SHORTCUTTING SUPPLY CHAINS FOR HUMANITARIAN RELIEF

A How-To Guide

FIELD READY

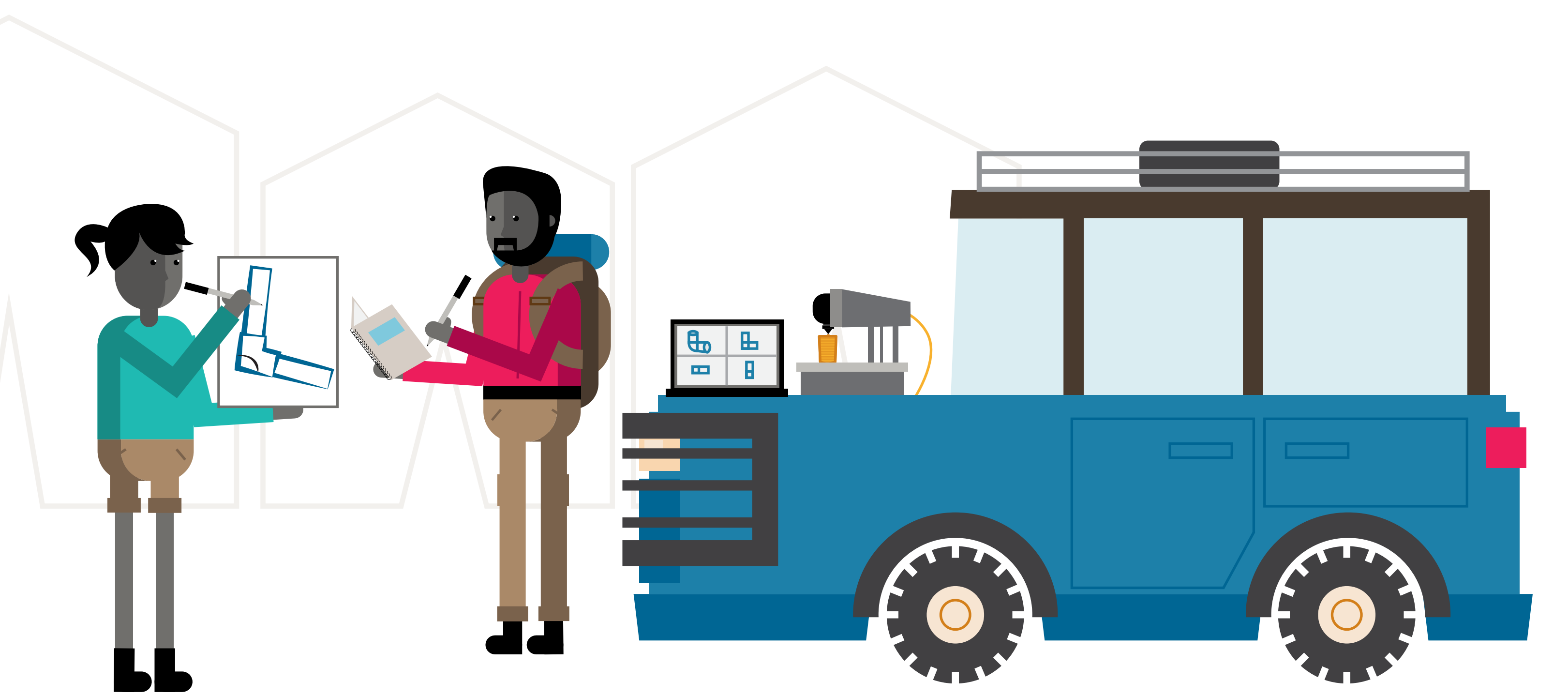
Version 1.0

We believe in empowering communities to improve their situations by making humanitarian supplies in the field.

We are excited to share our tools for humanitarian relief with you!

This handbook will help you empower communities, individuals, and aid agencies to improve situations using proven tools and methods. We're proud of our work in Haiti, Nepal, and Syria and believe that the stories and experiences we share will inspire new thinking, plans and action.

-Field Ready Team



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Introduction

Whether you’re new to Field Ready or been working with us for a while, we’re excited to have you on the team. Each chapter of this guide is divided into levels of expertise. Focus on concepts that you are comfortable with, and over time, you will gain more skills to “level up” in areas that interest you the most.

Adhering to Ethical Standards

As a humanitarian organization, Field Ready adheres closely to humanitarian principles, and holds ethical practice as a cornerstone of what we do. This means that we place people at the center of our work - we ensure no harm occurs as a result of an intervention, and perform actions that ultimately promote the rights, dignity and capabilities of people affected by disasters. Whenever innovative activities are undertaken, they must be done with fairness, equity and accountability. We expect our partners to conform to this ethical standard and recommend all others do so as well.

Contents

Levels of Expertise

This book focuses on Levels 1 & 2

Level 1: Introduction

Level 2: Basic Competency

Level 3: Proficiency

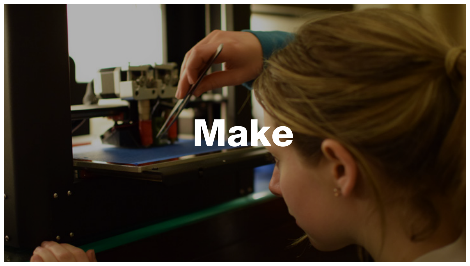
Level 4: Mastery

Means & Methods

Field Ready employs best practices and advanced thinking inspired by the fields of relief and development, human-centered design, engineering, the maker movement, and manufacturing. While keeping in mind the context and realities on the ground, we generally adhere to the following five-step process.

We take extra care in understanding the situation and those we work with. We use deep understanding and empathy as tools that allow us to work toward practical and sustainable solutions together.

Using an iterative process, we consider both technology, and how people can benefit from its proper use. We collaborate closely with end-users where they live and work to ensure viable impact.



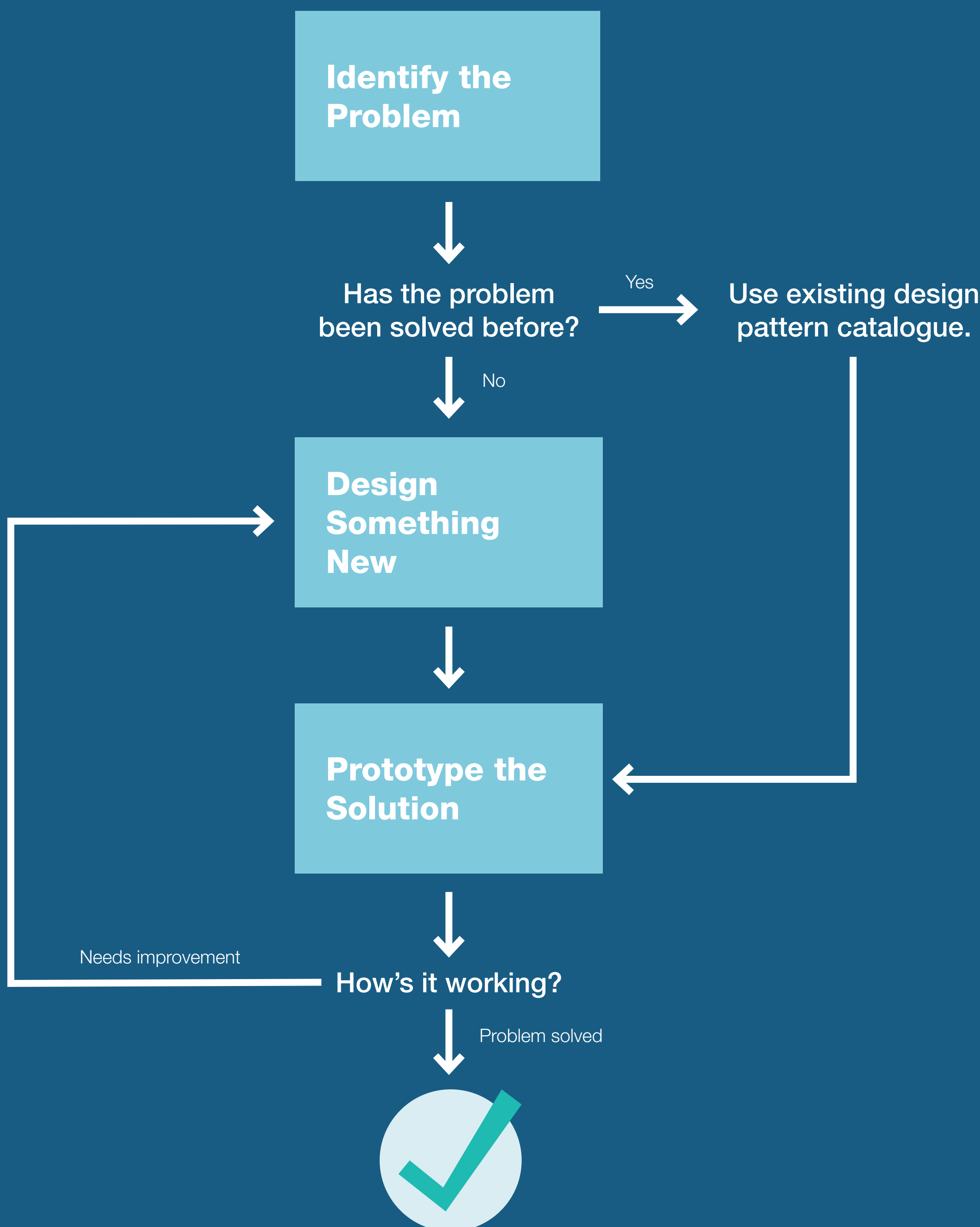
We deploy experienced makers and humanitarians with applicable tools, skills, and technologies to create solutions on demand. This way we get people what they need, when they need it, where they need it. We possess the capacity to meet unique needs and then to share those solutions at scale.

We share our learnings and solutions from the field with others so that they too can find faster solutions themselves. Digital files can also be shared, distributed, and downloaded for free from anywhere in the world to ensure a global benefit with even more people building on eachother’s solutions.

We deploy experienced team members to lead by example and demonstrate appropriate uses of technology. We share our knowledge, skills, and people to create solutions in the face of any challenge.

The Field Ready Process

Follow these steps to solve humanitarian problems effectively.



Implement the solution and share your results so others can learn from your successes.

Problem Identification

Common Problem Categories

The humanitarian relief community classifies problems into the categories below.

Water, Sanitation & Hygiene (WASH)

Health & Medical

Food & Nutrition

Safety & Security

Power

Shelter

Communications

Logistics

We use **Problem Identification** to figure out what we can do to have the greatest impact.

