water and the oil refuses to mix in — it beads up and separates. Offset printing turns that everyday fact into a way to put an image on a flat plate.

The printing plate is treated so that two kinds of areas exist side by side on the same flat surface:

- **Image areas** are made *oil-loving* and *water-repelling*. (The technical words are **oleophilic** = oil-loving, and **hydrophobic** = water-fearing.) These areas grab onto greasy, oil-based ink.
- **Non-image areas** (the blank background) are made *water-loving* and *oil-repelling*. (The word is **hydrophilic** = water-loving.) These areas hold a thin film of water, and that water film pushes the oily ink away.

On every single turn of the press, two things happen in order:

1. **Water first.** Dampening rollers wet the plate with a thin film of **fountain solution** (mostly water plus helpers — gum arabic, a buffer to control acidity, sometimes alcohol or an alcohol substitute, and a fungicide). The water clings only to the water-loving blank areas.
2. **Ink second.** Inking rollers then roll oil-based ink across the plate. The ink sticks only to the oil-loving image areas. Where the plate is already wet, the ink is repelled and slides off.

```
PLATE SURFACE (flat — same level everywhere)
+-----------------------------------------------+
|  blank   [IMAGE]   blank   [IMAGE]   blank    |
|  ~water~          ~water~           ~water~   |  <- water film
|   (oil-loving image areas now grab the ink)   |
+-----------------------------------------------+
      step 1: dampen  ->  step 2: ink
```

The pressroom skill of getting exactly the right amount of water versus ink is called **ink-water balance** (or just "water balance"), and it is the single hardest thing to keep right on a running press. Too much water washes out the color; too little lets ink creep into the blank areas (called **scumming** or **toning**).

Key takeaway: Offset doesn't carve or raise an image. It uses the fact that oil and water repel to make a flat plate where ink sticks only where you want it — every revolution, water first, ink second.

A note on "waterless" (dry) offset

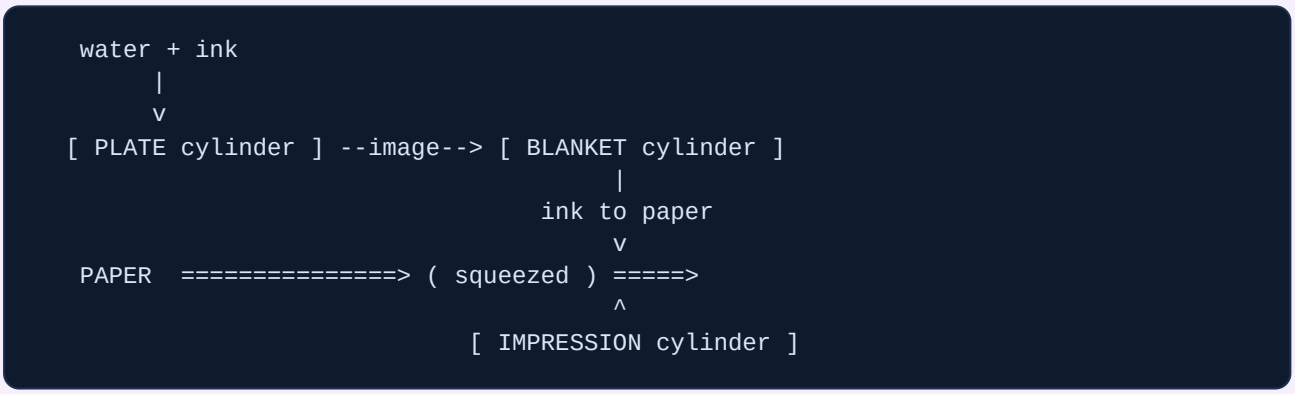
There is a variant that skips the water entirely. The plate is coated with **silicone** in the blank areas, and silicone naturally repels ink, so no fountain solution is needed. This removes the tricky water-balance

problem and gives sharper dots, but it requires temperature-controlled inking and special inks — so it stays a specialist choice, not the default.

Inside the machine — the three cylinders

An offset press builds its image with three rotating drums, called cylinders, stacked so they touch. Follow the ink's journey through them.

Cylinder	What it holds	What it does
Plate cylinder	The thin metal printing plate (one plate per color)	Gets dampened with water, then inked. Now carries the inked image.
Blanket cylinder	A soft rubber/composite "blanket"	Receives the inked image from the plate (image becomes mirror-reversed here), then presses it onto the paper. The rubber conforms to the paper for an even lay-down.
Impression cylinder	A hard backing roller	Squeezes the sheet of paper against the blanket — the "kiss" of pressure that transfers ink to paper.



Two roller systems feed the plate cylinder:

- The **dampening (fountain) system** — rollers that lay down the thin water film.
- The **inking system** — a long "train" of a dozen or so rollers that meter the ink and spread it into an extremely thin, even film (typically only about 0.2–0.4 thousandths of an inch — far thinner than digital toner). Small adjusters called **ink keys** let the operator control how much ink flows in each vertical zone across the sheet.

Here is the crucial scaling fact: **each color needs its own complete set** — its own plate, plate cylinder, blanket, and inking train. That bundle is called a **printing unit** (or "tower"). A four-color press is really four units in a row, and the sheet travels through them one after another, picking up one color at each station — known as printing **wet-on-wet**.

Key takeaway: Plate → blanket → paper, pressed by the impression cylinder. One color = one full printing unit. More colors means more units, more plates, and (as we'll see) more cost to set up.

Building color — CMYK process and spot colors

How does an offset press reproduce a full-color photograph with only a few inks? Through a system called **four-color process**, almost always written **CMYK**:

- **C** = Cyan (a blue)
- **M** = Magenta (a pink-red)
- **Y** = Yellow
- **K** = Key, which means black. (It's called "K" instead of "B" to avoid any confusion with Blue.)

The press never mixes these inks in a bucket. Instead, each color is broken into a pattern of tiny dots called a **halftone**. Lay overlapping dots of cyan, magenta, yellow, and black next to and on top of each other, and from normal reading distance your eye blends them into millions of apparent colors. Four plates, four units, full-color result.

Spot colors (Pantone)

Sometimes CMYK isn't good enough. A brand color has to be *exactly* right every time — Coca-Cola red, Tiffany blue, a specific corporate orange. Building that color from four overlapping dot patterns can drift slightly from press to press. The solution is a **spot color**: an ink pre-mixed to one exact hue, like a paint can mixed to a recipe, and printed from its own dedicated plate and unit.

The most common spot-color system is **Pantone** (the **PMS**, or Pantone Matching System). Each color has a number — for example "PMS 165" is a specific orange. Designers specify the number, and any shop in the world mixes the same ink. Spot colors also let you print things CMYK simply cannot reproduce: **metallics** (gold, silver), **fluorescents/neons**, and certain bright pastels.

Press configuration	Units	Typical use
1-color	1	Black-only text, forms, basic flyers
4-color (CMYK)	4	Standard full-color printing
5–6 color + coater	5–6+	CMYK plus brand spot color(s) and/or a varnish/coating
Perfector (e.g. 10-unit)	8–10	Prints BOTH sides in one pass — e.g. 5 colors per side

A **perfecting press** (or "perfector") is simply a press that flips the sheet internally and prints the back during the same pass, instead of running the stack through twice.

> **Common mistake:** Adding a spot color "just because it looks nice." Every spot color is an extra plate, an extra unit, and extra wash-up time — real money. Reserve spot inks for true brand-critical or special-effect needs; do the rest in CMYK.

Why offset is cheap to repeat but expensive to start

This is the single most important idea in the chapter, especially for software. Offset has a big **fixed setup cost** you pay once per job, then a tiny cost for each additional copy.

Plates and CTP

The image is burned onto each plate by a laser, directly from the digital file — a process called **CTP (Computer-to-Plate)**. (This replaced an older route that went through photographic film.) Plates are usually aluminum. The rule to remember: **one plate per color, per side**. So a double-sided full-color (CMYK) job needs `4 colors × 2 sides = 8 plates`. Plates commonly run roughly **$300–$800 each** depending on size and shop, so the plates alone for a full-color job can total hundreds to low thousands of dollars before one sellable sheet exists.

Make-ready

Make-ready is all the prep work to get the press producing good sheets: mounting plates, setting the ink-water balance, lining up the colors (**registration**), tuning the ink keys, and running test sheets until the color and alignment are right. Those test sheets are **spoilage** (waste). On a modern automated press make-ready can be quick (a few minutes), but for jobs with mixed spot inks and strict color approval it runs much longer. Either way it is a **fixed** cost — you pay it once whether you print 500 copies or 50,000.

> **Example:** A double-sided full-color flyer needs 8 plates. Say plates cost $500 each ($4,000) plus an hour of make-ready and a few hundred waste sheets. That's a few thousand dollars spent *before the first good copy*. But once the press is running, each extra 1,000 copies costs only paper + ink + a little press time. Print 1,000 copies and that setup is brutal per copy; print 100,000 and it disappears into pennies each.

> **Key takeaway:** Offset = high fixed cost (plates + make-ready + waste) + very low cost per extra sheet. That shape is the reason the per-copy price falls steeply as the run gets bigger — and it's exactly what your pricing engine must model.

The two families — sheet-fed vs web offset

Offset presses come in two broad types, defined by how paper is fed in.

	Sheet-fed offset	Web offset
Paper feed	Individual pre-cut sheets, one at a time	A continuous roll ("web") of paper
Speed	Up to ~18,000 sheets/hour	~4–5× faster; some run 3,000 ft/min (~915 m/min)
Stock flexibility	Very high — thick board, packaging, specialty stocks	Limited to roll-suitable stocks
Best for	Short-to-medium runs, top quality, thick/specialty stock	Very high volume (tens of thousands+)
Typical work	Brochures, business cards, posters, books, folding cartons, premium packaging	Magazines, catalogs, newspapers, high-volume direct mail

Sheet sizes for sheet-fed presses fall into rough format classes: half-size around 20×29 in, full-size around 28×40 in, and very-large-format up to about 41×56 in and beyond. A single big sheet can carry up to roughly 48 book pages, which are later folded and cut.

Web offset splits again by how the ink dries

- **Coldset** (non-heatset) — ink dries by *soaking into* porous, uncoated stock like newsprint. Cheap, fast, lower quality. This is how newspapers and low-cost flyers are printed.
- **Heatset** — the web passes through hot-air dryers and then chill rollers that set the ink. This works on coated *and* uncoated stock and gives the glossy finish of magazines and catalogs.

Because of its enormous setup and waste, **web offset only pays off at very high volumes** — generally above 5,000–10,000 impressions, and ideally in the tens of thousands or more. Below that, sheet-fed (or digital) wins.

Key takeaway: Sheet-fed = flexible, high-quality, short-to-medium runs. Web = fast, roll-fed, lowest cost only at huge volumes. Choose web for long runs on roll-friendly stock; sheet-fed for quality, thick, or specialty work.

Inks — conventional, UV, and LED-UV

How the ink dries shapes what the press can print on and how fast finished work can move.

Ink type	How it dries	Trade-offs
Conventional	Soaks into the stock + slowly oxidizes in air	Cheapest; needs anti-set-off **powder spray** and drying time/racks before finishing; can smear if rushed
UV	Stays liquid, then instantly hardens ("cures") under UV light	Tough, glossy, abrasion-resistant; prints on non-absorbent stock (plastics, foils); no spray powder or drying wait — finish immediately
LED-UV	Cures under LED diodes (typically 395 nm) instead of mercury lamps	~65% less energy, instant on/off (no warm-up), little heat, low/no ozone; **low-migration** versions are safe for direct food packaging

Conventional inks dry partly by soaking in and partly by reacting with air over time — which is why fresh sheets get dusted with anti-smear **powder spray** and left to dry before they can be cut or folded. **UV inks** don't dry by soaking at all; they stay wet until a burst of UV light makes them harden in an instant. That means you can print on plastic and foil (which absorb nothing) and send sheets straight to finishing — some shops report large throughput gains. **LED-UV** is the newer, greener curing technology that uses long-lived LED diodes instead of hot mercury lamps, runs cool enough for thin heat-sensitive films, and offers food-safe formulations.

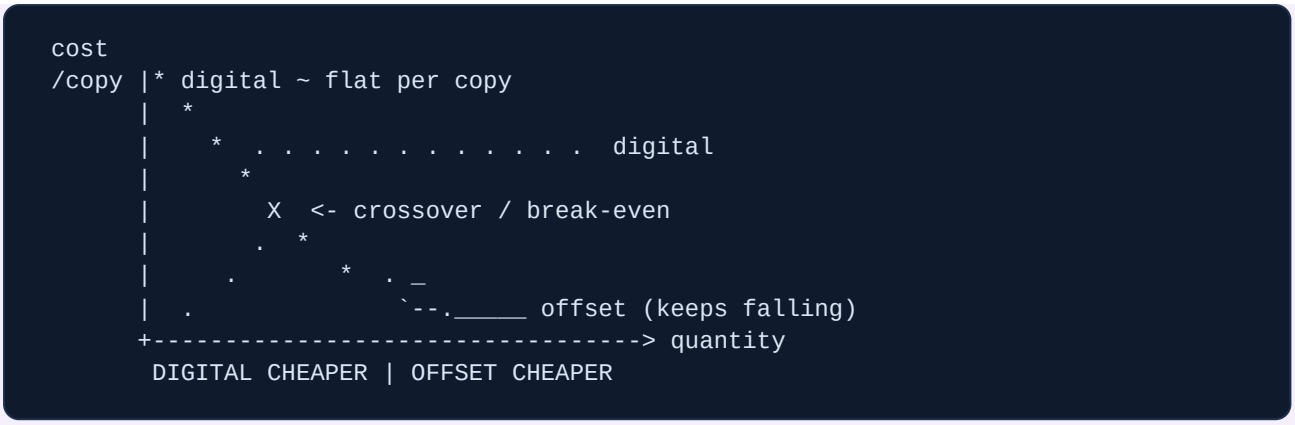
> **Common mistake: Set-off** — stacking conventional-ink sheets before they're dry, so wet ink transfers onto the back of the sheet above. Caused by too little spray powder or rushing the job. UV/LED-UV avoids it because the ink is cured before the sheets stack.

The big economic idea — the offset-vs-digital crossover

Now we combine everything into the decision that drives pricing software. Compare the two cost shapes:

- **Offset:** high fixed setup (plates + make-ready + waste) + very low cost per copy. Cost-per-copy *falls steeply* as the run grows, because the fixed cost spreads over more copies.
- **Digital:** almost no setup + a flat, fixed cost per copy (the "click charge" for toner/ink). Cost-per-copy stays *roughly constant* no matter the quantity.

Plot both as cost-per-copy against quantity and the two lines **cross**. That intersection is the **crossover point** (or **break-even point**).



Left of the crossover, digital is cheaper. Right of it, offset is cheaper. A simple formula gives the break-even quantity:

`break-even qty = offset setup cost ÷ (digital cost per unit − offset cost per unit)`

> **Example:** Offset setup $700, digital $0.22/copy, offset $0.11/copy. Break-even = 700 ÷ (0.22 − 0.11) = 700 ÷ 0.11 = **~6,364 copies**. Below that, print digital; above it, print offset.

Be careful: **there is no single magic number**. The crossover depends on size, page count, number of colors, spot inks, finishing, and stock. Rules of thumb cited in the trade scatter widely — some shops use ~500 copies, others ~1,000, others 2,500–3,500 for a standard 4-color job. That spread is itself the lesson: your software should *compute* the crossover per product from real cost inputs, not hard-code "1,000."

Below the crossover, digital wins on more than price. It needs no plates and almost no make-ready, turns around fast (often 1–2 days), and — crucially — it can do **Variable Data Printing (VDP)**: changing the content on every single copy (names, addresses, QR codes, serial numbers, languages). **Offset cannot do variable data at all** — the plate is fixed, so every copy in the run is identical.

> **Common mistake (in software):** Offering a "personalize each copy" or "add recipient name" option on a product that will route to offset. It's physically impossible. VDP/personalization options must be disabled whenever the chosen method or quantity routes to offset.

When a shop chooses offset

Choose OFFSET when…	Choose DIGITAL when…
Volume is above the crossover (lowest per-copy cost)	Run is short / below the crossover, or a proof/reprint
Exact brand/Pantone color, metallic, or fluorescent is needed	Each copy must differ (variable data, versioning)
Premium quality, large format, or thick/specialty stock	Fast turnaround with no plate/setup budget
Content is static and identical across the whole run	Content changes often
Inline finishes via extra units (varnish, coating, custom inks)	—

Example — four jobs, four answers:

- **100,000-copy catalog** → heatset web offset. Setup amortizes to pennies; web speed finishes it overnight.
- **5,000 full-color brochures** with a brand PMS color → sheet-fed offset, 5–6 units. Classic offset sweet spot.
- **250 postcards, each with a different name + unique QR code** → must be digital. VDP is impossible on offset, and the quantity is tiny anyway.
- **Daily newspaper** → coldset web offset. Uncoated newsprint, absorption drying, massive run, lowest cost, quality secondary.

File preparation — the mistakes that cost real money

Most offset failures aren't on the press — they're in the **file** the customer sends. These are exactly the checks good web-to-print software should run automatically at upload.

- **RGB instead of CMYK.** Screens use RGB and can show colors offset ink can't reproduce. Sending RGB causes surprise color shifts. Convert to CMYK with the correct profile before output.
- **Missing bleed.** If color should run to the page edge, the artwork must extend past the trim line so cutting doesn't leave white slivers. Standard bleed = **0.125 in (3 mm)** on every side.
- **Low-resolution images.** Print needs about **300 ppi at final size**. A 72-ppi web image prints blurry and pixelated.
- **Unembedded fonts.** If fonts aren't embedded or converted to outlines, the press may substitute a different font and reflow the text. Always embed or outline.
- **Ignoring dot gain.** Halftone dots *spread* when wet ink hits paper, darkening midtones and shadows. Coated stock gains ~12–15%; uncoated ~18–22%. The separation/profile must compensate.
- **Spot vs process confusion.** A stray spot color creates an unwanted extra plate (extra cost); a spot meant to stay spot but flattened to process prints the wrong color.

Best practice: Export a print-ready **PDF/X** (e.g. PDF/X-1a): CMYK only, fonts embedded, transparency flattened, correct ICC color profile, 0.125 in bleed, 300 ppi images. This single preset prevents most of the mistakes above. And always approve a contract proof *before* plates are made — fixing color on a running press is far more expensive than fixing the file.

How this maps to print software (PF360-relevant)

Everything above turns into concrete things your application must model. A few of the most important:

- **Model the offset cost curve directly.** Price = a *fixed setup component* (plates × number of colors × number of sides + make-ready) **plus** a *per-unit component* (paper + ink + press time). This naturally produces a falling per-copy price as quantity rises, which is why offset products quote in **quantity tiers / price breaks** (e.g. 250 / 500 / 1,000 / 5,000). Digital products price as a near-flat per-unit cost.
- **Auto-route offset vs digital.** For the ordered quantity, compute the setup-amortized offset price and the flat digital price, pick the cheaper, and explain it to the buyer in plain language ("At 250 we'll print this digitally; at 2,000 offset becomes cheaper").
- **Capture specs as priced options.** Number of process colors (1 vs 4), each added spot/Pantone color (an extra plate/unit → setup add-on), coating/varnish (extra unit), and single- vs double-sided (doubles plate count). Each option must drive *both* setup cost and per-unit cost.
- **Preflight at upload.** Check CMYK (warn on RGB), require 0.125 in bleed, require ≥300 ppi, embedded fonts, and a PDF/X export — and report problems as plain-language fixes, never raw error codes.
- **Gate variable data to digital only.** Disable personalization/VDP options whenever the method or quantity routes to offset.
- **Express minimums and over/under-runs.** Offset jobs often carry a minimum order quantity and an over/under tolerance (because make-ready spoilage and finishing make exact counts impractical). The cart and quote should state these clearly.

Key takeaway: Offset is the high-volume workhorse: a flat plate split by oil-and-water chemistry, ink offset through a rubber blanket, one printing unit per color. Its economics are "expensive to start, cheap to repeat," which creates a crossover quantity with digital that your pricing engine must compute — and a set of file, color, and option rules your preflight and product model must enforce.

Digital Printing — Toner, Inkjet & Variable Data

In the last chapter you met **offset printing** — the workhorse that needs metal plates, a long setup, and a big run to be worth it. Now meet its opposite. **Digital printing** is what makes a print-shop SaaS like the one you are building even possible: a customer orders a single business card or fifty personalized postcards online, and a press produces them an hour later with no plates and no minimum order. This chapter explains the two machines that do this, the one trick they can do that offset cannot (printing something different on every single piece), and exactly when digital is the right tool versus offset.

What makes a print "digital"?

Let me define it plainly. **Digital printing** means the image goes straight from a computer file to the press, with **no physical printing plate** and no fixed image carrier. The press "re-draws" the image from data for *every single sheet* it prints.

That last point is the whole chapter in one sentence. With offset, a fixed metal plate stamps the *same* image over and over. With digital, the machine re-imagines the image from scratch on each impression — so each impression *can be different* at essentially zero extra cost.

Analogy: Offset is a **rubber stamp** — you carve it once (expensive), then every press is identical and cheap. Digital is a person **handwriting** each card — there is no carving step at all, and they can write a different name on every card without slowing down. The stamp wins when you need 10,000 identical cards; the writer wins when you need 50 cards, each personalized, by tomorrow.

Here is the chain of consequences that drives everything else in this chapter. Memorize it:

```
no plates  ->  no makeready  ->  cheap short  ->  fast      ->  on-demand  ->  every p
to make        (setup) cost      runs              turnaround     (qty = 1)     can be u
                                                                                (variab
```

There are two dominant families of production digital presses. We will take them one at a time:

Family	Plain meaning	Also called	Typical home
Electrophotography (EP)	Uses dry powder or liquid **toner** fused with heat — same physics as an office laser printer, scaled up	Toner, "laser", xerographic	Short-run commercial, business cards, versatile everyday work
Production inkjet	Fires tiny liquid **ink droplets** from fixed printheads, only where the image needs them	Drop-on-demand (DoD)	Books, billing/statements, direct mail, very high volume

Key takeaway: "Digital" = file-to-press, no plates. Because the press re-images every impression, short runs are cheap, turnaround is fast, and — uniquely — every printed piece can carry different content.

Electrophotography (toner / "laser") — how it actually works

A production toner press is a giant, fast, precise cousin of the laser printer in an office. The core component is a **photoconductor drum** (often abbreviated **OPC**, organic photoconductor) — a rotating cylinder coated with a material that holds an electric charge in the dark but loses that charge wherever light hits it. **Toner** is the fine powder that becomes your image: a mix of plastic **resin** (the part that melts), **pigment** (the color), wax, and charge-control additives.

The press repeats a seven-stage cycle thousands of times per minute. Here is the loop:

```
1 CHARGE      drum given a uniform electric charge in the dark
    |
2 EXPOSE      laser/LED writes the image by discharging spots
    |         -> leaves an invisible "latent" charge pattern
3 DEVELOP     charged toner powder sticks to the image areas
    |
4 TRANSFER    toner pulled from drum onto the paper
    |
5 FUSE        heat + pressure melt the resin, bonding it to paper
    |
6 CLEAN       leftover toner scraped off the drum
    |
7 ERASE       drum neutralized, ready for the next sheet
    \__________________ repeat _________________/
```

Two ideas are worth defining because they explain a lot:

- **Latent image:** the invisible pattern of charged and discharged spots on the drum after the laser writes. It is "latent" because you cannot see it yet — toner makes it visible in the develop stage.
- **Triboelectric effect:** charging by friction. Agitating the toner gives the particles an electric charge, so they obey "opposite charges attract, like charges repel" and land only where the image is.
- **Fusing:** the fuser uses heat and pressure to melt the resin so it bonds to the paper. This is why **toner sits as a thin plastic-like layer on top of the sheet** — you can sometimes feel a faint sheen or relief. Inkjet and offset, by contrast, soak into or sit flatter on the surface.

Modern presses expose the drum with **VCSEL** arrays (vertical-cavity surface-emitting laser — many tiny lasers in a grid) or **LED** arrays, which place dots very precisely.

Toner types and their real specs

Toner type	Particle size	Quality ceiling	Notes & examples
Pulverized (ground) toner	~6.2–10.2 microns, irregular shape	up to ~600 dpi	Older, cheaper; the classic powder
Chemically grown (emulsion-aggregation)	<5 microns, tightly controlled shape	1,200–2,400 dpi	Lower melt temperature = greener & faster. Xerox EA, Ricoh PxP, Konica Minolta Simitri
Liquid toner (HP Indigo "ElectroInk")	1–2 micron pigment in carrier oil	near-offset look	Very thin, glossy, sharp; great Pantone coverage. Many stocks need priming/pre-treatment
Nanography (Landa, emerging)	pigment "tens of nanometers"; ~500 nm dried film	frontier	Water-based; prints on almost any stock with no pre-treatment

A **micron** is one-thousandth of a millimeter; smaller, rounder particles mean sharper detail and smoother gradients. **dpi** (dots per inch) measures how finely the press can place dots — higher numbers mean finer detail.

Example: The **HP Indigo 100K** (a B2 sheetfed liquid-toner press) runs about **6,000 B2 sheets per hour** in enhanced mode. The **Xerox iGen 5** is a dry-toner press that can add a 5th station for spot, white, or clear toner and handle sheets up to 35 inches long. These are not desktop printers — they are industrial presses that happen to use the same physics as your office laser.

Key takeaway: Toner presses charge a drum, write an invisible image with light, coat it with charged powder, and melt that powder onto paper. They are versatile across many stocks out of the box; liquid toner (Indigo) gets closest to the premium offset look.

Production inkjet — how it works

Inkjet builds the image from millions of tiny ink droplets. The key principle is **drop-on-demand (DoD)**: each nozzle fires a droplet *only* when the image data calls for one. There is no waste spraying between drops — the press paints exactly the pattern of dots the file describes, using fixed printheads that span the page width (single-pass) or scan across it.

There are two ways to push a droplet out of a nozzle:

	Piezoelectric DoD	Thermal DoD ("bubble jet")
How a drop forms	An electric signal flexes a piezo crystal that physically squeezes ink out — **no heat**	A tiny heater flash-boils the ink, the vapor bubble ejects a droplet
Ink range it handles	Wide: UV, aqueous (water-based), latex, solvent; viscosity ~2–12 centipoise	Narrower; ink must boil cleanly
Durability / cost	More durable heads, more ink chemistry options	Cheaper heads
Where you see it	Most industrial/production presses	Desktop/office, some wide-format (Memjet, HP)

A couple of terms: **viscosity** (measured in centipoise) is how thick a liquid is — water is ~1, honey is thousands. **UV ink** is "pinned" (partly set) and then fully **cured** by a UV lamp; **aqueous** (water-based) ink is dried. The curing method drives which papers and finishes are possible.

Real production-inkjet numbers

- **SCREEN Truepress JET** continuous-feed roll press: web speeds up to ~**225 meters per minute**.
- **Memjet** thermal page-wide head: ~223 mm print width, 20+ m/min, can fire up to ~**750 million drops per second** at roughly 2 picoliters (~14-micron droplets). A picoliter is a trillionth of a liter — these drops are almost unimaginably small.

- High-end production sheetfed/web inkjet commonly runs **1,200 dpi at ~1,000 feet per minute**.

Inkjet comes in two formats that matter for software pricing and turnaround:

- **Sheetfed (cut-sheet):** individual sheets — commercial print, marketing collateral.
- **Continuous-feed (web/roll):** a continuous paper roll — books, transactional documents (bills, statements), and direct mail at huge scale.

Key takeaway: Inkjet fires droplets on demand from fixed heads. Piezo (no heat) dominates industrial presses and handles many ink types; continuous-feed inkjet wins at very high volumes like books and billing.

Toner vs inkjet — choosing between the two digital families

Factor	Toner (EP)	Production inkjet
How image sits	Melted plastic layer on top (slight sheen/relief)	Absorbed into / cured on surface (flatter, more offset-like)
Substrate range out of the box	Huge: papers, board, films, synthetics, label stock	Historically needed coated/treated "inkjet-optimized" stock or a primer; UV inkjet widened this a lot
Color / spot matching	Solid CMYK; liquid EP (Indigo) excels at Pantone/spot	High-end now matches or beats many gamuts; spot weaker than Indigo
Best at	Versatility, standard short/commercial runs	Very high volume — books, transactional, mass mail
Operating model	Dry toner is simple, low-mess, robust; Indigo richer but needs more maintenance/pre-treatment	Continuous-feed throughput is unmatched

Two terms there: **substrate** is just printer-speak for "the thing you print on" (paper, board, film, fabric). **Gamut** is the full range of colors a process can reproduce — a wider gamut means more vivid and more accurate colors. **Pantone** / **spot color** means a specific pre-mixed ink (like a brand's exact red) rather than building the color from CMYK dots.

Key takeaway: Pick toner for versatility and premium short-run look (Indigo for Pantone-heavy coated work); pick production inkjet when volume is very high (books, statements, mass direct mail).

Quality vs offset today — the gap has mostly closed

For decades the rule was "offset is higher quality, digital is for proofs and short runs." That rule is now mostly out of date, and you should not let it drive product decisions.

Why? Because of how human eyes actually work. At normal viewing distance, the eye can only resolve so much detail:

Viewing situation	Resolution the eye needs
Held at arm's length (flyer, poster)	150–300 dpi is plenty
Fine type / macro detail	300–600 dpi
Production inkjet delivers	1,200 dpi
Chemical toner delivers	up to 2,400 dpi

Both digital families already *exceed* what the eye can resolve at typical viewing distances. So the "raw dpi" debate is mostly settled.

Common mistake: Judging a press by dpi alone. Addressable dots are *not* the same as perceived quality. What actually matters is drop volume and control, **dot gain** (how much each dot spreads on the paper), the **screening/dither algorithm** (how the press arranges dots to fake continuous tones), gray-component handling, and how the ink interacts with the substrate. A 600-dpi press with great screening can look better than a 1,200-dpi press with poor screening.

Offset still edges out on…	Digital edges out on…
Very long-run color consistency	Per-piece variability (every piece different)
Certain spot, metallic, fluorescent inks	Fast proofing that matches the final exactly
The absolute finest detail with fresh plates	No makeready waste; instant reprint

Key takeaway: For most marketing collateral, business cards, flyers, and short-run books, a customer cannot tell digital from offset. Quality is no longer the deciding factor — **volume, economics, and turnaround are**. Your SaaS should compete on those, not on a stale "digital is lower quality" assumption.

Economics — when digital beats offset (the break-even)

The two methods have **opposite cost shapes**, and understanding this is the single most important thing for a pricing engine.

	Offset	Digital
Setup (fixed) cost	**High** — plates + makeready	**Near zero**
Per-unit cost	**Low**	**Higher & flat** (toner/ink "click" charges)
Cost-per-piece as volume rises	Drops sharply	Stays roughly flat

(**Makeready** = all the setup work before a real run: mounting plates, getting ink and registration right, wasting some sheets dialing it in. **Click charge** = the per-impression fee many digital presses cost out at.)

Because the two lines cross, there is a **break-even quantity** — the run length where offset's lower per-unit cost finally pays back its big setup. The formula:

$$\text{Break-even qty} = \frac{\text{Offset setup cost}}{(\text{Offset cost/unit}) - (\text{Digital cost/unit})}$$

Example: Offset setup = $700. Digital = $0.22/unit. Offset = $0.11/unit. Break-even = 700 / (0.22 - 0.11) = 700 / 0.11 ≈ **6,364 units**. Below ~6,364 pieces, digital is cheaper; above it, offset is.

The exact crossover varies by job — present it as a *range*, never one magic number:

Situation	Typical crossover
Under ~500–1,000 units	Digital almost always cheaper
Standard CMYK marketing work	Often 3,000–5,000 units; some jobs put offset ahead past ~4,200 units (saving 15–25% at high volume)
Precise Pantone matching needed	Crossover drops to ~1,500–2,500 (offset's spot-ink advantage kicks in sooner)
Books	POD ~$8–25/copy to produce vs offset ~$2–6/copy — but offset means printing & warehousing a big run up front

Key takeaway: Offset = high setup, low per-unit. Digital = no setup, flat per-unit. A good pricing engine knows the break-even and quotes the cheaper method at a given quantity — or at minimum never charges a makeready penalty on a short digital run.

Print-on-demand (POD) economics

Print-on-demand means you print *only after* the order is placed. Digital makes this possible because there is no setup to amortize over a big run.

POD wins on	POD costs you
Zero inventory, no upfront capital	Higher per-unit cost
No warehousing, no dead/obsolete stock	Thinner margins than selling pre-printed inventory
Single-unit fulfillment (qty = 1 is fine)	Per-order packaging/fulfillment overhead

Example (books): Base print ~$4–6/copy, plus ~$2–3 fulfillment/packaging per order. POD gross margins land around **10–25%**; wholesale dropship ~15–30%; specialty/art books can reach 40–60% (a 150-page art book selling at $50–80 might cost $15–25). Amazon KDP's paperback royalty is **60% of list price minus print cost** — a 200-page B&W paperback at $14.99 yields (14.99 × 0.60) − $3.70 = **$5.29 per sale**.

Common mistake: Forgetting shipping. A single paperback shipped US→Europe can cost ~$10–14 — up to **60% of a typical book's retail price**. For heavy or single items, shipping can quietly erase the whole margin. **Lesson for your checkout:** surface the true per-unit cost *and* shipping early, before the customer commits — or thin POD margins evaporate.

Key takeaway: POD trades higher per-unit cost for zero inventory risk. Margins are thin, so accurate cost capture and honest, early shipping totals at checkout are non-negotiable in your software.

Variable Data Printing (VDP) — the trick offset can't do

This is digital's superpower. **Variable Data Printing** means elements change *piece to piece* within a single continuous run — names, addresses, offers, images, charts, maps, and QR/coupon codes — all driven by a data source like a CSV file, spreadsheet, database, or API. The mental model is simple:

Analogy: A VDP run is a **mail merge that prints itself**. Think of a spreadsheet where **each row becomes one printed piece**. Row 1 prints "Dear Maria… your Honda Civic is due for service"; row 2 prints "Dear James… your Ford F-150 is due"; and so on — all in one uninterrupted run, at full press speed.

This is *only* possible because digital re-images every impression. With a fixed offset plate it is physically impossible. VDP comes in increasing levels of sophistication:

Level	What changes	Example
Simple mail-merge	Just name/address	"Dear [Name]" letters
Versioning	Whole variants per segment/region	Different offer for East vs West coast
Full 1:1 / transpromo	Every element + image conditionally personalized by rules	A statement that also shows offers tailored to that one customer

Example: An auto dealership postcard prints each recipient's **name**, their **specific car model**, their **service history**, and a map to the **nearest dealer** — different on every card. A retail store-opening invite can even print a personalized **driving route from the recipient's home address**. Personalized direct mail draws roughly a **6% response rate vs ~2%** for generic mail (ANA figures) — a strong ROI argument you can put in front of store owners.

VDP under the hood (so your software cooperates with the press)

Variable jobs use industry file formats like **PPML** and **PDF/VT**. The reason matters: the press's **RIP** (Raster Image Processor — the software that turns a page into the dot pattern the press fires) must **cache the static, reusable parts** (logo, layout, fixed text) and only re-process the *variable* objects per record. Otherwise it would re-RIP the entire page for every piece and the press would crawl.

Common mistake (VDP-specific): Dirty data. Mis-mapped columns, empty fields, text that overflows and reflows the layout, or wrong image keys mean you print *thousands* of wrong pieces at once. **Always validate the data and proof a sample set before the full run.** A bad VDP run is the most expensive single mistake in this whole chapter.

> **Key takeaway:** VDP = one row of data → one personalized piece, in a single run. It is unique to digital, drives far higher response rates, and lives or dies on clean, validated data.

Web-to-print fit — why this all matters for your SaaS

Here is the punchline for a print-shop SaaS builder. A **web-to-print (W2P)** storefront takes many **small, on-demand, often personalized** orders. That is *exactly* digital printing's sweet spot — short runs, no setup, per-piece variation, fast turnaround. Offset's makeready would make most storefront orders uneconomic. Digital and web-to-print are a natural pair.

A good W2P system automates the whole chain so humans barely touch it ("lights-out" prepress):

```
catalog  ->  online editor    ->  preflight /   ->  order data  ->  pr
             or file upload       proof &            flows to        o
                                  approval           RIP / MIS       p
```

The single biggest source of production errors is **manually re-keying** customer details and files between systems. W2P's core value is eliminating that highest-friction point — getting clean, print-ready files and order data straight from the customer to the press automatically. Real products in this space worth knowing by name: **Xerox XMPie PersonalEffect/StoreFlow**, **EFI/Fiery StoreFront**, **EPS MarketDirect StoreFront**, **Ricoh W2P**, **RSA (Rochester Software Associates)**, and **DesignNBuy**.

How this maps to features you build

- **Pricing engine must model digital's cost curve:** near-zero setup + flat per-unit/per-click cost — the opposite shape from offset. The calculator should pick the cheaper method at a given quantity (the break-even logic above), or at least price short runs *without* a makeready penalty.
- **Allow true single-piece and small-batch orders:** digital makes qty=1 economic. Do not inherit offset-era minimum-quantity rules — they kill digital's whole advantage.
- **Treat Variable Data as a first-class product type:** the buyer uploads a CSV or fills fields, and the system generates N personalized outputs (one row = one

piece). You will need a data-mapping UI, a per-record proof, and you must **snapshot the dataset onto the order** so history survives even if the source file changes.

- **Preflight is mandatory in the pipeline.** ("Preflight" = automatically checking a file is print-ready before it goes to press.) Check resolution (≥300 dpi raster at final size), color space (CMYK vs RGB), **bleed** (3–5 mm / 0.125–0.25 in of artwork past the trim so no white slivers appear), embedded fonts, overprint, and safe margins. Auto-flag problems and explain them in plain language to non-technical store owners.
- **Color-space handling:** screen previews are RGB, but print output is CMYK. Warn that vivid/neon RGB colors and unverified Pantones will shift or dull in print, and ideally offer a soft-proof.
- **POD/dropship workflow:** order-after-sale, no inventory; surface true per-unit + shipping cost early; margins are thin so accurate cost capture matters.
- **Turnaround as a sellable promise:** digital's fast turnaround lets you show realistic, plain-language delivery dates per method.

Common mistakes to design against: uploading RGB (dull/shifted CMYK output, especially neons); choosing Pantone colors the chosen press can't reproduce (toner CMYK can't match many spots; Indigo can do more); no bleed or no safe zone (white edges or trimmed-off content); low-resolution images (pixelation); skipping preflight; dirty VDP data; treating digital like offset by slapping on makeready charges or minimum quantities; and making late "harmless" edits without re-proofing.

Best practice: Choose the method by **quantity + personalization need + spot-color need**, not by an outdated "digital is lower quality" belief. Short runs (under ~500–1,000), on-demand, or any per-piece variation → digital. Long static runs needing exact spot color at scale → offset. Use liquid EP (Indigo) for premium coated/Pantone work, dry toner for versatile everyday short runs, production inkjet for high-volume books/transactional/mail. Build VDP on validated data + a sample proof + standard formats (PDF/VT, PPML). Bake preflight and plain-language file-fix guidance into the storefront so non-technical sellers can't ship bad files. And price digital on its real, flat-per-unit cost curve with genuine single-unit ordering.

Key takeaway: Digital printing is the engine under every web-to-print storefront. No plates means cheap short runs, fast turnaround, on-demand fulfillment, and — uniquely — variable data so every piece can be personalized. Your software's job is to price that flat cost curve honestly, allow qty=1, preflight files for non-technical owners, treat variable data as a real product type, and never bolt offset-era assumptions onto a digital press.

Screen, DTG, DTF & Pad — Apparel, Promo & Specialty

So far you have mostly thought about ink on paper. This chapter moves to a different world: putting a design onto a **T-shirt, a hoodie, a coffee mug, a pen, or a tote bag**. The print industry calls this **decoration** — adding a logo or artwork onto a physical product that already exists. Decoration is where most "custom merch" (merchandise) orders live, and it is a huge part of any print-shop SaaS.

Here is the single most important idea for this whole chapter: **there is no one "best" method.** The right method depends on four things — **how many items, how many colors, what fabric or material, and where the design goes.** A good print shop (and good software) picks the method that is cheapest and most durable for that exact combination. By the end of this chapter you will understand the five main methods well enough to make that call yourself.

> **Analogy:** Choosing a decoration method is like choosing how to travel. A bicycle (DTG) is perfect for one short trip. A bus (screen printing) is wasteful for one person but the cheapest way to move a hundred people. A motorcycle (DTF) is flexible and good for in-between trips on almost any road. A specialized off-road vehicle (pad printing) is the only thing that can reach places the others physically cannot.

The big picture: five ways to put art on stuff

Let's name the players before we go deep. Each gets a full section below.

Method	What it does (plain words)	Best for
Screen printing	Pushes thick ink through a stencil; one stencil per color	High-volume shirts & promo, few colors
DTG (Direct-to-Garment)	An inkjet printer that sprays ink right onto the shirt	Short runs, full-color photo art on cotton
DTF (Direct-to-Film)	Prints to a film, then heat-presses it onto the item	Short-to-medium runs on any fabric/color
Pad printing	A soft pad lifts ink and presses it onto curved objects	Pens, mugs, golf balls, hard goods
Embroidery	Stitches the design with thread (no ink)	Logos on caps, polos, premium workwear

Key takeaway: Match the method to the *order* (quantity + colors + fabric + placement), never to habit or preference. The rest of this chapter teaches you how each method works so that match becomes obvious.

Screen printing — the volume workhorse

Screen printing (also called **silkscreen** or **serigraphy**) is the oldest and most common way to decorate apparel in bulk. The idea is simple: ink is pushed through a fine mesh screen that has a **stencil** on it. A stencil is a mask that blocks ink everywhere *except* the shape of your design, so ink only reaches the shirt where you want it.

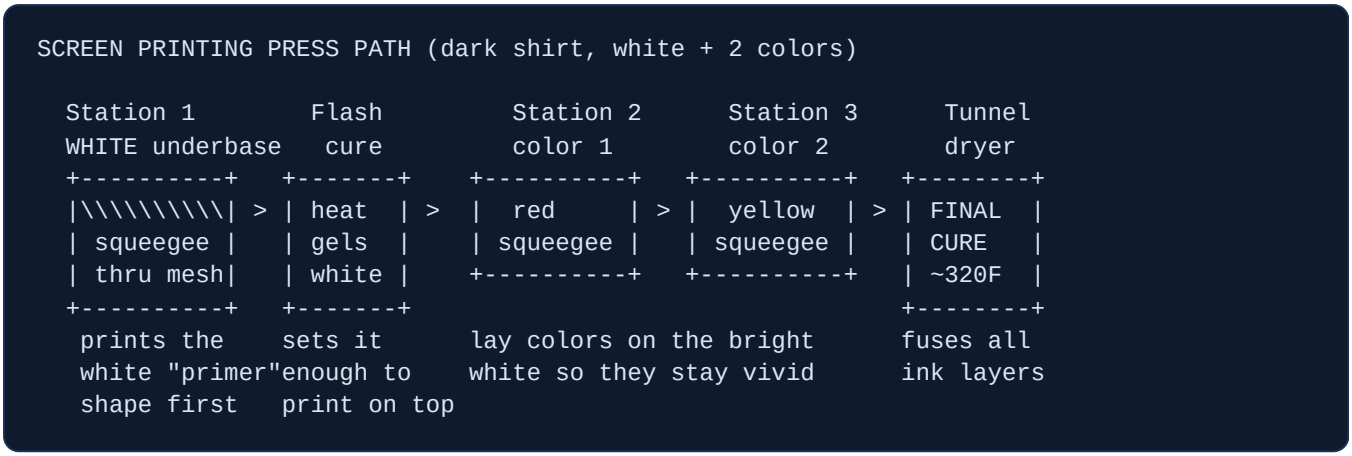
The "one screen per color" rule — memorize this

This is the fact that drives all of screen-printing economics. **Each ink color needs its own separate screen, its own setup, and its own pass across the shirt.** A design with 4 colors means 4 screens, 4 setups, and 4 layers of ink. More colors = more setup cost and more time.

Example: A one-color white logo on a navy shirt needs 1 screen. A four-color band logo needs 4 screens. If each screen costs roughly $20–$75 to make and align, that 4-color job starts with $80–$300 of setup *before a single shirt is printed.* That is why screen printing is brutal for tiny orders and unbeatable for big ones.

The parts and the process

- **Mesh:** woven polyester fabric stretched tight on a frame. **Mesh count** = threads per inch. Low count (e.g. 110) = bigger holes = more ink = bold, thick deposit but less fine detail. High count (156, 200, 230, 305) = smaller holes = less ink = fine lines and dot patterns. Most T-shirt work lives at **110–160 mesh**, with 110 as the default workhorse.
- **Photo-emulsion stencil:** the screen is coated with a light-sensitive liquid called **emulsion**. Artwork printed on clear film is laid on top and the screen is hit with UV light. UV *hardens* the emulsion everywhere except where the dark artwork blocks the light. Washing the screen rinses out the soft (un-hardened) emulsion, leaving open mesh exactly in the shape of the design.
- **Squeegee:** a rubber blade that drags ink across the screen and forces it through the open mesh onto the garment.
- **Registration:** lining up each color's screen to a shared reference so the colors stack perfectly. Bad registration = blurry, ghosted, misaligned prints.
- **Off-contact:** a tiny gap (about a nickel's thickness) between screen and shirt so the mesh "snaps back" cleanly after each stroke. Too much gap causes smearing and registration drift.



Underbase and flash cure (the dark-garment trick)

On a dark shirt, colored ink would sink in and look dull. So printers first lay down a **white underbase** — a layer of white ink shaped like the design that acts like primer, keeping the colors on top bright. Between layers, a heater called a **flash cure** gels that white just enough to print on top of it. Crucially, the underbase must be *flashed* (partly set), not fully cured — over-flash it and the next color won't stick.

Ink types

	Plastisol (most common)	Water-based / discharge
Where ink sits	On top of the fabric	Soaks into the fibers
Feel ("hand")	Thick, slightly plastic-y	Soft, almost "no-feel"
Look	Vibrant, opaque, bold	Soft, vintage, eco-friendlier
Curing	Fuses fast at ~320°F (160°C)	Harder — must hold heat long enough to evaporate *all* water
Difficulty	Forgiving	More technically demanding

Common mistake: Getting the **cure** wrong. Under-cured ink cracks and washes out after a few washes; over-curing scorches the fabric. Properly cured screen prints survive **50–100+ washes** — the most durable of all the apparel methods. Always run a wash test before a production run.

Key takeaway: Screen printing has *high setup per color* but a tiny per-unit cost once running. That makes it expensive for one shirt and dirt-cheap at 100+. Best for bulk apparel and promo with few, bold colors.

DTG — Direct-to-Garment

DTG is, in plain words, **a printer for shirts.** It is an inkjet printer that sprays water-based pigment ink directly onto the garment — full-color, photographic, unlimited colors in a single pass, with no screens at

all. If you can print it on paper, you can print it on a shirt.

The process (five stages)

1. **Artwork prep** in special software (a "RIP") that drives the printer.
2. **Pretreatment** — spray a clear solution onto the garment and press it dry. This is the make-or-break step: it lets the water-based ink sit up and bond instead of soaking into the threads, and on dark shirts it's what keeps the white bright.
3. **White underbase** printed on dark garments (same role as in screen printing).
4. **Color layer** jetted on top.
5. **Heat cure** (press or tunnel dryer) to bond the ink.

Common mistake: Skipping or unevenly applying pretreatment. Too little = the print washes out and looks dull; too much = staining around the design. And DTG only behaves on **cotton** (especially smooth ringspun/combed cotton). On 100% polyester the water-based ink won't bond — printing poly and expecting cotton results is a classic error.

Example: A typical 4-color chest print priced by a DTG shop: ~$12/shirt at 1 unit, ~$10 at 25 units, ~$8 at 100 units. Notice the per-unit price barely drops — that's the signature of DTG. No setup to amortize means no big discount for volume.

Feel and durability: soft hand because the ink absorbs into the fabric; roughly **40–60 washes**, keeping about 82% of color after 50 washes and fading gracefully rather than cracking.

Key takeaway: DTG has near-zero setup and a flat per-unit cost. Perfect for **1 to ~30 full-color cotton pieces**, samples, and print-on-demand stores with no minimums. Wrong choice for big runs (no volume discount) or for poly fabrics.

DTF — Direct-to-Film (the fast-growing one)

DTF flips DTG around. Instead of printing onto the shirt, you print the design (including white ink) onto a sheet of **PET film** (a clear plastic film), coat it with a special powder, melt the powder, then **heat-press** the film onto the garment and peel the film away. It's a transfer method — the design is made first and applied second.

The process

1. Print the design + white ink onto the PET transfer film.
2. Sprinkle **hot-melt adhesive powder** (a thermoplastic glue powder) onto the still-wet ink.
3. Cure/melt the powder in an oven or heat press (no pressure) so it forms a sticky backing.

4. Heat-press the film onto the item (~300–325°F for ~15 seconds), then peel the film — "hot peel" or "cold peel" depending on the film.

Why DTF is exploding in popularity

- **Works on almost anything:** cotton, polyester, blends, nylon, leather, tote bags, hats, dark or light — no pretreatment needed (unlike DTG).
- **Low setup** compared to screen printing, so low minimums are fine.
- **Gang sheets:** you can tile many different designs onto one big film sheet, slashing the cost per design.
- **Stock and apply later:** pre-print transfers, store them, and press on demand.

The adhesive powder's grain matters: fine powder = smoother, softer feel; coarse = a raised, textured feel. The finished transfer is thin (~50–80 microns) but sits slightly *on top* of the fabric — more texture than DTG, softer than thick plastisol. Durability is roughly **30–50 washes**, retaining ~88% color after 50 (slightly better color retention than DTG), with the main risk being edges cracking or peeling over time, especially if laundered too hot.

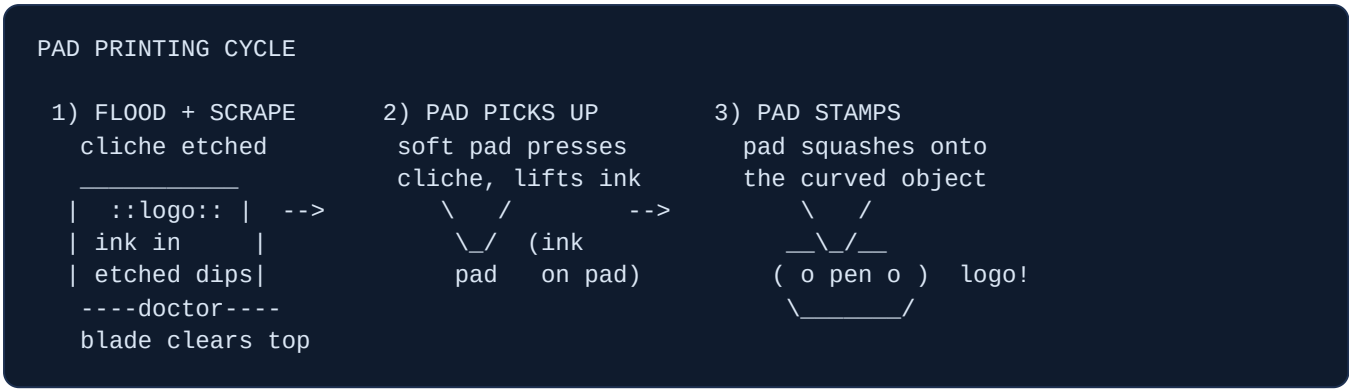
> **Key takeaway:** DTF sits *between* DTG and screen printing on cost, but beats DTG on fabric flexibility. Best for **short-to-medium runs under ~100 units** on mixed or non-cotton materials. Above ~100 of the same simple design, screen printing wins again.

Pad printing — for curved and odd objects

Screen printing, DTG, and DTF all need a roughly flat surface. But how do you put a logo on a **pen, a golf ball, or the curved rim of a mug**? That's **pad printing** (also called **tampography**). It is an *indirect* method: a soft silicone pad lifts a 2D image and presses it onto a 3D or irregular surface.

The three key parts

- **Cliché:** a metal or photopolymer plate with the design *etched* (carved) into it. The etched recesses hold the ink.
- **Ink cup:** floods the cliché with ink, then a doctor blade scrapes the surface clean so ink stays only inside the etched design.
- **Silicone pad:** soft and deformable; it presses onto the cliché, picks up the inked image, then presses down onto the product, molding itself around the shape to lay the ink down.



Because the pad deforms, it can print on convex, concave, and uneven surfaces that no flat method can touch: pens, golf balls, mug handles, bottle caps, electronics, toys, automotive parts. Image area is small, and multi-color is possible but — like screen printing — each color needs its own cliché and its own pass with careful registration.

Key takeaway: Pad printing is the dominant method for **promotional hard goods** — the "small logo on a pen or giveaway" technique. Often it's the *only* practical choice when the object can't lie flat.

Embroidery — stitched, not printed

Embroidery is the odd one out: the design is **stitched into the fabric with thread**, not printed with ink. It looks and feels premium, textured, and is extremely durable.

How its economics differ — this is the interesting part

- **Digitizing:** a one-time step that converts artwork into a **stitch file** (instructions telling the machine where each stitch goes). It costs ~$20–$150 (often $40–$100) and stays on file forever, so reorders skip it.
- **Cost driver = stitch count, not color count.** This is the opposite of screen printing. Thread colors are essentially free once digitized, but a denser, larger design costs more because it has more stitches. A base rate of ~$11/piece up to ~5,000 stitches is common.

	Embroidery wins	Screen printing wins
Order size	Small orders, reorders	Large runs
Design type	Small logos: caps, polos, jackets	Big, colorful, or photographic art
Color cost	Colors are free (after digitizing)	Every color = another screen
Look	Premium, raised, textured	Flat, smooth ink

Key takeaway: Embroidery is priced by stitch count, charges digitizing once, and is unbeatable for premium logos on caps, polos, and uniforms. It can't do gradients or photos, and big coverage gets heavy and stiff.

A note on dye sublimation (poly-only specialty)

You'll hear about **dye sublimation**, so know what it is. Heat turns dye-based ink into a gas that bonds *into* polyester fibers, leaving zero hand feel, no cracking, and true edge-to-edge "all-over" prints. The hard constraint: it only works on **light/white 100% polyester** (or poly-coated hard goods like mugs). It cannot print on cotton or dark garments. Best for jerseys, sportswear, and all-over-print fashion.

The merch decision — cost & volume trade-offs

Now the payoff. The two big levers are **quantity** and **color count**. Screen printing's high setup gets cheaper per unit as quantity climbs; the digital methods (DTG/DTF) start cheap and stay flat. The point where screen printing becomes cheaper is the **break-even quantity**, and it moves with how many colors the design has.

Design complexity	Screen printing becomes cheaper at roughly…
1 color	~8–12 units
2–3 colors	~15–24 units
4–6 colors	~25–50 units
Full-color / photographic	~75–100+ units

A widely-cited rule of thumb: **DTG is cheaper under ~36 units, screen printing above** — but always adjust for color count and fabric using the table.

Five real decisions:

- **500 two-color event tees → screen printing** (cheapest per unit, durable, simple art).
- **12 full-color photographic band shirts on cotton → DTG** (no screen cost, unlimited color).
- **40 mixed-fabric hoodies + poly bags, one vivid logo → DTF** (one method, any material, low minimum).
- **250 branded pens / golf balls → pad printing** (curved surfaces).
- **75 company polos + caps, left-chest logo → embroidery** (digitize once, reorder forever).

Best practice: Decide by *order size* + *color count* + *fabric* + *placement* — in that order — not by what your shop "usually does." And supply the right artwork: vector / spot-color files for screen and pad printing; high-resolution full-color (PNG/RGB) for DTG and DTF.

How this touches your print software (PF360-relevant)

If you're modeling decoration in a print-shop SaaS, each method has a *different cost shape*, and your pricing engine must reflect it — a single flat per-unit price will silently overcharge small orders and undercharge big ones.

- **Screen print:** setup fee *per color* (`number_of_colors × screen_setup_fee`) + per-unit; quantity-tier breaks; a flash/underbase surcharge for dark garments.
- **DTG / DTF:** little or no setup, flat per-unit; price by print-area size; dark-garment (white underbase) surcharge.
- **Embroidery:** price by **stitch-count bands** + a one-time digitizing fee — and store the digitized file as a reusable asset so reorders skip the fee.
- **Pad print:** per-color cliché setup + per-impression; enforce a small maximum image size.

What to capture as product options: decoration method, number of ink colors, placement(s) (left chest / full front / back / sleeve), garment color (light vs dark → drives underbase logic), and fabric type (cotton / poly / blend → gates which methods are even valid).

Best practice — a real UX win: Have the quote calculator *auto-recommend* the cheapest method at the entered quantity and color count, in plain language: *"At 24 shirts with 2 colors, screen printing saves about $40 versus DTG."* A non-technical store owner shouldn't need to memorize break-even tables — the software should know them.

Common mistake (to guard against in software): Letting a user pick a method that physically can't do the job — DTG on 100% polyester, sublimation on cotton or dark fabric, or photographic art forced onto a few spot-color screens. Validate the method against fabric and color count and warn before checkout, not after the order fails in production.

Key takeaway: Order snapshots must persist decoration method, color count, stitch count, placement, and garment color. These drive production *and* the pricing basis for reorders and dispute resolution — drop them and history can't explain why an order was priced the way it was. And because screen films and embroidery digitizing are reusable, surfacing "your reorder reuses your setup — no setup fee" is both honest and a genuine selling point.

Wide-Format & Flexography — Signage, Banners, Packaging & Labels

So far we've mostly talked about putting ink on paper at "normal" sizes. This chapter steps into two very different worlds that you, as someone building print-shop software, will eventually have to model: the world of **big things** (banners hanging off a building, a bus wrapped in vinyl, a glowing lobby sign) and the world of **mass-produced packaging** (the snack bag, the shampoo label, the cardboard box). The first is done with **wide-format inkjet**. The second is done with **flexography**. They almost never compete for the same job, and knowing which is which will let your software quote, preflight, and price each one correctly.

Let's define the two terms in plain words before we go further:

- **Wide-format inkjet** — a big digital printer that sprays ink, the same basic idea as your home printer, but able to print things 1.5 to 8+ feet wide (and "grand-format" goes past 100 inches, up to billboards). It uses **no plates**, so every single print can be different at no extra cost.
- **Flexography (flexo)** — a high-speed roll-fed press that uses a soft, flexible rubbery **plate** with a raised image, like a giant ink stamp on a spinning cylinder. It needs a plate per design per color, so it only makes financial sense when you print the same thing tens of thousands of times.

> **Analogy:** Wide-format is a *photocopier* — push a button, get one of whatever you want, change it freely. Flexo is a *cookie cutter* — expensive to make the cutter, but once you have it, stamping out 500,000 identical cookies is dirt cheap per cookie.

Part A — Wide-Format Inkjet: the big-and-flexible world

Wide-format is **digital**: the artwork goes from a file, through software called a RIP (we'll meet it later), straight to a printhead that moves back and forth spraying microscopic ink droplets. Because there's no plate to make, it's perfect for short runs, one-offs, and anything where each piece is unique. The typical jobs it produces:

- **Banners** — vinyl or fabric, indoor and outdoor.
- **Posters and point-of-sale (POP/POS) displays** — the standing cardboard display by a store checkout.
- **Vehicle wraps** — printed vinyl that covers a car, van, or bus.
- **Rigid signage** — lobby signs, real-estate signs, directional signs on stiff board.
- **Wall, window, and floor graphics**, backlit (light-up) displays, canvas/fine-art, and **soft signage** (printed fabric for trade-show booths).

The four ink chemistries — the most important decision

The single biggest choice in wide-format is **which ink**, because the ink decides what you can print on, how long it lasts outdoors, how fast it dries, and how safe it is to run indoors. A "chemistry" here just means what the ink is made of and how it sticks/dries. Four families dominate.

Eco-solvent — color pigment carried in a mild, low-odor solvent (a liquid that slightly "bites" into the surface). That bite lets the ink key into uncoated vinyl and become waterproof and scratch-resistant without any primer. It's the workhorse of the sign trade: cheaper machines and ink, ~3 years outdoor life unlaminated and 5+ laminated. The catch is it needs **dwell time** (drying/off-gassing time) before you can laminate it, which can slow down finishing.

Latex (water-based resin) — about 60–70% water plus tiny plastic (latex) particles and pigment. Onboard heaters drive off the water and melt the latex into a film, so prints come out **fully dry and odorless**, ready to finish immediately. It's the "greenest" common option (often GREENGUARD Gold certified, safe in hospitals/schools, no special ventilation) and prints on a huge range of media including plain paper, wallpaper, and textiles. The downsides: the heat can wrinkle thin heat-sensitive films, and the hardware costs more.

UV-cure (UV-curable) — a liquid ink that is instantly hardened ("cured") into solid plastic by UV lamps the moment it lands. Because it sits **on top** of the surface instead of soaking in, it prints on almost anything: glass, metal, wood, acrylic, foamboard, even leather — rigid or flexible, often with no primer. It dries instantly (fast throughput) and can lay down white ink, gloss varnish, and raised textured effects. The catch: cured UV ink is rigid, so on a sharply stretched surface (a deep vehicle-wrap curve) it can **crack**. Modern **UV-LED** lamps removed most of the old heat and ozone problems.

Dye-sublimation — heat turns solid dye into a gas that bonds *into* polyester fabric fibers. The color becomes part of the cloth, so the result is soft, vivid, washable, and won't crack or peel. This is how "soft signage" is made: tension-fabric booth walls, flags, backdrops that fold into a small case.

(There's also older "true/hard solvent" — toughest outdoor life, 5–7 years, but smelly, high-VOC, and being phased out; and **aqueous** water-based inks for indoor fine-art and photo prints, which need lamination to survive outdoors.)

Factor	Eco-solvent	Latex	UV-cure	Dye-sub
Sticks without primer on…	Vinyl	Broad range	Almost anything (widest)	Polyester only
Outdoor life	3 yr / 5+ laminated	3–5 yr	Good (rigid)	Indoor / soft signage
Ready to finish	Needs dwell time	Immediate (heat-dried)	Instant	After heat press
Odor / eco-safety	Some odor	Best (low-VOC)	Low (UV-LED)	Low
Stretch / wrap curves	Flexes well	Flexes well	Can crack on deep stretch	Very flexible (fabric)
Hardware / ink cost	Lowest	Higher	Higher	Specialized

Key takeaway: Pick ink by the *three* questions: what surface (UV = widest), how long outdoors (solvent/cast-wrap = longest), and how green/fast (latex = cleanest, UV = fastest dry). There is no single "best" ink — only best-for-this-job.

Machine architecture: roll-to-roll vs flatbed vs hybrid

Wide-format printers come in two body styles, and the difference decides whether you can print a stiff board directly or have to glue a print onto it.

Roll-to-roll (roll-fed) — a roll of flexible media (vinyl, canvas, film, fabric) unwinds, travels under a printhead that sweeps side to side, then rewinds or gets cut at the far end. The *media* moves; the head moves across. Great for banners and anything that can bend around rollers, with high throughput and a lower entry price. The downside: for a *rigid* sign you must print on adhesive vinyl and then **mount** (glue) it onto a board — extra labor, extra material, and the risk of bubbles.

Flatbed — the substrate lies flat and still on a vacuum bed (suction holds it down) while the printhead gantry travels over it. Almost always UV ink. It prints **directly** onto rigid sheets — foamboard, acrylic, aluminum composite, wood, glass, even tile up to a few inches thick — with no mounting step. Higher resolution and registration because the object doesn't move. The downsides: higher cost, the bed size limits sheet size, and most are rigid-only.

Hybrid — one UV machine with both a flat bed and roll-feed attachments, so it does rigid *and* roll media. The compromise: more flexible but usually not best-in-class at either. Popular for shops that can't afford two separate machines.

```
ROLL-TO-ROLL (media moves, head sweeps)
  [supply roll]==>==[print head <===>]==>==[take-up roll/cut]
                       (vinyl, banner, fabric)

FLATBED (object still, head travels over it)
        +----------------------------+
   head |  ===> gantry travels ===>   |
        |  [ rigid acrylic / board ]  |  <- vacuum bed
        +----------------------------+
```

Substrates: the real materials

"Substrate" just means the material you print on. Wide-format has its own vocabulary worth knowing because your product catalog will list these by name.

Material	What it is	Typical use
13 oz scrim vinyl	Polyester mesh sandwiched in PVC; the standard banner weight	General single-sided outdoor banners
18 oz vinyl	Heavier, often double-sided	Long-term / blockout banners
Mesh banner (8–11 oz)	Open weave, ~30–37% airflow	Windy fence / building banners (won't sail)
Foamboard / Gatorboard	Foam between paper liners (Gator = tougher)	Indoor short-term rigid signs
Coroplast (corrugated plastic)	Fluted polypropylene	Yard / real-estate / political signs
ACM / Dibond	Aluminum skins over a plastic core	Durable outdoor rigid signs
Acrylic / PVC (Sintra)	Premium rigid panels	Lobby and retail signage
Canvas, backlit film, perf window film	Specialty media	Fine-art, lightboxes, one-way window graphics

Cast vs calendered vinyl deserves its own callout because getting it wrong is the classic vehicle-wrap disaster. Both are vinyl film, but they're made differently:

	Calendered	Cast
How it's made	Rolled/squeezed like dough	Poured as liquid, then cured
Thickness	~2.5–4 mil (thicker)	~2 mil (thin)
"Memory"	Wants to shrink back & lift	No shrink memory; conforms
Life	~1–5 yr	5–7 yr
Use	Flat / simple curves, cheaper	Full vehicle wraps, deep curves (e.g. 3M IJ180Cv3)

The **overlaminate** is a clear protective film applied over the print. Rule: it must be *equal or higher* grade than the base film, or it shortens the whole system's life. A cast print needs a cast laminate (e.g. 3M 8518 gloss / 8520 matte).

Example: A full **vehicle wrap** is 2-mil cast vinyl printed with eco-solvent or latex, covered with a matching cast laminate, then heat-formed into the door rivets and recesses. It lasts 5–7 years and peels off cleanly. The same job in cheap calendered film would lift off the curves within weeks.

Common mistake: Using calendered film on a curved wrap, skipping or mismatching the laminate, or specing solid vinyl where a windy site needs **mesh** — the banner then acts like a sail and tears out its grommets.

Key takeaway: In wide-format, ink + substrate + laminate are a *system* rated to work together. Mixing grades (cheap vinyl, wrong laminate) breaks the system and the graphic fails early.

Part B — Flexography (Flexo): mass-producing packaging & labels

Flexography is a completely different beast. It is **high-speed rotary relief printing**. Let's unpack that:

- **Relief** = the image is *raised* on the plate, like a rubber stamp. Only the raised parts touch the material and leave ink.
- **Rotary** = the plate is wrapped around a spinning cylinder, not pressed flat, so it can run fast and continuously.
- **Web** = a continuous roll of material (film, paper, foil) fed through the press, as opposed to separate sheets. Flexo is web-fed / roll-to-roll.

It is **analog**: you make a physical plate for every design and every color. That upfront tooling cost is why flexo only pays off on **long runs** — but at scale, it is the cheapest, fastest way on earth to print packaging and labels. It is the dominant process for snack bags, pouches, shrink sleeves, product labels, and cardboard boxes.

How a flexo print unit works — the ink train

Every color is its own "station," and the web threads through them one after another. Inside one station, ink travels through a precise sequence:

1. An **ink fountain / chamber** with a **doctor blade** (a thin metal scraper) feeds ink to the anilox.
2. The **anilox roller** — an engraved metal roller (usually ceramic-coated) covered in millions of microscopic cells that each hold a precise, metered amount of ink. The doctor blade wipes off the excess so every pass lays an identical thin film. *The anilox is the heart of ink control.*
3. The anilox inks only the **raised areas** of the **plate**, which is mounted on the **plate cylinder**.
4. The **impression cylinder** presses the web against the plate, transferring the image to the material.
5. Inline **drying** (hot air, infrared, or UV) sets the ink before the next color — then often inline **finishing**: die-cut, laminate, slit, and rewind, all in one pass.

```
ONE FLEXO STATION (repeat per color)
 ink--->[ anilox ]  doctor-blade wipes excess
            |  meters exact ink film
            v
         [ PLATE ]  raised image (a rubber stamp)
            |
   web ===>=+=>===  [ impression cylinder ] press & print

FULL LINE:  unwind ==> C ==> M ==> Y ==> K ==> spot ==> white
            ==> varnish ==> dry ==> die-cut/slit ==> rewind
```

Flexo inks are **low-viscosity** (runny, fast-drying) — solvent-based, water-based (preferred for food and paper packaging), or UV-curable.

The two parts that decide quality: anilox and plate

Two specs come up constantly when print pros talk flexo, and your quoting/preflight logic may need to reason about them:

- **Anilox specs:** measured in **LPI** (how many cell lines per inch, ~200–1200+) and **cell volume in BCM** (billion cubic microns of ink per square inch). High line count + low BCM = a fine, light laydown for delicate highlights. Low line count + high BCM = a heavy laydown for solid blocks of color, white, and coatings. Matching the right anilox to the job is core craft — shops keep separate aniloxes for solids vs screens.
- **Plates:** made of **photopolymer** (a light-hardening plastic). UV light is shone through a digital mask; the unexposed areas wash out (with solvent, water, or heat), leaving the raised relief. Plates are described by **durometer** (hardness, on the Shore A scale) and thickness. Modern digital plates with "flat-top dots" hold tiny highlight dots more reliably. A soft **mounting tape** under the plate cushions it and affects how much the dots spread.

Substrates and applications

- **Flexible film** (BOPP, PE, PET, laminates) — snack bags, pouches, shrink sleeves.
- **Paper & labelstock** — pressure-sensitive (peel-and-stick) labels; the #1 flexo market.

- **Corrugated & cartonboard** — shipping boxes and folding cartons.
- **Foil, metallized films, cellophane, kraft**, plus tags, tickets, tissue, envelopes, and wallpaper.

Printing corrugated boxes — three methods

Cardboard is a special case because its rough, fluted surface limits how fine the printing can be. There are three ways to decorate it, trading quality against cost:

Method	How	Quality / use
Post-print flexo	Print directly onto the finished box, water-based	Cheapest, ~150–300 m/min, lower detail; logos & line art on shipping boxes
Preprint flexo	Print the liner roll *before* gluing to fluting	~400–600 m/min, better quality, very high volume
Litho-lamination	Offset-print a paper label, laminate it onto corrugated	Highest (photographic, metallics) but high minimums & lead time; retail shelf-display boxes

Example: A plain kraft **shipping box** gets a 1–2 color direct post-print flexo logo at 200 m/min. A glossy **retail display box** on the store shelf is litho-laminated for photo-quality graphics. Seasonal or on-demand boxes go digital.

Flexo vs digital — the run-length economics

This is the decision your quote engine must get right. Flexo has high setup cost but low per-unit cost; digital has near-zero setup but higher per-unit cost. So they cross over at a **break-even** quantity.

	Flexo (analog)	Digital (toner/inkjet label press)
Setup / plates	~$200–$400 per color; makeready 30–60 min	No plates; changeover ~5–10 min
Setup waste	~50–200 m per changeover; 8–12% on small runs	~3–7% short-run waste
Speed	High (~100–200 m/min narrow-web)	Lower (~20–60 m/min)
Variable data	No (each version needs plates)	Yes — names, lot codes, versions
Sweet spot	One SKU at ~50k–500k+	~10–50 SKUs at ~1–5k each, or any variable job

Practical break-even is roughly **2,000–5,000 labels per SKU**, shifting with color count, plate cost, and changeover time.