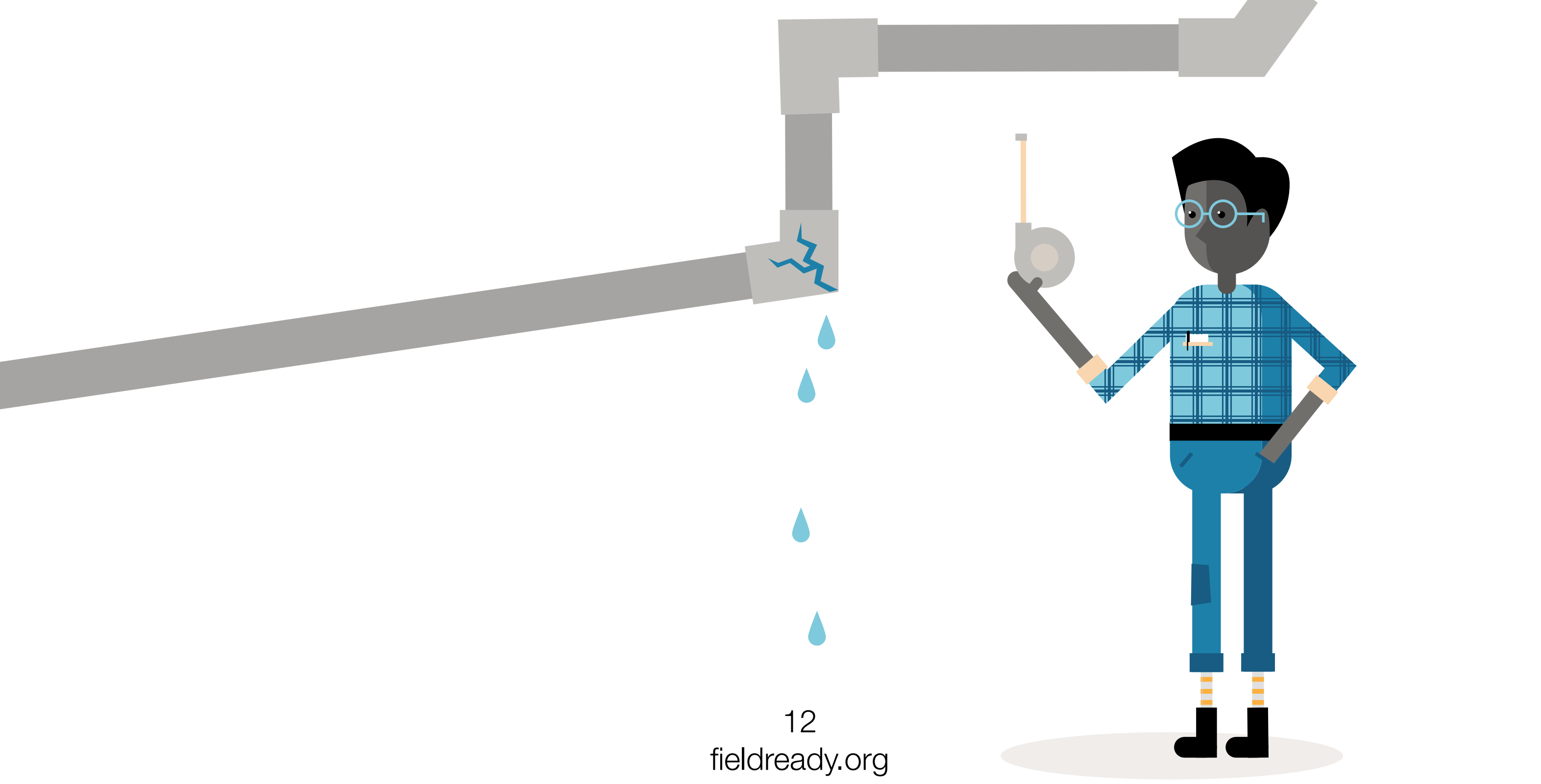
Problem identification has 3 steps:

Step 1: Find Problems
Assess the situation and list any problems that can be solved using Field Ready's process.

Step 2: Document Everything
Photograph and measure parts and pieces that need to be replaced or will connect to parts you plan to create to solve the problem.

Step 3: Prioritize
Rank problems based on importance and difficulty to help you decide what to tackle first.

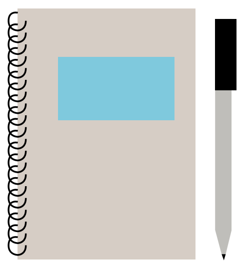
The rest of this chapter provides more detail about each of these steps, as well as useful methods to help you get started.



Problem Identification

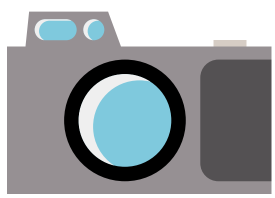
What to Bring

Make sure you bring these items with you when you go out into the field:



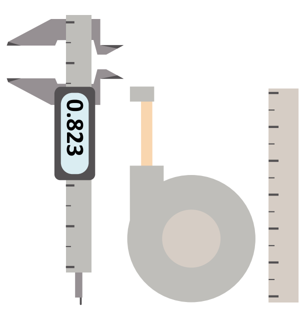
Notebook & Pen

To take notes while you observe and interview the community.



Camera or Phone

To document the environment, mark locations, and snap close-ups of important details.



Measuring Tools

To figure out the exact dimensions of parts and connections.

Other Tools

In case you need to disassemble parts or unscrew panels.

Step 1: Find Problems

When approaching a situation for the first time, grab your notebook and observe the environment. Ask others (and yourself) this set of questions, taking notes as you go. Each answer is an opportunity to improve the situation.

1. **What's broken?**
   Are there things you can fix and replace? Troubleshoot the situation to identify needed parts or repairs.
2. **What could be safer?**
   Look for sharp edges, sanitation risks, reused medical devices, bare wires, or other potential safety hazards.
3. **What's missing?**
   What does the community really need? What basic necessities aren't present? Identify things the community needs yet doesn't have.
4. **What could work better?**
   Are there inefficiencies that could be improved? Things that could be more durable? What are the bottlenecks? Are there costs that could be reduced using Field Ready's process?
5. **If you had a magic wand, what's the one thing you would change?**

Once you have a list of problems, separate ones that could be solved using the Field Ready method from those that probably can't. If problems seem too complex, try breaking them up into manageable chunks.

Problem Finding Methods

These methods identify problems effectively.

Problem Identification

Think Aloud

Observe someone performing a task to gain insights about their situation.

Think Aloud is a technique for observing people in action. Ask your subject to narrate what they are thinking and doing as they perform a task, including what they see, the steps they take, how they are feeling, and what barriers they face. Keep a close eye on how they accomplish the task and make note of pain points or difficulties. The notes you collect will help you understand challenges and identify specific opportunities to improve situations.

How It Works

It is important to introduce yourself and establish a rapport with each individual you interview and observe.

1. **Identify a task.**
   Pick a task to observe that is high priority. Explain the purpose and goals of the observation, and don't forget to get permission.

2. **Observe.**
   Ask your interviewee to think aloud, explaining what they are thinking as they move step by step through the task.

3. **Take notes and listen.**
   The only times you need to speak are when you need to remind your subject to continue thinking aloud and to ask “Why?” for more detail to understand their thought process. Be sure to make note of things you don’t understand so you can follow up in detail after the observation.

Tips

- Avoid demonstrations - you want to observe real work.
- If you have a helper, have them record video of the activity for future reference.
- The task can be big or small. You may also observe a series of related tasks. Keep it focused on things that will help you solve problems using the Field Ready approach.

Contextual Inquiry

Interview people in context to better understand things from their perspective.

This in-person method is similar to taking a tour. By conducting an interview in your interviewee's environment, you'll experience contextual details that are nearly impossible to notice when you're not in the field. You will observe things that others wouldn't remember to share in conversation, over the phone, or when they are off-site. Contextual Inquiry helps you understand people and culture better because it combines the interview with authentic observation.

This is important because as outsiders, you and your team typically approach situations with different priorities, perspectives, and life experiences than the communities, aid agencies, and people you're helping.

How It Works

1. **Create a high-level topic guide to use during your visit.**
   Talk with your subject ahead of time and make a list of the items and spaces you're interested in learning about. (You can find more on creating topic guides in a later section.)

2. **Do your homework**
   Get permission to visit (including photo and video permission) and set

a date and location to meet ahead of time. Make sure you ask if there is a dress code or other safety requirements. Should you wear pants? Are shorts permitted? Do you need steel-toed shoes? A hair-net? Eye protection? Are there cultural aspects of dress you should consider? Talk with your interviewee ahead of time and make a list of items and spaces that you're interested in learning about.

3. **Bring an assistant.**
   It's always best to have a second pair of eyes to help take notes, snap photos, and record video or audio if possible. And when entering an unknown environment, it's safest to use the buddy system. Avoid community leaders as this can create unhelpful dynamics - try to bring a local speaker, translator, advocate, or expert.

4. **Conduct the interview.**
   Start a conversation where you ask open ended questions about each topic in your guide. Pay close attention to your surroundings. Take notes on what you see and ask specific questions about relevant objects, spaces, or processes you observe.

Tips

- Bring your passport and any other paperwork needed to enter the facility.
- If you're not familiar with the region or culture, find an assistant who can also serve as a translator, in-country chaperon, and/or cultural expert.
- Prepare by educating yourself. Who will you interact with? What cultural norms exist? Are there concerns regarding the facilities or environment you will visit? Be safe and follow the rules and customs.
- As you notice potential opportunities, ask detailed questions. Really try to understand how complex and how important each opportunity might be to the affected community you are helping.
- Try to interview more than one person to collect a range of perspectives.

In-Depth Interview

Talk to aid workers, experts, and community members about their needs.

Talking to people is the quickest way to understand their needs and identify opportunities to help.

How It Works

1. **Create a topic guide.**
   A topic guide is a simple list of things you need more information about. It is not a script, but a general guide that standardizes the interview process across several individuals. (More on creating topic guides later.)
2. **Plan interviews.**
   Whether conducting one interview or a series, work with someone to identify candidate(s) and schedule when to talk to them. It's always better to get more than one perspective, especially when talking about complex challenges.
3. **Conduct the interview.**
   Introduce yourself, state the purpose of the interview, and ask if the interviewee has any questions for you before you begin. Start a conversation, ask open ended questions about each topic in your topic guide.

Tips

- Verify whether it's okay to record beforehand.
- Once you confirm recording is permitted, get consent by having the interviewee sign a consent form. You can do this when you initially plan the interview, or at the beginning of each interview.
- Understand relevant cultural issues. Have a translator if needed, and have your topic guide reviewed by a translator or cultural expert.
- Interviews can be conducted over the phone, internet (using apps like Google Hangouts or Skype), or in person. In-person interviews typically provide the most context and the best information.
- If you can, have an assistant take notes while you conduct the interview. Depending on the situation, you may need a translator, recorder, in-country chaperon or cultural expert.

Topic Guide

Plan for the discussions and interviews you will lead.

A topic guide is a outline of the conversation, including questions and topics, that you would like to have with people. This is not a script, but a general guide that standardizes the interview process across several individuals. As you create your topic guide document, you can leave large spaces in between topics or questions so that you can record the interviewee's responses.

The topic guide helps interviewers stay on track and on time, and it frees them to pay closer attention to context and discussion. The guide also keeps interviews' notes organized for future synthesis.

How It Works

1. **Identify key topics.**
   Create a list of topics that you're looking to understand on your own or with your team.
2. **Compose questions.**
   Create open-ended questions to help people feel like they can share details (specific yes-no questions don't provide room to elaborate).

Tips

- Include a few warm up questions. Start broad. Then, as you progress, narrow the focus.
- Run through the topic guide with someone who won't be interviewed, to make sure everything flows and the wording of questions is clear.
- Open-ended questions will evoke a number of different responses. Note any probes - specific bits of information - that you are looking to collect from every respondent, e.g. years of experience, desired outcomes, feelings.
- Leave space on the sheet between each question for recording the answers.

Sample Questions

Start with the sample questions below if you are interviewing an **aid worker**. You'll want to ask very different questions if your subject is someone else.