Example: A snack-bag **shrink sleeve** runs on an 8-station UV flexo press on BOPP film — CMYK + 2 spot PMS colors + a white backer + matte varnish, reverse-printed and laminated — for hundreds of thousands of units at a very low cost each. A craft startup ordering 800 labels across 6 flavors should go digital instead.

Common mistake (flexo prepress): Underestimating **dot gain** — dots fatten and shadows plug when impression pressure is too high (it should be the lightest possible "kiss"), ink is too heavy, or the mounting tape is too soft. Also forgetting the **distortion factor**: because the plate stretches when wrapped around the cylinder, prepress must *shrink* the artwork lengthwise or the repeat length and registration come out wrong. And weak **trapping** (overlapping adjacent colors slightly) on a shifting web leaves white gaps between colors.

Key takeaway: Flexo wins on long, stable runs where the plate cost is spread across huge volume; digital wins on short runs, many versions, and variable data. The smartest software *recommends the right method automatically* based on the quantity the customer enters.

Part C — When to use which (decision summary)

Use…	When…
Wide-format inkjet	Large physical size, short runs/one-offs, every piece can differ, signage/display/wraps/rigid panels, fast turnaround, flat per-unit cost (digital, no plates)
Flexography	Packaging & labels on a continuous web, long stable runs, lowest per-unit cost at scale, food-safe inline finishing (analog, plates amortized)
Digital label/packaging press	Short-run packaging, many SKUs, variable data — bridges the gap below flexo's break-even

They rarely fight over the same job: wide-format owns signage and display, flexo owns mass-produced packaging and labels.

Part D — How this touches your print software

Everything above turns into concrete things your platform must model. Here's where the craft meets the code.

The RIP and color management

A **RIP (Raster Image Processor)** is the core software layer for wide-format. It converts a PDF or vector file into the dots the printer sprays, applying color management, halftoning, ink limits, and linearization,

then drives the printhead. Common names: Onyx PosterShop, Caldera, SAi Flexi (Flexi also does **print-and-cut** for contour-cut decals). Color management relies on **ICC profiles** — a profile per *printer* + *ink* + *media* combination — so "what you see ≈ what prints." Your software should let a store map each substrate to its profile, plus hold spot/PMS color libraries.

Preflight in plain language

Customers upload bad artwork constantly. Your preflight should auto-check resolution, color space (warn on RGB), embedded fonts, **bleed and safe-zone**, transparency, and spot-color count — and report it in words a non-technical user understands: *"Add 0.25 inch of bleed,"* not *"trim box / media box mismatch."*

Common mistake (wide-format prepress): Art built to the exact trim size with no bleed leaves white slivers after cutting; add 0.125"–0.25" bleed and keep critical content inside a safe margin. Low-resolution images blown up huge pixelate (though far-viewed billboards tolerate lower DPI than a close-up POP display). Sending RGB with no ICC profile gives unpredictable color on the substrate.

Pricing models — two completely different shapes

- **Wide-format = area-based:** price per square foot/meter × material × ink mode × finishing (grommets, hems, pole pockets, lamination, contour cut, mounting). Substrate and finishing are *option dimensions* in your product model.
- **Flexo / labels = setup + run-length based:** a one-time plate/tooling charge per color, plus a per-1,000 unit price, plus a minimum order quantity. Strong economies of scale mean **tiered quantity-break pricing**, and the flexo-vs-digital break-even logic belongs right in the quote engine so it can suggest the cheaper method.

Other software touchpoints

- **Nesting / tiling / imposition** — gang multiple jobs onto one roll or sheet to cut waste (true-shape nesting); tiling splits an oversized graphic into seamable panels for grand-format.
- **Die-lines / contour cut** — cut paths must travel with the file as a named spot color (e.g. "CutContour" / "Thru-cut"). Labels, stickers, and packaging need a die-line layer concept in your data model.
- **Variable data (VDP)** — digital's superpower (lot codes, names, versions). Model VDP fields; remember flexo cannot do this without new plates.
- **Cost estimating** — capture substrate usage, ink usage, waste %, and changeover so quotes reflect real cost, and steer the customer to digital below break-even and flexo above it.

Best practice: Model substrate, ink mode, and finishing as first-class option dimensions, attach an ICC profile to every substrate, and bake the flexo-vs-digital break-even into the quote engine. Then your software can do what an expert estimator does — pick the right process and price it honestly — without the store owner needing to know any of this craft.

Key takeaway: Wide-format and flexo are opposite ends of print: one is big-and-unique (area-priced, digital, no plates), the other is small-and-mass-produced (setup-priced, analog, plate-driven). Get the *pricing shape*, the *substrate-to-profile mapping*, and the *plain-language preflight* right, and your platform can quote and prepare both correctly for owners who've never touched a press.

Color, Files & Prepress — CMYK, Pantone, Bleed, Proofs & Preflight

So far you have learned about paper, presses, and finishing. This chapter is about the step that sits *between* a finished design file and ink actually hitting paper. That step is called **prepress**.

Prepress means "before the press." It is everything done to a design file to make sure it will print correctly: getting the colors right, getting the file mechanically correct (resolution, edges, fonts), catching mistakes before they cost money, confirming the look with the customer, and arranging the pages on the big sheet that goes through the press.

> **Analogy:** Prepress is like the airport check-in and security line before a flight. The plane (the press) is expensive and fast, and once it takes off you cannot fix a mistake. Prepress is where someone checks your ticket, weighs your bags, and catches the problem on the ground — because fixing it in the air is impossible.

For you as a software builder, this is the most important chapter in the whole guide. Online design editors, file-upload validators, automatic proofing, and PDF generation all live in prepress. If your software gets these rules right, customers send clean files and the print shop stops losing money on reprints.

1. RGB vs CMYK — why colors look different on screen than on paper

Color works in two completely different ways depending on whether you are looking at *light* or at *ink*.

- **RGB** stands for Red, Green, Blue. It is **additive** color — it mixes *light*. It starts at black (no light at all) and *adds* light to build color. All three at full strength make white. Anything that glows uses RGB: monitors, phones, tablets, cameras, scanners.
- **CMYK** stands for Cyan, Magenta, Yellow, and Key (which means black). It is **subtractive** color — it mixes *ink*. It starts with a white sheet of paper, and each ink *subtracts* (absorbs) some of the light bouncing off the paper. This is how all physical printing works.

Why is black called "Key" instead of "Black"? Because black is the *key* plate that all the fine detail and text line up to, and using "B" could be confused with Blue. In theory, Cyan + Magenta + Yellow together should make black, but in real ink they make a muddy brown. So a real black ink (K) is added for deep, crisp blacks, sharp text, and to use less ink overall.

```
RGB (LIGHT, on screens)        CMYK (INK, on paper)
start = BLACK (no light)       start = WHITE (blank paper)
add light --> brighter         add ink  --> darker
R+G+B (all on) = WHITE         C+M+Y+K (all on) = near-black
BIG color range               SMALLER color range
```

The gamut problem — the root cause of color shift

A **gamut** is the full range of colors a device or color system can produce. Here is the key fact: **the RGB gamut is much larger than the CMYK gamut.** A glowing screen can show colors that ink on paper simply cannot make.

When a color exists in RGB but cannot be made in CMYK, we say it is **out of gamut**. During conversion to CMYK, that color gets pushed to the nearest printable color — and you *see* the difference. That is the "color shift" everyone complains about.

Example: A brilliant electric blue on screen often prints as a dull purple. A neon green loses its glow and turns flat. Bright orange and vivid purple also suffer. Smooth screen gradients can show visible "banding" (stripes) once converted, because CMYK has fewer steps to work with.

Best practice: Convert the design to CMYK *during design*, not at the last second. That way the designer sees the realistic, slightly duller colors on screen and is not shocked by the printed result. A monitor emits light, so it will always look more vivid than ink on paper — set that expectation with customers up front.

Key takeaway: Screens add light (RGB, big color range); print subtracts with ink (CMYK, smaller range). Colors shift because the screen can show colors ink cannot reproduce. Always work and preview in CMYK before printing.

2. Spot / Pantone color vs process color

There are two fundamentally different ways to lay color on paper.

- **Process color** (also called 4-color, CMYK, or "4CP") builds *every* color out of tiny dots of just four inks: Cyan, Magenta, Yellow, Key/black. Look at a magazine photo under a magnifying glass (a "loupe") and you will see millions of tiny overlapping colored dots. Your eye blends them into smooth color. This is how all photographs are printed.
- **Spot color** is a single, *pre-mixed* ink applied as one solid, even coat — no dots, no blending. It is usually chosen from the **Pantone Matching System (PMS)**.

The **Pantone Matching System** is a worldwide library where every ink has a number and name, like "Pantone 185 C" or "Pantone 286 C". The promise is consistency: the same Pantone number means the same exact color, on any press, anywhere in the world. That is why brands rely on it.

Common mistake: The letter suffix matters. "C" means Coated paper, "U" means Uncoated, "M" means Matte. The same Pantone number looks noticeably different on coated vs uncoated stock — so "Pantone 185 C" and "Pantone 185 U" are not interchangeable.

Aspect	Process (CMYK)	Spot (Pantone)
How it's made	4 inks, dots blend in the eye	1 pre-mixed solid ink
Best for	Photos, gradients, multicolor art	Logos, exact brand colors, large solid fills, special effects
Plates & cost	4 plates, fixed; cheap for full color	1 plate per spot; press cleanup adds cost; pricey past 1–2 spots
Consistency	Can drift run to run; an approximation	Exact and repeatable
Special effects	No	Yes — metallic, fluorescent/neon, pastels outside CMYK range
Coverage on solids	Dot pattern (can look slightly textured)	Smooth, dense, even solid

Example: Think of iconic brand colors — a specific coffee-shop green, a famous soda red, a luxury jewelry blue. These are spot colors so they print identically on every box, bag, and sign. A full-color brochure photo, by contrast, is process color.

You can also combine them: 4-color process for the photos *plus* one spot ink for a precise brand color. That is common in premium print. Pantone publishes "bridge" charts that show the closest CMYK recipe for each spot color — but for vivid or metallic Pantones the CMYK version is noticeably off, which is a frequent source of client disappointment.

Key takeaway: Use process (CMYK) for photos and rich multicolor work; use spot (Pantone) when an exact, repeatable brand color or a special effect (metallic, neon) matters. Spot costs more per extra color, so 1–2 spot jobs are where it shines.

3. ICC profiles and color management

To keep color consistent from a designer's monitor, to a proof, to the final press, the industry uses **ICC profiles**.

An **ICC profile** (ICC = International Color Consortium) is a small standardized data file that describes exactly how one specific device or condition reproduces color. It maps that device's color numbers to a neutral, device-independent reference. A **color management system** uses these profiles to translate color from one space to another in a predictable way.

There are two broad kinds: *input/display* profiles (for monitors, cameras) and *output* profiles (for a specific press-and-paper combination). The output profiles below are real industry standards — your software and your printer will refer to them by name.

Profile / standard	What it's for
GRACoL 2013 (CRPC6)	US standard for premium sheetfed offset on *coated* paper — brochures, high-end marketing. Assumes a G7-calibrated press.
SWOP	US web offset on thinner, cheaper publication paper. Smaller color range than GRACoL because the paper holds less ink.
FOGRA39 (ISO Coated v2)	Long-time European standard for coated offset, used worldwide.
FOGRA51 (PSO Coated v3)	The newer European coated standard that largely replaces FOGRA39.

("G7" is just a calibration method that fixes gray balance and tone so different presses match.) Profiles come from groups like ECI (Europe → FOGRA) and IDEAlliance (US → GRACoL/SWOP). The simple rule: **ask the printer which output profile to use.** "US coated sheetfed" usually means GRACoL/CRPC6; "European coated" usually means FOGRA51 or FOGRA39.

Rendering intents — how out-of-gamut colors get handled

When a color cannot be printed, the color management system must decide *how* to substitute it. That decision is the **rendering intent**. There are four:

Rendering intent	What it does	Best for
Perceptual	Gently squeezes the whole color range to fit, keeping the *relationships* between colors. Loses a little absolute accuracy.	Photographs (avoids banding, keeps detail in bright areas)
Relative Colorimetric	Keeps in-range colors exact; only clips the out-of-range ones to the nearest printable color. Usually paired with Black Point Compensation. The safe default.	Most graphics and commercial print
Absolute Colorimetric	Like Relative, but also simulates the source paper's white. Used to make one paper look like another.	Proofing / simulating another stock
Saturation	Maximizes punch and vividness over accuracy.	Charts, business graphics where pop matters more than realism

Best practice: The default for most automated and image flows is **Relative Colorimetric + Black Point Compensation**. Calibrate monitors regularly with a hardware tool so the screen is trustworthy, soft-proof using the destination output profile, and embed the correct profile in the delivered PDF.

Key takeaway: An ICC profile is a "color translation map" for one device or press/paper combo. Ask the printer which output profile to target, and for most jobs let the system use Relative Colorimetric with Black Point Compensation.

4. Resolution and DPI — making sure images are sharp enough

People mix up two terms constantly. Let's separate them.

- **PPI (Pixels Per Inch)** describes a digital image file — how many pixels are packed into each inch. This is the number that actually governs how much detail your file holds.
- **DPI (Dots Per Inch)** describes the printer — how many ink dots it lays down per inch. In everyday speech people say "DPI" for both, but technically they are different.

Use case	Target resolution (at final printed size)
Standard quality print (photos, color work)	**300 PPI**
Images that contain text or fine line detail	**400 DPI**
Screen display (the reason web images look low-res in print)	72 DPI (Mac legacy) / 96 DPI (Windows)
Large-format banners / billboards (viewed from far away)	100–150 DPI, sometimes lower

Effective resolution — the trap that catches everyone

Resolution and physical size are tied together. If you take a 300 PPI image and stretch it to twice its size (200%), its **effective resolution** drops to 150 PPI — because the same pixels now have to cover twice the area. What matters is the resolution *at the final placed size*, not the number stored in the file.

Common mistake: The biggest myth in print. Changing the "DPI" field in software from 72 to 300 does *not* add real detail. The software just invents new pixels by guessing (this is called upsampling or interpolation), and the result is soft and blurry. A "72-turned-300" image is still a low-resolution image wearing a costume. You can safely *shrink* (downsample) an image, but you can never truly turn a small low-res image into sharp print.

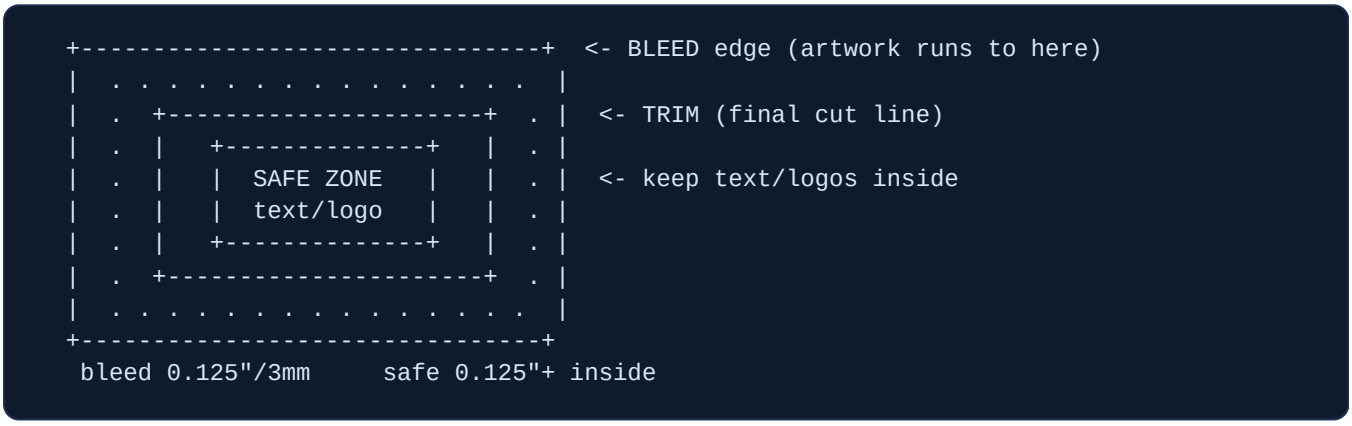
Example for software: A customer drags a 600×400-pixel logo into your editor and stretches it to fill an 8-inch-wide banner area. Stored "DPI" might say 300, but the effective resolution is only about 75 PPI at that size. Your preflight check should compute resolution *at final placed size* and warn: "This image may print blurry. Please upload a larger version." Never silently upscale it for them.

Key takeaway: Aim for 300 PPI (400 for text-in-image) *at final size*. Shrinking is fine; faking a higher number by upscaling is not. Always validate effective resolution at the placed size, never the file's stored label.

5. Bleed, trim, safe zone, crop marks, and registration

Paper is cut after it is printed, and cutting is never perfectly precise. These five terms exist to make sure the cut looks clean no matter how the blade drifts.

- **Trim** — the final cut size, the dimensions the customer holds (for example, a 5"×7" card).
- **Bleed** — artwork extended *past* the trim edge, so that if the blade drifts slightly there is still ink there instead of a white sliver. Backgrounds and images must run into the bleed.
- **Safe zone (safety margin)** — a margin *inside* the trim where all important content (text, logos) must stay, so nothing critical gets chopped off.
- **Crop marks (trim marks)** — short lines at the corners, outside the artwork, telling the cutter where to slice.
- **Registration marks** — crosshair/bullseye targets printed in all four plates at once, used to check that the color plates line up.



Term	Standard amount
Bleed (all four sides)	**0.125" (1/8 inch) in the US, 3 mm in Europe/UK**
Safe zone (inside trim)	At least 0.125" / 3 mm; many shops recommend 0.2" / 5 mm
Gripper edge (press grabs the sheet here)	~3/8" to 1/2" of the lead edge — no printing allowed there

Example: A 5"×7" card with 0.125" bleed on every side means the full artwork file is **5.25"×7.25"**. Important content should stay within roughly 4.75"×6.75" (the safe zone).

Common mistake: Designing a card with the background stopping exactly at the trim line. Any tiny cutting drift then shows a white edge. Or placing a logo right against the edge so it gets trimmed off. Always extend the background into the bleed and keep critical content in the safe zone.

Key takeaway: Build the document at trim size plus 0.125"/3mm bleed on all sides, run backgrounds into the bleed, and keep all important content inside the safe margin. In an online editor, show trim, bleed, and safe-zone guides visually so customers cannot get it wrong.

6. Overprint, knockout, and trapping — protecting against misalignment

When two colors sit on top of each other on the page, the press has to decide whether the bottom color stays or gets removed.

- **Knockout** is the default. The top shape "knocks out" (removes) the ink beneath it, leaving a hole in the bottom layer exactly where the top object sits, so the two colors do not mix.
- **Overprint** means the top object prints *on top of* the ink below — the colors physically overlap and mix, with no hole knocked out.

Now, **registration** is how precisely the separate color plates (C, M, Y, K, and any spots) line up on the press. **Misregistration** happens when the plates shift slightly during the run, and a tiny white gap can appear between two adjoining colors.

Trapping is the fix: deliberately creating a tiny overlap between two touching colors, so a small plate shift cannot reveal a white gap. Trapping is only needed where different colors meet.

Best practice — overprint small black: Small 100% black text and thin black rules should be set to *overprint*, not knockout. Black is opaque and usually printed last, so overprinting it over a color is invisible — and it removes the risk of an ugly white halo around the letters if registration drifts. Let the printer's software handle trapping for everything else.

Common mistake (a silent failure): A *white* object accidentally set to overprint **disappears completely** — white "ink" overprinting onto a color shows nothing at all. Equally bad, a colored object set to overprint by accident mixes with whatever is below it and turns a muddy or wrong color, which can quietly ruin a brand spot color. Always check overprint settings in preflight.

Key takeaway: Knockout (default) keeps colors separate; overprint lets them mix. Overprint small black text to avoid white halos, but watch for the classic disaster of white-or-color objects accidentally overprinting. Leave trapping to the printer's RIP unless you truly know what you're doing.

7. Rich black and total ink coverage (TAC)

There is more than one way to make "black," and choosing wrong causes real problems.

Type of black	Recipe (C/M/Y/K)	Total ink	Use for
True / standard black ("100K")	0 / 0 / 0 / 100	100%	Small text, thin lines — crisp, single plate, no registration risk
Rich black	60 / 40 / 40 / 100	240%	Large black areas — deeper, denser black
Registration black	100 / 100 / 100 / 100	400%	ONLY crop/registration marks outside trim — never a design color

TAC (Total Area Coverage, also called TIC, Total Ink Coverage) is the sum of the four CMYK percentages at any single point on the page. It is the total amount of wet ink the paper has to absorb there.

Paper / press type	Typical TAC limit
Coated, commercial sheetfed	300% (some allow ~320–340%)
Web offset / newsprint	~240–260%
Recommended rich black	240% (safely under the 300% ceiling)

Common mistake: Using rich black for small text or thin lines (the extra plates blur the edges if registration drifts) — or using true 100K for a large fill (it looks like flat dark gray). And never use registration black (400%) as a design color: that much wet ink smears, stamps onto the back of the next sheet, and never dries.

Example of a real failure: If TAC goes over the limit, the paper is soaked with wet ink. The result is "set-off" — the wet ink stamps onto the back of the sheet stacked on top — plus smearing, very long drying times, and wavy "cockled" paper. Print-on-demand vendors reject files that exceed their ink limit. A quick (crude) fix is to convert the file to RGB and back to CMYK with the right output profile, which pulls the ink totals back under the cap.

Key takeaway: Use K100 for small text, rich black (C60 M40 Y40 K100 = 240%) for large areas, and keep total ink under the printer's TAC limit (commonly 300%). Registration black (400%) is for marks only, never artwork.

8. Preflight — catching file errors before the press

Preflight is the automated inspection of a print file against a set of rules (a "profile") to catch errors *before* plates are made or the press runs. The name comes from a pilot's pre-flight checklist. It produces a report and often auto-fixes problems.

A standard preflight check looks for:

- **Color space** — any stray RGB or unwanted spot colors in a CMYK job; correct output profile assigned.
- **Image resolution** — any placed image below the target effective PPI (e.g. under 300) at final size.
- **Fonts** — every font embedded or converted to outlines. A missing font gets substituted on the printer's machine, which breaks the layout and spacing.
- **Bleed and trim** — required bleed present, trim box defined, safe margins respected.
- **Overprint/knockout problems** — like the disappearing white object.
- **TAC / ink limit** — exceeded anywhere.
- **Transparency, hairline rules too thin, small black not overprinting, PDF version compliance.**

PDF/X — the safe delivery formats

Standard	What it enforces	When to use
PDF/X-1a	All color must be CMYK or spot (no RGB), all fonts embedded, transparency flattened. Conservative and bulletproof.	The safest, most universal choice
PDF/X-4	Newer; allows live transparency and ICC color (RGB plus profiles permitted). Modern workflows.	When the printer's RIP supports it

Real-world preflight tools to know by name: **Enfocus PitStop** (a desktop Acrobat plugin, plus a server version), **callas pdfToolbox** (the other dominant engine, desktop and server), and Acrobat Pro's built-in Preflight (400+ checks). For unattended production pipelines there are workflow servers like **Enfocus Switch** and **Fiery JobFlow**.

Best practice: Always run preflight before sending a file. Export to PDF/X-1a (or X-4 if the printer's RIP supports it), per the printer's spec.

Key takeaway: Preflight is the automated safety check that catches RGB colors, low-res images, missing fonts, missing bleed, and ink-limit problems before they reach the press. Deliver as PDF/X-1a or PDF/X-4.

9. Proofing — confirming the look before the run

A **proof** is a preview the customer approves before the expensive press run. There are three levels.

	Soft proof	Hard proof	Contract proof
What it is	On-screen / PDF preview	A physical printout	A certified physical print, legally binding
Color accuracy	Low (RGB monitor)	High (real or simulated stock)	Highest — guaranteed match
Cost & speed	Free, instant	Costs money, must be shipped	Most expensive
Use it to check	Layout, content, typos	Color-critical jobs	Color that must be guaranteed

A **soft proof** is a digital preview, usually a PDF emailed to the client. It is great for checking layout, content, and typos — but because a monitor glows in RGB, the color it shows is close but *not* color-accurate.

A **hard proof** is a physical printout of the actual print data, often on the real stock, so you can judge color, sharpness, and detail in your hand. A **contract proof** is a hard proof that both printer and customer formally agree is the color standard the press run must match; it is usually certified to a standard (like FOGRA or G7) with a verification strip, and high-end systems claim about 95%+ color accuracy. The most accurate proof of all is a "press proof" (run on the actual press with actual ink), but it is also the most expensive.

Common mistake: Trusting a soft proof on an uncalibrated screen to judge exact color, then being upset when the printed brand color looks different. For color-critical work, pay for a hard or contract proof.

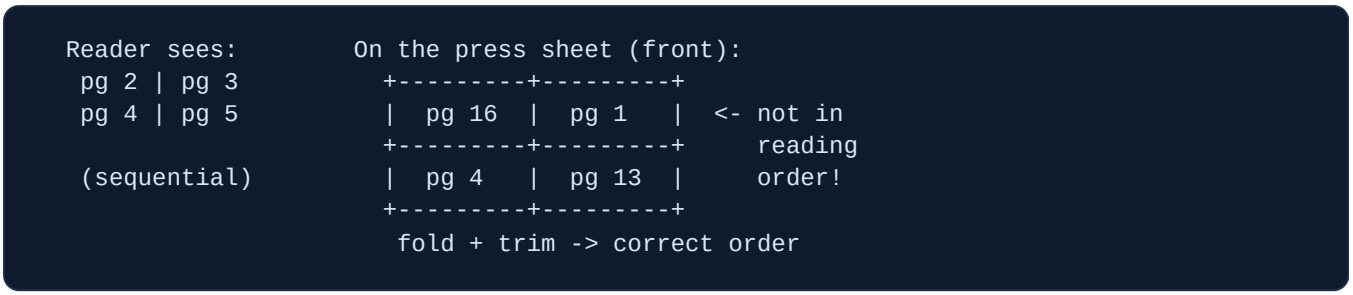
Key takeaway: Soft proofs catch typos and layout for free but cannot guarantee color. When the exact color matters, step up to a hard proof, and to a certified contract proof when the color must be legally binding.

10. Imposition — arranging pages on the press sheet

Imposition is arranging multiple pages or copies onto one large press sheet in a specific layout, so that after printing, folding, trimming, and binding, the pages end up in the correct reading order. It saves paper and press time.

- A **signature** is one large sheet printed with several pages per side, then folded into a section of a book. Common counts are 8, 16, or 32 pages per signature — always a multiple of 4.
- **Reader spreads vs printer spreads**: readers see pages in order (2 next to 3); on the press, non-consecutive pages sit side by side (page 16 may sit next to page 1). Imposition handles that rearrangement.

- **N-up / step-and-repeat**: ganging many copies of a small item (business cards, labels) onto one sheet to cut cost.



Method	How it works
Sheetwise	Separate plates for front and back; high-volume jobs.
Work-and-turn	One plate images both halves. Print one side, turn the sheet left-to-right (same gripper edge), print again, then cut in half = two finished copies. Halves the plate count.
Work-and-tumble	Like work-and-turn but flip top-to-bottom (gripper edge changes); for smaller runs.
Ganging	Combining several *different* jobs on one sheet to share the setup cost.

Remember the **gripper edge** — the ~3/8"–1/2" lead edge the press physically grabs, where nothing can be printed. Good imposition respects it. Correct imposition ensures proper folding and binding order, minimizes paper waste, and prevents bindery problems.

Key takeaway: Imposition is the puzzle of placing pages on a big sheet so they read correctly after folding and cutting. Signatures are multiples of 4; work-and-turn halves plate costs; ganging shares setup across jobs.

11. How all of this touches your print software

This chapter is the engine room of a web-to-print SaaS. Here is where each concept shows up in code.

- **Online design editor / upload validator.** On upload or export, enforce the rules so non-expert customers cannot submit broken files: flag or convert RGB to CMYK (with a chosen output profile); reserve and display bleed (0.125"/3mm) and safe-zone guides on the canvas; validate *effective* resolution at final size (warn or block under 300 PPI) and never silently upscale; embed fonts or outline text on PDF generation.
- **Print-ready output.** Generate a PDF/X-1a or PDF/X-4, and optionally a job ticket for the production workflow.
- **Inline preflight.** Tools like printQ wrap engines such as PitStop or pdfToolbox to check the uploaded file against the chosen product in real time. Rules should be configurable *per product type*: minimum

resolution, required color profile, font embedding, bleed/trim/safe-zone. Errors can be auto-fixed in the editor or flagged to the user.

- **Automated preflight servers.** PitStop Server, callas pdfToolbox Server, Enfocus Switch, and Fiery JobFlow run unattended in the pipeline — check, fix, impose, and route.
- **In-browser soft proofing.** Generate a PDF proof for approval, but clearly caveat that screen color is not print color; ideally simulate the output profile.

What to model in your data — per-product prepress attributes

Each product type in your catalog should carry its own prepress rule set, which becomes the preflight profile:

Attribute to capture per product	Example value
Color mode	CMYK
Required output profile	GRACoL2013_CRPC6
Minimum effective resolution	300 PPI (400 for text-heavy)
Bleed size	0.125" / 3 mm
Safe-zone margin	0.125"–0.2"
TAC / ink limit	300%
Allowed spot colors	none, or a defined Pantone list
Delivery PDF standard	PDF/X-1a or X-4

Best practice for the UI: Translate the jargon. Your customers are not prepress operators. Say "We'll add a 1/8-inch safety border so nothing important gets cut off," not "Configure bleed and TAC." Reserve terms like "knockout," "TAC," and "registration" for the production-facing side, and show plain-language guidance to the buyer.

Key takeaway: Prepress rules become per-product configuration that drives an automatic preflight. Build the rules in (CMYK, bleed, safe zone, min DPI, ink limit, font embedding, PDF/X output), validate every uploaded file against them, and speak plain language to the customer while keeping the precise specs for production.

12. Quick reference — the ten most common file mistakes

Common mistakes that cause reprints:

1. RGB files sent for CMYK print → dull, shifted colors (blues turn purple, neon goes flat).
2. Low-resolution (72 PPI) images, or upscaling 72→300 → pixelated, soft print.
3. No bleed / background not extended → white edges or cut-off content.
4. Critical text or logo outside the safe zone → trimmed off.
5. Fonts not embedded or outlined → substituted fonts, broken layout.
6. Pantone spot colors specified on a CMYK-only job → poor approximations or surprise extra cost.
7. Rich black on small text, or true 100K black on large fills → blurry edges or flat dark gray.
8. Registration black (400%) used as a design color, or TAC over the limit → set-off, smearing, won't dry.
9. White objects/strokes accidentally set to overprint → they vanish; colored ones overprinting → muddy color.
10. Skipping proofing, or trusting a soft proof for color-critical color matching.

Best practice checklist:

- Design and convert in CMYK using the printer's output profile; soft-proof with it.
- Ask the printer for: output profile (GRACoL/CRPC6 or FOGRA51/39), TAC limit, bleed size, required PDF standard.
- Build at trim + 0.125"/3mm bleed; keep content inside the safe margin.
- Images ≥300 PPI (≥400 for text-in-image) at final placed size; never upscale.
- Embed or outline all fonts; export PDF/X-1a (or X-4 if the RIP supports it).
- K100 for small text; rich black C60 M40 Y40 K100 for large areas; never registration black as artwork.
- Overprint small 100% black text/rules; let the printer handle trapping.
- Run preflight before sending; review a proof (hard or contract proof when color matters).

Substrates & Materials — Paper, GSM, Coatings & Specialty Stocks

A **substrate** is simply the material you print on — paper, cardstock, plastic film, vinyl, or board. The word sounds technical, but it just means "the thing the ink lands on." This chapter teaches you the language of substrates, because that language is how print shops decide you can be trusted.

Analogy: Walk into a coffee shop and say "I want a hot brown drink." You'll get served, but the barista knows you're a beginner. Say "double-shot flat white, oat milk" and you're treated as someone who knows the craft. In printing, "thick shiny paper" is the hot brown drink. "16pt C2S silk, grain long" is the flat white. Same product, completely different conversation.

Here is the core challenge you must understand before anything else: **two separate measuring systems collide in this industry.** The rest of the world uses the **metric system** (GSM, microns). The United States uses an older **pound (lb) system** that, as you'll see, is genuinely confusing — even to people in the trade. Any software that quotes or sells print must handle *both* and convert between them. Let's start there.

1. Paper Weight — GSM vs US "lb" Basis Weight

Paper weight tells you, roughly, how heavy and substantial a sheet feels. Heavier usually means thicker and more premium — but as you'll learn in section 2, "heavier" and "thicker" are not the same thing.

GSM — the clean, universal system

GSM stands for **grams per square meter**. The definition is wonderfully simple: take one sheet that measures 1 meter by 1 meter, and weigh it in grams. That weight is the GSM.

> **Key takeaway:** GSM is *absolute*. 90 GSM is 90 GSM no matter what kind of paper it is, who made it, or what country you're in. This is why GSM is the international standard and the number you should store internally in software. When in doubt, anchor everything to GSM.

Here are weight anchors worth memorizing — they map a number to a real-world feel:

GSM	What it feels like
~80 GSM	Standard office copy/printer paper
90–120 GSM	Quality letterhead, nicer text pages
120–170 GSM	Flyer and brochure body paper
200–250 GSM	Light postcard / thin card
300–400 GSM	Business card cardstock
400–600+ GSM	Premium / luxury cards

US "lb" basis weight — and why it confuses everyone

The American system measures weight in **pounds (lb)**, and this is where beginners (and plenty of professionals) get tripped up. The **basis weight** is the weight of **500 sheets** (a stack called a **ream**) — but cut to a special **basis size**, which is the large uncut "parent" sheet for that grade. It is *not* the size you actually buy.

The fatal problem: **every grade of paper has a different basis size.** So the pound number is measured against a different starting sheet depending on the type of paper.

Grade family	Basis size (the uncut parent sheet)
Bond / Writing	17 × 22 in
Text / Book / Offset	25 × 38 in
Cover	20 × 26 in
Index	25.5 × 30.5 in
Tag	24 × 36 in

Common mistake: Assuming a pound number means the same thing across grades. It does not. **80 lb Text feels like a sturdy flyer. 80 lb Cover feels like a business card.** Same "80 lb," wildly different sheets — because Text is weighed on a 25×38 parent and Cover on a 20×26 parent. The "lb" number only tells you the weight *within one grade family*, never across families. This is the single biggest source of confusion in paper buying.

Example: A customer calls and says "I want 80 lb paper for my business cards." If you blindly order 80 lb *Text*, you'll deliver something close to flyer paper — flimsy and embarrassing. They almost certainly meant 80 lb *Cover* (~218 GSM). Always ask "Text or Cover?" — or better, talk in GSM and skip the ambiguity entirely.

Conversion reference

Because each grade converts differently, you need category-aware conversion tables. Here are the common ones:

Pounds (lb)	As Text	As Cover	As Bond
16 lb	—	—	60 GSM
20 lb	—	—	75 GSM
24 lb	—	—	90 GSM
60 lb	90 GSM	163 GSM	—
70 lb	105 GSM	189 GSM	—
80 lb	120 GSM	218 GSM	—
100 lb	150 GSM	270 GSM	—

Rough multipliers if you need a quick mental estimate: Text → Cover ≈ ×0.55; Cover → Text ≈ ×1.80; Bond → Text ≈ ×2.50. And a famous overlap that shows just how slippery pounds are: **50 lb Bond ≈ 80 lb Text ≈ ~120 GSM** — three different names for essentially the same sheet.

Key takeaway: Default to GSM internally; show lb as a friendly alias for US users. Never make a non-technical shop owner do basis-weight math — your software should convert on the fly, using the correct table for the grade (Text, Cover, or Bond each have a different curve).

2. Caliper / Thickness — Points, Mil & Microns

Caliper is the physical **thickness** of a sheet, measured with a **micrometer** (a precision tool that squeezes the sheet and reads its depth). Crucially, caliper measures thickness — *not* weight.

Common mistake: Treating weight (GSM) and thickness (caliper) as the same thing. They don't track perfectly. A fluffy, bulky *uncoated* sheet can be *thicker* than a heavier *coated* sheet of the same GSM, because coatings and a polishing process called **calendering** compress the fibers. Two stocks both labeled "300 GSM" can have visibly different thicknesses.

The units

Unit	Meaning	Used for
Point (pt)	1/1000 of an inch (0.001"). So 14pt = 0.014"	Cards, postcards, board
Mil	Same as a point — 0.001"	Plastics, films, synthetics
Micron (µm)	1/1000 of a millimeter (metric)	International specs

Common mistake: Confusing the print **point** (1/1000 inch, thickness) with the **typography point** (1/72 inch, font size). They share a name but are completely unrelated. "14pt cardstock" and "14pt type" mean entirely different things.

The business-card thickness ladder

Business cards are spec'd by points, and this ladder is industry-standard vocabulary:

Caliper	~GSM (coated card)	Feel / use
8–10 pt	~200–230	Flimsy, low-end
12 pt	~260	Light
14 pt	~310	**The workhorse default for business cards**
16 pt	~350	**Premium-feeling standard**
18 pt	~400	Heavy, substantial
32 pt	~0.813mm	Thick luxury (often two sheets glued = duplexed)

Key takeaway: Spec card and postcard products by **pt**, and books or flyers by **GSM** (plus opacity). Store both weight and caliper in software, because they answer different questions: weight drives shipping cost, caliper drives how the product *feels* in the hand.

3. Coated vs Uncoated, and the Finish Spectrum

Whether paper is **coated** or **uncoated** changes everything about how it looks, feels, and behaves with ink.

Coated paper

A thin layer of clay or polymer is applied to seal the surface. Ink then sits *on top* of the sheet instead of soaking in. The result: sharper images, denser and more vibrant color (printers call this good **ink holdout**), and tighter control of **dot gain** (the tendency of ink dots to spread and swell on contact). Coated stock is also durable — it resists smudges, fingerprints, and moisture, which is why menus and cards are usually coated. The downside: it's hard to write on with a pen, because ink and graphite won't grip a sealed surface (unless it's a matte coat).

Uncoated paper

No coating. The surface is porous and absorbs ink, giving softer, more muted color and a little extra dot gain (ink spread). It has a natural, tactile feel, no glare, and you can write on it easily — which is why letterhead, forms, and book pages are usually uncoated. Uncoated stock also carries an "organic / premium" branding signal. It comes in surface textures: **wove** (smooth), **laid** (fine ribbed lines), **linen** (cloth-like), and **felt**.

The coated finish spectrum

Finish	Sheen	Strengths	Weaknesses
Gloss	High shine	Punchy color, photo contrast — marketing pieces	Glare under light, hard to read text, shows fingerprints
Silk / Satin	Semi-gloss (the midpoint)	Eye-catching but low glare; great for text + images together	Less "pop" than gloss
Matte / Dull	Minimal sheen	Easy reading, elegant, can be written on	Less color vibrancy, can scuff

Silk and **satin** are interchangeable words for the same thing; some shops also call matte coated stock "**dull**."

C1S vs C2S — high-trust vocabulary

These abbreviations tell you which *sides* are coated, and using them correctly signals real fluency:

- **C2S = Coated 2 Sides.** Both sides sealed. Used for brochures, postcards, catalog pages, and double-sided business cards.
- **C1S = Coated 1 Side.** One side coated for print quality, the back left uncoated. Used for hang tags, labels, table tents, book/dust covers, and packaging — because the uncoated back accepts glue, writing, or lamination.

Best practice: Match the finish to how the piece is used. Gloss for photos and marketing; matte for anything text-heavy or written on; silk/satin when you need both readability and a bit of shine. A glossy form that people must write on is a guaranteed complaint.

Key takeaway: Coating decides color vibrancy, durability, and writeability. C1S/C2S decides which side can be glued or written on. Capture both as structured fields — coating (gloss/silk/matte/uncoated) and sides (C1S/C2S) — never as free text.

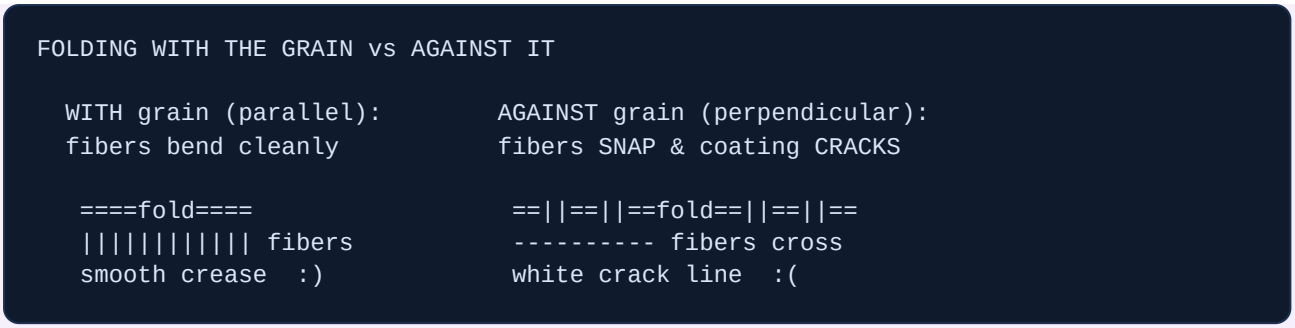
4. Grain Direction — the Detail That Earns Respect

Here's the concept that quietly separates pros from amateurs. During manufacturing, paper flows through the machine in one direction, and the tiny fibers line up *with* that flow. That alignment is the **grain direction**.

- **Grain Long (GL):** fibers run parallel to the *longer* edge of the sheet.
- **Grain Short (GS):** fibers run parallel to the *shorter* edge.

The labeling convention: grain runs in the direction of the **last dimension listed**. So `23 × 35` is grain long (grain runs in the 35" direction), while `35 × 23` is grain short. Some mills bold or underline the grain dimension, and "M" can mark the machine direction.

Why grain matters so much



- **Folding & scoring:** Always fold parallel to the grain. A parallel fold bends fewer fibers, giving a clean crease. Folding *against* the grain snaps fibers and **cracks the coating**, leaving a visible white line — especially ugly on heavy coated stock, and it looks like a defect. The fix is to **score** first (press a crease line before folding).
- **Binding books:** Grain must run *parallel to the spine*. Then the book lies flat and pages turn easily. Wrong grain gives stiff pages and a warped, wavy spine — a defect called **gusseting** that's nearly impossible to fix.
- **Press feeding:** Grain perpendicular to the feed path keeps the sheet stiff through the rollers, reducing jams and improving registration (color alignment).
- **Dimensional stability:** Paper expands and contracts *across* the grain up to ~400% more than along it as humidity changes. Wrong grain causes curl and misregistration on multi-pass jobs.

Four quick ways to detect grain

1. **Tear it:** tears straight and clean *with* the grain; jagged *against* it.
2. **Bend it:** less resistance bending parallel to grain; stiffer against.
3. **Fold it:** folds smoother along the grain.
4. **Dampen it:** moisten one side — the sheet curls along the grain axis.

> **Key takeaway:** For any folded or bound product, capture grain (GL/GS) and validate that fold lines run parallel to it. Auto-recommend scoring on heavy or coated stock. This one check prevents the cracked-fold defect that ruins finished brochures and cards.

5. Brightness, Whiteness & Opacity — the Three "White" Metrics

These three numbers all describe "how white and clean" a paper looks, and they're constantly confused. They measure genuinely different things.

Metric	What it measures (plain English)	Typical range
Brightness	How much of one specific *blue* light wavelength (~457nm) the sheet reflects. Higher = colors pop more.	80–100 (premium copy = 92, 96, 100)
Whiteness	Reflectance across the *full* visible spectrum in daylight — the perceived "how white" to the human eye.	0–100
Opacity	How well the sheet *blocks light* — stops you seeing print from the other side or the sheet beneath.	80–98

The **shade** or **tint** is the hue of the white: "true white," "blue-white" (cool, looks crisp), or "cream/natural" (warm, easier on the eyes for long reading like books). Many papers contain **Optical Brightening Agents (OBAs)** — chemicals that absorb invisible UV light and re-emit it as blue, faking extra brightness. The catch: under different lights the paper can look different (a mismatch called **metamerism**), and OBAs can yellow over the years.

Common mistake: Printing double-sided on thin, low-opacity stock. The result is **show-through** (ghosting) — you can read the back through the front. For anything duplex, and especially for book interiors, pick high-opacity paper. Higher GSM and added fillers raise opacity.

Key takeaway: Brightness ≠ whiteness ≠ opacity. Brightness makes color pop, whiteness is the perceived shade, opacity stops show-through. Match opacity to duplex and book products, and warn when a thin low-opacity stock is chosen for two-sided printing.

6. Common Stocks — a Grade Glossary

"Stock" is just the trade word for "type of paper." Here are the families you'll meet constantly:

Stock	What it is & where it's used
Bond / Writing	Office paper and letterhead. Copy paper = 20 lb bond (~75 GSM). Flat, takes a pen, feeds in laser printers.
Text / Book / Offset	Lighter sheets for interior pages, flyers, brochures, book bodies. "Offset" = uncoated text built for offset presses. 60–100 lb text (90–150 GSM).
Cover / Cardstock	Thick and rigid — business cards, postcards, folders, covers. 65–130 lb cover; coated or uncoated.
Index	Stiff, smooth, dimensionally stable — index cards, file dividers, tabs.
Tag	Strong and durable — tags and tickets.
Bristol	Mid-weight smooth board — postcards, drawing.
Recycled	Contains post-consumer waste (PCW). Slightly lower brightness; "100% PCW" is an eco-branding claim.
Kraft	Brown, unbleached pulp. Strong, rustic look — bags, tags, eco packaging.
Synthetic "paper"	Plastic-film stock (polypropylene/BOPP, Teslin, Yupo, vinyl). Waterproof, tear-proof — menus, IDs, outdoor tags, nursery labels. Measured in mil.

Common mistake: Sending a synthetic/plastic stock through with ordinary ink. Plastic doesn't absorb conventional ink, so it won't dry or adhere — you'll get smearing. Synthetics need UV-cured or latex ink, or special handling.

Packaging board — a separate world

Paperboard is solid, single-layer board used for **folding cartons** (the retail boxes products come in). It's spec'd in points, like cards.

Board type	Description & use
SBS (Solid Bleached Sulfate)	Premium, clay-coated, bright white. Food and high-end retail; best print quality.
CRB / CCNB (Coated Recycled Board)	Recycled blend with a gray interior; the cheapest folding cartons.
CUK / SUS (Coated Unbleached Kraft)	Strong, brown, moisture-tolerant, printable — beverage carriers, rugged packaging.

Corrugated fiberboard is different again: a wavy **fluted** layer sandwiched between two flat liners — this is for *shipping boxes*, not folding cartons. It's spec'd by flute size (A/B/C/E/F) and strength tests

(ECT/burst), not GSM. Note that grain matters on board too: align grain across panels for stiffness and to avoid cracking on score lines.

Wide-format / banner substrates

Banners are roll-fed and weighed in ounces per square yard (oz/yd²) or GSM:

- **Scrim vinyl banner:** the standard. 13 oz (~400–500 GSM) for most uses; 18 oz (~550+ GSM) for heavy-duty, long-term outdoor.
- **Mesh vinyl:** perforated so wind passes through (fences, building wraps). ~250–350 GSM.
- **Fabric / polyester banner:** 150–300 GSM; elegant, low-glare — trade shows, retractable displays.

The rule of thumb: higher GSM or oz = sturdier and more wind/UV resistant.

7. Choosing the Right Substrate by Product

Put it all together into practical defaults:

Product	Recommended substrate
Business cards	Cover/cardstock, 14pt or 16pt (~310–350 GSM), C2S silk or matte. Gloss for photo-heavy designs; uncoated/cotton for premium tactile; 32pt duplex for luxury.
Flyers / leaflets	Text weight ~100 lb text / ~150 GSM. Gloss for vibrant single-use marketing; matte if text-heavy or written on.
Postcards	Cover stock, 14pt. Watch USPS caliper minimums for mailing (~0.007" minimum, 0.009"+ for the postcard rate).
Brochures (folded)	Text weight that folds cleanly; fold parallel to grain; score heavy coated stock to avoid cracking.
Booklets / books	Body 70–100 lb text (90–150 GSM) with high opacity; cover 80–100 lb cover or C1S; grain parallel to the spine.
Posters	Gloss or satin text/photo paper; heavier for durability.
Banners	13 oz scrim vinyl by default; mesh if windy/outdoor; fabric for indoor premium.
Packaging boxes	SBS for premium/food; kraft for eco/rugged; CRB for budget; corrugated for shipping.

Common mistake: Ignoring USPS caliper minimums for mailed postcards. A postcard too thin gets rejected at the postcard rate, surprising the customer with extra cost. Software should warn before checkout.

8. How This Touches Print Software

Everything above must become structured data, not free text. "Thick paper" is the anti-pattern — it can't be converted, priced, or validated.

- **Stock as a structured attribute.** A product or size should carry: `weight_gsm`, `weight_lb` + `basis_category` (text/cover/bond), `caliper_pt`, `coating` (gloss/silk/matte/uncoated), `sides` (C1S/C2S), `grain` (GL/GS), `brightness`, `opacity`, `recycled_pct`, and `material_type` (paper/synthetic/vinyl/board).
- **Dual-unit display + conversion engine.** Show GSM and lb together, converting on the fly with category-aware tables (Text, Cover, and Bond convert differently). Never force a US shop owner to do basis-weight math.
- **Plain-language labels for non-technical owners.** Show "Standard (300 GSM / 14pt)" or "Premium thick (350 GSM / 16pt — like a credit card)" rather than raw "C2S 16pt." Tooltip the jargon (C2S = "coated both sides").
- **Pricing.** Substrate is a major cost driver — heavier, coated, or synthetic stock pushes a higher price tier. Stock choice should feed the price calculator (and for banners, square-foot × material tier).
- **Preflight warnings.** Flag fold direction vs grain (crack risk), low opacity for duplex, USPS caliper minimum for mailed postcards, and ink compatibility for synthetic stock.
- **Shipping weight linkage.** GSM × sheet area gives physical weight, which feeds the shipping module's weight tiers. Substrate GSM is the physical input to shipping cost.
- **Snapshot on the order.** Capture the chosen substrate spec onto the order record at purchase time. A stock can be renamed or discontinued later, but the placed order must remember exactly what was bought.

Best practice: Quote and store every stock in one complete shape — for example, "350 GSM (16pt) cover, C2S silk, grain long." That single string answers weight, thickness, grade, coating, sides, and grain. It's the vocabulary that earns trust, and it's exactly the data your software needs to price, validate, and fulfill the job correctly.

Key takeaway: Master the two weight systems (GSM is your anchor), keep weight and thickness separate, know your coatings and C1S/C2S, and never forget grain on folded work. Speak this language and both print shops and your own software will treat you as a professional.

Finishing & Bindery — Everything After the Press

The press lays ink on paper. But a stack of flat, ink-covered sheets is not yet a business card, a brochure, or a book. **Finishing** is everything that happens *after* the press — the cutting, folding, coating, and binding that turns printed sheets into a real, usable product.

You will also hear this stage called **bindery** or **post-press**. They mean the same thing: the back half of the print shop where flat output becomes a finished object. As a software builder, this is the part of the craft most likely to surprise you, because it is where a beautiful job most often gets *ruined* — text trimmed off, foil out of place, a fold that cracks. Understanding finishing is what lets your product configurator offer the right options, validate them, and price them correctly.

> **Analogy:** Think of a restaurant. The press is the stove — it cooks the food. Finishing is the plating, the garnish, the bread on the side, and finally putting everything on the plate so it arrives as a "meal." The cooking can be perfect and the plating can still ruin the dish.

The big picture: two buckets of work

Finishing splits into two broad families:

1. **Converting / finishing operations** — work done on individual sheets or pieces: cut, score, fold, laminate, coat, foil, emboss, die-cut, perforate, drill, pad, round corners.
2. **Binding** — joining many sheets or folded sections into one book or booklet (saddle stitch, perfect bind, wire-o, hardcover, and so on).

The bindery also handles the unglamorous-but-essential prep steps:

- **Collating / gathering** — putting sheets or folded sections into the correct page sequence before binding.
- **Jogging** — placing a stack on a vibrating table so every sheet aligns to a clean, square edge before it is cut or bound. (A guillotine is only as accurate as the alignment of the stack feeding into it.)

> **Key takeaway:** Finishing is not a minor afterthought. It is frequently the slowest stage (the bottleneck) and the highest-defect stage in the whole shop. Most "the print is wrong" complaints are actually finishing problems.

The finishing line, in order

```
PRESS  -->  the rest of this chapter
  |
  v
+-------------------------------------------------+
| CUT / TRIM    cut sheets to size, separate n-up  |
| SCORE/CREASE  prepare clean fold lines           |
| FOLD          half, tri, z, gate, accordion      |
| COAT/LAMINATE varnish, AQ, UV, spot UV, film     |
| DECORATE      foil stamp, emboss, deboss         |
| DIE-CUT       custom shapes, windows, tags       |
| SPECIAL       perf, drill, pad, round corners    |
| COLLATE       put pages in order                 |
| BIND          stitch / glue / wire / case        |
| FINAL TRIM    trim the bound block flush         |
+-------------------------------------------------+
  |
  v
PACK & SHIP
```

Not every job uses every step. A flyer might only get cut. A hardcover book travels the whole line. We will walk through each step in this order.

1. Cutting & trimming

Almost every job starts here. The workhorse is the **guillotine cutter**: a stack ("lift") of sheets is jogged square, placed on a flat bed, clamped down hard, and a heavy angled steel blade shears through the entire stack in one stroke.

Two words you will use constantly:

- **Cutting** — slicing sheets down to size or separating multiple copies printed on one big sheet. When several copies share one sheet, we say it was printed **n-up** (e.g. "8-up" = 8 business cards on one sheet).
- **Trimming** — the final cut that brings a piece (or a bound book) to its exact finished size and removes the excess paper around the artwork.

For bound books there is a special machine, the **three-knife trimmer**, which trims the top (head), bottom (foot), and open edge (face / fore-edge) of a book block to its finished size in one pass. The spine is not trimmed because it is the bound edge.

Why bleed and safe zones exist

Here is the single most important number in finishing: **a guillotine is not perfectly precise.** A normal, well-run cutter has a tolerance of about **±1/16 inch (about 1.5 mm)**. The blade can drift slightly, the stack can shift, paper stretches. So the final cut lands a hair off from where the artwork "intended."

That tiny wobble is the entire reason for three design concepts you must enforce in software:

Term	Plain meaning	Typical amount
Bleed	Artwork (background colors/images) extends *past* the cut line, so if the blade drifts you never get a thin white sliver of unprinted paper at the edge.	3 mm (0.125")
Trim line / cut line	The exact final size — where the blade is supposed to cut.	the finished size
Safe zone / margin	Keep all important text and logos *inside* this line so the cut tolerance never clips them.	3–5 mm inside trim

Common mistake: Designing artwork that ends exactly at the trim line with no bleed. After cutting, you get white slivers on the edges. The opposite mistake is putting a phone number 1 mm from the edge — well inside the ±1.5 mm tolerance — so half the jobs come back with the number clipped.

Example: A 3.5" × 2" business card should be built on a canvas of about 3.625" × 2.125" — that extra 1/16" all around is the bleed. The cut brings it to 3.5" × 2", and any logo should sit at least 3 mm in from that edge.

Key takeaway: Bleed and safe zones are not aesthetic preferences — they are a direct response to the guillotine's ±1/16" mechanical tolerance. Your preflight should auto-add 3 mm bleed and flag any critical content inside the safe margin.

2. Scoring vs creasing — so paper folds without cracking

You cannot just fold thick or coated paper. Bend it cold and the surface coating and ink crack along the fold, leaving an ugly white line. The fix is to prepare a controlled hinge first.

- **Scoring** — pressing a thin line partway into the paper to create a hinge. A raised "male" rule forces the sheet down into a "female" channel, weakening it along that line so it folds straight and easily.
- **Creasing** — instead of cutting fibers, creasing *compresses and displaces* them, pushing the paper into a rounded "bead" of fiber that becomes the hinge. Creasing is gentler and almost always better for heavy or coated stock.

Analogy: Scoring is like the perforated line on a cardboard box flap — a built-in weak line to bend along. Creasing is like wetting and rolling a stiff leather belt so it bends in one clean place instead of cracking.

When is it required? (real rules of thumb)

Stock	What to do
Light stock, folding *with* the grain	Often folds fine with no prep
100 lb text (148 gsm) or heavier	**Score** before folding
Uncoated cover up to ~100 lb	Scoring usually enough
Coated stock over 80 lb cover (216 gsm)	**Crease** — do not just score
Any digital / toner-printed stock	**Always crease**, at any weight

(**gsm** = grams per square meter, a metric weight for paper. Higher gsm = thicker, stiffer stock. We cover paper weights in the paper chapter.)

Toner deserves special attention: **digital/toner prints crack much more easily** than offset ink because the toner sits in a brittle layer on top of the surface rather than soaking in. So for any toner job, crease regardless of weight.

Grain direction — the silent fold-killer

Grain is the direction most paper fibers line up in, set when the paper was made. Folding *parallel to* the grain is clean and easy. Folding *against* (across) the grain fights the fibers and cracks readily.

The bindery rule is blunt: **"Never fold across the grain."** If a layout forces an against-grain fold, then scoring or creasing becomes mandatory even on otherwise light stock.

Common mistake: Scoring the *wrong side* of the sheet. The rule: score so the paper bulges *away* from the score, which means scoring on the *inside* of the fold. Score the wrong side and the bead pushes the wrong way, and you still crack. This is one of the most repeated bindery errors.

Key takeaway: Above ~216 gsm coated, or for any toner stock, the configurator should *automatically* add a crease step when a fold is chosen — and warn if the fold runs against grain.

3. Folding

Once a clean hinge exists, machines fold the sheet. Two main machine types:

- **Buckle folder** — the sheet is driven into a plate where it "buckles," and rollers pinch the buckle into a fold. Fast; best for lighter paper.
- **Knife folder** — a thin blade pushes the sheet down between two rollers to make the fold. Slower but handles heavier stock and clean right-angle folds.

Folds and pages — the doubling rule

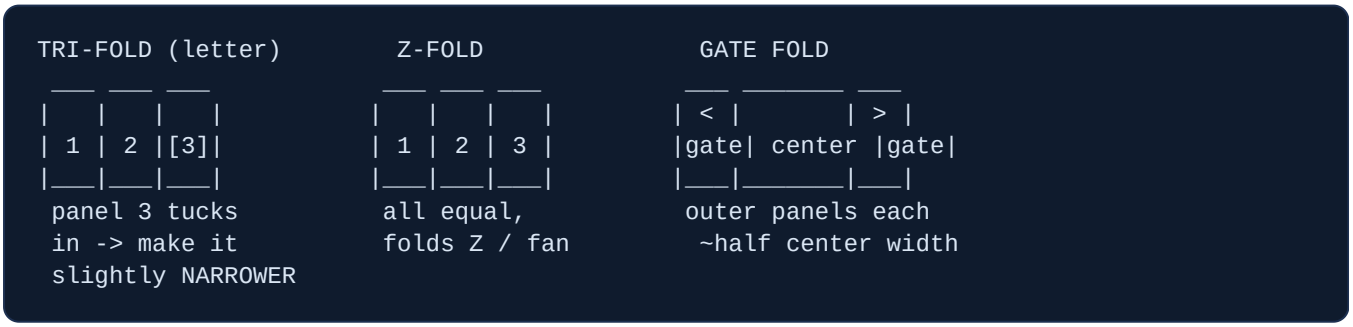
Each right-angle fold **doubles** the number of pages, which is why books are printed in folded sections called **signatures**:

Folds	Pages produced
1 fold	4 pages
2 folds	8 pages
3 folds	16 pages

Common fold types

Using a letter sheet (8.5" × 11") for the panel math:

Fold	What it looks like	Panels
Half / Bi-fold	One fold down the middle	4 (two per side)
Tri-fold (letter / C-fold)	Two parallel folds, panels tuck inward like a letter in an envelope	6
Z-fold	Two folds in a zig-zag; opens like a fan	6, all equal
Gate fold	Two outer "doors" fold in to meet in the middle	outer panels ≈ half the center's width
Accordion	Many equal panels, fan-style	4+ equal
Roll fold	Panels roll inward, each tucked panel slightly smaller	good for many panels
Double parallel	Fold in half, then in half again the same direction	8
French fold	Folded twice at right angles (a cross fold)	—



Common mistake: Making all three tri-fold panels equal width. The innermost *tucked* panel must be slightly narrower (e.g. 3.625" vs ~3.688") or it buckles and won't sit flat inside. A Z-fold, by contrast, *does* use equal panels because nothing tucks inside anything. Your panel-math must differ by fold type.

Key takeaway: Each fold type has its own panel-width rules. Software that generates fold templates must know that tri-fold and roll-fold need a narrowed tuck panel, while z-fold and accordion use equal panels.

4. Coatings — liquid surface treatments

A **coating** is a clear liquid applied over the sheet to protect it and change its look (shiny, dull, or velvety). Coatings are *liquids*; lamination (next section) is a *film*. From cheapest to priciest: varnish ≈ aqueous < UV < lamination.

Coating	What it is	Look & protection
Varnish	Basically clear ink run through a press unit	Gloss, satin, or matte; cheapest; modest protection. Can be *flood* (whole sheet) or *spot* (selected areas, needs its own plate).
Aqueous (AQ)	Water-based clear coat rolled over the whole sheet (no plate needed)	Gloss/matte/satin/soft-touch; resists dirt and fingerprints; dries fast; eco-friendlier. The everyday "protective" coat.
UV coating	Liquid that is cured instantly to a hard shell by ultraviolet light	Highest shine and best scuff resistance of the liquid coatings; costs more than AQ.
Spot UV	UV coating applied *only* on chosen areas, often over a matte background	Dramatic glossy-on-matte contrast; only a couple of microns thick but gives a slight raised feel. Needs its own mask layer in the artwork.
Soft-touch	A velvety, suede-like coating (or film)	"Peach-skin" texture, fingerprint-resistant, premium feel. Popular on luxury cards and packaging.

Example: A premium business card with matte lamination and **spot UV** on just the logo. The card feels soft and dull, but the logo is glossy and catches the light — a high-end effect that costs only a small spot-UV add-on plus a separate mask layer in the file.

Key takeaway: Aqueous is the default "protect it" coat; UV is the "make it shine" coat; spot UV and soft-touch are premium add-ons. Spot UV and spot varnish both need a *separate named mask layer* in artwork, not baked into the color.

5. Lamination — bonding a plastic film

Lamination bonds a thin plastic film to one or both sides of the sheet using heat and pressure (called **thermal lamination**). It is the toughest, most water- and tear-resistant finish — and the most expensive standard option.

Finishes: **gloss** (vivid, reflective), **matte** (low glare; makes dark colors look deep and rich), and **soft-touch / velvet** (suede feel).

The most common film is **BOPP** (a stretched polypropylene plastic) — cheap, recyclable as a single material, odorless. Film thickness is measured in **mils** (1 mil = 1/1000 inch); common hard films are 3, 5, and 10 mil. Soft-touch BOPP is thinner, around 15–25 µm (micrometers).

Lamination vs UV coating (a common buyer question)

	Lamination (film)	UV coating (liquid)
What it is	A physical plastic sheet you could peel	A sprayed/cured liquid layer
Coverage	Full coverage, both sides possible	Whole sheet or spot
Durability / waterproofing	Best — strongest moisture and tear barrier	Good shine, but a weaker barrier
Weakness on folds	Can crack at a fold if not creased first	Can chip on heavy handling
Cost	Highest of standard finishes	Less than lamination

Common mistake: Laminating a heavy card and then folding it without a crease. The plastic film (and the coating under it) cracks along the fold every time. Crease first, fold second.

Key takeaway: Lamination is the premium, durable choice for covers, menus, and cards. Soft-touch BOPP can even take foil, spot UV, and embossing on top without losing its feel — useful for stacking premium effects.

6. Foil stamping (hot foil)

Foil stamping uses no ink at all. A heated metal **die** (a custom-shaped stamp) presses a roll of metallic or colored **foil** against the stock; wherever the die touches, the foil transfers and sticks. The result is shiny gold, silver, or colored detail.

The die metal you choose is a real cost-and-quality tradeoff:

Die metal	Cost	Best for
Magnesium	Cheapest (acid-etched)	Short runs, small areas, smooth paper
Copper	Mid	Larger areas, textured paper, longer runs, finer detail
Brass	Most expensive (hand-sculpted / CNC)	Very long runs, sculptured work, and combination foil + emboss

Foils come in metallic (gold/silver/copper), solid pigment colors, holographic, and clear/matte. There is also **digital foil** (a toner-based "sleeking" process) that needs no die — economical for short runs.

Best practice: Design foil areas as solid black art on their own layer — solid black grabs foil most fully and cleanly. And foil needs heat: thermal/digital foil generally needs a die temperature of at least about **300°F** to transfer properly.

Common mistake: Quoting a custom foil die for a tiny order. The die is a one-time tooling cost; on a 50-piece run it can cost more than the rest of the job. For short runs, push customers toward digital foil instead.

7. Embossing & debossing

- **Embossing** — pushing an image so it rises *above* the surface (raised).
- **Debossing** — pressing an image *into* the surface (sunken).

Both use the same idea: **two matching dies** — a raised "male" die and a recessed "female" counter-die — that fit together with the paper squeezed between them under heat and pressure, permanently deforming the stock.

Variations:

- **Blind emboss/deboss** — no ink, no foil; just the raised or sunken texture. Subtle and tactile.
- **Combination ("combo") die** — emboss *and* foil in one strike (foil sits on the raised shape). Brass dies are standard for this.
- **Multi-level / sculptured emboss** — several depths in one die for dimensional artwork (logos, seals).

Analogy: An embossed logo on a wedding invitation is like the raised seal on an official certificate — you can feel it with your fingertips. A debossed logo is like the pressed-in lettering on a leather notebook cover.

8. Die-cutting — custom shapes

Die-cutting cuts paper or board into non-rectangular, custom shapes. The classic tool is a **steel-rule die**: sharp steel blades bent into the desired outline and mounted in a plywood base, pressed down to cut. Used for custom-shaped cards, hang tags, pocket folders, window cut-outs, and packaging cartons.

The blueprint for all of this is the **dieline** — a flat, unfolded vector drawing that tells the machine exactly where to **cut**, where to **crease/fold**, and where to **glue**.

Two cut depths to know:

- **Kiss-cut** — cut only the top layer, leaving the backing intact (how stickers peel off their sheet).

- **Through-cut** — cut all the way through every layer.

For short runs or prototypes where a steel die isn't worth it, shops use **digital cutting tables** (brand names: **Kongsberg**, **Zünd**, Roland) that read a dieline and drive a knife along the path — no physical die required.

9. Other finishing operations

Operation	What it does	Used on
Perforation (perf)	A line of tiny cuts so a section tears off cleanly	Tickets, coupons, tear-off reply cards, NCR books
Drilling	Precise round holes punched with a rotating hollow bit (handles thick lifts)	3-ring binder pages, hang tags
Padding	Gluing one edge of a stack with flexible compound so sheets tear off one at a time	Notepads, scratch pads, carbonless pads
Corner rounding	Trimming sharp 90° corners to a smooth radius	Business cards, loyalty cards, booklets
Sequential numbering	Printing incrementing numbers on each piece	Tickets, invoices, raffle books
Edge painting / gilding	Coloring or gold-leafing the stacked page edges	Luxury cards, premium books

Perforation strength

Perfs are specified by **TPI** ("teeth/ties per inch") — how many uncut bridges hold the tear line together per inch:

- **3–6 TPI** = easy release (tears off with a light pull).
- **10–18 TPI** = stiff, secure release (holds firmly, needs a deliberate tear).

> **Example:** A raffle ticket wants an *easy* 3–6 TPI perf so it pops off in a customer's hand. A check-stub or a document page that must not fall out accidentally wants a *secure* 10–18 TPI perf.

10. Binding methods — the big comparison

Binding joins many pages into one product. Choosing the wrong method is one of the most expensive mistakes, because each method has hard limits on page count and behavior. Here are the main ones.

Saddle stitch

Folded sheets are nested inside each other and **wire staples** are driven through the center fold (the "saddle"). The folded crease is the spine.

- **Page count must be a multiple of 4**; practical range ~8–64 pages (some shops up to ~80). Best at 16–48.
- Cheapest, fastest, lies flat when open. But there's no flat spine to print a title on, and it can't go thick.
- Uses: thin booklets, magazines, programs, comics, small catalogs.

Common mistake — "creep": As nested sheets stack up, the inner pages stick out farther than the outer ones (also called *shingling* or *push-out*). When the book is trimmed flush, those inner pages lose width and their content shifts toward the spine. Designers must apply **creep compensation** — shifting inner-page margins outward — or inner content gets trimmed off and cross-spine images break. Your imposition logic must do this automatically based on page count and stock thickness.

Perfect binding

Pages are gathered into a block, the spine edge is **ground and roughened** so glue grabs it, a wrap-around (usually soft) cover is glued on, and the book is trimmed flush on three sides — giving a flat, printable spine.

- **Needs about 80+ pages** (the spine needs thickness for the glue to hold); no real upper limit.
- Standard glue is **EVA** (hot-melt) — cheap, but can get brittle and crack in cold or with heavy use.
- Uses: paperback books, thick catalogs, annual reports, manuals.

PUR binding (the upgrade)

Same process as perfect binding, but with **PUR** (polyurethane-reactive) glue, which chemically cures into a far stronger, more flexible bond than EVA.

- Opens wider and flatter without cracking the spine; survives heat, cold, and heavy use; needs *less* glue (thinner spine); bonds tricky coated and heavy stocks where EVA fails.
- Downside: costs a bit more and needs cure time (full strength hours later).
- Uses: high-quality softcover books, cookbooks, premium and coated-stock catalogs.

Wire-O / coil / comb (mechanical binding)

Pages are punched with a row of holes and a metal or plastic element threads through them. These all **lie perfectly flat and fold all the way back** on themselves.

- **Wire-O** — double-loop metal wire; premium metallic look; folds back 360°.
- **Coil / spiral** — a single plastic or metal coil; durable and drop-resistant; huge color range; casual look.
- **Comb** — a plastic comb (cheapest); can be re-opened to edit pages; doesn't lie quite as flat.
- Uses: workbooks, manuals, cookbooks, calendars, notebooks, presentations.

Case binding (hardcover)

Signatures are sewn (often **Smyth-sewn**) or glued into a **book block**, trimmed, then attached with **endpapers** to a rigid **case** (board covered in cloth, paper, or leatherette), usually with a foil-stamped title and sometimes a dust jacket. The most durable and premium binding, with the widest cover-decoration options.

- Uses: hardcover books, photo books, yearbooks, archival editions.

The comparison table

Method	How joined	Page range	Lies flat?	Printable spine?	Best for
Saddle stitch	Staples through fold	8–64 (×4)	Yes	No	Thin booklets, magazines
Perfect bind (EVA)	Glued spine	80+	Not fully	Yes	Paperbacks, catalogs
PUR bind	PUR glue spine	80+	Wider/flatter	Yes	Premium & coated-stock books
Wire-O / coil / comb	Element through holes	Wide	Yes, folds back	No	Manuals, calendars, workbooks
Case (hardcover)	Sewn block + rigid case	Wide	Varies	Yes	Hardcover & archival books

Other niche methods you may encounter: **side-stitch** (staples through the side for thick stacks that won't saddle-stitch — doesn't lie flat), and **layflat / Smyth-sewn layflat** binding so wedding and photo-book spreads open completely flat.