1. **What is your job title?**
2. **How long have you worked in this industry?**
3. **Have you worked in other positions in this organization or in this industry? If yes, please describe.**
4. **Did you receive formal or informal training that prepared you to work in this field? If yes, please describe.**
5. **As you conduct your work, what are the three things that are most "top of mind" for you on a daily basis? Why?**
6. **Are there basic things that have to be in place for you to do your work (shelter, power, transportation, etc.), or does it depend on the situation? Please describe.**
7. **What methods do you use to identify challenges and solve them?**
8. **Describe a short-term issue that you (or you and your team) had to tackle and how you solved it.**

Step 2: Document Everything

Make sure you take plenty of notes about each problem and the parts you think you'll need to solve it. Record everything you can, focusing on accurate measurements and the most important details. As you document a problem, use the prompts below as a guide.

1. **Identify which parts to make.**
   Identify the part or parts you'll need to make to solve the problem.
2. **Measure thoroughly.**
   Record everything you can about the size, dimensions, thickness, and connectors for each part you want to make. Don't forget to measure whatever the part connects to as well.
3. **Capture important details.**
   Does the part need to be made from a certain material? Are there moving parts or other sources of complexity that may influence how the part should be made? Capture any specific details about each part that may be useful when designing a solution.

Documentation Methods

These methods document problems effectively.

Sketching

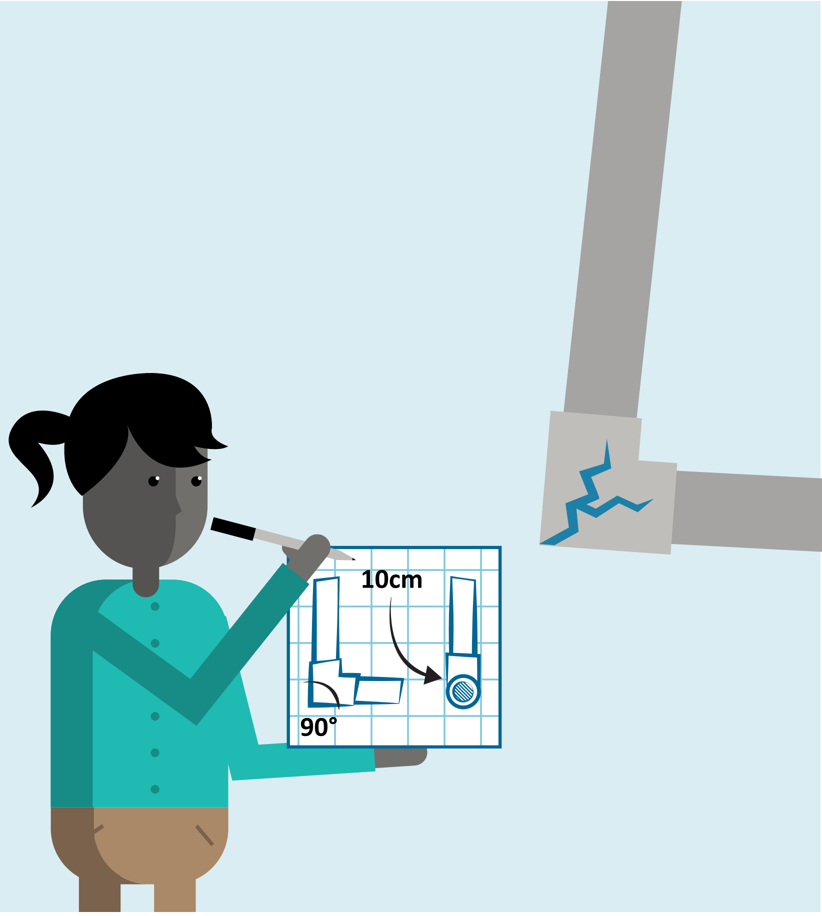
Photography

Measurement

Problem Identification

Sketching

Making detailed sketches helps you communicate and design solutions.



Sketching is a great way to capture the details of a problem.

How It Works

1. **Start drawing.**
   Figure out what you need and sketch it. This might be a part you need to replace, an adapter, or a completely new part or set of parts.

2. **Measure and annotate.**
   Make sure you measure your part. Things like the part's scale, dimensions, length, thickness, diameter, inner-diameter, and angles are important for making parts that fit and function correctly.

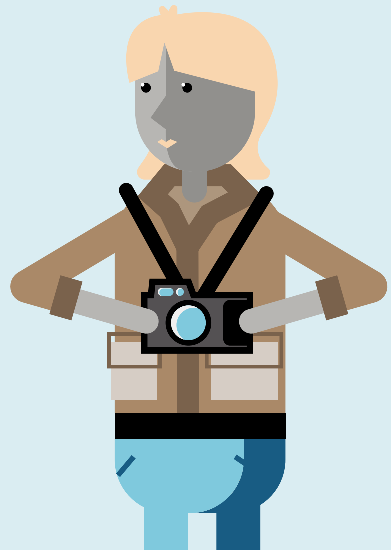
3. **Capture details.**
   Look for markings, brand names, part numbers, symbols, and other details that can help you.

Tips

- Sometimes it's helpful to draw the same part or object from different angles.
- Focus on the problem area.
- Bring measuring tools like calipers, a tape measure, and/or a ruler.
- Write down questions and issues you might need to follow up.
- Use graph paper if you have it, and try to keep the different parts of your drawing to scale.
- Bring tools. You might need to disassemble parts or unscrew panels to see inside whatever you are sketching.
- If you don't have a scanner, you can photograph your sketches to share them with remote team members.
- Trace the part on paper to get an accurate sense of scale.

Problem Identification

Photography



Snap and share photos of the problem area to use as reference and communicate measurements.

Use your phone or a camera to take photos of the problem area.

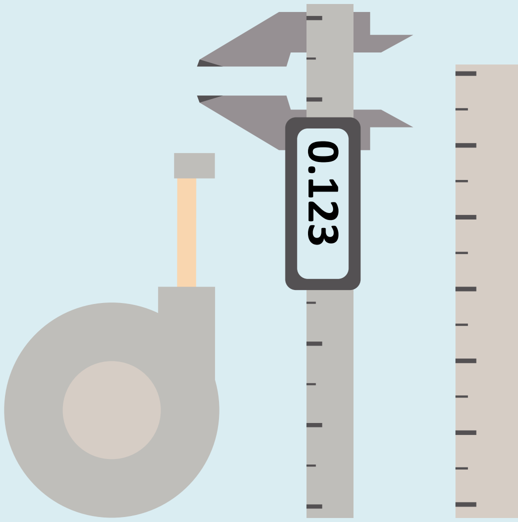
How It Works

1. **Snap detail shots.**
   Capture as many important details about the problem as you can with your camera.
2. **Capture the surroundings.**
   Take a few photos of the overall problem space, systems or devices that connect to what you are focusing on. This will help you make sure your solution integrates with the overall system.

Tips

- Make sure you take photos of the entire system and close-ups of the problem area(s).
- Stage a ruler, calipers, or other measuring device in the scene so someone looking at your photo can easily understand the scale.
- Make sure your camera is focused and use a flash when there's not enough light.
- Bring tools. You might need to disassemble things or unscrew panels to see inside whatever you are photographing.
- If you have a smartphone or GPS, remember to record location.
- Make sure you have enough storage space before you set out. If using a camera, bring multiple SD Cards and use one for each overall problem area.

Measurement



Good measurement is the key to success.

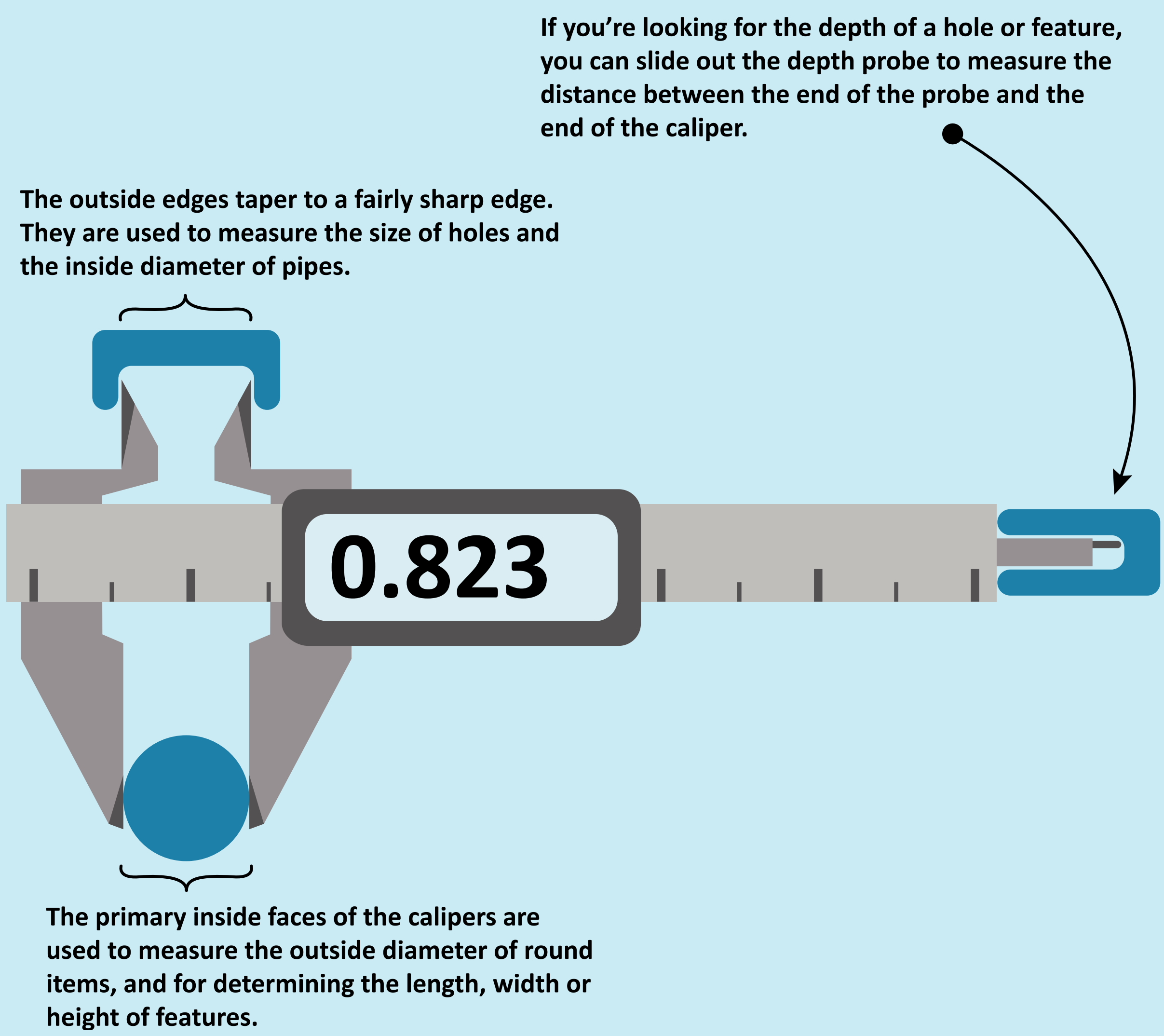
In order to design and make functional things, you'll need to measure existing parts and pieces. It helps to take a photo of the object and the measuring device together as a way to document the measurements. Make sure the photo is taken straight on, and that you can read the markings on the measurement device.

Measuring Devices

1. **Tape Measures**
2. **Rulers**
3. **Calipers**
4. **Advanced Measuring Devices**
   There are more specific and advanced tools available as well. A Theodolite or Total Station is used to survey land, a laser tape measure is helpful for taking multiple measurements very quickly, a 3D scanner is useful for capturing a person's body geometry or the geometry of a device you are looking to design replacement parts for, and a trundle wheel (or measuring wheel) is used to gain rough measurements of long distances.