Common mistakes in binding: picking saddle stitch for a too-thick book (staples can't reach, it won't close flat); picking perfect bind for a too-thin book (under ~80 pages the spine won't glue); using cheap EVA on a heavy-use or coated job that really needed PUR, so spines crack and pages fall out.

Key takeaway: Binding choice is driven first by page count and second by use. Validate it: saddle stitch needs pages divisible by 4 and ≤ ~64; perfect and PUR need ≥ ~80; anything that must lie flat for daily use wants wire-o or coil.

11. Which finishing fits which product

Product	Typical finishing
Business cards	Cut, optional corner-round, laminate or coat, optional spot UV / foil
Postcards / flyers	Cut, optional AQ or UV coat
Brochures	Score/crease + fold (tri, z, gate…)
Thin booklets (≤64 pp)	Saddle stitch
Books / thick catalogs (80+ pp)	Perfect bind or PUR
Hardcover books	Case binding
Manuals / workbooks / calendars (must lay flat)	Wire-O or coil
Notepads	Padding
Tickets / coupons	Perforation + sequential numbering
Binder inserts	Drilling (3-hole)
Custom shapes / packaging	Die-cutting from a dieline

12. How finishing shapes your print software

Finishing is where the craft turns into *data and validation rules* your platform must model. The big ones:

- **Dielines as named spot colors.** For die-cut and folded products, the cut and fold lines must be vectors on their own layer, drawn as *named spot colors* — the industry convention is cut lines = Magenta, fold/crease lines = Cyan, each given an explicit spot-color name (e.g. "CutContour", "Crease"). The prepress system (RIP) reads those *names* as production instructions. If they're left as ordinary process colors, they get printed as artwork instead of routed to the cutter — a real, common failure. Your design studio must export these as separate named spot layers, never flattened into the CMYK image.
- **Every special finish gets its own mask layer.** Foil, spot UV, and emboss areas must each live on a separate named layer (a 1-bit mask where "filled = apply this finish"). Never bake them into the color channels.
- **Auto-generate bleed, safe zone, and fold guides.** The editor should enforce ~3 mm bleed and a 3–5 mm safe margin (more near folds and glue flaps), draw fold guides, and run a **preflight** that flags content in the safe zone, missing bleed, low-resolution images (under 300 dpi), non-CMYK color, un-outlined fonts, and open (non-closed) dielines — all before the order is accepted.
- **Creep compensation in imposition.** For saddle-stitched booklets, the layout engine must shift inner-page margins automatically based on page count and stock thickness.

- **Finishing options = priced add-ons with constraints.** Lamination type, spot UV, foil color, corner rounding, binding method, drilling, and numbering ranges are option-driven price rules. Critically, they carry *validation*: binding type must check page count (saddle ≤ ~64 and ×4; perfect/PUR ≥ ~80); a fold above the gsm thresholds should auto-require a crease; foil and emboss should add a one-time **tooling/die charge** (model it as a separate one-time line item, not per-unit) and may set a minimum order quantity.
- **Finishes affect the 3D/mockup preview.** Soft-touch and matte vs gloss change the material shader; fold lines and binding type change the rendered shape.

Best practice summary: 3 mm bleed all sides; 3–5 mm safe margin; CMYK; 300+ dpi; fonts outlined. Match grain to fold and crease (not just score) for coated >216 gsm and all toner stock. Validate binding against page count. Prefer PUR over EVA for longevity and coated stock. Put every special finish on its own named spot-color layer. Order foils as solid-black art and ensure die temperature ≥300°F. Apply creep compensation for nested booklets. Treat dies as one-time tooling cost and route short runs to digital cut/foil.

Key takeaway: Finishing is where most print jobs are won or lost. For a software builder, mastering it means three things in your platform: **named-spot-color dielines and finish masks**, **preflight gates** (bleed, safe zone, dpi, color, closed dieline), and **option rules that price *and* validate** each finishing choice — especially binding-vs-page-count and crease-vs-stock-weight.

Print Shop Operations — Workflow, Imposition, Batching & Turnaround

You can model a beautiful product, take a clean order, and capture a perfect file — and still ship late or lose money. Why? Because between "order placed" and "box on the truck" sits a real factory: machines that cost a fortune to switch between jobs, files that need fixing, customers who have to sign off, and a clock that is always ticking. This chapter teaches how a print shop actually runs a day of work, and — just as important — **what your software has to model so the shop floor and the customer both see the truth.**

We will start with the big picture (the path every job walks), then zoom into each station, then end with the statuses your production system must track. By the end you should be able to look at any order and say: "It is here, waiting on that, and it will be done then" — which is exactly what a non-technical shop owner needs from your product.

1. The production spine — what a shop does in a day

Every shop, no matter the printing method, walks each job down the same path. Memorize this — it is the backbone (the "spine") that your software statuses will mirror.

```
ORDER     FILE      PROOF &    PREPRESS    SCHEDULE   MAKE-
INTAKE -> CHECK  -> APPROVE -> & IMPOSE -> ON PRESS -> READY ->
(specs)  (preflight) (GATE)   (gang/nest)  (queue)   (setup)

 PRINT -> FINISHING ->  QC   -> PACK / SHIP -> INVOICE
(press) (fold/bind/cut)(check)  (or pickup)   (bill)
```

Two key ideas before we go deeper:

- **A shop is a queue-management problem.** Many small jobs — different papers, sizes, colors, deadlines — all compete for a few expensive machines. The skill is *sequencing* them so the shop wastes the least setup time and still hits promised dates.
- **Two tracks run in parallel all day.** The **prepress queue** is digital file work — it can be batched and reordered freely because it is just software and screens. The **press/production schedule** is physical machines — switching jobs is slow and costly, so this track is rigid and is the one everything is scheduled around.

> **Analogy:** Think of a restaurant. Prep work (chopping, marinating) is the prepress queue — you can do it in any order, ahead of time. The single hot grill is the press — only one steak fits at once, switching from fish to steak means scrubbing it down, so the line cook sequences orders to avoid constant cleaning. A print shop is the same kitchen with paper instead of food.

Key takeaway: The press is the **bottleneck** — the slowest, most expensive resource that everything else waits on. Build your scheduling thinking around press availability, not around when the order arrived.

2. The job ticket (work order, docket, "job bag", traveler)

A **job ticket** is the single record that carries *all* the specs for one job and travels with it through the whole shop. Historically it was a literal printed envelope or folder — the "job bag" — with the artwork, proofs, and an instruction sheet tucked inside, physically walked from station to station. Today it is a database record, often with a **barcode** the operator scans at each station to update status and log how long the work took.

The ticket is the single source of truth. Every field on it maps to a decision a press operator or bindery worker must make. **A missing field = a phone call back to the customer = a stalled job.**

Ticket field	Plain meaning	Decision it drives
Customer & due date	Who, and when it must be ready	Scheduling priority
Quantity	How many ordered	Run length, digital vs offset
Flat size + finished size	Size before folding vs after folding/trimming	Imposition, finishing
Stock	Paper type & weight (e.g. 16pt gloss cover)	What loads on the press
Ink / colors	e.g. `4/4` or `4/0` + any spot colors	Plates, ink units, wash-up
Coating / finish	Gloss, matte, soft-touch, none	Extra press unit or pass
Finishing ops	Fold, score, perf, bind, laminate, die-cut	Bindery routing
Bleed / trim marks	Print past the cut line + where to cut	Imposition, cutting
Proof requirement	Does the customer sign off first?	Whether to wait at the gate
Shipping / pickup	How it leaves	Pack & logistics

The ink-count shorthand you must model

Printers describe color with a "front/back" notation. The number is how many ink colors print on each side.

Notation	Means
`4/4`	Full color (CMYK) on both front and back
`4/0`	Full color front, blank back
`4/1`	Full color front, single (usually black) ink back
`1/0`	One ink (e.g. black) front, blank back
`PMS 185 + black`	One spot color (a pre-mixed exact ink) plus black

CMYK = the four process inks (Cyan, Magenta, Yellow, blacK) mixed to make most colors. A **spot color** / **PMS** (Pantone Matching System) ink is one specific pre-mixed color — used when a brand needs an exact, repeatable shade.

Common mistake (software): Modeling color as a simple boolean "color: yes/no". You must capture **front ink count, back ink count, and any named spot colors** separately — they drive plate counts, press setup, and price. A boolean throws away the information the shop floor actually needs.

Key takeaway: Make the job ticket a **first-class entity** in your data model with real print fields (flat vs finished size, stock, front/back ink counts + spots, coating, finishing list, bleed, proof flag). Everything downstream reads from it.

3. Prepress and the preflight queue

Prepress means everything that happens to a file before ink touches paper: fixing the file, converting colors, handling fonts, checking resolution, laying it out on the sheet (imposition), and making the proof.

The first step is **preflight** — an automated inspection of the customer's file, like a pre-flight checklist on an aircraft. The system scans the file against a set of rules; files that **pass** flow forward automatically, files that **fail** get flagged for a human to fix or to bounce back to the customer. The flagged-file pile is where shops stall, so this is a place to invest in good software.

Preflight check	Standard	Why it matters
Image resolution	~300 DPI at final size (below ~200 flagged; 72 = fail)	Low-res prints pixelated/blurry
Bleed	0.125" (1/8", ~3mm) past the trim	Prevents white slivers after cutting
Color space	CMYK, not RGB	RGB shifts color on press — the #1 failure
Fonts	Embedded or outlined	Else press substitutes & text reflows
Marks & size	Trim/crop marks, correct dimensions/page count	Cutter and imposition need them

DPI (dots per inch) / **PPI** (pixels per inch) measures image detail. A photo that looks crisp on a screen at 72 DPI becomes a blocky mess when blown up to print at 300 DPI — screens are forgiving, paper is not. **Bleed** is artwork extended slightly past where the paper will be cut, so that small cutting wobble never reveals an unprinted white edge. The **safety margin** (keep important content ~0.125" *inside* the trim) is the opposite buffer — so nothing important gets sliced off.

Example: A customer uploads a 72-DPI logo and a background that stops exactly at the edge. Preflight flags both: the logo will pixelate, and with no bleed the cut may leave a hairline white border on one side. Caught at upload, it costs a 30-second email. Caught after a 5,000-piece run, it costs scrapping the whole run.

Best practice: Run **preflight at the front door** — inside your web-to-print upload step — so the customer fixes their own file *before* it ever enters the production queue. Tools that do this include Adobe Acrobat Preflight, Enfocus PitStop, Esko, and GlobalVision.

Key takeaway: Preflight turns a vague "the file is bad" into specific, fixable problems. Build pass-through vs flag-for-review paths, and push the check as early as possible.

4. Imposition — arranging work on the big sheet

Presses do not print one business card at a time on a tiny piece of paper. They print on a large sheet and you cut it apart later. **Imposition** is the art of arranging multiple pages or copies on that big sheet so that after printing, folding, and trimming, everything ends up the right size and in the right order.

Vocabulary you will hear:

- **N-up** — how many copies fit on one sheet. "8-up" means 8 copies (or pages) print in a single pass.
- **Signature** — one large sheet that folds down into a section of a book. Common book signatures are 8, 16, or 32 pages, which is why book page counts come in those multiples.

- **Step-and-repeat** — the *same* small item repeated many times across one sheet (business cards, labels, stickers) to maximize copies per sheet.
- **Gripper / gripper edge** — the leading edge the press mechanically grabs to pull the sheet through. About 0.375"–0.5" there is unprintable; imposition must leave it clear.
- **Grain direction** — the way paper fibers line up; it must be planned at imposition because it affects how cleanly the sheet folds (critical for booklets).

Sheetwise vs work-and-turn vs work-and-tumble

These describe how you print the back of a sheet. They matter because the right choice can roughly **halve** the sheets you have to print.

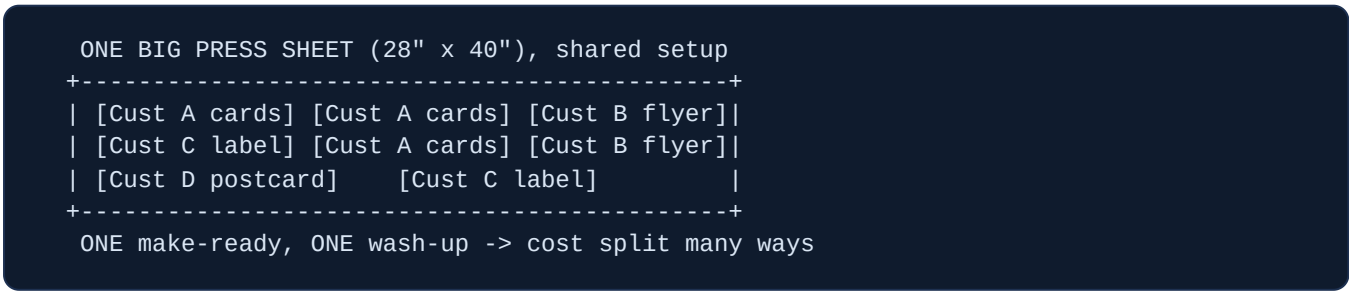
Method	How the back gets printed	Trade-off
Sheetwise	Two separate plates/forms — print fronts, flip, print backs from the second set	Simplest; uses two plate sets, full sheet count
Work-and-turn	Front and back of the SAME job on one plate; sheet flips left-to-right, same gripper edge	One plate set, ~50% fewer sheets; needs a bigger press
Work-and-tumble (work-and-flop)	Like work-and-turn but sheet flips top-to-bottom, using a DIFFERENT gripper edge	Registration is harder; used only when work-and-turn won't fit

Registration = how precisely the front lines up with the back (and color to color). Because work-and-tumble uses a different gripper edge for the second pass, the alignment is touchier — so shops prefer work-and-turn whenever the sheet size allows.

> **Key takeaway:** Imposition is where "what the customer designed" becomes "what the press actually prints." Your software does not have to do imposition, but it must hand prepress clean flat/finished sizes, bleed, and page counts so imposition is even possible.

5. Gang runs and batching — the core cost lever

Here is the single biggest money idea in commercial print. A **gang run** combines *multiple different customers' jobs* onto one big press sheet so they share the expensive one-time setup. (That is different from step-and-repeat, which repeats one job.) A **combination run** is the same trick but for one customer's related items — say a brochure, matching business card, and letterhead ganged together.



Why it saves so much money: the fixed costs of a press run — making plates, setting up, the ~250 waste sheets of make-ready, the wash-up afterward — are the same whether you print 100 pieces or 10,000. Spread that fixed cost across a dozen different jobs and each one's share becomes tiny. This amortization is a major reason full-color printing got cheap.

Hard constraint: everything ganged together MUST share the same **paper stock**, the same **ink set** (usually 4-color CMYK), and ideally the same **coating** and run length. You cannot gang a thick gloss cover job with a thin uncoated text job. *This rule is exactly why shops batch work by stock + color.*

Standard sheet-fed offset sheet	Size
Full sheet	28" × 40"
Half sheet	28" × 19" (also 20" × 26")
Quarter sheet	13" × 19"

Good gang candidates are high-volume, standard-size, 4/4 CMYK products: business cards, flyers, postcards, door hangers, simple brochures. But ganging has real downsides:

- **Color compromise.** One ink balance must serve every job on the sheet. A job needing a deep rich blue can suffer next to one needing soft skin tones, and heavy solid ink areas can cause **ghosting** (a faint unwanted image) on a neighbor.
- **No custom quantities.** You get the gang's fixed run length — which is exactly why brokers sell tiered quantities like "100 / 250 / 500", not "327".
- **Reprint penalty.** Re-running one job means re-running all its sheet-mates too (wasteful), so gang shops fold reprints into the *next* gang — which adds turnaround time.
- **Regulatory limits.** The FDA prohibits gang-running pharmaceutical labels unless clearly differentiated, for traceability — a real constraint for regulated print.

Example (the broker model): Wholesale "trade printers" like 4over gang thousands of orders from many resellers every day on fixed daily cut-off schedules. A reseller who misses today's 2pm cut-off rides tomorrow's gang. The customer trades scheduling flexibility for a very low price — a deliberate business model your software's "held for gang" status can support.

Key takeaway: If you support ganging, your software needs **batching metadata**: which jobs can share a sheet (same stock + ink + coating), a "Held for Gang/Batch" status, and reprint-links back to the original job.

6. Nesting — ganging's wide-format cousin

Wide-format printing (banners, vinyl, fabric, posters) prints on a long **roll** of media instead of cut sheets. **Nesting** is the roll's version of imposition/ganging: arranging multiple graphics efficiently across the roll's width to waste as little material as possible.

> **Example:** You have a 36"-wide roll and three 8"×10" files. Rotate each so it is 10" tall and 8" wide, then place all three side-by-side across the roll. All three print in only about 8" of roll length instead of 30" — a big saving in expensive media and ink.

Nesting is handled in the **RIP** — the **Raster Image Processor**, the software that turns a design into the exact dots the wide-format printer fires, and that also controls layout, tiling (splitting an oversized graphic across panels), true-shape nesting (fitting irregular shapes together), and cut paths for the cutter. Smart/auto-nesting (now often AI-driven) can cut media and ink waste by up to about 50%. Major RIPs include Onyx (Thrive/RIPCenter), Caldera, ErgoSoft, Flexi, ColorGATE, CADlink, and AcroRIP (for DTF).

> **Key takeaway:** Sheet jobs get **imposed/ganged**; roll jobs get **nested in the RIP**. Same goal — pack the surface, waste nothing — different machine and different software.

7. Press scheduling and make-ready

Make-ready is all the non-printing setup before the first good sheet comes off: mounting plates, loading the stock, mixing and loading ink, getting registration right, "coloring up", and running roughly 250 waste sheets until color and alignment are correct. It is largely a **fixed cost** — the same whether the run is 100 or 50,000 — which is precisely why short runs feel expensive and why ganging/batching pays off.

A **changeover** is the cost the scheduler fights: the time and waste of switching the press from one job to the next. The whole scheduling craft is sequencing jobs to minimize changeovers:

- **Group by same stock** — so you do not reload and recalibrate paper between every job.
- **Group by same/similar ink** — so you avoid a full wash-up; run all jobs sharing a spot color together.
- **Sequence ink light→dark** when sharing an ink unit, so cleaning between is minimal.

Digital vs offset — which queue a job belongs in

	Offset	Digital (toner/inkjet)
Make-ready / plates	High (plates + ~250 waste sheets)	Little or none, no plates
Per-unit cost	Very cheap at high volume	Flat — same per piece
Best for	Long runs, gang runs	Short runs, variable data, fast turnaround
Setup speed	Slow	Fast

Best practice: Route jobs by run length — short or personalized work to **digital**, long or gangable work to **offset**. Your pricing and scheduling logic should know which path a job is on, because it changes both cost and turnaround.

Key takeaway: Make-ready is the fixed cost that dominates short runs. Batching by stock + ink + finishing is how a shop protects its margin — and your scheduler should encourage, not fight, that grouping.

8. Turnaround and lead time — standard vs rush

Turnaround time (lead time) is the number of business days from **approved files to the job being ready/shipped**. Read that carefully: the clock typically starts at *proof approval*, not at order placement. This one detail causes more broken promises than almost anything else.

Product	Standard turnaround	Rush
Digital short-run (cards, flyers)	~1–4 business days	Same-day / next-day common
Offset commercial (brochures, multi-color)	~3–10 business days (up to 2–3 weeks with special finishing)	Available with surcharge
Books / heavy offset (binding, foil, emboss)	~8–12 weeks standard (10–15 with intricate finishing)	~3–6 weeks, surcharge
Wide-format	~1–3 business days	Same-day available

What drives lead time: finishing complexity (binding, foil, die-cut), color and page count, stock availability, current shop backlog — and crucially, **how fast the customer approves the proof**. A customer who sits on a proof for three days pushes the entire schedule back three days, through no fault of the shop.

Rush orders jump the queue. They may demand dedicated make-ready, overtime, or express shipping, so they carry a **rush surcharge** and an explicit faster service-level promise (SLA).

Common mistake (software): Starting the turnaround clock at order time. If the customer takes four days to approve the proof, a "3-day turnaround" promise is already broken before production even starts. **Start the production clock at proof approval, and pause the SLA while you are waiting on the customer.**

Key takeaway: Communicate realistic, product-specific turnaround measured *from approval*, and model rush as its own SLA + surcharge tier.

9. Proof approval — the hard stop

A **proof** is a preview of the final job the customer signs off on before anything goes to press. There are three kinds, increasing in accuracy and cost:

Proof type	What it is	Color accuracy / cost
Soft proof	Digital PDF / on-screen preview	Cheap; NOT color-accurate
Hard / contract proof	A calibrated printed sample — the legal color reference	Accurate; moderate cost
Press proof / press check	Customer/printer inspects the first good sheets on the actual press	Most accurate; most expensive

The **approval gate** is an absolute hard stop: nothing goes to plates or press until the customer signs off. Sign-off also shifts liability — once approved, the customer owns whatever was on that proof.

Common mistake: Trusting a soft proof for color. A monitor is RGB and backlit, so it physically cannot show exact CMYK ink-on-paper color. Set this expectation up front ("on-screen color is a guide, not a guarantee") to prevent disputes. For critical color, a hard proof is the contract.

Best practice (software): Build a self-service proof portal — the customer views the proof, annotates regions, and approves in one click; the system **timestamps and version-locks** the approved file. For identical reorders, offer **auto-approve / skip proofing** to save a whole cycle.

Key takeaway: Treat proof approval as a true gate that *starts the turnaround timer* and *pauses the SLA* while you wait on the customer. Support annotate-and-approve plus auto-approve for reorders.

10. Quality control (QC)

QC happens both during printing and after finishing.

- **At press (in-line):** check registration, read the **color bars** (small printed patches) with a **densitometer** or **spectrophotometer** (instruments that measure ink density/color), watch for dot gain, doubling, and slurring, and compare against the approved proof.
- **Post-press:** verify the correct finished size, fold accuracy, binding integrity, piece count, and inspect for defects before packing.

Overs and spoilage: shops deliberately run **overs** — a few percent extra sheets (often +5–10%) — to cover make-ready waste and pieces rejected at QC, so the customer still receives the full ordered quantity. This means **ordered quantity and run quantity are different numbers**, and your software must model both.

Common mistake: Running exactly the ordered quantity with no overs. After QC throws out a handful of defective pieces, you ship short — and now you owe a reprint of a tiny quantity, the most expensive kind of run.

Key takeaway: Model **ordered qty vs run qty (+ overs)** as separate fields. The customer is promised the ordered number; the floor plans for more.

11. The software layer — MIS, web-to-print, JDF

Three pieces of software tie the shop together. As a builder, you are usually building one of them and integrating with the others.

Print MIS

MIS = Management Information System — essentially a print-specific ERP. It owns estimating/quoting, order management, job tickets, scheduling, shop-floor data collection (barcode scans), inventory, costing, and invoicing. It understands print concepts a generic ERP does not — gang runs, dockets, imposition, decoration-method costing. Vendors: Tharstern, PrintVis, EFI (Pace/Monarch), Avanti, PressWise, ePace, Ordant, ShopVOX, Printavo.

Web-to-print (W2P)

The customer-facing storefront (the kind of product this guide is about). It takes the order, file, and specs online and pushes them straight into the MIS/production with no re-keying. Online order intake is "stage 1" of shop automation.

JDF / JMF / XJDF / PrintTalk

These are the standards that let different vendors' systems speak one common language.

Standard	What it carries	Used between
JDF (Job Definition Format)	An XML job ticket — both customer "intent" and machine "process"	End-to-end, all systems (maintained by CIP4)
JMF (Job Messaging Format)	Real-time messaging — commands + live status/tracking	MIS ↔ devices/presses
XJDF	The simplified, modern successor to JDF	The current direction
PrintTalk	An XML business wrapper (quote/order/PO) around a JDF product	Ecommerce/W2P ↔ MIS

CIP4 = the Cooperation for Integration of Processes in Prepress, Press, and Postpress — the body that maintains these standards. The point of JDF is that one digital ticket can flow from storefront to press to bindery without anyone re-typing the specs.

Hotfolders and barcode data collection

A **hotfolder** is a watched folder: drop the approved artwork in, and automation routes it straight to the RIP/press queue — no manual file transfer, which removes a classic bottleneck. **Barcode shop-floor data collection** means operators scan the job ticket at each station, giving live status plus automatic labor/time capture that feeds both scheduling and true job costing.

> **Key takeaway:** If you ever integrate real presses, plan for **W2P → MIS → RIP/press via JDF/JMF/PrintTalk + hotfolders**, with barcode scans for live status and costing. Even if you do not, design your order spec to map cleanly onto JDF "intent" so future integration is possible.

12. The job status state machine — the spine your software must model

Everything above collapses into one thing your product must get right: the list of statuses a job moves through. Here is a defensible state machine that mirrors what real MIS and W2P systems expose.

```
Order Received -> Awaiting Files -> In Preflight
       |                              |
       |                   [Preflight Failed] -> (wait on YOU)
       v                              v
Proof Ready / Awaiting Approval  <------+
       |  \--> Changes Requested --(loop back)
       v        (CLOCK STARTS at approval)
Approved -> In Prepress / Imposed / Scheduled
                    |  (or: Held for Gang/Batch)
                    v
In Production -> In Finishing -> In QC ->
Ready/Packed/Shipped -> Completed / Delivered

Cross-cutting: On Hold | Cancelled | Reprint(->original)
```

Status	What is happening
Order Received / Pending	Intake; payment may be pending
Awaiting Files / Files Received	Customer artwork in or expected
In Preflight (sub: Preflight Failed)	Automated file check; failure waits on customer
Proof Ready / Awaiting Approval	**Gate** — turnaround clock usually starts here
Changes Requested	Loop back to fix and re-proof
Approved / Ready for Production	Signed off, liability shifted
In Prepress / Imposed / Scheduled (or Held for Gang)	Assigned to a press & queued, or waiting for a batch
In Production / Printing	On the press
In Finishing / Bindery	Cut, fold, bind, laminate, die-cut
In QC	Quality check against the approved proof
Ready for Pickup / Packed / Shipped	Tracking number where relevant
Completed / Delivered	Done
On Hold / Cancelled / Reprint	Cross-cutting; Reprint links to the original job

Two design rules make this state machine genuinely useful:

- **Audit every transition.** Record *who, when, and which station* on each move (a barcode scan or a user action). This serves both customer transparency and shop costing/dispute resolution — and matches the audit-logging standard for business-critical actions.
- **Name the two "waiting on YOU" waits.** Jobs stall at exactly two customer-dependent points: (a) preflight failure waiting on a fixed file, and (b) proof waiting on approval. A good system surfaces these clearly as "waiting on you" *and pauses the SLA clock* so the shop is not blamed for the customer's delay.

Best practice (UX for non-technical owners): Expose a **simple customer-facing subset** — Received → Proof Ready → In Production → Shipped — in plain language, while keeping the richer shop-floor view for staff. The customer should never see "Imposed" or "Held for Gang"; they should see "We're getting your job ready to print."

Key takeaway: The status state machine *is* the production spine. Model it as a real, auditable workflow with the proof gate starting the clock, two SLA-pausing customer waits, a "held for gang" branch, and reprint links — and you have captured how a print shop actually runs a day.

13. The mistakes that cost real money — a checklist

Mistake	What goes wrong	The fix
No bleed / content in trim zone	White slivers after cutting; can scrap a whole run	Preflight bleed at upload
RGB left unconverted	Color shifts on press (#1 prepress failure)	Require/convert to CMYK; flag in preflight
Fonts not embedded	Substitution, reflowed text, broken layout	Embed or outline; preflight check
Low-res images (72 DPI)	Pixelated print at 300 DPI size	Resolution check at final size
Ganging incompatible jobs	Color complaints, ghosting	Batch only same stock/ink/coating
Clock starts at order, not approval	Broken delivery promises	Start timer at proof approval; pause on customer waits
Under-running (no overs)	Short shipment after QC rejects	Model and run overs (+5–10%)
Manual file handoffs	Lost files, wrong version to press	Hotfolder → RIP automation
No batching discipline	Constant changeovers eat short-run margin	Sequence by stock, then ink light→dark

Chapter takeaway: A print shop is a queue of competing jobs flowing down one fixed spine — intake, preflight, proof gate, imposition/ganging, scheduled press, finishing, QC, ship. Money is made or lost at three levers: **preflight early** (don't let bad files into the queue), **batch/gang by stock + ink** (amortize make-ready), and **start turnaround at proof approval** (don't promise time the customer is spending). Model all of it as an auditable status state machine, and your software tells everyone — owner and customer alike — the one thing they need: where the job is, what it's waiting on, and when it will be done.

Print Shop Economics — Costing, Make-Ready, Margins & Quoting

Up to now you have learned how ink lands on paper. This chapter is about how a print shop turns that craft into a business that survives. As a software builder, this is the chapter where the physical world meets your code: every quote your app produces, every "price break" table, every order total, is really a small piece of accounting. If you understand the money model, your quoting engine will produce numbers a real shop owner can trust. If you do not, your app will confidently hand customers prices that quietly lose the shop money — the worst possible bug, because nobody sees it until the accountant does.

We will start with the single big idea that explains almost everything about print pricing, then build up the full cost stack, the margin math people get wrong, the offset-vs-digital decision, and finally the pricing models your software has to support.

The one idea that explains everything: high fixed cost, low variable cost

Before any definitions, here is the engine behind print pricing. Printing — especially traditional offset printing — is a **high fixed cost, low variable cost** business. You spend a lot of money *before* the first good copy comes off the press (the machine, the plates, the setup), and then each additional copy costs almost nothing.

Two quick plain-English definitions so the rest of the chapter makes sense:

- **Fixed cost:** money you spend that does *not* change with how many pieces you print. Whether you print 50 flyers or 5,000, this cost is the same.
- **Variable cost:** money that scales *with* the number of pieces. Print twice as many, pay roughly twice as much of this.

> **Analogy:** Think of baking a cake to sell slices. Buying the oven and turning it on is a fixed cost — it costs the same whether you bake one cake or ten. The flour and eggs are variable — more cakes, more ingredients. A print shop is an extreme version: the "oven" (press + plates + setup) is hugely expensive, but the "flour" (ink on one more sheet) costs almost nothing. So the cost per slice plummets the more slices you sell.

This is why a small order feels "expensive per piece," why shops set minimum order charges, and why every real print price list shows the per-unit price *dropping* as quantity goes up. It is not a sales gimmick — it is the math of spreading a big fixed cost over more pieces.

> **Key takeaway:** A print job is mostly a big one-time setup cost plus a tiny per-piece cost. Almost every "weird" thing about print pricing — quantity discounts, minimum orders, offset vs digital — falls out of that single fact.

The three cost buckets: fixed, variable, and per-job setup

In practice, shop costs fall into three buckets, not two. The third one — the per-job setup cost — is the most important for your software to model correctly.

Bucket	Plain meaning	Examples	Changes with quantity?
Fixed / overhead	Cost of being open at all	Rent, equipment loan/lease, equipment depreciation, salaries, insurance, software subscriptions, base utilities	No — same every month
Per-job setup (semi-fixed)	One-time work to get ready for *this specific job*	Make-ready, plate creation, screen burning, file/RIP prep, digitizing artwork	No — paid once per job, then spread over the run
Variable / per-piece	Cost of each additional copy	Paper/substrate, ink/toner, blank garments, plates' worth of stock, click charges, run labor, packaging, shipping	Yes — scales with how many you print

The per-job setup bucket is the one that gets **amortized** — spread out — across the run. Hold onto that word; it is the heart of quantity pricing and the next section.

Example: A shop pays $4,000/month rent (fixed), spends $700 making plates for your business-card job (per-job setup), and spends about one cent of paper and ink per card (variable). If you order 500 cards, that $700 setup is spread over only 500 pieces. If you order 50,000, the *same* $700 is spread over 50,000 pieces. Same job, wildly different per-card cost.

Common mistake: In software, lumping setup cost into the per-piece price. If your calculator treats the $700 plate cost as "$1.40 per card" and then multiplies by quantity, a 5,000-card order is charged $7,000 in setup instead of $700. Setup must be a *flat per-job* line that you divide by quantity — never a per-unit rate you multiply.

What a machine really costs per hour: depreciation and the Budgeted Hourly Rate

A serious shop does not guess its costs. It calculates a **Budgeted Hourly Rate (BHR)** for each machine — the all-in cost, in dollars, of running that machine for one hour with every expense accounted for. The official definition from the industry: BHRs "distribute 100% of an organization's expenses across each piece of production equipment so all costs are fully absorbed in estimates."

In plain words: take *every* dollar the shop spends in a year, assign each dollar to the machine (or department) it belongs to, then divide by the hours that machine actually produces work. The result is the true cost per hour. Anything you charge above that hourly cost is profit.

What gets rolled into a BHR

- Wages **plus** benefits (payroll taxes, workers' comp, health insurance) — not just the hourly wage.
- Building/rent, leases, property taxes, insurance.
- **Equipment depreciation** (explained next).
- Repairs and maintenance.
- Utilities (often split by floor space each machine uses).
- Production and office supplies, sales expense, general admin.

Depreciation in plain English

Depreciation means spreading the cost of an expensive machine across the years you will use it, instead of pretending you spent it all in one month. The simplest method is **straight-line depreciation**:

```
Annual depreciation = (Cost - Salvage Value) / Useful Life

"Salvage value" = what the machine is worth when you're done with it
"Useful life"   = how many years you expect to use it
```

Example: A digital press costs $200,000 and you expect 5 years of useful life. Straight-line depreciation = $200,000 / 5 = **$40,000 per year**. If that press runs about 2,000 productive hours a year, the depreciation alone is about **$20/hour**. Then you layer in labor, rent share, utilities, and supplies for that machine to reach its full BHR — often several times that $20.

The productivity factor — do not divide by all the clock hours

A machine is not productive every hour it is plugged in. There is maintenance, cleaning, idle time, and waiting for jobs. Shops multiply available hours by a **productivity factor** (a target of around 85% is common) to get the real productive hours, then divide costs by *that*.

```
BHR = (all annual costs assigned to a machine)
      ------------------------------------------
      (available hours  x  ~85% productivity factor)
```

Common mistake: Dividing yearly cost by every clock hour in the year. If you assume the press is busy 100% of the time, your hourly rate comes out too low, and every quote built on it quietly underprices the job. Always divide by *productive* hours, not calendar hours.

Key takeaway: A shop's real cost to run a machine for an hour (its BHR) includes wages-plus-benefits, rent, utilities, supplies, and depreciation — divided by the hours it actually produces work. Quote on materials and wages alone and you never recover the rent or the press loan. In software, the BHR is the number your run-labor line should multiply against.

Make-ready: the cost that makes unit price drop with quantity

Make-ready (also called setup) is all the one-time work to get a press ready for a specific job before any sellable copies come out: mounting plates, getting color registered, balancing ink and water, loading the right stock, and running test sheets until the output is correct.

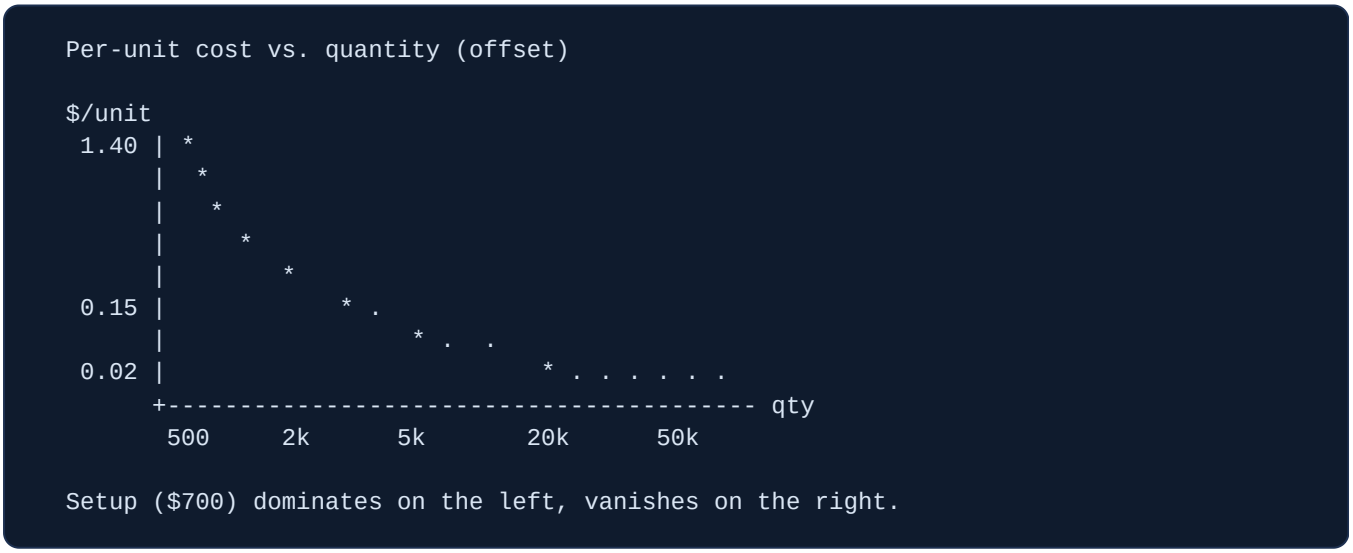
For offset, make-ready typically eats **2–4 hours of press time and roughly $500** in labor and materials — *on top of* the plates. And plates are not cheap: an offset plate set runs about **$300–$800**, averaging around $700. A full-color (CMYK) job needs four plates, one per ink.

Amortization, shown with real numbers

Amortization is just "spreading a one-time cost across all the pieces in the run." Per-unit setup cost = total setup ÷ quantity. Watch what happens to a $700 plate cost as the run grows:

Quantity	Setup spread per piece ($700 ÷ qty)	Variable (paper + ink) per piece	Total cost per piece
500	$1.40	~$0.01	**~$1.41**
5,000	$0.14	~$0.01	**~$0.15**
50,000	$0.014	~$0.01	**~$0.024**

Same product. The variable cost barely moves, but the setup-per-piece collapses, so the total per-piece cost drops about **60×** from the small run to the big run. That is exactly why a real price list shows **quantity breaks** — discrete bands where the per-unit price steps down. Industry behavior: offset discounts typically kick in around 5,000 units and get dramatic by 50,000, where per-unit cost can fall 30–40%.



Key takeaway: Quantity discounts are not marketing generosity — they are the arithmetic of amortizing a fixed setup cost over more pieces. Your quoting engine should compute per-piece price as `(setup / qty) + variable_per_piece`, then apply margin. That single formula produces correct, falling unit prices automatically.

The variable costs: materials, click charges, ink, and labor

Materials are usually the biggest single cost

Paper, substrate, or blank garments are typically **40–50% of total job cost** — the single largest line on most jobs. Substrate prices move with the market, so a quote built on last year's paper cost can be wrong by the time it is accepted.

Digital "click charges" — flat per copy

A **click charge** is how digital presses bill: a flat cost for every sheet/impression printed (a "click"), covering toner or ink plus the maintenance contract. The crucial feature: the click charge is *flat per piece* and does **not** drop with quantity. Illustrative click charges run roughly **$0.11–$0.22+** per impression.

	Offset	Digital
Upfront setup	High (plates + make-ready, ~$700+)	Near zero (no plates)
Cost per copy	Very low (~$0.002–$0.01/impression)	Flat click charge (~$0.11–$0.22)
Unit price as qty rises	Falls sharply (setup amortizes away)	Stays flat (no economy of scale on the click)

Analogy: Offset is like buying a bulk membership — a steep entry fee, then near-free per item. Digital is pay-as-you-go — no entry fee, but you pay the same per item forever. For a few items, pay-as-you-go wins. For a warehouse-load, the membership wins. (We turn this into break-even math below.)

Labor across the whole chain

Labor is not just the press operator. It spans file/art prep, plate or screen making, make-ready, the run, finishing/bindery (cutting, folding, binding), cleanup, and packing. Always cost **loaded labor** — wages plus benefits plus the operator's share of overhead — which is exactly what the BHR already captures.

Waste, spoilage, and overs — the materials you pay for but cannot sell

Here is a hard truth that catches new shops: you must *buy and charge for more material than the customer ordered*, because some of it gets ruined. The industry has precise words for this.

Term	Plain meaning	Typical amount
Make-ready waste	Sheets burned getting to the first good copy	~100 sheets for a simple 2-sided leaflet; 400 sheets typical; 500+ for tricky color
Running waste / spoilage	Bad sheets produced during the run itself	~7.5% average on sheet-fed jobs; range 1%–17.5%, outliers to 25%; falls as a % on very long runs
Overs / unders	Extra copies printed to guarantee the ordered count after spoilage	Often 1–2% extra ("overs"); trade custom allows delivering slightly over/under

Apparel shops apply a similar cushion: add roughly **15% on top of wholesale blank garments** to cover damaged or misprinted goods.

Common mistake: Quoting and ordering the *exact* customer quantity. If a customer orders 5,000 flyers and you buy exactly 5,000 sheets, the first ~400 sheets of make-ready plus running spoilage mean you deliver short — and reprinting eats your entire profit. Always pad materials by a waste/overage percentage in both your purchasing and your quote.

Key takeaway: Waste is not an accident to ignore — it is a planned, quantifiable cost. Your software should add a configurable waste/overage percentage to the materials line, and ideally let it vary by job complexity and run length.

How a quote is built up: the cost stack

A professional quote is a stack of cost elements, summed up, with overhead recovered and markup added. The dominant approach is **cost-plus pricing** — add up your true cost, then add a markup to reach your target profit.

Best practice: Itemize the quote so the customer sees setup, materials, finishing, and shipping as separate lines. A non-technical buyer who sees a $700 setup line instantly understands why 250 cards cost nearly as much as 1,000 — the setup is the same. Transparency justifies the price and heads off the "why so expensive?" argument.

Markup vs margin — the math people get wrong and lose money on

This is the single most important piece of arithmetic in the chapter, and it is the one shop owners and developers confuse most often. Both describe profit, but they measure it against different bases.

- **Markup** = profit measured against **cost**. `Markup% = (Price − Cost) / Cost`
- **Margin** = profit measured against the **selling price**. `Margin% = (Price − Cost) / Price`

Because cost is smaller than price, the markup percentage is always a *bigger* number than the margin percentage for the same job. They are never equal (except at zero).

If your markup is…	Your margin is actually…	What happened to a $10 cost
50%	**33.3%**	Price $15 — profit $5 is a third of $15
100%	**50%**	Price $20 (doubled) — profit $10 is half of $20
200%	**66.7%**	Price $30 — profit $20 is two-thirds of $30
300%	**75%**	Price $40 — profit $30 is three-quarters of $40

Common mistake: "I want a 50% margin, so I'll add 50% markup." Adding 50% to a $10 cost gives $15 — but $5 profit on a $15 sale is only a **33.3% margin**, not 50%. To actually get a 50% margin you must add **100% markup** (price $20). This off-by-a-denominator error silently underprices a shop on every single job and overstates how profitable they think they are. It is a leading cause of print shops slowly going broke while looking busy.

Industry norms, so your defaults are sane:

- **General print jobs:** roughly 200–400% markup, landing at 50–70% gross margin.
- **Screen printing / apparel:** commonly 30–50% markup; a stated rule of thumb is "mark up at least 50% over cost."

Key takeaway: Decide your target as a **margin** (it ties directly to profitability), then convert to the markup you need to apply. The conversion is `markup = margin / (1 − margin)`. In software, always compute and store margin server-side from the final price and true cost — never let a "50%" field be ambiguous, and never confuse the two in the calculator.

Offset vs digital: the break-even quantity, in dollars

The "membership vs pay-as-you-go" analogy becomes a concrete decision. Offset has high fixed cost and tiny per-piece cost; digital has near-zero fixed cost and a flat per-piece click. The **break-even quantity** is the run size where offset's falling per-unit cost finally drops below digital's flat per-unit cost.

```
Break-even Qty =        Offset Setup Cost
                 ---------------------------------------
                 (Digital per-unit  -  Offset per-unit)
```

Example: Setup (plates + make-ready) = $700. Digital click = $0.22/unit. Offset per-unit (paper+ink) = $0.11/unit.
Break-even = $700 / ($0.22 − $0.11) = $700 / $0.11 = **~6,364 units**.
Below ~6,364 copies, digital is cheaper (you skip the $700 setup). Above it, offset wins because the setup has been amortized away.

Run size	Usually cheaper	Why
Under ~500–1,000	Digital	No plates or make-ready to pay for
~1,000–3,000	It depends — run the math	The crossover zone; depends on setup cost and click rate
Over ~3,000–5,000	Offset	Setup spread thin; cheap per-impression cost dominates

You will hear rules of thumb like the "500-copy rule," but the honest answer is that the break-even depends on the actual setup cost and click rate. For standard CMYK work in 2026 the crossover is

often cited around 3,000–5,000 units (a median near ~4,200). The point is not the exact number — it is that your software should *calculate* the break-even from the shop's real inputs, not hard-code a habit.

Common mistake: Choosing the process by habit. Running 200 business cards on offset means paying for plates nobody needed; running 50,000 flyers on digital means paying a flat click charge forever when offset would have been a fraction of the cost. Wrong process = guaranteed money lost on otherwise good jobs.

Key takeaway: The offset-vs-digital choice is a break-even calculation, not a preference. A quoting engine that knows both cost structures can compute the cheaper process for any quantity and even show the customer the crossover quantity — a genuinely useful, trust-building feature.

Rush premiums and turnaround pricing

Time is a sellable variable. A tight deadline forces the shop into overtime labor, bumping or displacing other paying jobs, and dedicating press time — all real costs. Shops legitimately charge a **rush premium**, usually as a percentage surcharge or a higher press rate for expedited tiers (same-day, next-day).

Best practice: Model turnaround as an explicit pricing input alongside paper grade and complexity. A standard 5-day job, a 2-day rush, and a same-day rush should be selectable tiers, each with its own multiplier — so the premium is consistent and visible, not negotiated ad hoc.

Common pricing models your software must support

1. Per-piece / per-unit

A flat price each. Simple and transparent — common for digital short runs and business cards. Easy for customers to understand, but it hides the setup-vs-variable structure, so it works best where setup is small.

2. Tiered quantity breaks

The dominant model. Quantity is split into bands, each with a lower unit price than the last — this encodes setup amortization directly into the price list. Here is a real-shaped screen-printing table (price per shirt, one ink color):

Quantity band	Price per shirt (1 color)
1–12	$3.50
13–24	$2.50
25–48	$1.75
49–72	$1.25
73–144	$0.90

Around 50 shirts is often the "sweet spot" where unit cost drops roughly half versus the smallest band — the screen-burning setup is finally spread thin enough.

3. Square-foot (wide / large format)

For banners, signage, and posters, price = area in square feet × a rate per square foot. Typical rates run **$1.99–$8.99/sq ft**, with a market standard around **$8/sq ft** for digitally printed vinyl banners; budget vinyl can be ~$3/sq ft, and specialty or large unique materials $15.99+/sq ft.

> **Example:** A 6 ft × 3 ft banner = 18 sq ft. At the $8/sq ft market rate that is 18 × $8 = **$144**. At a $3/sq ft budget rate it is **$54**. Finishing (grommets, hemmed edges) and a design fee are usually added on top if no print-ready file is supplied.

4. Cost-plus / BHR-driven

The most rigorous: estimate from machine BHR × time + materials + waste, then add markup to hit the target margin. This is how print MIS (Management Information System) software and professional estimators work, and it is the model that produces the most defensible numbers.

> **Best practice:** Set a **minimum order charge** on every product so small jobs at least recover their setup. Without it, a 25-card order quoted purely per-piece can be sold below the cost of making the plates.

The classic margin killers (a checklist)

- **Confusing markup with margin** — systematically underpricing every job.
- **Forgetting waste/spoilage** — buying and charging the exact order quantity, then eating the ruined sheets.
- **Not amortizing setup** — a flat per-unit price that loses money on small runs and overcharges (and loses the bid on) large runs.
- **Ignoring overhead and depreciation** — quoting on materials and wages only, never recovering rent or the press loan.
- **Wrong process choice** — paying for plates on a tiny run, or a flat click forever on a huge run.

- **Manual quoting errors** — copy-paste slips, outdated substrate costs, mis-applied discounts.
- **Under-charging rush** and **bundling design into the print price for free.**

Why accurate quoting software matters (and what yours must do)

Manual quoting is slow and fragile. A careful manual quote takes **30–120 minutes**; a shop doing ten quotes a day can burn an entire shift on estimating. Worse, manual quotes carry stale paper costs and arithmetic slips that "wipe out margins or trigger reprints" — the shop wins the job but loses money on it. Print MIS and quoting tools report up to a **90% reduction in pricing errors** because they pull live rates and apply the rules consistently.

This is precisely where a print SaaS earns its keep. Translating everything above into concrete requirements for a price-calculator / quoting engine like Print-Flow-360:

- **Separate setup from per-unit cost** and amortize setup across quantity — store the one-time cost as a flat per-job value, divide by quantity, never multiply a "per-unit setup."
- **Support tiered quantity breaks and square-foot pricing** (wide format) as first-class pricing models, not bolted-on hacks.
- **Compute margin correctly server-side** — store target margin, derive markup, and never let the two be confused in the calculator. The same job must price identically in the admin tool and the storefront.
- **Bake in a waste/overage percentage** on materials, plus rush multipliers and finishing/option costs.
- **Pick or compare offset vs digital** from the shop's real setup and click costs, so the quote uses (and can show) the cheaper process at the chosen quantity.
- **Produce an itemized, transparent quote** — setup, materials, finishing, shipping — so a non-technical owner and their customer both understand the price.

Common mistake (software): Letting the admin calculator and the storefront calculator drift apart. If one amortizes setup and the other does not, or one uses markup where the other uses margin, the customer sees a price the shop cannot honor — a silent, profit-leaking bug. Keep the two engines in lockstep and prove it with tests on real quantities.

Key takeaway: Good quoting software does not just speed things up — it *enforces the economics of this chapter*: it amortizes setup, applies the correct margin, adds waste, prices the right process, and bills rush and finishing. That is the difference between a price the shop can live on and a confident number that quietly bleeds the business dry.

Supply Chain, Logistics & Fulfillment for Print

You can print the most beautiful brochure in the world, but the customer never sees it until it lands on their doorstep — intact, on time, and without a surprise bill at the door. This chapter is about that journey: how raw paper becomes a finished print, gets packed so it survives the trip, gets onto the right truck or plane, crosses borders without getting stuck, and arrives. We call this whole journey the **order-to-delivery spine**.

If you are building software for a print shop, this chapter also tells you exactly what your order system must *capture* — the weights, dimensions, carriers, and tracking numbers — so that the physical world and the database agree.

The two halves of the spine: inbound and outbound

Let's define the two big halves first, in plain words.

- **Inbound** = getting *raw materials* into the shop so production can happen. The main raw material in print is the **substrate** — the physical thing you print on (paper, cardstock, vinyl, fabric, rigid board). Inbound also covers ink, toner, and finishing supplies.
- **Outbound** = getting the *finished print* to the customer: packing it, picking a carrier, shipping, tracking, clearing customs if it crosses a border, and delivering.

> **Analogy:** Think of a restaurant. Inbound is the kitchen's grocery delivery — flour, vegetables, meat. Outbound is the waiter carrying the finished plate to the table. A print shop is a restaurant where almost everything is cooked to order: there is no shelf of finished meals waiting.

Why print is different from normal ecommerce

This is the single most important idea in the chapter. In a typical online store, the product already exists on a warehouse shelf as a finished item (a "SKU" — Stock Keeping Unit, a unique code for one sellable product). Fulfillment means *pick it, pack it, ship it*.

Print is **made-to-order**. The finished brochure does not exist until someone buys it. So:

- Your **inventory is raw material** (paper, ink), not finished goods.
- **Fulfillment overlaps with production** — "is it ready to ship?" depends on "is it printed yet?"
- The big risks shift to **inbound material availability** and **production lead time**, not warehouse picking.

> **Example:** A normal store with 200 mugs in a warehouse can ship in an hour. A print shop selling custom wedding invitations has zero finished invitations on the shelf — it has reams of paper. The order triggers printing, then cutting, then drying, then packing. "Fulfillment" cannot start until production finishes.

One more print quirk: the **physical range is enormous**. A single greeting card weighs about 10 grams and ships as a small parcel. A run of 50 boxes of brochures weighs over 100 pounds and ships on a wooden pallet by freight truck. *One software model has to handle both.*

> **Key takeaway:** In print, the warehouse holds raw paper, not finished products. The order is a production trigger first and a shipment second. Your software must treat "ready to ship" as the end of production, and must handle everything from a 10-gram card to a 120-pound pallet.

Inbound: sourcing materials & managing inventory

Production stalls the moment you run out of the right paper. Managing inbound material is about never being surprised by a stockout — while not drowning cash in a warehouse full of paper you don't need yet.

The core inventory terms

Term	Plain meaning
Lead time	How long from "I order this material" to "it's on my shelf." Days for common paper; weeks to months for specialty stock.
Safety stock	A buffer of extra material kept on hand to absorb surprises (a rush order, a late supplier).
Reorder point	The stock level that triggers "order more now." Hit it, and you reorder before you run dry.
Purchase Order (PO)	The formal document you send a supplier saying "I want this much of this material at this price."

The reorder point has a simple formula:

```
Reorder point = (avg daily usage x lead time in days) + safety stock

  Example: a shop uses 5 boxes of gloss cardstock/day,
  supplier lead time is 6 days, safety stock is 10 boxes.
  Reorder point = (5 x 6) + 10 = 40 boxes.
  When stock drops to 40 boxes -> issue a new PO.
```

Manual vs automated procurement

Procurement just means "the act of buying the materials." The old, manual loop looks like this:

```
spot low stock -> contact suppliers -> get quotes -> compare
   -> get approval -> issue PO -> wait for delivery
```

That is fine for standard paper (hours of work), but painful for specialty substrates or unusual quantities, which can take **days** just to source. Modern **automated procurement** reverses the flow: the production

floor reports how much material it consumed; the system forecasts demand; when stock hits the reorder point it *auto-generates a PO* to a pre-approved supplier. Vendors in this space (e.g. ERP systems and procurement platforms like GelatoConnect) report material-cost reductions in the range of **5–20%** when shops move from manual to automated sourcing, mostly from better timing and supplier comparison.

Best practice: Order specialty substrates **4–6 weeks ahead**. Standard house stock might restock in days, but a custom textured fine-art paper or an unusual size can be weeks to several months out. Never promise a customer a delivery date that ignores the substrate's lead time.

A real strategic choice here is **single-source vs multi-supplier**: buying everything from one supplier gives you price leverage and simplicity, but if that supplier has a shortage, your whole shop stalls. Spreading across suppliers costs a bit more but keeps you running. This is a resilience-vs-price tradeoff.

Common mistake: Treating finished print like stocked SKUs. There is no shelf of finished booklets to "pick." The real constraints are *raw stock on hand* plus *available press time*. Software that models print inventory as finished-goods counts will mislead everyone.

Key takeaway: Define a reorder point and safety stock for every key material, respect substrate lead times when quoting delivery, and prefer automated reordering so production never stalls on a stockout.

Outbound mode 1: parcel (small packages)

Now the finished print exists and has to travel. There are two fundamentally different shipping modes, and choosing the wrong one wastes money. The first is **parcel**.

Parcel = an individual package handled door-to-door by a carrier. The familiar names are **UPS, FedEx, DHL, USPS**. Parcel gives you real-time tracking, frequent pickups, and works for anything from a postcard to a medium box.

Parcel has hard physical limits. Typical caps:

Limit	Typical value
Max weight	150 lbs per package
Max length	108 inches
Max length + girth	165 inches

Girth is a measure of how "fat" a package is around its middle: `girth = 2 x width + 2 x height`. Carriers add it to the length to catch long-but-thin or bulky items.

Parcel pricing depends on several inputs, not just weight:

- **Billable weight** — the greater of actual weight vs *dimensional* weight (explained below).
- **Zone** — how far the package travels (explained below).
- **Surcharges** — additional-handling fees, oversize fees near the limits, a **Delivery Area Surcharge (DAS)** for remote ZIP codes, and a **residential surcharge** for delivering to a home rather than a business.

Key takeaway: Use parcel when the package is **under 150 lbs and within the size limits**. Remember the price is driven by billable weight, distance zone, and surcharges — not just the number on the scale.

Outbound mode 2: LTL freight (pallets)

When print goes big — a full run of brochures, a stack of catalogs, signage — it ships on a **pallet** (a wooden platform, also called a skid) by **LTL freight**.

LTL = "Less-Than-Truckload." Your palletized goods share a trailer with other shippers' loads, so you pay for the space you use rather than a whole truck. LTL covers roughly **150 to 15,000 lbs**. Above that you book **FTL** ("Full Truckload") or a flatbed — your goods get the whole truck.

Common mistake: Forgetting the pallet itself. LTL carriers weigh and measure the *entire load including the wooden pallet*, not just the cartons on top. Under-declare it and you get hit with **reweigh fees** and possible reclassification (a higher, costlier freight class).

How LTL pricing works: freight class + lane + accessorials

LTL has its own pricing language. The key concept is **freight class**, set by the **NMFC** (National Motor Freight Classification) system. There are 18 classes from **Class 50** (densest, cheapest) to **Class 500** (lightest/bulkiest, most expensive). The class is driven by four factors: *density, stowability, handling, and liability*. Since a mid-2025 NMFC reform, **density now sets the class for most freight**.

Density = how much weight is packed into the space. The formula:

```
Density (lbs/ft3) = Total Weight (lbs) / Total Volume (ft3)

  Volume (ft3) = (L x W x H in inches) / 1,728
  (1,728 = number of cubic inches in one cubic foot)

  Higher density -> LOWER class number -> CHEAPER to ship.
```

Good news for print: **boxed paper is dense**, so it lands a favorable (low) class.

Class	Density	Example goods
Class 70	~15–22.5 lbs/ft³	Boxed paper & print products, machinery parts, plumbing fixtures
Class 100	~9–10.5 lbs/ft³	Boxed light goods, wine cases

On top of the class and the **lane** (the origin-to-destination route), carriers add **accessorials** — fees for extra services beyond a simple dock-to-dock drop:

Accessorial	Typical cost	When it applies
Liftgate service	$75–$150	Customer has no loading dock; truck needs a powered platform to lower the pallet
Inside delivery	$75–$200	Driver must bring goods inside, past the curb/dock
Residential surcharge	Varies	Delivery to a home address
Limited-access / appointment	Varies	Schools, sites needing scheduled delivery
Reweigh fee	Varies	Declared weight was wrong

Named LTL carriers include **FedEx Freight, UPS Freight, Old Dominion, SAIA, Estes, and YRC**. Note: many of them now also apply dimensional weight (next section) to LTL, not just parcel.

Best practice: When a shipment sits *near the 150 lb / size boundary*, quote it **both ways** — parcel and LTL — and compare the base rate plus every accessorial plus reclassification risk before choosing. The cheaper mode is not always obvious.

Key takeaway: Pallets ship LTL (150–15,000 lbs). Price = freight class (driven by density — and boxed print is dense, so cheap) + the lane + accessorials like liftgate. Always include the pallet's own weight and size.

Dimensional weight: why a light box can cost a lot

This concept catches more print shops off guard than any other. **Dimensional weight** (also called volumetric weight, or "DIM weight") exists because a carrier charges for the *space* your package takes up in the truck, not only its weight on a scale. A big, light box — very common in print: rolled posters, foam-core signs, framed pieces, heavily-padded fragile prints — would otherwise occupy expensive truck space for almost no revenue.

So carriers compute a *pretend* weight from the package's size, and bill you the larger of the two:

```
Billable weight = the GREATER of (actual weight, DIM weight)

DIM weight = (L x W x H in inches) / DIM divisor
```

The **DIM divisor** is a number the carrier publishes; a smaller divisor means a higher DIM weight (more expensive). The 2026 divisors:

Carrier	DIM divisor	Note
UPS / FedEx	139	Domestic and international
USPS	166	For packages over 1 cubic foot (1,728 in³). Changing to 139 on July 12, 2026 (matching UPS/FedEx)

Two rules make this worse for oddly-sized print pieces:

- **Round-up rule** (effective Aug 18, 2025 on FedEx & UPS): any fractional dimension is rounded *up* to the next whole inch *before* the formula runs. So 11.1" becomes 12". This quietly raises the billed weight.
- **Billed weight rounds up too** to the next whole pound.

> **Example:** A fine-art poster rolled in a 24 x 6 x 6 inch tube. Volume = 24 × 6 × 6 = 864 in³. DIM weight = 864 ÷ 139 ≈ 6.2 lbs, rounded up to ~7 lbs. Even though the rolled prints weigh *under 2 lbs*, you are billed at ~7 lbs because the box is bulky for its weight.

The print-specific lesson: **your packaging choice directly changes the bill.** Sometimes a strong, compact tube beats an over-reinforced flat box on *both* protection and DIM cost.

> **Key takeaway:** You pay for the greater of actual or dimensional weight. Light, bulky print can be billed far above its scale weight. Every packaging decision is also a shipping-cost decision — so your software must store dimensions, not just weight.

Shipping zones: distance, by ZIP not by miles

A **zone** is the carrier's measure of how far a package travels from origin to destination. It is based on groupings of ZIP codes, not literal mileage. Domestic US zones run from **Zone 1** (local, roughly within 50 miles) to **Zone 8** (over 1,800 miles). A higher zone means higher cost and longer transit (the package passes through more sorting hubs).

Two consequences matter for print software:

- **Zone is tied to the origin.** The same customer is a different zone from two different print facilities. This is the core argument for *distributed fulfillment* — printing near the customer to drop the zone.
- **Heavy packages feel zone jumps more.** The price gap between Zone 2 and Zone 7 is much bigger for a 40-lb box of catalogs than for a 1-lb envelope. So zone strategy matters most for heavy print (books, catalogs, signage).

Key takeaway: Zone = distance by ZIP grouping (1 = local, 8 = far). It depends on which facility ships, so printing closer to the customer lowers both cost and transit time — most dramatically for heavy print.

Packaging & protecting print

Paper is fragile in specific, predictable ways. Good packaging targets the four damage modes:

Damage mode	What happens	Defense
Bending	Automated sorters flex the package	Rigidity — backer board or a tube
Corner/edge crush	Stacking and drops crush corners	Corner protectors; cylinders distribute pressure
Moisture	Rain/humidity warps and stains paper	Poly sleeve or wrap
Surface scuffs	Matte and fine-art papers mark easily	Slip sheet / protective sleeve against abrasion

The core principle is **rigidity + zero internal movement**: stop the print from flexing, and stop it from sliding around inside the package. Format choice depends on size:

- **Small/flat prints** — a *rigid mailer* with a firm backer board. Stays light, holds shape, keeps postage low. Add a protective sleeve and a slip sheet against scuffing.
- **Large prints (16x20 and up)** — usually safer *rolled in a strong tube* with end caps. Shipping a large piece flat needs so much reinforcement that weight and DIM size spike. The tube's cylinder shape distributes pressure and resists corner damage. Use corrugated kraft tubes, typically 2" or 3" diameter; protecting the *ends* is critical.
- **Framed/rigid pieces** — foam corner protectors, glass-protection tape, bubble wrap.

Best practice: Treat packaging as a three-way tradeoff: *protection vs DIM weight vs material cost*. For a large poster, a well-built tube often wins on all three at once versus a giant reinforced flat box.

Key takeaway: Defeat bending, crushing, moisture, and scuffs with rigidity and no internal movement. Flat-mail small prints, roll large ones in tubes, pad framed pieces — and remember the format you choose also sets the dimensional weight.

Cross-border: customs, duties & documentation

The moment a shipment crosses a national border, a government wants to know what's inside, where it came from, and what it's worth — so it can charge **duties** (taxes on imported goods). Three documents do most of the work.

Document / data	What it is	Why it matters
Commercial invoice	The shipment's "ID card": shipper, recipient, honest goods description, quantity, value, country of origin	The single most important doc. Vague descriptions ("accessories", "samples") now trigger delays and scrutiny
HS code	Harmonized System code — a standardized number classifying every internationally shipped item	A small misclassification materially changes the duty owed; getting it right is a critical lever
Electronic shipment data	Standardized data submitted *before* goods enter (especially the EU)	Filed ahead so customs can pre-clear; missing it stalls the shipment

Intrinsic value and the death of "de minimis"

Intrinsic value = the price of the goods *only*. It excludes shipping, insurance, and other fees *if those are shown separately* on the invoice. So €140 of goods + €20 shipping has an intrinsic value of **€140**, not €160.

Intrinsic value used to matter because of **de minimis** — a low-value threshold below which goods entered *duty-free*. That safety net is collapsing worldwide in 2025–2026:

Region	Old de minimis	2025–2026 change
United States	$800 duty-free	Eliminated in late 2025 — goods now face duties regardless of value
European Union	€150 duty relief	Abolished from July 1, 2026 (Council Reg (EU) 2026/382). A transitional flat €3 customs duty per item applies to consignments ≤ €150 until July 1, 2028, then normal classification-based duties via the EU Customs Data Hub

Common mistake: Assuming small cross-border print orders still slip through duty-free. They don't anymore. A low-value order now owes duty and needs full classification data (HS code, honest description, country of origin). Build for it.

Incoterms: who pays and who carries the risk

Incoterms ("International Commercial Terms") are a standard set of three-letter codes that split responsibility between seller and buyer across the journey — who pays transport, who insures, who handles export and import clearance, and who pays the duties. The Incoterm even sets the *customs value* used to calculate duty. Three are worth knowing:

Incoterm	Seller's job	Buyer's job	Best for
EXW (Ex Works)	Just make goods available at the seller's premises — minimum obligation	Everything else: export clearance, all transport, import clearance, duties, VAT, risk	Rarely good for a storefront — heavy burden on the buyer
DAP (Delivered At Place)	Deliver to a named place in the buyer's country; pay transport; bear risk to that point	Import clearance, duties, taxes, unloading	Buyer is comfortable clearing customs themselves
DDP (Delivered Duty Paid)	Maximum obligation — arrange all transport AND pay import clearance, duties, and VAT in the destination country	Nothing extra — just receive the goods	Best customer experience; heaviest seller burden

In plain terms: **DDP** = "delivered, all costs included, no surprises for the buyer." **DAP** = "delivered, but you (the buyer) clear customs and pay the duties yourself." For a print storefront, this single choice decides whether your customer gets a surprise duty bill from the courier at the door.

Common mistake: Choosing DDP without realizing the seller eats *all* import duties and formalities — and that some countries even bar foreign entities from completing import paperwork. DDP is the best experience but a real strain on a small print seller. Pick it deliberately, not by accident.

Example (cross-border, US→EU): A box of custom business cards, €120 of goods + €18 shipping. Intrinsic value = €120 (under €150). From July 1, 2026, with de minimis gone, it owes the transitional flat €3/item EU duty. A commercial invoice and HS code are required. The seller chose **DDP**, so the customer pays nothing extra at the door — the seller pre-paid the duty.

Key takeaway: Cross-border print needs an honest commercial invoice, a correct HS code, and a chosen Incoterm. De minimis is gone, so even small orders owe duty. DDP vs DAP decides who absorbs that duty — and whether your customer is happy or ambushed.

POD, drop-ship & 3PL: letting someone else fulfill

Not every shop prints and ships everything itself. Three related models outsource part of the spine:

- **Print-on-Demand (POD)** — the product is printed *and* shipped only *after* a sale clears. There is no finished-goods inventory to store. The order itself triggers production.
- **Drop-ship** — a print partner or 3PL produces and ships directly to the end customer, *under the store's brand*. The storefront never physically touches the product.
- **3PL** (third-party logistics) — an outside company that warehouses, kits, picks, packs, and ships on your behalf.

Major POD/drop-ship platforms include **Printful, Printify** (1,300+ products), **CJdropshipping, Lumaprints, InterestPrint, Amplifier, and Gelato**. Specialist print-kit 3PLs include **SHIPHYPE and Harte Hanks**, which handle inventory, kit assembly, custom packaging, and quality control (QC).

The POD order-to-delivery flow (and why webhooks matter)

```
sale comes in
   -> order auto-approved as soon as payment clears
   -> print provider selected
   -> production
   -> QC
   -> packaging
   -> ship
   -> tracking number + carrier sent BACK to the store
      via WEBHOOK
   -> order auto-marked "Fulfilled" with tracking attached
   -> customer gets a shipping-confirmation email
```

A **webhook** is a message the fulfillment platform pushes *to your software* the instant something happens (e.g., "shipped, here's the tracking number"). It is the opposite of *polling*, where your software keeps asking "any updates yet?" Webhooks land in **seconds**; polling typically lags **5–15 minutes**.

> **Key takeaway:** POD/drop-ship/3PL let a partner produce and ship under your brand with no finished inventory. The tracking number flows back via webhook and auto-completes the order — so build your software to *receive* webhooks, not poll.

Kitting: bundling components into one package

Kitting means assembling several separate components into *one* ready-to-ship package. It's common in print marketing: a "welcome kit" might combine a brochure + business cards + a branded folder + an insert, all packed together. A key sub-task is **insert control** — making sure the right printed inserts go into the right kit (the correct flyer for the correct region, for example).

Kitting is usually most cost-effective through a 3PL that offers custom kitting: they hold the component inventory, assemble to your spec, apply custom packaging, and run QC before shipping.

> **Key takeaway:** A kit is many printed components combined into one shippable package. Get the insert mix right, and let a kitting 3PL handle component inventory and assembly at scale.

Partial shipments & backorders

Because print items are made on different presses on different days, one order often can't all be ready at once. Two terms:

- **Split shipment** (a.k.a. partial shipment) — one order divided into two or more shipments, each sent separately to the same destination.

- **Backorder** — an item not yet available or produced. The ready portion ships now; the rest follows when it's done.

Common causes in print: items produced on different presses or days, one item finishing before another, an oversized item needing its own box, inventory split across warehouses, backordered material, or multiple ship-to addresses.

Common mistake: *Not telling the customer.* Receiving half an order now and half later — with no warning — is the #1 source of confusion and anger. The shipment splitting itself is fine; the silence about it is what breaks trust.

Handling it well:

- Apply an order-routing rule like **"minimize split fulfillment"** — prefer a single location/run that has everything, in the fewest packages.
- Use **automated, rules-based splitting** so no human has to intervene per order.
- Send **proactive comms per shipment**, with separate tracking for each parcel.
- Offer a checkout choice: *consolidated delivery* (slower, one box) vs *faster partial delivery*.
- Use analytics to find which products or sites split most often, and fix the root cause.

Key takeaway: Split shipments and backorders are normal in print. The way to keep customers happy is to minimize splits where you can, automate the rest, and communicate every shipment with its own tracking.

Multi-carrier shipping software & rate shopping

Rather than integrating with each carrier separately, most shops use a **multi-carrier shipping API** — one integration that reaches many carriers at once. Examples: **ShipStation/ShipEngine** (200+ carriers), **EasyPost**, **Shippo** (40+ global), **ShipWise**, **Veeqo**. Core capabilities:

- **Rate shopping** — query many carriers in real time and pick the cheapest or fastest by your business rules.
- **Label generation** — print the shipping label.
- **Address validation** — catch bad addresses before they cause failed deliveries or label errors.
- **Tracking feed** — pipe carrier updates into customer notifications.
- **Parcel analytics** — spot overspend and surcharge patterns.

Best practice: Prefer **webhook-based tracking** (updates in seconds) over polling (5–15 minute lag). The customer sees "Shipped" almost immediately, which reduces "where's my order?" support tickets.