Calipers

Calipers can typically be found in a market where there are machine shops, building supplies, industrial supplies, etc. They are a critical asset for creating accurate digital models of the parts you need to manufacture.



Step 3: Prioritize

After identifying and documenting a list of problems and opportunities, it's time to prioritize them so you can get started on the ones that will have the most impact. Answer the following questions to rank problems and opportunities:

1. **Are there any emergencies?**
   Solve problems that address the most immediate need first, while keeping an eye out for bigger picture solutions too.
2. **How much impact will this solution have?**
   How many people will your solution help? How important will it be? Is it solving their most pressing problems? Will the solution be temporary or lasting?
3. **How hard will this solution be to implement?**
   Is this solution complex or simple? Can you solve the problem quickly, or will it take a lot of time and effort? How long will making the parts take?
4. **Will this solution be reused?**
   After you solve this problem locally, can other communities benefit from it? How widespread is the problem you are solving?

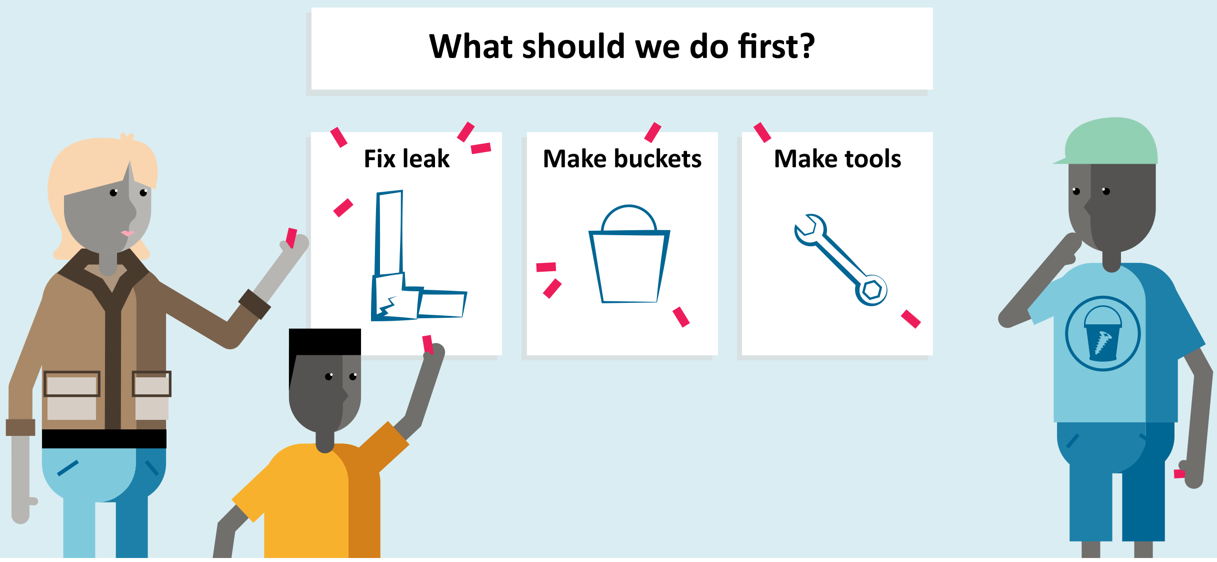
Useful Methods

These methods will help you prioritize problems for maximum humanitarian impact.

Visualize the Vote

Importance / Difficulty Matrix

Visualize the Vote



A quick poll of available team members can reveal preferences and opinions, democratize decision-making and harnesses a group's collective intelligence.

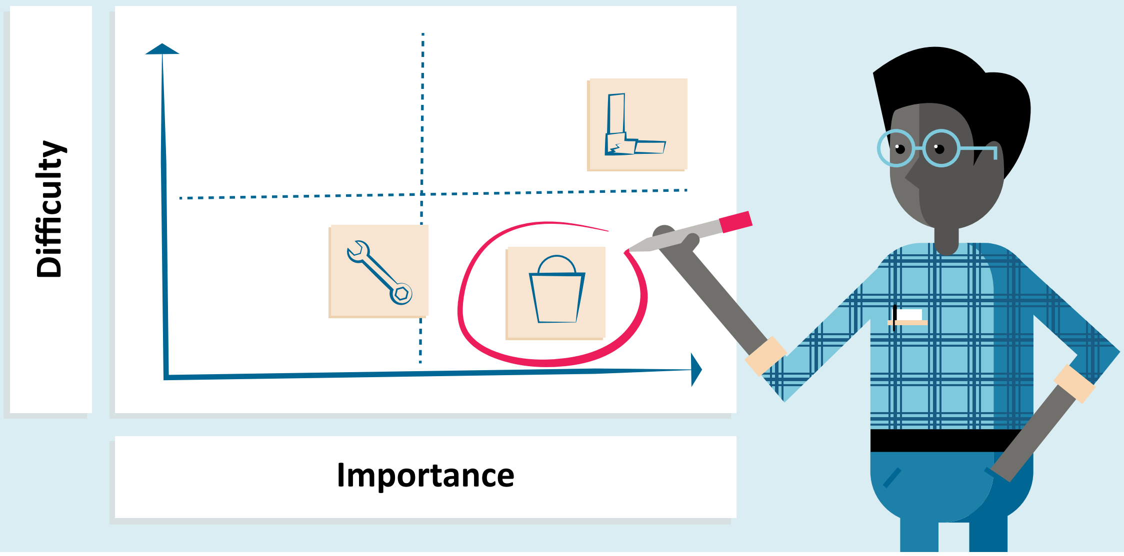
How It Works

1. Identify the subject of your polling activity.
2. Give everyone one sticky note to cast an overall vote, and two sticky notes of another color to cast as detail votes.
3. Announce the criteria for voting.
4. Have presenters describe each concept.
5. Instruct everyone to vote simultaneously. This helps ensure people don't average early and focus on just a few ideas.
6. Tally the votes and invite discussion.

Tips

- Use multiple colors for voting. One common method is to use one color for the overall concept and another for details. Another is to use one color for ideas people like and another for those they'd be willing to invest in solving.
- Use bold colors that stand out in photographs.
- Let people vote more than once on the same thing if they really value it.
- After voting, try to think of clever ways to combine solutions to solve more than one high priority item.

Importance / Difficulty Matrix



Plotting importance versus difficulty helps you prioritize tasks based on key considerations.

How It Works

1. Create a matrix on a poster or white board. Make the x-axis represent importance (increasing from left to right) and the y-axis represent difficulty (increasing from bottom to top).
2. List all possible problems using sticky notes or index cards.
3. Prioritize them along the horizontal axis based on importance. How much impact will solving each problem have?
4. Then, prioritize them along the vertical axis based on difficulty. How complex is each problem? How much time, money, expertise, and effort will each require?
5. Items that are very importance and low difficulty (bottom-right) are where you want to focus first. Items that are both high importance and high difficulty (upper-right) are strategic. Anything that is very difficulty and not that important should be postponed until your team solves everything else.

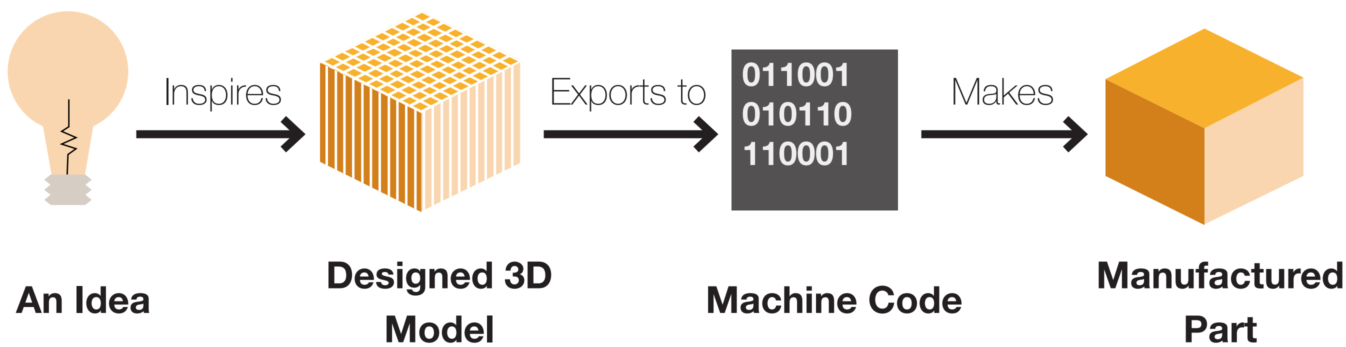
Tips

- When plotting problems on the matrix, remember they are relative to eachother.
- Avoid placing all of the problems in the same ‘quadrant’. This exercise is about making tough choices and figuring out what is truly most important and most difficult.
- Work as a team and reach consensus. If people disagree, have a conversation to understand why.

Technology

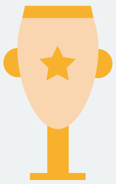
Field Ready is all about sidestepping the traditional supply chain to bring aid where it's needed most. We do this by leveraging innovative technologies and advanced manufacturing techniques.

How Field Ready Manufacturing Works



Technology

3D Printing



Level 1: Introduction

Learn basic 3D printing theory and how to print pre-loaded files.

(2 hour time commitment)

Level 2: Basic Competency

Learn how to print and upload designs, troubleshoot basic problems and learn 3D printer maintenance.

(4 hour time commitment with additional practice)

Level 3: Proficiency

Learn how to make 3D designs using 3D modeling (CAD), troubleshoot advanced problems and maintenance.

(20 hour time commitment with additional practice)

Level 4: Mastery

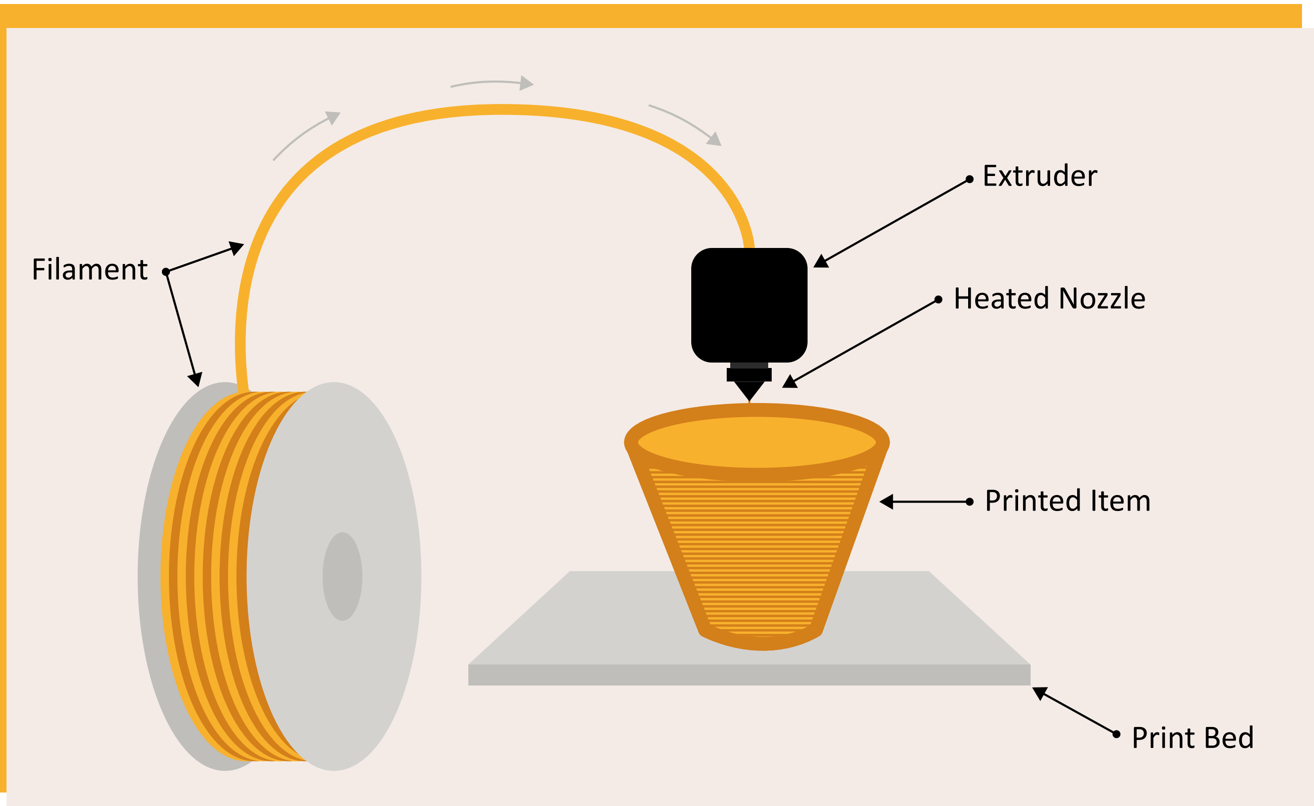
Master all aspects of printing, advanced 3D modeling and learn how to build and reconstruct 3D Printers.