What a print order system must capture (software requirements)

This is the section to bookmark if you build the software. The physical realities above translate into concrete fields your order model must store. Capture these **per line item / per shippable unit**:

Field	Why it's needed
Weight (actual) + calculated DIM weight	Carrier rate calls, freight class/density, parcel-vs-LTL decision
Dimensions (L×W×H)	DIM weight, freight density, packaging selection, size limits
Packaging type (tube / flat mailer / box / pallet)	Drives both protection and DIM weight
Ship-to address + residential/commercial flag + access (dock/liftgate)	Drives accessorials and surcharges
Origin facility	Determines the zone
Carrier + service level chosen	The actual shipping method
Tracking number(s) — plural	One order can have many (split shipments)
Shipment/fulfillment status supporting partial fulfillment	Which items/quantities shipped in which shipment; what's still pending/backordered
Cross-border fields: HS code per item, country of origin, declared/intrinsic value, Incoterm (DDP/DAP), customs description	Customs clearance and accurate duty

The structural rule: one order, many shipments

The biggest mistake in print order schemas is a *single tracking-number field* on the order. Print orders split constantly, so the model must be:

```
ORDER
  +-- SHIPMENT 1
  |     carrier, service, tracking #, weight, dims,
  |     line items + quantities in THIS shipment
  +-- SHIPMENT 2 (the rest, shipped later)
  |     its own carrier, tracking #, items...
  +-- (backordered items: still pending)
```

One order → many shipments → each shipment with its own carrier, tracking number, weight, and item list. Without this, you literally cannot represent "half shipped, half still in production" — so the system tells the customer "shipped" while part of the order isn't.

Common mistake (software): A single tracking-number column. It cannot represent split shipments, so the order gets marked "Shipped" while items are still on the press. This is exactly the "partial fulfillment" gap that recurs in print-SaaS order spines.

Snapshot discipline & the silent-drop trap

Capture weight, dimensions, shipping cost, carrier, and customs fields **onto the order at fulfillment time** as a frozen snapshot. If you later edit the product catalog (change a weight, a size), historical orders must *not* rewrite themselves — the order should remember what was true the day it shipped. This mirrors the established pattern of snapshotting addresses and totals onto orders.

Equally important: **cross-border fields are the ones most often silently dropped**. If the checkout collects an HS code or Incoterm but the form's validation rules don't list it, the value vanishes — and the courier rejects the shipment, or the customer gets a surprise duty bill. Every captured field must round-trip: *validate → save → read back → render.*

Best practice (software): Make weight round-trip from product config → order snapshot → carrier rate call. Do rate shopping by sending weight + dimensions + origin + destination to a multi-carrier API, then show the store owner *human-readable options* ("UPS Ground — $14.20, arrives Thu"), never raw API codes. Ingest tracking via webhook and show the customer plain language ("Shipped — arriving Tue") with a tracking link, never a raw status code.

Key takeaway: Model the order as one-order-to-many-shipments, capture weight + dimensions + carrier + tracking + customs per shippable unit, snapshot it at fulfillment time, and validate every cross-border field so it can't be silently dropped. The physics of shipping only works in software if the data model matches it.

Quick reference: the numbers that matter

Item	Value
Parcel weight cap	150 lbs
Parcel size limits	Length + girth ≤ 165 in; max length 108 in; girth = 2W + 2H
LTL range	150–15,000 lbs (above → FTL)
DIM divisor	UPS/FedEx 139; USPS 166 → 139 on Jul 12, 2026
DIM round-up to whole inch	Since Aug 18, 2025 (UPS/FedEx)
Density volume divisor	1,728 (in^3 per ft^3)
NMFC classes	50 (cheap/dense) → 500 (expensive/bulky); Class 70 ≈ 15–22.5 lb/ft^3
Zones	1 (≤50 mi) → 8 (>1,800 mi)
Liftgate / inside delivery	$75–$150 / $75–$200
US de minimis ($800)	Ended late 2025
EU de minimis (€150)	Ends Jul 1, 2026; flat €3/item until Jul 1, 2028
Tracking latency	Webhook seconds vs polling 5–15 min
Specialty substrate lead time	Order 4–6 weeks ahead
Automated procurement savings	5–20% material cost

Chapter takeaway: Print fulfillment is unusual because the product is made-to-order — inventory is raw paper, and shipping starts when production ends. Master the two outbound modes (parcel under 150 lbs, LTL pallets above), respect dimensional weight and zones, pack for rigidity, handle cross-border with honest invoices and the right Incoterm now that de minimis is gone, and build your software around one-order-to-many-shipments with weight, dimensions, carrier, tracking, and customs captured and snapshotted. Get the data model right and the rest of the spine has somewhere to live.

Sustainability & Eco-Printing

Walk into almost any print buyer's office today — a corporate marketing manager, a school administrator, a government procurement officer — and somewhere in their brief you will find the word "sustainable." Print is a physical product made from trees, oil-based inks, energy, and water, so it gets watched closely. As the person building the software that sells print, you don't pour the ink or fell the trees, but you decide what the buyer *sees*, what the catalog *captures*, and whether a green claim is *provable* or just decoration. This chapter teaches you the craft of eco-printing so you can model it honestly in software.

Let's define the broad idea first. **Sustainability** in print means meeting today's printing needs without using up resources or polluting in ways that harm the future — using renewable materials, less energy, less waste, and being honest about it. **Eco-printing** is the practical set of choices that get you there: recycled paper, plant-based inks, efficient presses, smart finishing, and waste avoidance.

Why this matters: the green buying factor

Two forces are pulling in the same direction. First, buyers increasingly *want* eco-friendly print — especially business buyers (called **B2B**, meaning business-to-business: one company buying from another). Many corporate, government, and education purchase requests now *require* recycled content or forest certification just to qualify a supplier.

Second — and this is the subtle part — buyers are also **skeptical**. Surveys consistently show a majority of consumers distrust vague green claims, and regulators estimate a large share of online environmental claims could be misleading. So buyers want eco, but they have learned to disbelieve adjectives like "eco-friendly" with nothing behind them.

Key takeaway: The winning move is not to *claim* more green; it is to *prove* more green. A store that surfaces verifiable facts — a certification license number, an exact percentage of recycled content, an offset tracking ID — beats a competitor shouting "100% green!" with no evidence. Build your software to carry proof, not slogans.

Recycled content: PCW, recycled fiber, and deinked pulp

Paper is made from **fiber** — tiny strands of cellulose that come from wood (or recovered paper). Where that fiber comes from is the whole sustainability story.

Let's define the key terms before using them:

Term	Plain meaning	Environmental value
Virgin pulp	Fiber made directly from freshly cut trees.	Lowest recycled credit; needed to add strength/brightness.
Recycled paper (umbrella term)	Contains *any* reclaimed fiber — could be a little or a lot.	Varies wildly — the word alone tells you little.
Pre-consumer (post-industrial) waste	Factory scraps: trimmings, misprints, mill offcuts that never reached a buyer.	Lower credit — it was already inside the supply chain and likely recycled anyway.
Post-consumer waste (PCW / PCRF)	Paper that *finished its life with a real user* — used office paper, newspapers, cardboard from homes and offices.	Highest value — it diverts material from the landfill and replaces virgin pulp.
Deinked pulp	Recovered paper that has had its printing ink, glue, and "stickies" industrially removed to make clean new pulp.	Enables recycled fiber to be reused in white printing papers.

Analogy: Think of recycling a glass of water through coffee filters. **Pre-consumer** waste is spillage you caught before anyone drank — barely a saving. **Post-consumer** waste is water you reclaimed after it was actually used — a genuine second life. And every pass through the filter (each recycling cycle) loses a little; paper fiber gets shorter each time and can only be recycled roughly 5–7 times before it is too short to hold together.

That fiber-shortening explains why recycled stock can be slightly weaker, a touch less bright, and have more **tooth** (a rougher, more textured surface). To keep brightness and strength up, mills usually *blend* recycled fiber with virgin pulp. A very common blend in fine printing papers is around 20% recycled content. The strongest, most credible label is **100% PCW** — everything from post-consumer sources.

Resource	100% PCW paper vs virgin (typical cited figures)
Energy	Recycled uses roughly 30–70% less; ~33% less for 100% PCW
Water	Around 49% less for 100% PCW
Landfill	Diverts used paper from the dump

Common mistake: Treating "recycled" and "100% post-consumer" as the same thing. A sheet labeled simply "recycled" might be mostly cheap pre-consumer mill scrap. In your software, store *recycled %* and *PCW %* as **separate fields** — conflating them lets a store make a stronger claim than the paper earns.

Key takeaway: Post-consumer waste (PCW) is the gold standard of recycled content. Capture the exact recycled % and PCW % per paper stock so buyers (and your honest-claims logic) can tell real recycling from token recycling.

Forest certifications and chain of custody

If paper does come from trees, the next question is: were those trees grown and harvested responsibly? That is what **forest certifications** answer. A certification is a third-party stamp saying a forest meets agreed environmental and social rules. Three names dominate:

Program	What it is	Notable trait
FSC (Forest Stewardship Council)	A global NGO with one strict global standard — biodiversity, no GMOs, indigenous and worker rights.	The most recognized and trusted label by buyers.
PEFC (Programme for the Endorsement of Forest Certification)	A global umbrella that *endorses national schemes* rather than running one standard.	Largest by total area (~71% of the world's certified forest); strong for small/family forests.
SFI (Sustainable Forestry Initiative)	A North American standard (US/Canada), now independent and endorsed by PEFC.	World's largest *single* standard by acreage; focus on legal, responsible sourcing.

Chain of custody: the concept that makes a label legitimate

Chain of custody (CoC) is the documented, unbroken trail of fiber from the forest (or recycling site) through *every* processing and trading step — mill, paper merchant, printer — all the way to the finished job sold with the claim. The critical rule: *every link in the chain must hold its own valid certification.* If the printer does not have a CoC license, the printer cannot legally put the FSC logo on the job, **even if the paper itself was certified.**

What the FSC labels actually mean

Label	Meaning
FSC 100%	All fiber from FSC-certified forests.
FSC Mix	A blend of FSC-certified fiber, "Controlled Wood," and recycled. Can only carry the "FSC Mix" label at **70% or more** qualifying input.
FSC Recycled	All fiber from recycled sources, with a **minimum 90% post-consumer**; the remaining 10% or less may be pre-consumer or FSC virgin.

Behind the scenes, certifiers track percentages with **control systems**: a *transfer* system (claim passes through when inputs are uniform), a *percentage* system (the label % mirrors the certified share), and a *credit* system (banking credits from certified inputs and selling an equal output volume as certified).

Common mistake: Reading "FSC Mix 70%" as "70% recycled." A forest logo proves *sourcing and traceability* — not recycled content, not low carbon, not chlorine-free. Those are separate attributes. Never let your storefront copy blur certification into recycling.

Key takeaway: A certification logo is only as real as the printer's chain-of-custody license. In software, store the certification *type* (FSC 100% / FSC Mix XX% / FSC Recycled / PEFC / SFI) **and** the CoC license number — without the license number, the logo should not display.

Inks: vegetable/soy versus petroleum

Ink is pigment (the color) carried in a liquid (the "carrier oil") that dries onto paper. The carrier is where sustainability splits:

- **Petroleum inks:** carrier oils made from fossil/mineral oil — a finite resource that releases more harmful vapors.
- **Soy / vegetable inks:** carrier from soybean oil (or linseed and other plant oils) — a renewable resource.

One word you must define here: **VOC** stands for *volatile organic compound* — a chemical that evaporates into the air as ink dries, harming pressroom air quality and contributing to smog. Lower VOCs are better for workers and the planet.

Factor	Soy / vegetable ink	Petroleum ink
VOC content (one cited comparison)	~0.8%	~4.6%
VOCs released on drying	As low as ~4%	~25–40%
Color	Clearer oils → brighter, sharper; can need slightly less ink	Standard
Deinking / recycling	Removes more easily → cleaner recycled fiber, less sludge	Harder to deink
Drying speed	Slower on uncoated/absorbent stock (setoff risk)	Faster
Cost	Slightly higher	Lower

Common mistake: Assuming "soy ink" is 100% soy or fully natural. Typical renewable content is only about 20–70%; the pigments and some additives are still petroleum-derived, and "vegetable ink" is an unregulated marketing term. Don't let a store imply "all-natural ink" from a partial soy blend.

Key takeaway: Soy/vegetable inks cut VOCs sharply and deink more cleanly, which is a genuine win — but they are partial, not pure. Model an honest "ink type" flag per product or press, not an overstated "natural" badge.

Press technology: waterless, UV/LED, and energy

How a press runs affects its footprint as much as what goes into it.

Waterless offset

Traditional offset printing uses a water-based "fountain solution" (often containing isopropyl alcohol) to keep ink off the non-printing areas. **Waterless offset** removes that solution entirely, cutting water use and the VOCs from the alcohol, while giving sharper dots and less startup paper waste.

UV and LED-UV curing

UV inks dry ("cure") instantly under ultraviolet light instead of by evaporating solvent. Because they are nearly 100% solids, they are *virtually VOC-free* and need no anti-setoff powder. **LED-UV** is the more sustainable upgrade — it cures with energy-efficient LED lamps instead of mercury bulbs:

Aspect	LED-UV advantage
Energy	~50% less than infrared/hot-air; up to ~90% less than conventional mercury UV
Emissions	No mercury and no ozone released into the pressroom
Lamp life	~10,000–20,000 hours vs ~1,000 hours for mercury lamps (far less lamp waste)
Speed	Instant cure — ideal for short runs and print-on-demand

Common mistake: Forgetting that some UV-cured coatings can complicate recycling and deinking. A low-energy press is great, but always verify recyclability for the specific stock-and-coating combination.

Key takeaway: Retrofitting mercury-UV to LED-UV is a textbook "reduce first" win — massive energy and lamp-waste savings before anyone buys a single carbon offset.

Carbon footprint, offsetting, and the "paper vs digital" myth

A **carbon footprint** is the total greenhouse gas a product causes, measured in **CO2e** (carbon-dioxide-equivalent — a common unit so all gases can be added up). Rough figures: making paper emits about 0.7–1.2 kg CO2e per kg of paper, and printing energy is around 1 gram of CO2 per page.

The paper-vs-digital myth

"Going paperless is greener" is repeated everywhere, and it is only sometimes true. Digital reading is *not* automatically clean — it carries the footprint of manufacturing devices, running data centers, and powering screens for every minute of viewing.

Example: Cited comparisons illustrate the nuance: a single web search is roughly 0.7 g CO2e; a business card is under 0.12 g over its whole life. Printing a 700-page report once might emit around 85 g CO2e — while reading it on a screen can cost on the order of 226 g *per hour*. Paper's footprint is **fixed at print time**; digital's **grows with every view**. The more a document is reused, the more print can actually win.

Analogy: Print is like buying a reusable water bottle — one upfront cost, then free forever. Screen reading is like buying a new bottled water every time you're thirsty — cheap once, expensive across a thousand sips. Neither is automatically "the green choice"; it depends on how often it's used.

The real villain isn't paper — responsibly grown forest fiber is renewable and stores carbon — it's **waste and overproduction**: printing things nobody reads.

Carbon-neutral printing and offsetting

An **offset** is paying for an emissions reduction elsewhere (planting trees, funding clean energy) to cancel out emissions you couldn't avoid. Relevant standards to recognize: **ISO 16759** (calculating a print job's carbon footprint), **ISO 14068** (carbon-neutrality claims), and the older **PAS 2060**. Offset credits are verified by registries such as **Verra** (Verified Carbon Standard), **Gold Standard**, the **American Carbon Registry**, and the **Climate Action Reserve**.

Real programs include HEIDELBERG's CO2-offsetting program, ClimatePartner's carbon-neutral printing, **PrintReleaf** (auto-replants trees equal to paper consumed and tracks it), and Xerox's ISO-14068-verified Verified Carbon Neutrality Service. The best ones issue a **unique tracking ID per job** (e.g., TÜV-verified) so a buyer can trace exactly which offset cancelled their order — the antidote to greenwashing.

```
THE EMISSIONS HIERARCHY  (do them in order)

1. REDUCE   trim runs, gang jobs, print-on-demand   <-- first
2. SWITCH   recycled stock, soy ink, LED-UV, green power
3. OFFSET   buy verified credits for the leftover    <-- last
            (with a unique traceable ID per order)
```

Common mistake: Buying offsets while changing nothing else, then calling the shop "carbon neutral." Offsetting *without* reduction is one of the clearest greenwashing signals. Offsets cancel the *residual* after you've already reduced and switched.

Key takeaway: Don't let buyers assume "paperless = green." Teach the truth in your copy: paper's footprint is fixed at print, digital's grows with every view, and the real enemy is overproduction — which leads straight into waste reduction.

Waste reduction: gang runs and print-on-demand

The greenest sheet is the one you never wasted. Two techniques do most of the heavy lifting.

Gang runs

A **gang run** places several *different* jobs together on one large press sheet, sharing the same paper and run. Imagine fitting four customers' business cards onto one big sheet that gets cut apart afterward. This maximizes sheet use, needs fewer plates, less **makeready** (the test sheets wasted while setting up a press), and lower energy per finished unit.

Print-on-demand (POD)

Print-on-demand means producing only *after* an order arrives, instead of guessing demand and printing big batches in advance. Its environmental superpower is eliminating **overproduction** — the unsold inventory that ends up in landfills (a notorious problem in apparel and merchandise). Short-run **digital/inkjet** presses also avoid the dozens of setup sheets an offset press wastes, and printing at the facility nearest the customer cuts shipping distance.

	Gang run	Print-on-demand
Core idea	Many jobs on one sheet	Print only after the order
Saves	Plates, makeready, paper, energy/unit	Overproduction, dead stock, shipping
Best for	Standard sizes, batched short runs	Variable, on-demand, small quantities
Trade-off	Needs matching stock/timing	Higher cost & footprint *per piece*

Common mistake: Claiming POD is greener "per item." It isn't — a huge offset run is more efficient per piece. POD wins on *avoided overproduction*, not per-piece efficiency. Be precise in marketing copy.

Key takeaway: Your platform already enables the single biggest sustainability lever in print — print-on-demand — by producing only what's ordered. Surfacing "made only when you ordered it — no overproduction" is an honest, defensible eco message.

End of life: recyclable vs compostable, and why finishes hurt

What happens after the print is used? Two terms get confused constantly:

- **Recyclable:** can be reprocessed into new material *where facilities exist*. For paper, the practical test is **repulpability** — can a mill break it back down into fiber?
- **Compostable:** breaks down into non-toxic matter under composting. But *industrial* compostable (needs a special facility) and *home* compostable are very different, and the vaguer word **biodegradable** often means almost nothing without proof.

Why decoration kills recyclability

Beautiful finishes are often the enemy of recycling:

Finish	Recycling impact
Plastic film lamination (gloss/matte PP or PE)	The biggest killer — the plastic layer blocks repulping, needs special costly equipment, and won't compost.
Foil stamping (metallic foil)	The foiling itself leaves no plastic film, so the board often stays fully recyclable — *unless* a laminate is added over it. Foil ≠ lamination.
Wax coatings / metallized films	Hard or costly to recycle; don't degrade.
Heavy UV varnish	Can interfere with deinking depending on the grade.
Water-based (aqueous) coating	The friendly choice — gives a scuff/moisture barrier while staying *repulpable and recyclable*.

Analogy: Plastic-laminating a recycled-paper box is like wrapping an organic apple in shrink-wrap and calling the meal eco-friendly. The good intention underneath is sealed inside something the recycler can't process.

The design principle is **mono-material**: keep the whole piece one recyclable material where possible — avoid mixing paper with bonded plastic. Substrate options worth knowing include recycled board, FSC virgin paper, stone paper, agri-waste/alternative fibers (bamboo, cotton, hemp), and even **seed paper** (embedded with seeds so it can be planted).

Key takeaway: A finish can quietly cancel a stock's eco credentials. Foil can stay recyclable; plastic lamination usually doesn't. Your software should flag when a "green" stock is paired with a recyclability-killing finish — a contradiction the buyer deserves to see.

Greenwashing: marketing eco credentials honestly

Greenwashing is making an environmental claim look better than reality — through vague words, misused logos, or cherry-picked facts. In the US, the **FTC Green Guides** (rules from the Federal Trade Commission on environmental marketing) set the standard, with states like California pushing enforcement further.

Claim	What the Green Guides require
"Recyclable"	Must be qualified ("recyclable where facilities exist") if fewer than 60% of consumers can access recycling for it.
"Biodegradable / degradable"	Needs credible scientific evidence it fully breaks down in a reasonably short time in the disposal method most people use (landfill rarely degrades).
"Recycled content"	State the percentage; distinguish pre- from post-consumer.
"Carbon neutral," "non-toxic"	Require scientific substantiation.
"Eco-friendly," "green," "sustainable"	Vague unqualified general-benefit claims are the classic greenwash flag — deceptive without specifics.

The common greenwashing mistakes

- Vague adjectives with no metric ("eco," "natural," "green").
- Showing an FSC or recycling symbol without a valid license or without the actual certified product.
- "100% recycled" when it's mostly pre-consumer scrap, or "recyclable" on a film-laminated item no facility will take.
- Offset-only "neutrality" with zero real reduction.
- "Biodegradable" on plastic that merely fragments into smaller plastic.

- Cherry-picking one good attribute (recycled paper) while hiding a worse one (plastic lamination, air freight).

Best practice: Be specific, quantified, and provable. Instead of "eco-friendly business cards," say: "Printed on 100% post-consumer recycled paper, FSC Recycled certified (license FSC-C######), with soy-based inks." Show cert numbers, offset IDs, and a link (or QR code) to the evidence. Disclose trade-offs honestly — if you used foil, say so. Use recognized third-party certifications, never a homemade green leaf logo.

Key takeaway: Honest eco-marketing is structured fact, not adjectives. The safest claim is one a regulator could read off your data fields. This is exactly where your software earns its keep.

How this touches print software: what to model and surface

You don't run the press, but you decide whether a green claim is backed by data. Here's how the craft maps into the product you build.

Catalog data to model (per stock and per product)

- **Sustainability attributes per paper stock:** recycled %, **PCW %** (separate field), certification type (FSC 100% / FSC Mix XX% / FSC Recycled / PEFC / SFI) plus **CoC license number**, brightness, and a chlorine-free flag (**PCF** = Process Chlorine Free, **TCF** = Totally Chlorine Free).
- **Ink-type flag** per product or press: soy/vegetable vs conventional, and UV/LED.
- **Finish recyclability flags:** mark film-laminated / foiled / aqueous-coated, and *warn* when an "eco" stock is paired with a recyclability-killing finish (a UX guardrail — never silently sell a contradiction).

Buyer-facing features

- **Eco badges and a filter facet:** "Recycled," "FSC Certified," "Soy Ink," "Carbon Neutral" — filterable in product listings, each with a plain-language tooltip (a non-technical buyer won't know "PCW" or "CoC").
- **An eco block on the product page:** the certification logo + license number, recycled %, ink type, and *what each means*, linking to evidence.
- **A carbon estimate per order** using an ISO-16759-style calculation, with an optional offset add-on at checkout (PrintReleaf-style "replant N trees" or Verra credits) that records a **unique tracking ID on the order and invoice**.
- **Default to the greener option** where price and quality allow (recycled stock as the default; opt in to virgin) — matching the "set responsible defaults" principle.
- **Honest-copy enforcement:** templated claims pull from structured certification data; don't let a store free-type "eco-friendly" with no backing.

Common mistake (the silent-lie trap): Showing sustainability attributes only from the live catalog. A catalog can change after an order ships, erasing the proof. **Snapshot** the certification, recycled %, ink type, and offset ID onto the order at purchase time — so the buyer's claim stays provable forever, even if the product is later edited.

Example: A B2B buyer orders 5,000 brochures and adds the offset option at checkout. Your order snapshot stores: stock = FSC Recycled (FSC-C######), 100% PCW, soy ink, LED-UV; offset = 12 kg CO2e cancelled, PrintReleaf certificate ID #ABC123. Months later their auditor asks for proof for an ESG (Environmental, Social, Governance) report — and your invoice already carries every verifiable fact. That captured, traceable proof is the feature that wins the enterprise account.

Key takeaway: Your job in eco-printing is to be the system of record for *provable* green. Model the attributes precisely, snapshot them onto every order, surface them in plain language, default to the responsible choice, and never let a store make a claim the data can't back. That is sustainability done as software — and it's exactly what skeptical modern buyers reward.

Putting It Together — Modeling Print in Software (PF360 lens)

Every earlier chapter taught you a piece of the print craft: paper, color, presses, finishing, files, shipping. This chapter is the synthesis. We take all of that physical reality and ask one question a software builder must answer: **what does the data model need to look like so the screen tells the truth about the factory?**

Before we go further, two plain definitions you'll see throughout:

- **Data model** — the shape of the information your software stores: which fields exist, what type they are, and how records connect (an order has many line items, a line item has one spec, and so on).
- **Spec** (short for specification) — the full description of *exactly* what is being printed: size, paper, colors, finishing, quantity. In print, the spec is the heart of the order.

The core insight: a print job is a recipe, not a product row

Normal e-commerce models a **SKU** — a Stock Keeping Unit, which is one fixed sellable thing with a known price sitting on a shelf. A t-shirt comes in S/M/L; you pick one and the price is looked up from a table. That model works because the variants are finite and the price already exists.

Print breaks this. A print product is a **configured manufacturing spec** — the customer assembles a recipe (size × paper × ink-sides × quantity × finishing), and the price, weight, file requirements, and turnaround all *change with the recipe*. There is no shelf and no pre-known price; the software computes everything from the configuration.

> **Analogy:** A normal SKU is a candy bar at a checkout — pick it up, scan the barcode, done. A print job is a coffee order at a busy café: "large, oat milk, two shots, extra hot, no foam." The price, the cup size, and the prep time all depend on the combination. You don't look up "large oat two-shot" on a shelf — the barista builds it from rules. Your software is the barista.

Three specific things make print software hard, and generic Shopify-style models get all three wrong:

1. **Price is computed, not looked up.** It comes from many interacting attributes, not a single row.
2. **There is a mandatory human gate mid-order: proof approval.** The order pauses, waits on the customer, and legally cannot proceed without a recorded sign-off.
3. **The order produces a physical thing through a multi-stage pipeline that can split (partial shipment) and merge with other customers' orders (gang run).** A single "shipped: yes/no" flag is not enough.

Where this category of software lives

Two industry terms you'll meet talking to shops:

- **Print MIS / Print ERP** — Management Information System (or Enterprise Resource Planning). The back-office software a shop runs: estimating/quoting, order entry, the **job ticket** (the printable work order that follows a job through the floor), scheduling, inventory of paper and ink, job costing, shipping, invoicing.
- **Web-to-print (W2P)** — the customer-facing online storefront that lets buyers configure and order, then feeds those orders into the MIS.

The industry's stated ideal is "ecommerce orders become MIS job tickets automatically — zero re-entry, zero errors." A platform like PF360 is essentially **W2P plus a light MIS**: it must both sell the configurable product and track it through production.

> **Key takeaway:** Model a print product as a *recipe* — attributes plus priced options plus compatibility rules plus a pricing strategy — never as a fixed-variant SKU with a looked-up price.

The product spec data model — what print actually needs to capture

The spec must be structured, machine-readable data (the industry literally passes it around as JSON, XML, CSV, or a **JDF** job ticket — Job Definition Format, the print industry's standard digital work-order file). Here is what every spec carries.

1. Size and dimensions

Capture **width, height, and units**. Two sizes can matter at once:

- **Flat size** — the size of the unfolded sheet (a tri-fold brochure is flat 11×8.5").
- **Finished size** — the size after folding/trimming (that brochure finishes at ~3.67×8.5").

For **wide-format** (large prints like banners and posters), size is *continuous* — any width × height — not a picklist. That single fact forces a different pricing engine (square-foot pricing, below). Also store the **bleed** size = trim size + 0.125" on each edge (defined fully in the file section).

2. Stock / substrate (the paper or material)

Substrate just means the material you print on. Its weight is expressed in three competing systems, and this is a classic data-model trap.

System	What it measures	Why it's tricky
GSM (grams per square meter)	Weight of a 1m² sheet	International, unambiguous — store this canonically
lb (US pounds)	Weight of a ream at a category's basis size	**Ambiguous** — "lb bond/text" and "lb cover" use different reference sheets, so the scales don't match
pt / point / caliper	Thickness in thousandths of an inch	Used for cardstock and business cards; measures thickness, not weight

Lock in these conversions and reference equivalents:

US weight	GSM	Typical use
20 lb bond	75 GSM	Copy paper
24 lb bond	90 GSM	Letterhead
80 lb text	118 GSM	Flyers
100 lb text	148 GSM	Brochures, booklet interiors
80 lb cover	216 GSM (≈10–11 pt)	Light cardstock
100 lb cover	270 GSM	Postcards, covers
110 lb cover	300 GSM (≈14 pt)	Premium cards
130 lb cover	350 GSM (≈16 pt)	Heavy premium cards

Conversion factors to GSM: **bond ×3.76, text ×1.48, cover ×2.70**. Business cards are commonly 14 pt and 16 pt; the USPS postcard minimum is **7 pt**.

Common mistake: Storing only the "lb" number. "100 lb" is meaningless without the category — 100 lb text (148 GSM) is a thin flyer page, while 100 lb cover (270 GSM) is stiff cardstock. Store **GSM canonically** and show friendly lb/pt equivalents in the UI.

Common mistake: Equating weight with thickness. GSM measures weight, not feel. A tightly-pressed (calendered) coated 200 GSM sheet can be *thinner* than a fluffy uncoated 200 GSM sheet. Don't let your UI imply "heavier = thicker."

Two more stock fields worth modeling for heavier work:

- **Grain direction** (long grain / short grain) — the orientation of the paper fibers. Folding *against* the grain on heavy stock cracks it, so the job ticket should allow specifying grain for thick stocks.
- **Coating** — gloss / matte / uncoated. This affects which inks and finishing options are compatible (foil and some coatings clash).

3. Color / sides — the 4/4 vocabulary (a trust signal)

Printers describe ink coverage as **front/back ink counts**. The number before the slash is the front; the number after is the back.

- **CMYK** = the 4 process colors: Cyan, Magenta, Yellow, Black (the "K"). So "4" almost always means full color.
- **4/4** ("four over four") = full color both sides.

- **4/0** = full color front, blank back.
- **4/1** = full color front, single ink (usually black) back.
- **1/1** = black both sides; **1/0** = black front only.

Beyond CMYK there are **PMS / Pantone spot colors** — exact branded inks mixed to a recipe (a logo red that must be identical every time). Each spot color is an extra ink, an extra plate, and extra cost.

> **Common mistake:** Modeling "sides" as a boolean (double-sided yes/no). The number of inks per side changes plates and press passes and therefore *price*. Model sides as a **priced choice** using the 4/4 vocabulary, with front and back independent.

4. Finishing options — priced choices with compatibility rules

Finishing (also called **bindery** or post-press) is everything done after the ink is on the sheet. These are the high-margin add-ons, and each one is a selectable option that can add *cost*, *production time*, and *weight*, and may be *incompatible* with certain stocks. The real terms a shop expects:

Term	Plain meaning
Lamination	Plastic film over the sheet — gloss / matte / soft-touch; adds durability and water resistance
UV coating / spot UV	Clear hard coat cured under UV light; "spot" UV = gloss on chosen areas only
Aqueous (AQ) coating	Water-based protective coat
Foil stamping	Metallic foil pressed on with a heated *die*; needs a one-time die; clashes with some coatings
Emboss / deboss	Raised / recessed impression
Die cutting	Cutting a custom shape with a die
Scoring	Pressing a crease so a fold is clean — *mandatory* on heavy stock before folding
Folding	Half / tri-fold / z-fold / gate
Perforation	A tear line
Rounded corners / drilling	Corner rounding; hole punching

For multi-page products, **binding** is the finishing choice that holds pages together:

Binding	How it works	Best for
Saddle stitch	Folded sheets stapled through the spine fold	Booklets up to ~64–80 pages; page count must be a multiple of 4
Perfect binding	Pages glued at a flat spine (PUR/EVA glue) with a wraparound cover	Thick books, catalogs
Spiral / Wire-O / coil	Metal or plastic coil through punched holes	Notebooks, manuals that lie flat
Case bound	Hardcover	Premium books

Best practice: Make finishing options **rule-based**, not just priced. The configurator must *block* impossible combinations — foil on a stock that can't take foil, folding heavy stock without a score, an odd page count for saddle stitch — rather than quietly accepting an order that can never be made. Prevent it, don't just price it.

5. Page count (multi-page products)

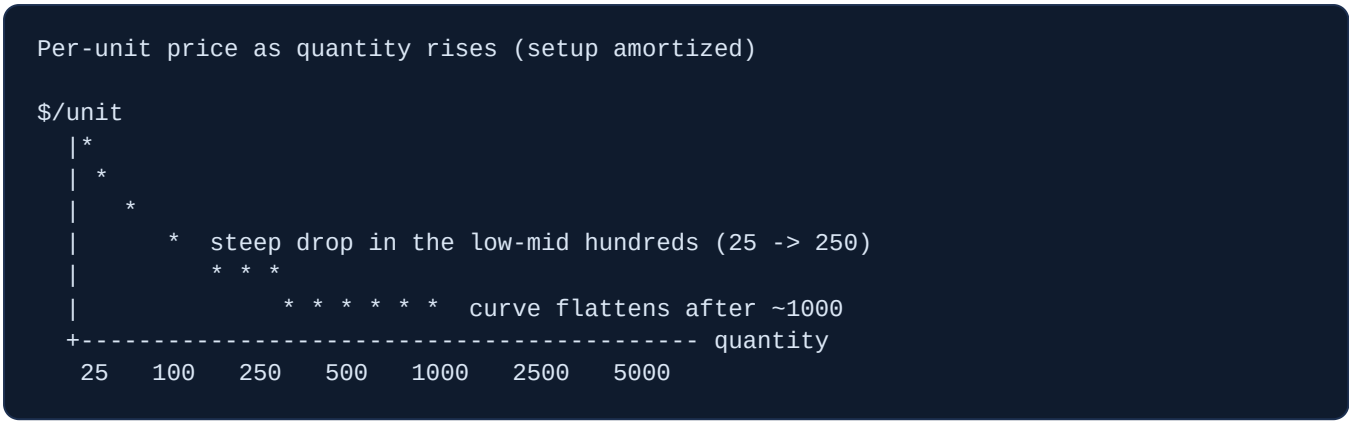
Booklets and books need a page-count field, and for saddle stitch it must be a **multiple of 4** (each folded sheet = 4 pages). Page count drives the binding choice, the **imposition** (how pages are arranged on the press sheet — defined below), and the price. Validate it.

Key takeaway: A spec = attributes (size, stock, sides, page count) + a set of priced options (finishing) + compatibility rules. Every option should carry a price delta, an optional time delta, an optional weight delta, and any one-time die/setup fee.

Pricing models — where print diverges hard from e-commerce

1. Quantity price breaks (tiered pricing)

This is the default for short-run work. The per-unit price *falls* as quantity rises because the **setup cost** (plates, press make-ready, prepress labor) is fixed and gets spread across the run. At low quantity, setup dominates the total; at high quantity, per-piece material cost dominates.



Breaks sit at thresholds the shop sets, e.g. 100 / 250 / 500 / 1000 / 5000. The steepest savings are in the low-to-mid hundreds; after 1000 the curve flattens. Model it as `price = setup_fee + (per_unit × qty)` with a tier table.

> **Example:** Because tiers are stepped, ordering *more* can sometimes cost *less in total* if it crosses into a much cheaper tier. If 500 cards land just below a big 1000-count break, the total for 1000 might be only a little higher — or even lower per the shop's tiers. A good UI surfaces a nudge: "Add 120 more to reach the 1000 price break and save."

Distinguish two flavors of quantity discount in your engine — they produce different totals, so pick one and be explicit:

Type	How it prices
Volume pricing	Once you hit a tier, *all* units are priced at that tier's rate
Tiered / graduated pricing	Each tier's units are priced at that tier's own rate (first 100 at rate A, next 400 at rate B…)

2. Square-foot pricing (wide / large format)

Banners, signs, and posters are priced by **area**: `price = width_ft × height_ft × rate_per_sqft`. Real-world rates run from about **$1.99 to $8.99 per square foot**; ~$8/sq ft is a common standard for digitally-printed banners, budget vinyl can drop to $3–$5/sq ft. The material drives the rate (vinyl is dearer than paper or fabric).

> **Example:** A 6' × 3' banner = 18 sq ft. At $8/sq ft that's ~$144 (material + print + labor). A 36" × 80" roll-up = 3' × 6.67' ≈ 20 sq ft; at ~$8 that's ~$160 before add-ons.

Two refinements: rates are often **degressive** (each successive square foot is cheaper — a built-in volume curve on area), and there is usually a **minimum charge** or minimum square footage. In PF360 terms, this is a distinct pricing *strategy* — a formula like `area * rate` — sitting alongside the per-unit tier tables, not bolted onto them.

3. One-time and per-color charges

Foil and die-cutting need a one-time **die charge**; offset spot colors need a **plate charge**; finishing can be billed per-piece or per-job. Model these as charges that are amortized over the run, separate from the per-unit price.

> **Best practice:** The customer-facing calculator and the admin estimate must produce *identical* numbers. Keep a single source of pricing logic so the storefront and the back office never disagree — a quote the shop can't honor is worse than no quote.

> **Key takeaway:** One pricing strategy cannot serve all products. Support tiered quantity breaks *and* square-foot *and* formula add-ons, and keep storefront and admin in lockstep.

Production status workflow — the lifecycle your model must track

An order isn't a single event; it's a journey through the shop floor. Model it as an explicit, *ordered* state machine. Here is the canonical path, with a few new terms defined inline:

```
Order received
   |
   v
Prepress  (preflight + imposition)
   |
   v
Proof  ---->  PROOF APPROVAL GATE  <----+
   |             |  requests changes    |
   |             +----------------------+  (revise, re-proof)
   |  approves
   v
Approved / scheduled
   |
   v
Printing (on press: make-ready + run + QC)
   |
   v
Finishing / bindery (cut, fold, laminate, bind)
   |
   v
Packaging  -->  Shipped  -->  Delivered

side states: On hold / awaiting files / awaiting payment /
             reprint / cancelled
```

Stage	What happens (plain English)
Order received	Job created, spec captured
Prepress	File prep and color management; the **preflight** check (file validation, below) and **imposition** (arranging multiple pages/copies on the big press sheet so it cuts apart correctly). Bad files bounce back to the customer here.
Proof	System generates a **proof** — a sample (a PDF "soft proof" or a printed "hard proof") for the customer to check
Proof approval gate	The customer approves or requests changes; revised proof; repeat. *This is the single biggest bottleneck and the timing anchor.*
Printing	For offset: making plates and **make-ready** (setting up and aligning the press before the real run); then the run, with quality-control checks for color consistency
Finishing / bindery	Trimming, folding, scoring, lamination, foil, binding, assembly
Packaging → Shipped → Delivered	Pack, hand to carrier with a tracking number, complete

Modeling rules that matter:

- **Two label sets.** Show customers plain language ("Proof ready", "In production", "Shipped"), keep internal codes for the floor. Never surface "PREPRESS_QC_HOLD" to a buyer.
- **The turnaround clock starts at proof approval**, not at order placement (more below).
- **Audit every transition** — who changed it, from what to what, and when. Status changes are business-critical for support and disputes.

The proof approval gate deserves first-class treatment

This is the one place an order legally and practically pauses on the *customer*. It must be a versioned, audit-logged gate: store every proof version, who approved it, and the exact timestamp. The approval timestamp is what anchors the production SLA clock.

Common mistake: No proof-approval record, or no version history. When a customer says "I never approved that color," the shop needs to show the exact proof version and the signed-off timestamp. Without an audit trail, the shop eats the reprint.

Key takeaway: Use an explicit ordered status machine with dual labels (customer-friendly + internal), audit every transition, and make proof approval a versioned, timestamped, first-class gate.

File / preflight requirements — the order isn't real without a valid file

Preflight is the pre-print validation of the customer's file (like a pilot's pre-flight checklist). Four core checks every print PDF must clear:

Check	Requirement	If it fails
Resolution	≥ 300 DPI at final size (1200 DPI for line art)	Blurry, pixelated print — the #1 rejection
Color mode	CMYK, not RGB	Colors shift on conversion; bright blues/greens worst
Bleed	0.125" (3mm) on all 4 sides, plus a safe/margin zone keeping critical content away from the trim line	White slivers at the edge after cutting
Fonts	All embedded or outlined	Printer substitutes wrong fonts and spacing

Quick definitions: **DPI** = dots per inch, a measure of image detail. **Bleed** = artwork extended *past* the trim so no white edge shows after cutting. **Trim** = the final cut size. **Crop marks** = guides showing where to cut. There are also two file standards to know:

Standard	Meaning
PDF/X-1a:2003	Safest: everything CMYK, fonts embedded, no transparency or live layers
PDF/X-4	Modern: allows live transparency, layers, and RGB/Lab/spot color

Shops run preflight automatically and **reject** non-compliant files with a report; production cannot start until the file is corrected and re-uploaded.

Best practice: Gate the order on a preflight pass/fail, but translate the result for a non-technical buyer. Not "RGB profile in PDF/X-1a, missing embedded glyphs" — say "Your file uses screen colors (RGB); print needs CMYK, so colors may shift. Please re-export and upload again." Then offer a clear re-upload loop. In PF360 this heavy file work belongs in the dedicated PDF service, behind a feature flag — not inline in the web app.

Key takeaway: Store file requirements per product, run automated preflight, gate the order on the result, and always return a human-readable failure plus a re-upload path.

Turnaround / SLA — model time honestly with two clocks

SLA = Service Level Agreement, the promised timing. The critical rule: **production turnaround and shipping transit are two separate clocks — never merge them.** If you blend them, customers blame the shop for a carrier's delay.

- **Production turnaround** = proof approval → ready to ship, counted in **business days** (no weekends/holidays), starting the day *after* approval. Typical standard is 3–5 business days; rush can be 24 hours, often with a cutoff ("approve before noon or it slips a day").
- **Shipping transit** = the carrier's separate clock once the parcel leaves.

> **Example:** A customer approves their proof Friday at 4pm. Production is "3 business days." The clock starts *Monday* (weekend skipped), so ready-to-ship is end of Wednesday. Add 2-day ground shipping → delivery the following Friday. Showing one merged "5-day" number would have promised Tuesday and broken trust.

Model implication: store `production_days` and rush options per product; compute the estimated ship/delivery date from the approval timestamp + a business-day calendar + the chosen shipping method; and display the two legs separately.

Weight & shipping — derive the physical numbers from the spec

Each finished piece has a weight. Total parcel weight = (per-piece weight × quantity) + packaging. Per-piece weight comes from the *stock* (GSM × sheet area) plus any weight-adding finishing (lamination, heavier covers). The packed parcel's dimensions drive **dimensional (DIM) weight** — carriers charge on size as well as actual weight for bulky-but-light parcels.

> **Best practice:** Make weight *derivable* from the spec (stock + size + quantity), allow per-product / per-size / per-option overrides, and **snapshot** the weight onto the order at purchase time. If a stock's weight is edited next month, last month's shipped orders must keep their original math. In PF360 this maps directly to the Weight module: per product/size/option-value weights → shipping tiers → order snapshot.

Partial fulfillment — the order can split

A print order often ships in parts: a multi-product order where one item finishes first, a "blind drop ship" sending pieces to several addresses, or staged delivery. **Partial shipment** means the order is delivered in fragments as items become ready, with the rest following later (and shipping may be charged per shipment).

> **Common mistake:** A single order-level "shipped: true/false" flag. That cannot represent "200 of the 500 booklets shipped, the banner ships tomorrow." An order needs **many shipments (1:N)**, each with its own line-item quantities, tracking number, and status. PF360 platform assessments flag full partial-fulfillment support as a real gap to build in from day one.

Gang run / batching — orders merge at production

A **gang run** places multiple separate jobs on *one* shared press sheet so they split the setup, plate, and press cost and waste less paper; the sheet is cut apart after printing. (A **combination run** is the same

idea for related variants.)

> **Example:** Two different 8.5×11 forms, 5,000 each, same paper and ink — ganged onto shared sheets, they save roughly 33% versus two separate runs. Imposition software can gang as many as ~160 different orders onto one layout, auto-rotating pieces to minimize waste.

The hard constraint: every ganged job must share the **same stock and ink/color spec**, and it works on sheet-fed CMYK presses. The downsides you must be able to model and communicate:

- **Color accuracy is harder** — roughly 10% color variance is "standard" in gang runs. Sensitive colors (orange, purple, brown, neutral gray, lime green) drift most.
- **"Ghosting"** — a neighbor's heavy solid ink area can faintly affect your piece.
- **Reprints cost more** — rerunning your piece reproduces the neighbors too.
- **Unsuitable** for special stocks, special effects, or tight brand-color jobs.

Model implication: a **batch / gang entity** that groups eligible jobs by shared *stock* + *color* + *size*. Jobs flow *individually* through prepress and proof, then *merge* at the printing stage, then split again for finishing and shipping.

> **Best practice:** Let customers opt out of gang runs for brand-critical color, and disclose the ~10% variance expectation up front so a slightly-off color isn't a surprise dispute.

Three concrete examples (the model end-to-end)

A. Business cards — short-run, gang-run candidate

- **Spec:** 3.5×2", 16 pt gloss-coated cover (~350 GSM), 4/4; options: matte lamination + rounded corners + spot UV.
- **Pricing:** quantity tiers (250 / 500 / 1000 / 2500), setup amortized; lamination per-piece, rounded-corner die one-time.
- **Production:** prepress → proof → approval → gang run with other 16 pt cards → cut → laminate → ship in 3–5 business days.
- **File:** 3.5×2" + 0.125" bleed, CMYK, 300 DPI, fonts embedded.

B. Vinyl banner — wide format, square-foot pricing, no gang

- **Spec:** 36"×80" (≈20 sq ft), 13 oz scrim vinyl, 4/0; finishing: hemmed edges + grommets every 2 ft.
- **Pricing:** 20 sq ft × ~$8 ≈ $160 + hem/grommet add-ons; degressive rate on larger sizes; minimum charge applies.
- **Production:** large-format printer (no plates); finishing = weld/hem + grommets; high weight → real freight cost.
- **File:** artwork scaled (often 1:1 or 1:10), CMYK; lower DPI acceptable at viewing distance.

C. Saddle-stitch booklet — multi-page, binding, partial fulfillment

- **Spec:** 8.5×11", 28 pages (multiple of 4), 100 lb gloss text interior (148 GSM) + 100 lb gloss cover (270 GSM), 4/4 throughout, saddle stitch, aqueous coat on cover.
- **Pricing:** per-page + cover + binding + quantity tiers; page count drives imposition into signatures.
- **Production:** prepress imposes signatures → proof (page sequence checked) → print → fold → collate → stitch → trim → ship. If ordered alongside other items, booklets may ship separately when bindery finishes → **partial fulfillment**.

Common mistakes (the software-builder checklist)

- Modeling print as fixed-variant SKUs instead of a configurable spec — can't represent size×stock×sides×finishing×qty.
- Treating "sides" as a boolean instead of the 4/4 vocabulary (full color vs spot, front/back independent).
- Looking up price instead of computing it; ignoring setup-fee amortization → wrong totals at low quantity.
- One pricing strategy for everything — wide format needs square-foot, cards need quantity tiers.
- No proof-approval gate, or no version/approver audit trail → "I never approved that" disputes.
- Starting the turnaround clock at order placement, and merging production + shipping time.
- Order-level single shipment (no 1:N) → can't do partial / backorder / multi-address.
- Not validating finishing/stock compatibility → impossible jobs accepted.
- Storing only ambiguous "lb" weight instead of canonical GSM → wrong stock and wrong shipping.
- No preflight gate, or surfacing raw rejection codes instead of plain "Your file is low-resolution; please upload 300 DPI."
- Not snapshotting spec/weight/finishing onto the order → later edits corrupt historical orders (the "silent-lie" class).
- Tangling non-priced custom/metadata fields with pricing-bearing options — keep them separate.

Vocabulary cheat-list — talk to a printer and earn trust

Use these terms correctly and a real shop will treat you as someone who understands the craft.

Term	Plain meaning
4/4, 4/1, 4/0, 1/1, 1/0	Front/back ink counts; 4 = CMYK full color, 0 = blank, 1 = single (usually black)
CMYK / RGB	Process print colors / screen colors (never submit RGB for print)
PMS / Pantone / spot	Exact branded ink; extra plate and cost
GSM / lb / pt (caliper)	Metric weight / US weight (category-dependent) / thickness
Cover vs text stock	Heavy (cards, covers) vs lighter (pages, flyers)
Grain (long/short)	Fiber direction — fold with the grain
Bleed / trim / safe area / crop marks	Art past the cut (0.125") / final size / keep content inside / cut guides
Preflight / imposition / make-ready / plate	File validation / arranging on the sheet / press setup / offset image carrier
Proof	Sample for approval (soft/PDF or hard copy)
Lamination / UV / spot UV / aqueous	Protective coats; spot UV = gloss on chosen areas
Foil / emboss / deboss / die cut / score / perf / drill	Finishing effects (foil and die cut need a one-time die)
Saddle stitch / perfect / spiral / case bound	Stapled fold / glued spine / coil / hardcover
Gang run / combination run	Sharing one press sheet across jobs
Setup / die / plate fee	One-time costs amortized over the run
Turnaround / rush	Production business-days from proof approval (separate from shipping); rush = expedited with cutoffs
12/14/16 pt; 7 pt	Common business-card calipers; 7 pt = USPS postcard minimum

How to talk to a printer

When you call a shop to validate your model or get a quote, lead with the spec in their language, not yours. Don't say "I need a small double-sided card thing in heavy paper." Say: *"3.5 by 2, 16-point gloss cover, 4-over-4, matte lamination both sides, rounded corners, 500 pieces — what's your standard turnaround from proof approval, and do you gang these?"* That one sentence tells them you know size, caliper, ink coverage, finishing, quantity, the SLA clock, and gang runs. Then ask the questions that fill gaps in your data model: "How do you handle a file that fails preflight?", "Do you charge shipping per shipment on partial deliveries?", "What's your color variance tolerance on gang runs?"

Key takeaway: The whole guide reduces to one engineering instruction — model the print product as a *spec/recipe* with priced options and compatibility rules; compute price by strategy (tiers or square-foot); gate the order on a versioned proof approval and an automated preflight; track an explicit, audited status machine; snapshot weight and spec onto the order; and support 1:N shipments and gang batching. Build that, and your software finally tells the truth about the factory.

Glossary of Terms

4/0 (four over zero)

> A printing spec meaning full color (4 inks: CMYK) on the front and nothing on the back. Read as "four-over-zero."

4/4 (four over four)

> Full color on both the front and the back of the sheet. The two numbers are the ink count per side.

Aqueous coating

> A water-based clear coat applied over the whole sheet on press to protect it and add a light gloss or matte finish. Cheaper and faster than UV coating.

Bindery

> The department (and the set of steps) that finishes a printed job after the press — folding, cutting, stitching, binding, and packing.

Bleed

> Extra artwork extended past the final trim line (usually 1/8 inch or 3 mm) so that when the paper is cut, color runs to the very edge with no white slivers.

C1S / C2S

> "Coated one side" and "coated two sides." Describes paper with a smooth clay coating on one face (C1S) or both faces (C2S) for sharper images.

CMYK

> The four process inks used in most color printing: Cyan, Magenta, Yellow, and Key (black). Mixing them in dots creates the illusion of many colors.

Coating

> Any clear layer added on top of ink — aqueous, UV, or varnish — to protect the print, change its sheen, or both.

Collate

> To gather printed pages into the correct order before binding (e.g. page 1, 2, 3 of a booklet rather than 100 copies of page 1).

Color management

> The practice of keeping color consistent from screen to proof to press, usually using ICC profiles so what the customer approves is what prints.

Crop marks

> Thin lines printed outside the artwork that show the cutter where to trim the sheet to final size.

Die-cut

> Cutting paper into a custom shape (a rounded label, a window, a folder pocket) using a sharp metal "die," like a cookie cutter for print.

Digital printing

> Printing directly from a file with no plates, using toner or inkjet. Ideal for short runs and variable data; higher cost per page but near-zero setup.

Dimensional weight (DIM)

> A shipping charge based on a package's size, not just its actual weight. Bulky-but-light print (like banners) is billed on the volume it takes up.

DPI / PPI

> Dots (or pixels) per inch — a measure of image resolution. 300 DPI at final size is the standard for crisp printing; low DPI prints blurry.

DTF (Direct-to-Film)

> An apparel method where the design is printed onto a special film, dusted with adhesive powder, then heat-pressed onto fabric. Works on many fabric types.

DTG (Direct-to-Garment)

> Inkjet printing of full-color designs directly onto a garment (usually cotton). Great for detailed, one-off, or short-run apparel.

Duplex

> Printing on both sides of the sheet. The opposite is simplex (one side).

EDDM

> "Every Door Direct Mail" — a postal program that lets shops mail to every address on a route without a name list. Common print-shop product.

Emboss / Deboss

> Pressing the paper to create a raised (emboss) or recessed (deboss) shape, with no ink, for a tactile premium effect.

Flexography (flexo)

> A high-speed printing method using flexible rubber plates on rolls, used for packaging, labels, and corrugated boxes.

Foil stamping

> Applying a thin metallic or colored foil to paper with heat and pressure for a shiny gold, silver, or holographic accent.

FSC

> Forest Stewardship Council — a certification that the paper comes from responsibly managed forests. A common eco selling point.

Gang run

> Combining several different jobs onto one large press sheet so they share setup and material cost. The key to cheap online print.

Grain (direction)

> The direction in which paper fibers line up. Paper folds and tears cleanly along the grain and cracks against it — critical for folding.

Gripper

> The mechanical fingers that grab the sheet to pull it through a press. The gripper edge cannot carry image and reduces usable sheet area.

GSM

> Grams per square meter — the international measure of paper weight/thickness. 80 gsm is copy paper; 300+ gsm is a business-card stock.

Gutter

> The inner margin space near the binding of a booklet or book, left clear so text is not swallowed by the fold or spine.

Imposition

> Arranging multiple pages on one large sheet in the right positions and rotations so that, after printing and folding, the pages come out in order.

Kiss-cut

> Cutting through a sticker's top layer but not its backing, so the sticker peels off while the sheet stays intact.

Lamination

> Bonding a thin plastic film over the printed sheet for protection and a gloss, matte, or soft-touch finish. Heavier and tougher than a coating.

Make-ready

> All the setup work before good copies come off the press — mounting plates, loading paper, aligning color, running test sheets. A fixed cost per job.

Offset lithography

> The dominant commercial method: ink is transferred from a plate to a rubber blanket to the paper. High quality and cheap at large volumes after setup.

Pad printing

> Transferring a small image from an etched plate via a soft silicone pad onto curved or odd-shaped objects like pens, mugs, and golf balls.

Pantone (PMS) / Spot color

> A pre-mixed ink matched to a numbered swatch (e.g. PMS 286). Used for exact brand colors and shades CMYK cannot reproduce.

Perfect binding

> A binding where pages are glued at the spine into a square-backed cover, like a paperback book or thick catalog.

Perforation (perf)

> A line of tiny cuts that lets a piece be torn cleanly by hand, such as a tear-off coupon or ticket stub.

Plate

> The thin metal sheet carrying the image for one ink, mounted on an offset press. New plates are needed for each new job (part of make-ready).

Preflight

> Automated checking of a print-ready file before production — resolution, bleed, fonts, color mode, and overprint — to catch errors early.

Prepress

> All file preparation between receiving artwork and printing: preflighting, color conversion, imposition, and proofing.

Proof

> A preview of the final job for approval — a soft proof (on screen / PDF) or a hard proof (a physical printed sample) signed off before the run.

Process color

> Color built from the four CMYK inks (as opposed to a spot/Pantone ink). Most photographs print as process color.

Registration

> The precise alignment of each ink/color layer on top of the others. Poor registration shows as blurry, off-color edges.

Saddle stitch

> Binding folded sheets with staples through the spine fold, used for thin booklets, magazines, and brochures.

Score

> A pressed crease that weakens the paper along a line so it folds cleanly without cracking — essential on thick or coated stock.

Screen printing

> Pushing ink through a fine mesh stencil onto the surface, one color per screen. Best for bold designs on apparel and large runs.

Self-cover

> A booklet whose cover is the same stock as the inside pages (versus a "plus cover" printed on heavier stock).

Spot UV

> A glossy UV coating applied only to selected areas (a logo, a word) so they shine against a matte background.

Spread / Choke (trapping)

> Tiny overlaps between adjacent colors so small registration errors don't reveal white gaps. Usually handled in prepress.

Substrate

> The material being printed on — paper, card, vinyl, fabric, plastic, metal. The umbrella term for "the thing the ink goes onto."

Text weight vs Cover weight

> "Text" is lighter paper for inside pages; "Cover" (card) is heavier stock for covers, postcards, and business cards.

Toner

> A dry powder fused to paper by heat in laser/digital presses. The digital equivalent of ink for many short-run jobs.

Trim size

> The final dimensions of the printed piece after it is cut down from the larger press sheet.

Turnaround

> The promised time from order/approval to a finished job ready to ship — a core field shops and customers care about.

UV coating

> A clear coat cured instantly with ultraviolet light, giving a very high gloss and tough finish. Can be full-sheet or spot.

Varnish

> An ink-like clear coating applied on press (gloss, matte, or satin) for protection or contrast; lighter than UV.

Variable data printing (VDP)

> Printing where text or images change from copy to copy — personalized names, codes, or addresses — driven from a data file.

Vector vs Raster

> Vector art is math-based lines that scale to any size cleanly (logos); raster art is pixels that blur when enlarged (photos).

Web vs Sheet-fed

> "Web" presses print on a continuous roll of paper at high speed (newspapers, mailers); "sheet-fed" presses print pre-cut sheets for higher quality.

Wide-format

> Large printing — posters, banners, signs, vehicle wraps — done on wide inkjet machines that handle rolls or rigid boards.

Frequently Asked Questions

These are the questions a software builder almost always asks when they first start modeling print. The answers are deliberately plain-English and practical. Where it helps the person building the SaaS, we note what to capture in your data model.

What is the difference between offset and digital printing, and when is each cheaper?

Offset presses transfer ink from metal plates onto a rubber blanket and then onto paper. Making those plates and "tuning" the press (called **make-ready**) costs time and money before a single good sheet comes out — but once running, each extra sheet is very cheap. **Digital** printing (toner or inkjet) has almost no setup; it prints like a giant office printer, so the cost is roughly the same per page whether you print 1 or 500.

Rule of thumb: short runs are cheaper digital; long runs are cheaper offset. The crossover for typical color jobs sits somewhere around **500–1,500 copies**, depending on size, paper and shop. Below that, go digital; well above it, go offset.

Why doesn't the color on my screen match the printed piece (RGB vs CMYK)?

Your screen makes color by emitting **light** and mixes Red, Green, Blue (**RGB**) — that's an *additive* system, and bright glowing colors are easy. Print makes color by laying down **ink** that absorbs light and mixes Cyan, Magenta, Yellow, Black (**CMYK**) — a *subtractive* system. CMYK simply can't reproduce some of the vivid blues, greens and oranges a screen can glow. So a neon screen blue prints duller. This is normal physics, not a bug.

The fix is to design and proof in CMYK, use a color profile (like **GRACoL** or **FOGRA**) so everyone shares the same target, and warn customers in software when their uploaded file is RGB.

What is GSM and how do I pick paper?

GSM = grams per square meter — the weight of one square meter of the paper. Higher GSM generally means thicker, stiffer, more premium-feeling stock. It is the cleanest way to specify paper because it doesn't depend on sheet size (unlike the US "pound" system, which does).

- **80–120 gsm** — letterhead, copy paper, cheap flyers.
- **130–170 gsm** — quality flyers, posters, magazine pages.
- **200–300 gsm** — postcards, menus, light covers.
- **300–400 gsm** — business cards, premium cards, packaging.

What is bleed, and why do print files need it?

Bleed is extra image area that extends past the final trimmed edge — usually **3 mm** (about 0.125 in) on each side. Cutting blades and folded sheets shift by tiny amounts, so if your background color stopped exactly at the edge, you'd get thin white slivers. Bleed gives the cutter a safety margin so ink runs all the way to the edge.

There are three zones: the **bleed** (cut into), the **trim** (the final size), and the **safe zone** (keep important text ~3 mm inside the trim so it isn't sliced off). Your preflight code should check that uploaded files include bleed.

What does "4/4" or "4/0" mean?

It's printer shorthand for **ink colors front / back**. The "4" means full-color CMYK (4 inks). So:

- **4/4** = full color both sides.
- **4/0** = full color front, nothing on the back.
- **1/0** = one ink (e.g. black) on front only.
- **4/1** = full color front, black-only back (common for flyers).

In software, model this as two fields: `front_colors` and `back_colors` — it drives both pricing and plate/press setup.

What is a gang run?

Ganging means combining several different jobs (from different customers) onto one big press sheet so they share the same make-ready and run together. It slashes per-job setup cost, which is why online "trade printers" can sell 500 business cards so cheaply. The trade-off: ganged jobs run on standard sizes/stocks and on the shop's schedule, so you give up customization and speed control.

How is a print job actually priced?

A quote is usually built from layers:

1. **Setup / make-ready** — fixed cost per job (plates, press tuning, file prep). Spread across the run.
2. **Materials** — paper/substrate + ink, scaled by quantity and size.
3. **Running / click cost** — press time (offset) or per-impression "click" charges (digital).
4. **Finishing** — cutting, folding, binding, lamination, etc.
5. **Overhead + margin** — the shop's profit and fixed costs.

Because setup is fixed, the **per-unit price drops as quantity rises**. That's why print uses quantity-tier pricing, not a single unit price.

What is make-ready and why does it cost so much?

Make-ready is all the work to get a press ready to produce good sheets: mounting plates, loading paper, balancing ink and water, and running waste sheets until color is correct. It is mostly a fixed cost per job and is the single biggest reason short runs are expensive on offset. Digital printing has almost no make-ready, which is its core advantage.

What finishing options should my product page offer?

Offer the common, high-demand ones and tie each to a price modifier:

- **Lamination / coating** — gloss, matte, or soft-touch (protects and changes feel).
- **Folding** — half, tri-fold, gate, etc. (for brochures).
- **Binding** — saddle-stitch (stapled), perfect bound (glued spine), spiral/wire.
- **Cutting / shaping** — round corners, die-cut shapes.
- **Embellishments** — foil stamping, embossing, spot UV (premium upsells).
- **Drilling/holes, scoring, perforation** — for hang tags, tear-offs, easy folds.

In software, model finishing as a list of selectable options, each with its own pricing rule and any constraints (e.g. saddle-stitch needs page count divisible by 4).

What is preflight?

Preflight is the automated check of a customer's file *before* it goes to press — like a spell-checker for print. It verifies bleed, resolution (DPI), color mode (CMYK vs RGB), embedded fonts, correct page size, and overprint settings. Good preflight catches problems early so you don't print 5,000 flawed pieces. For a SaaS, preflight-on-upload is one of the highest-value features you can build.

What is DPI / resolution and what number do I need?

DPI (dots per inch) measures how much detail an image holds at its print size. Too few dots and the image looks blurry or blocky ("pixelated"). The press standard is **300 DPI at final print size** for photos. Large signage viewed from far away can use far less (72–150 DPI) because distance hides the dots. Your uploader should compute effective DPI from pixel dimensions vs placement size and warn if it's too low.

What is a Pantone (spot) color and when do I need one?

CMYK builds colors by overlapping four inks, which can drift batch to batch. A **Pantone / spot color** is a single pre-mixed ink with a standardized recipe (PMS number) — so a brand red is identical everywhere. You need spot colors for brand consistency, metallics, fluorescents, or colors CMYK can't reach. They add a press unit and cost, so they're a paid option, mostly on offset.

What's the difference between DTG, DTF and screen printing for apparel?

Method	How it works	Best for
Screen printing	Ink pushed through a stencil/mesh, one screen per color	High volume, few colors, durable
DTG (direct-to-garment)	Inkjet prints directly onto fabric	Full-color, photo designs, low quantities
DTF (direct-to-film)	Print on film, then heat-press transfer	Many fabric types, small batches, vivid color

Screen printing has setup cost per color (like offset's make-ready), so it wins at volume. DTG and DTF have little setup, so they win for one-offs and full-color art.

Parcel vs freight shipping — what's the difference?

Parcel is individual boxes shipped via carriers like UPS/FedEx/USPS — fine for small, light orders. **Freight** (often **LTL**, "less-than-truckload") is for heavy or bulky shipments on pallets — large poster runs, boxes of catalogs, signage. The break point is usually around **68–70 kg (150 lb)** or when goods are palletized. Carriers also charge by **dimensional weight** (size, not just actual weight) for light-but-bulky items, so a big box of foam signs can cost more than its scale weight suggests.

What is dimensional (volumetric) weight?

Carriers bill the *greater* of actual weight or a calculated size-based weight, because a truck fills up by space, not just by mass. Typical formula: `(L × W × H in cm) ÷ 5000 = dim weight in kg` (the divisor varies by carrier and units). Light, bulky print (banners, foam board, packaging) is often billed on dim weight. Your shipping estimator must store box dimensions, not just weight.

Is digital printing eco-friendly?

It depends, but generally digital is greener **for short runs** because it skips plates and make-ready waste, prints on demand (less overproduction and obsolete inventory), and supports print-only-what-you-sell. Offset can be greener **at high volume** per unit. Bigger sustainability levers than process choice: using **FSC-certified** or recycled paper, vegetable/soy-based inks, water-based or UV-LED curing, right-sizing quantities to cut waste, and efficient nesting/imposition. "Eco" claims should be backed by certifications, not vibes.

What production statuses should an order move through?

A clean, plain-language status spine customers understand:

`Order Received → File Check (Preflight) → Approved / Proof Sent → In Production → Finishing → Quality Check → Shipped → Delivered`

Add side states for **Action Needed** (bad file, awaiting proof approval), **On Hold**, and **Cancelled/Refunded**. Each transition is worth logging (who, what, when) for support and disputes.

What is imposition and batching?

Imposition is arranging multiple pages or copies on one large press sheet so that, after printing and folding/cutting, everything ends up in the right order and orientation. **Batching** groups similar jobs (same stock, same size, same color setup) to run together and share setup. Both exist to cut waste and setup cost. In software you don't have to do imposition math, but you should capture the attributes (size, stock, color, finishing) that let a shop batch efficiently.

What's the difference between margin and markup?

They sound the same but aren't. **Markup** is profit as a percentage of *cost*. **Margin** is profit as a percentage of the *selling price*. A 50% markup is only a 33% margin. Mixing them up is a classic costing mistake that quietly erodes profit. Pick one convention in your pricing engine and label it clearly.

- `Markup % = (Price − Cost) ÷ Cost × 100`
- `Margin % = (Price − Cost) ÷ Price × 100`

Revision Cheat Sheet

A dense, scannable one-stop reference. Skim it before a meeting, a build session, or a quote.

Printing-Process Selector

Job	Volume	Best process	Why
Business cards, flyers	1–500	Digital	No setup; cheap short runs
Business cards, flyers	1,000+	Offset (often ganged)	Low per-unit at scale
Brochures, catalogs, books	High	Offset	Quality + cost at volume
Personalized mail / variable data	Any	Digital (inkjet/toner)	Each piece unique
T-shirts, few colors	High	Screen print	Setup per color pays off
T-shirts, full-color / one-off	Low	DTG / DTF	No screen setup
Banners, posters, signage	Any	Wide-format inkjet	Large sizes, on demand
Labels, flexible packaging	High	Flexography	Fast on rolls/film

Paper-Weight Quick Reference

Use	GSM	≈ US equivalent
Copy / letterhead	80–100	20–24 lb bond
Quality flyer / text page	120–170	32 lb bond / 60–70 lb text
Poster / brochure cover	170–250	80–100 lb text / 65–80 lb cover
Postcard / menu	250–300	90–110 lb cover
Business card / premium	300–400	110–140 lb cover
Folding carton / packaging	350–450+	12–18 pt board

Note: Specify in GSM where possible — US "lb" depends on sheet size and is ambiguous. `Text/book` stock is bendy; `cover/card` stock is rigid.

Color, Files & Prepress Checklist

- **Color mode:** CMYK for print (not RGB). Flag RGB uploads.
- **Bleed:** 3 mm (0.125 in) past trim on all sides.

- **Safe zone:** keep text ≥ 3 mm inside the trim line.
- **Resolution:** 300 DPI at final size (photos); large signage 72–150 DPI OK.
- **Pantone/spot:** use for exact brand color, metallic, fluorescent.
- **Total ink coverage:** keep ≤ ~300% to avoid set-off/smearing.
- **Fonts:** embed or outline; **black text:** use 100% K, not rich black.
- **File format:** print-ready PDF (PDF/X) preferred.
- **Preflight on upload:** bleed, DPI, color, fonts, page size.

"X/Y" Ink Notation

Notation	Meaning
4/4	Full color (CMYK) front & back
4/0	Full color front, blank back
4/1	Full color front, black-only back
1/0	One ink, front only

Finishing & Binding Quick List

- **Coatings:** gloss / matte / soft-touch lamination; spot UV; aqueous.
- **Folds:** half, tri-fold (letter), Z-fold, gate, roll fold.
- **Binding:** saddle-stitch (≤ ~64 pp; pages ÷ 4), perfect bound (glued spine, thicker books), spiral/wire-o (lay-flat), case/hardcover.
- **Cutting/shaping:** guillotine cut, die-cut, round corners.
- **Embellishments:** foil stamp, emboss/deboss, spot UV (premium upsells).
- **Other:** scoring (clean folds), perforation (tear-off), drilling (holes), numbering.

Production Status Spine

```
Order Received
   -> File Check (Preflight)
        -> [Action Needed: bad file / proof?]
   -> Proof Approved
   -> In Production (print)
   -> Finishing (cut/fold/bind/coat)
   -> Quality Check
   -> Shipped --> Delivered
   (side: On Hold | Cancelled | Refunded)
```

Offset vs Digital — Break-Even Rule of Thumb

	Offset	Digital
Setup cost	High (plates + make-ready)	~None
Per-unit cost	Very low	Flat per page
Cheaper when…	Long runs	Short runs / variable data
Crossover	≈ 500–1,500 copies (varies by size/stock/shop)	

- **Gang run** = many jobs share one sheet & one setup → cheap short-run offset.
- **Make-ready** = fixed setup cost; the main reason short offset runs are pricey.

Key Formulas

- **Markup %** = (Price − Cost) ÷ Cost × 100
- **Margin %** = (Price − Cost) ÷ Price × 100 (*always smaller than markup*)
- **Price from margin** = Cost ÷ (1 − margin)
- **Unit price** = (Setup + Materials + Run + Finishing + Overhead) ÷ Qty × (1 + markup)
- **Dim weight (metric)** = (L × W × H cm) ÷ 5000 = kg (carrier divisor varies)
- **Bill = greater of** actual weight or dim weight.

Shipping Quick Take

Mode	Use for	Threshold
Parcel (UPS/FedEx/USPS)	Small/light boxes	< ~68 kg (150 lb)
Freight / LTL (pallet)	Bulky/heavy runs, signage	Palletized or > 68 kg

Sustainability Levers (biggest first)

- Right-size the run — overproduction is the #1 waste.
- FSC-certified / recycled stock; vegetable/soy inks.
- Print-on-demand (digital) to avoid dead inventory.
- UV-LED / water-based curing; efficient nesting/imposition.
- Back "eco" claims with real certifications, not slogans.

Talk Like a Printer (vocab line)

`GSM` · `bleed/trim/safe` · `4/4` · `CMYK` · `spot/Pantone (PMS)` · `make-ready` · `gang run` · `imposition` · `preflight` · `saddle-stitch` · `perfect bound` · `spot UV` · `LTL` · `dim weight` · `click cost` · `aqueous coating` · `set-off` · `variable data`