(3+ months time commitment with extensive practice alongside experts)

Technology

3D Printing Introduction

Level 1

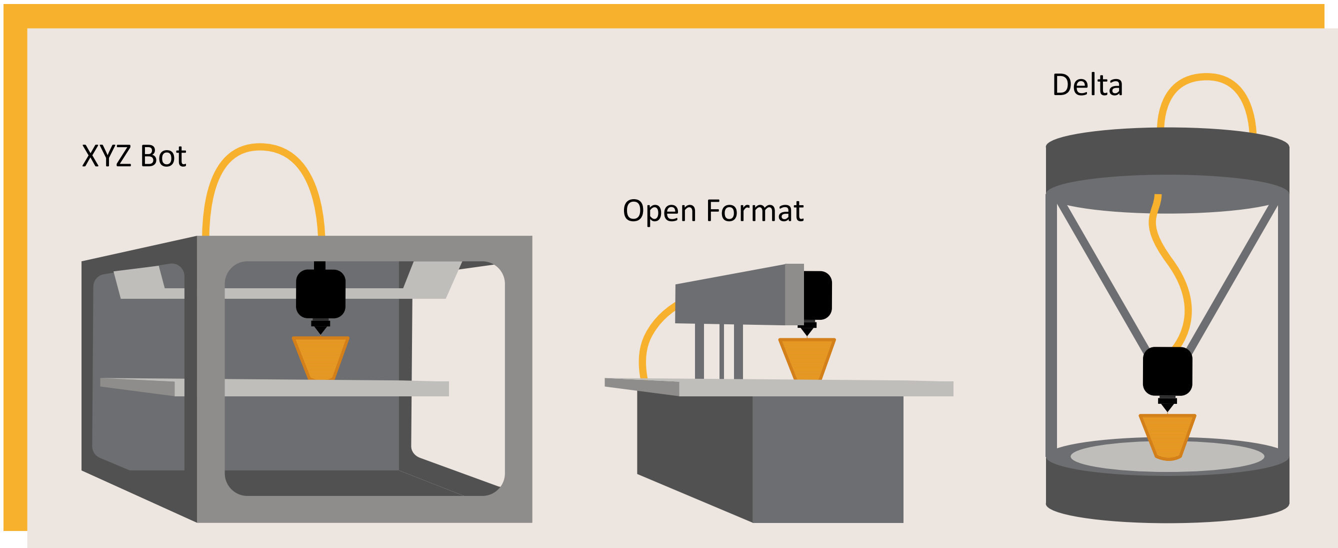


3D printers build objects one layer at a time, like sculpting a coil pot.

A long piece of plastic (called filament) is extruded (pushed through a hot tube), in a very specific pattern. The printer will continue to extrude plastic for each layer until the part is complete. The extruded plastic cools to form a solid part that you can use.

There are three motors that move the extruder (xyz or delta) and there is an additional motor that pushes the filament through the extruder.

The “print bed” or build surface is a flat area at the bottom of the printer where your part will be printed or built.



Basic Types of 3D Printers

All 3D printers function under the same general principles, but printers can look quite different from each other. There are a few typical categories of printers that most 3D printers fall under.

Dos and Don’ts

Don’t touch the extruder, it’s hot!

Don’t put your hands in the machine, you could interfere with its movement.

Always consult the device manual for safety information.

Make sure you put the printer in an area where it can sit for many hours without being disturbed - it’s hard to stop and start prints.

Make sure there are no drafts in the area you’re trying to print which can cause issues with the printing process. To prevent small drafts from reaching the print bed, tape cardboard to enclose the printer.

What can it print?

Most 3D printers can make plastic parts (some very high-end printers can make metal, ceramic, and glass parts).

Economical 3D Printers can often make hand-held size parts. There are many applications - we've made medical parts, replacement parts, fittings and adapters to make things work together.

How do you use a 3D printer?

The best way to learn 3D printing is through experience. Just give it a try (3D printers won't let you do anything that will break them, so feel free to experiment. If something appears to be wrong, you can always turn it off and get an expert to help.)

The first thing to try is a file that someone else has been printing. Insert the SD card with their file, choose the file, and press start.

You'll see the extruder heat up.

Then you'll see the extruder draw a line or ring on the print bed.

Then it'll start drawing the first layer on the print bed.

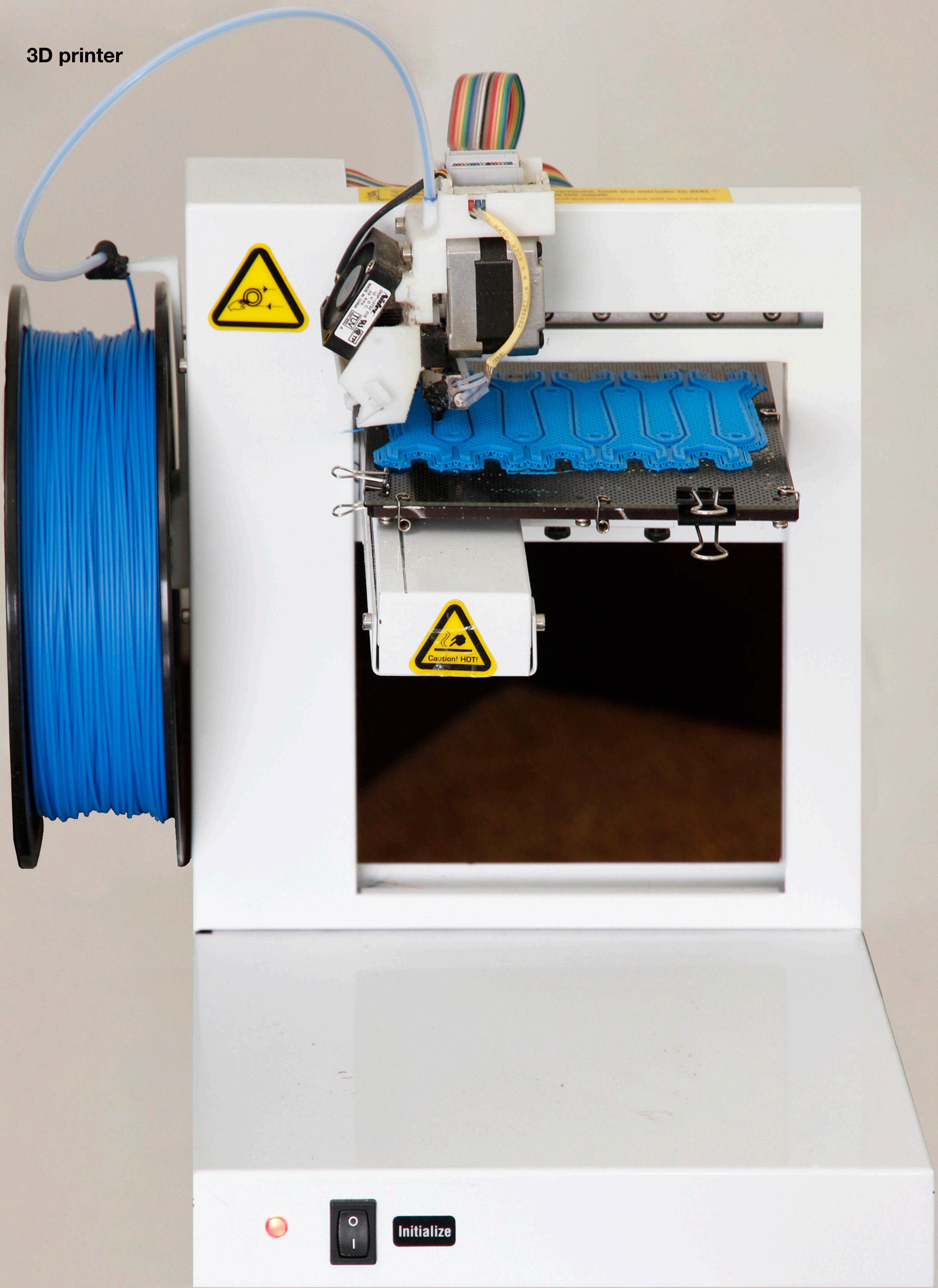
At first, you'll need to keep an eye on the printer at all times - then as you gain experience and understand safety issues, you can check in on it periodically to make sure everything is going well. The display usually shows you what temperature the extruder is, and how much time is left.

Printer Menus

Each printer has its own set of menus. You should get familiar with the utilities available for your printer. Your printer's user manual, utilities menu, or various online communities can help you get started with basics, like how to level the print bed and load or unload filament.

The next module will show you where you can find more files to print, where you can share your files with other people, and how to do some troubleshooting and maintenance on the printer.

3D printer



Technology

3D Printing Level 2

Level 2

Getting and Sharing 3D Models

There are several online communities that share 3D models of things that can be 3D-printed. The files can be uploaded and downloaded from free online databases, such as **thingiverse.com** and **grabCAD.com**. You'll come across many file types, you're looking for .STL files (STL stands for stereo lithography). If you're working on a team, an engineer or designer might email you a .STL file.

Print File Software: Slicer

3D printers require unique software to convert your 3D model into instructions for the printer. For many 3D printers, this is one piece of software that does two things 1) slice the model into many layers and 2) create a tool path that explains how to move the extruder to make the part.

Most printer software can be downloaded for free.

3D Printer Software with Slicers

MatterControl
Cura
Fusion 360
CraftWare
Repetier
Simplify3D
ReplicatorG
MakerWare (for MakerBot 3D printers)
Up (for Up! 3D printers)

Slicer Software Settings

Slicer settings are correlated to a physical part on the printer or to a specific aspect of what the printer is doing.

Extruder settings tell the software the size of the nozzle in the printer and the temperature at which to operate.

Filament settings tell the software what type and diameter of filament is being used in the printer.

Fan settings are used to cool the extruder (lower its temperature) and to cool the layers of the part that is being printed.

Layer and Toolpath settings are the parameters that control how the printer creates each layer. Shells are the solid perimeter of each layer. Infill is the pattern and amount of material used to create the center of each layer. Speed settings control how fast the printer moves when it's printing filament and moving between locations within each layer. Additional settings provide the ability to refine the spacing between each pass of the nozzle within each layer, how many layers to use for the top and bottom of parts, as well as other advanced parameters that you may need once you become an expert.

Filament	Extruder Temp.	Print Bed Temp.
PLA	180 - 215ºC	0-60º
ABS	195 - 240ºC	80-100º
(Max.)	240ºC	100º

Different filament materials require different temperatures for both the extruder and heated bed. This table shows some typical temperature settings for common filament types.

Troubleshooting

Here are some of the most common issues you'll run into when using a 3D printer, and ways to solve them.

Clogged Nozzle

If no filament is extruding, there might be hardened plastic blocking the tube. To unclog, turn on the extrude and when it is hot, carefully push filament through manually until a steady stream of plastic flows from the extruder tip

Print Bed Not Level

If your bed is not level, you'll have trouble making accurate parts or completed print jobs at all. Most printers have a bed leveling routine in the settings. If you suspect it is not level, follow the directions in the manual.

Skipping Extruder

If the filament is skipping, it usually means the extruder can't melt the filament fast enough to push it out. Try increasing the temperature by a few degrees or reducing the print speed. If there's still a problem, you may have a clog or the filament may be damaged or off-spec.

Warped Parts

Warping happens when your part doesn't cool evenly. To avoid warping, try using a printer with a heated bed. You can also slow the print speed, reduce the fill, reduce the number of shells, or print thinner layers. You might also try enclosing the printer to keep the heat more constant within the print area, if you have suitable materials.

Part Sticking to Print Bed

Sometimes your printed object stick too well to the print bed. Use a metal spatula or butter knife to slowly pry the object off the bed, taking care not to damage it.

Maintenance

Maintaining your 3D printer can prolong its life and ensure higher quality prints. Here are some common tasks you should perform regularly.

Clean and Oil Rails

Make sure the rails and other moving parts are free of dust and debris. Metal rails should be lubricated with a thin oil. Don't use silicone grease because it can get on the print bed and prevent adhesion.

Clean Belts

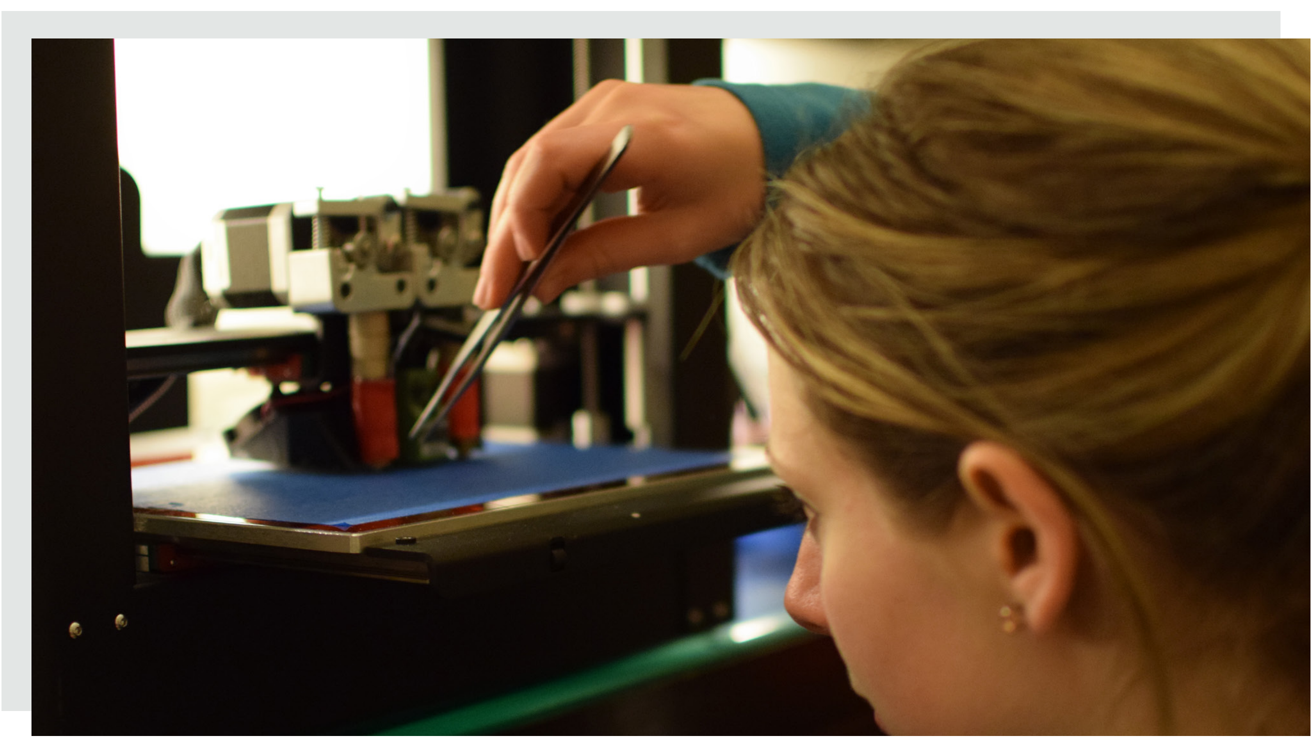
If dust and fibers are visible on the belts, wipe them with a lint-free cloth.

Clean Extruder Nozzle

To remove build up on the nozzle, carefully wipe the hot extruder with a lint-free cloth. Be very careful, because the extruder gets extremely hot.

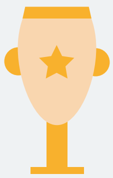
Printer Calibration

Refer to the printer's manual on how to calibrate your model. If it doesn't have a manual, try searching community forums for your specific printer model.



3D printed parts

CAD Modeling



Level 1: Introduction

View and manipulate CAD models, understand high-level concepts and conventions, learn how to 3D print files.

(2 hour time commitment with additional practice)

Level 2: Basic Competency

Use a simple user interface to adapt parametric models, print them, and troubleshoot.

(4 hour time commitment with additional practice)

Level 3: Proficiency

Learn how to build 3D models in CAD software.

(20 hour time commitment with additional practice)

Level 4: Mastery

Learn how to create advanced CAD models and parameterize them so that others can adapt them easily.

(3+ months time commitment with extensive practice alongside experts)

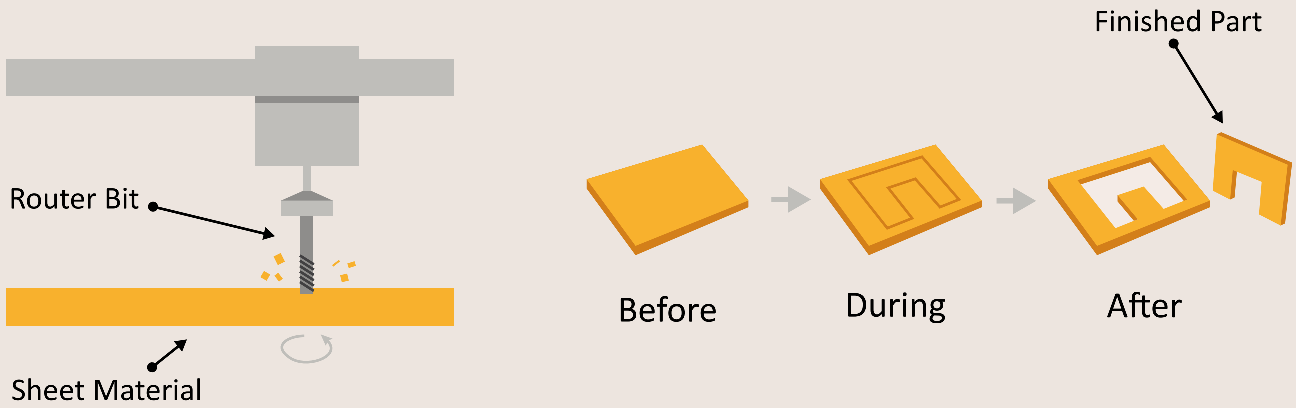
Additional Technologies

Beyond 3D printing, there are a number of additional manufacturing technologies that have lightweight supply chains which Field Ready uses in the field. Each has its own unique advantages.

- CNC Router
- CNC Plasma Cutter
- Thermoforming
- Laser Cutter
- Injection Molding

Technology

CNC Router



CNC Routers are most often used for cutting sheet goods into precise shapes and patterns. Small CNC routers typically make parts as large those used to make chairs, while larger routers can handle full 4’ x 8’ sheet goods for making tables and large building components.

Common Materials: plywood, plastics, aluminum

Good For

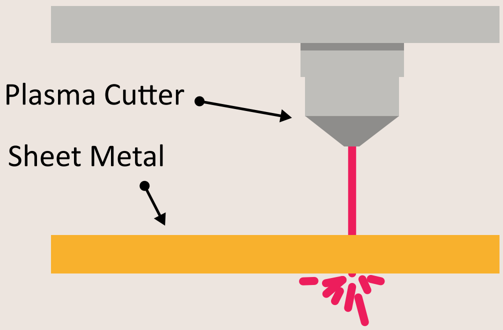
- Many open-source designs are available from online communities
- Parts can be flat-packed

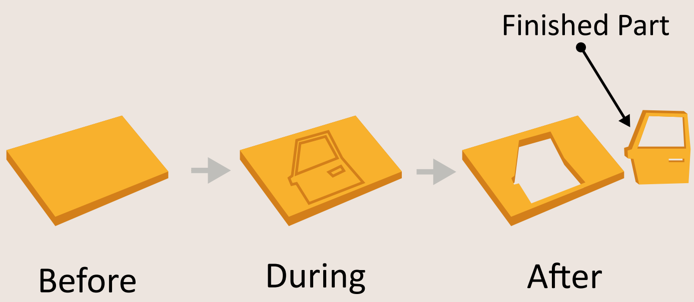
Considerations

- Tooling can be expensive
- Initial cost for machine is relatively high
- Requires a dedicated space

Technology

CNC Plasma Cutter





A very fast and somewhat accurate method of creating flat metal parts. A very hot arc is created at the cutting head to melt the metal sheet. Then compressed air is focused at the arc to blow away the molten metal. The machine takes instructions from digital files that describe your parts, no physical templates are required.

Common Materials: metals

Good For

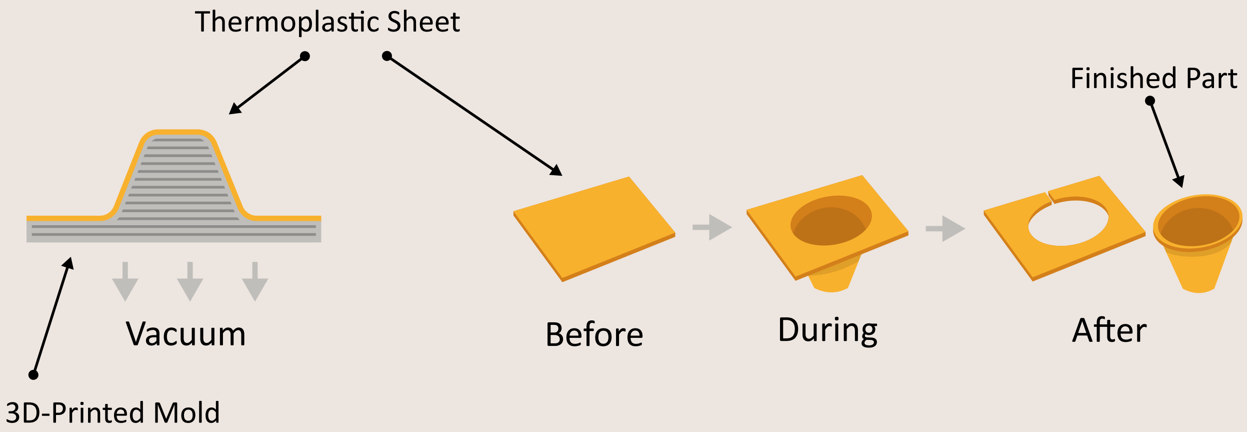
- Creating many parts in a short period of time

Considerations

- Requires a lot of electricity
- Requires a fairly clean and large dedicated space for equipment

Technology

Thermoforming



Thermoforming involves heating up a sheet of plastic, pulling it over a mold, and using air pressure to push the top and vacuum to pull the plastic tight to the mold. 3D printing can be used to create the forms used in this traditional manufacturing process. This enables shops to prototype before investing in a more permanent mold. It also enables shops to make a few parts without spending a lot of money creating a mold.

Common Materials: plastics

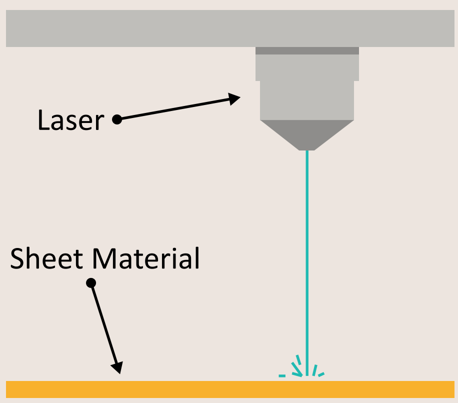
Good For

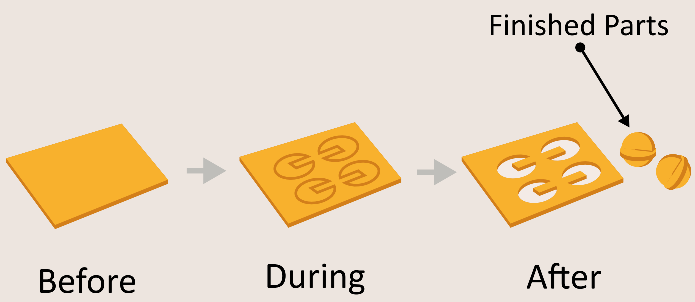
- Relatively inexpensive tooling
- Make many parts at once

Considerations

- Need good consistent heat source (requires good electricity)
- Requires existing thermoforming shop
- Sheets need to be trimmed down to finished parts

Laser Cutters





This is a very fast and accurate way of creating flat parts. This technology uses a powerful laser to burn through or etch 2D and cylindrical materials. Low-end lasers can be used to cut foam, fabrics, thin plywood, most plastics, and leather. High-end lasers can be used to cut metals too. Fairly high tolerances can be achieved, but take a few tries to accommodate variations between machines.

Common Materials: foam, thin plywood, most plastics, fabrics, and leather

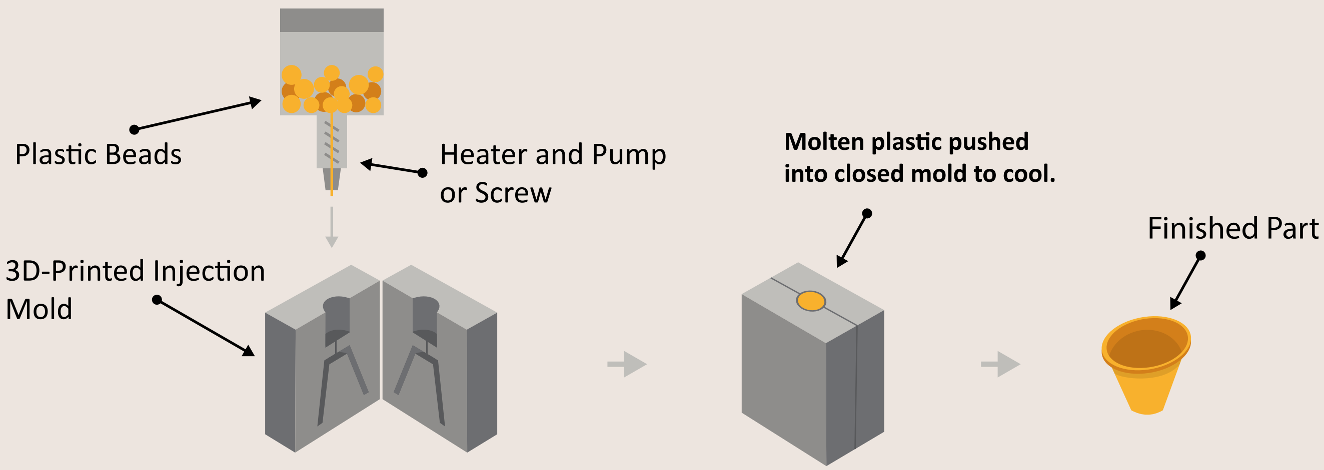
Good For

- Tapping into online communities with a wide variety of designs
- Cutting a fairly large number of parts in a short period of time
- Not just cutting through, but engraving

Considerations

- Need good consistent heat source (requires good electricity)
- Lasers can be a significant initial expensive
- Not good for thick or reflective materials

Injection Molding



Injection molding machines (there are small benchotop verions available) use plastic or metal molds to create hundreds of parts. Once you have a mold, the amount of time it takes to make a single part is much lower than 3D printing. The technology currently has many more materials options to create parts from.

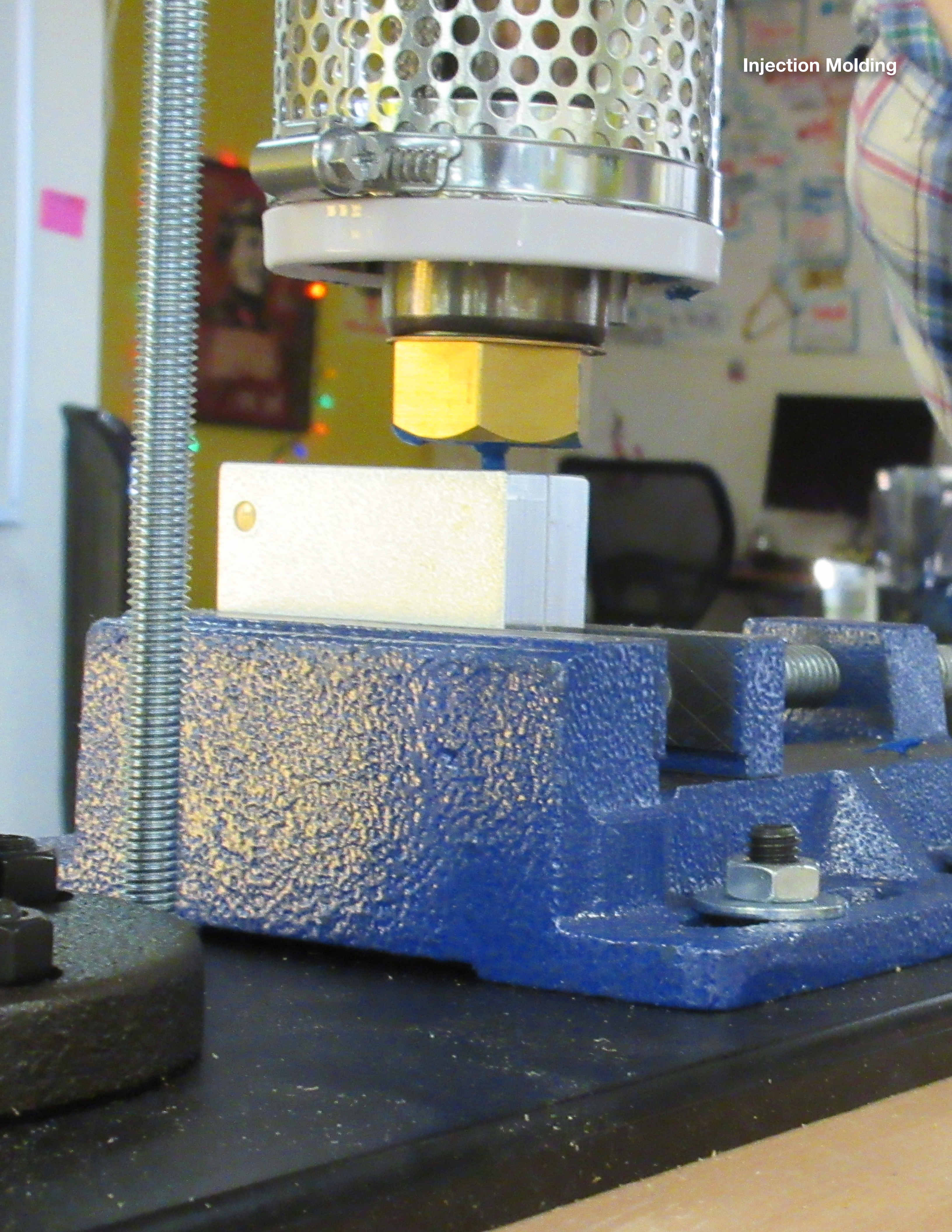
Common Materials: plastics, rubbers

Good For

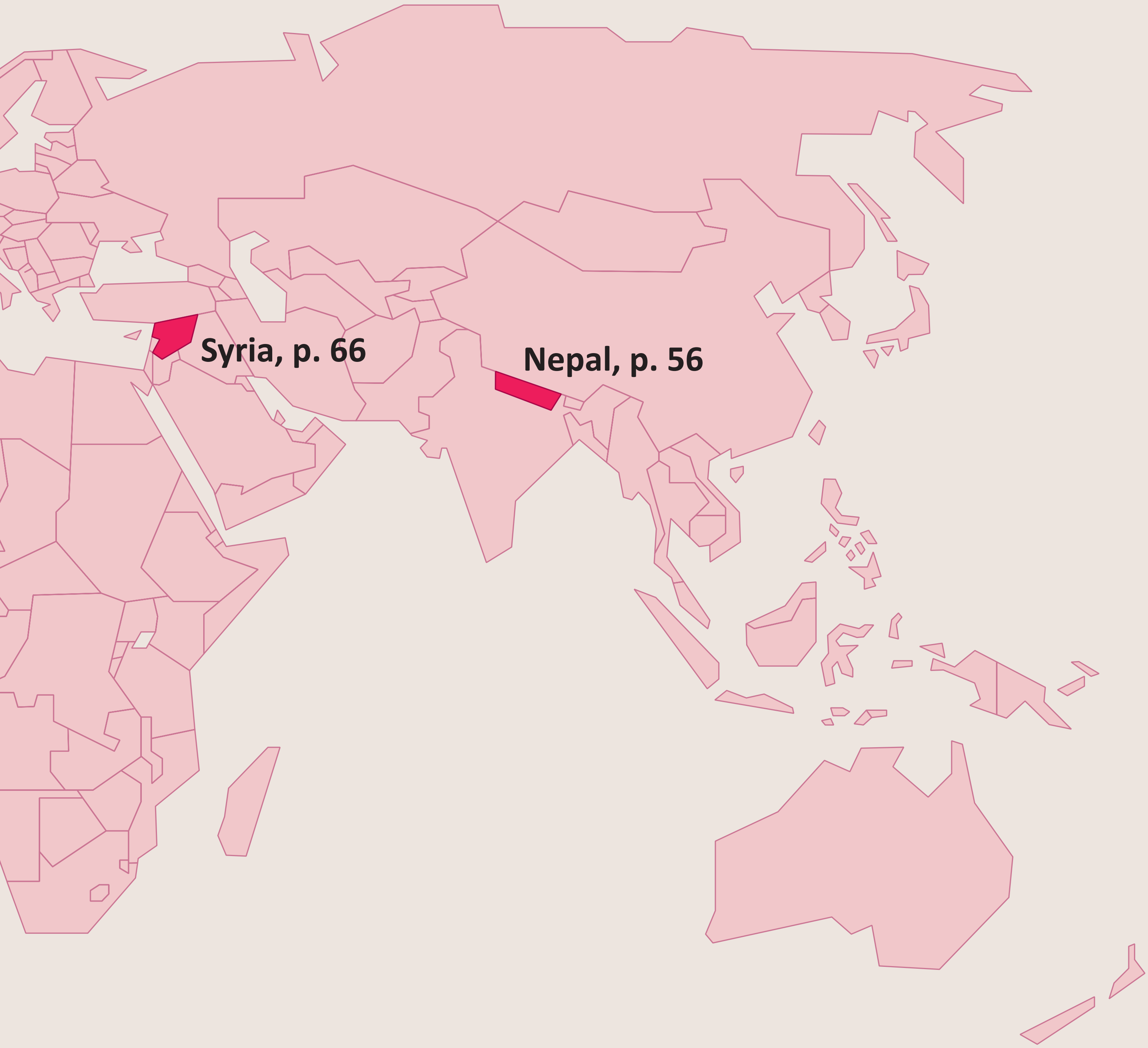
- Making a lot of parts that are all the same, in a short period of time
- Can make parts from plastics that cannot be used in 3D printing
- Molds can be 3D printed

Considerations

- Requires specialized equipment and molds



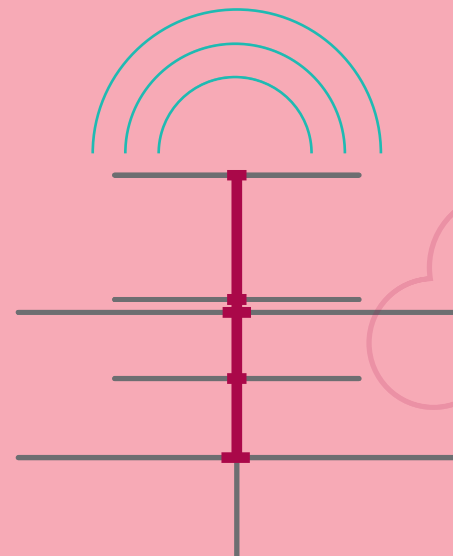
Case Studies


Syria, p. 66
Nepal, p. 56

Case Study

Radio Antenna

Nepal



Goal

To make better, more reliable antennas and increase radio coverage.

A group of amateur radio enthusiasts played an important role in the aftermath of the 2015 Nepal earthquake, using their home radio stations to relay messages to the army and police. However, the earthquake meant that many ground stations in their network had been destroyed, and unfortunately there were still some earthquake affected areas they could not communicate with.

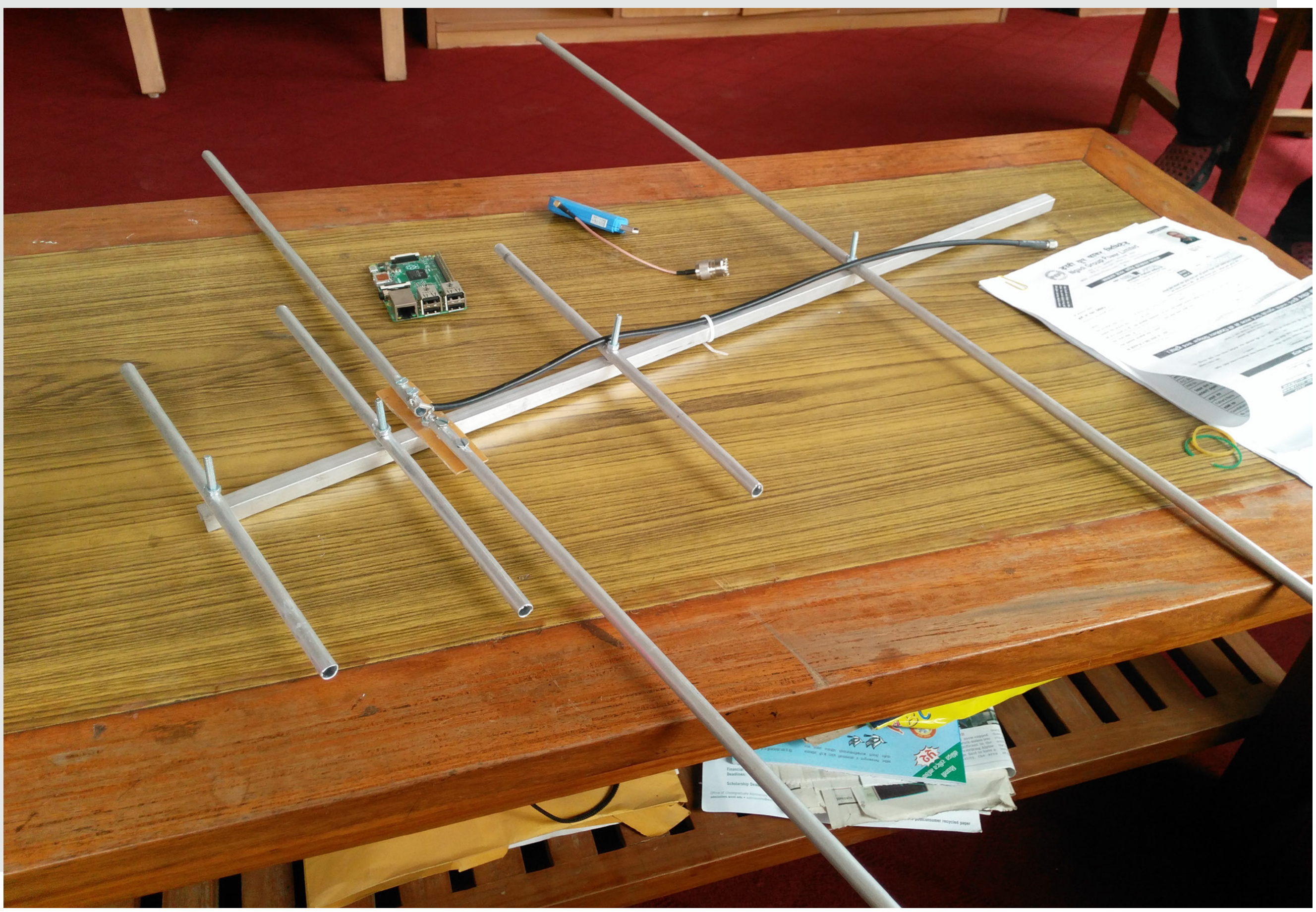
In preparation for future disasters, this group was seeking to increase radio coverage of Nepal by installing antennas that do not rely on station to station communication, but instead communicate via satellite. However, they were having trouble getting their radio antennas to work.

Problem Framing

There were many small problems accumulating that inhibited the performance of the antenna, such as the type of antenna, impedance matching, quality of the soldering, and assembly accuracy. We compared importance versus difficulty, searching for the one that would yield the most impact on performance for the least time and effort.

We chose to focus on assembly accuracy. Regarding radio transmission, the higher the frequency of the radio waves being transmitted, the smaller the antenna must be. The frequency for communicating via satellite is much higher than that used for ground station to ground station communication, hence the antenna that the team was working with was much smaller than they were used to. It is possible to easily build a large antenna by hand because errors in dimensions and inexact placement of parts does not matter much. However, small inaccuracies can lead to large differences in performance.

Antenna accuracey was good to focus on because it was likely to have a positive impact on antenna performance, and a prototype could be developed and tested within a couple of days. Focusing on type of antenna, impedance matching and soldering may have had just as much impact on performance, but were not as straightforward to test or solve.



The original antenna design

Prototyping new parts for the antenna

Technology

Field Ready worked with the team to design some simple 3D printed parts to quickly and accurately assemble the antenna, by snapping the components together into pre-defined locations. The 3D printed plastic chassis holds the metal rods of the antenna at precisely the correct locations, ensuring proper assembly accuracy from unit to unit.

Results

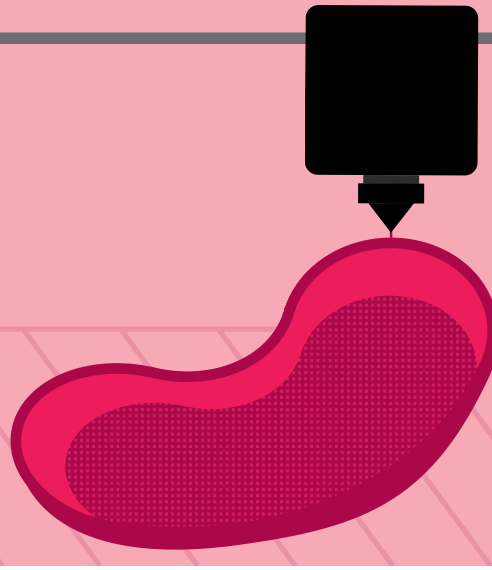
The work resulted in a significantly improved antenna, and a design that could easily and accurately be replicated.

Testing the final design

Case Study

Kidney Tray

Nepal



Goal

To create a kit of 3D printable medical items that can be produced in the field.

Problem Framing

Field Ready has visited a number of small, remote health posts and clinics alongside the international aid agencies that support them. Many small health posts and clinics experienced infrastructure damage and loss of equipment due to the earthquake, and aid agencies are working hard to rebuild and re-supply what is needed. However, remote locations, treacherous road conditions and international supply chains mean that it can take over four months to get new supplies to health clinics after a need has been identified.

The Field Ready team is working toward establishing kits to make important supplies in the field, significantly reducing this 4 month lead time. We initially created a shortlist of medical items to prioritize, based on appropriateness for 3D printing, value to health post staff, and ensuring no harm should be caused in the event of the item failing.

One of the items that made it to the ‘maybe’ section of our list was the kidney tray, although 3D printed non-surgical kidney trays are safe and the product is useful, we felt it was unlikely a 3D printed version would live up to the quality of its mass-produced counterparts.

Technology

We mocked up a couple of mini prototypes of a kidney tray, one replicating stainless steel designs we had seen, and one optimized for 3D printing without support material.

Results

To our surprise, when testing the prototypes with medical practitioners we received very positive feedback on the design optimized for 3D printing. The medical staff were pleased with how light the tray was compared to metal alternatives, and they really liked the large flat base because it made the tray more stable.

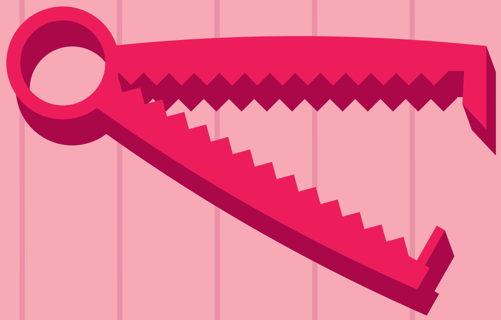
Gathering feedback on prototype tray and devices

Displaced persons camp, Nepal

Case Study

Umbilical Clamp

Haiti



Goal

To design and 3D print sterile umbilical cord clamps and other medical items for babies, mothers, and medical personnel.

Problem Framing

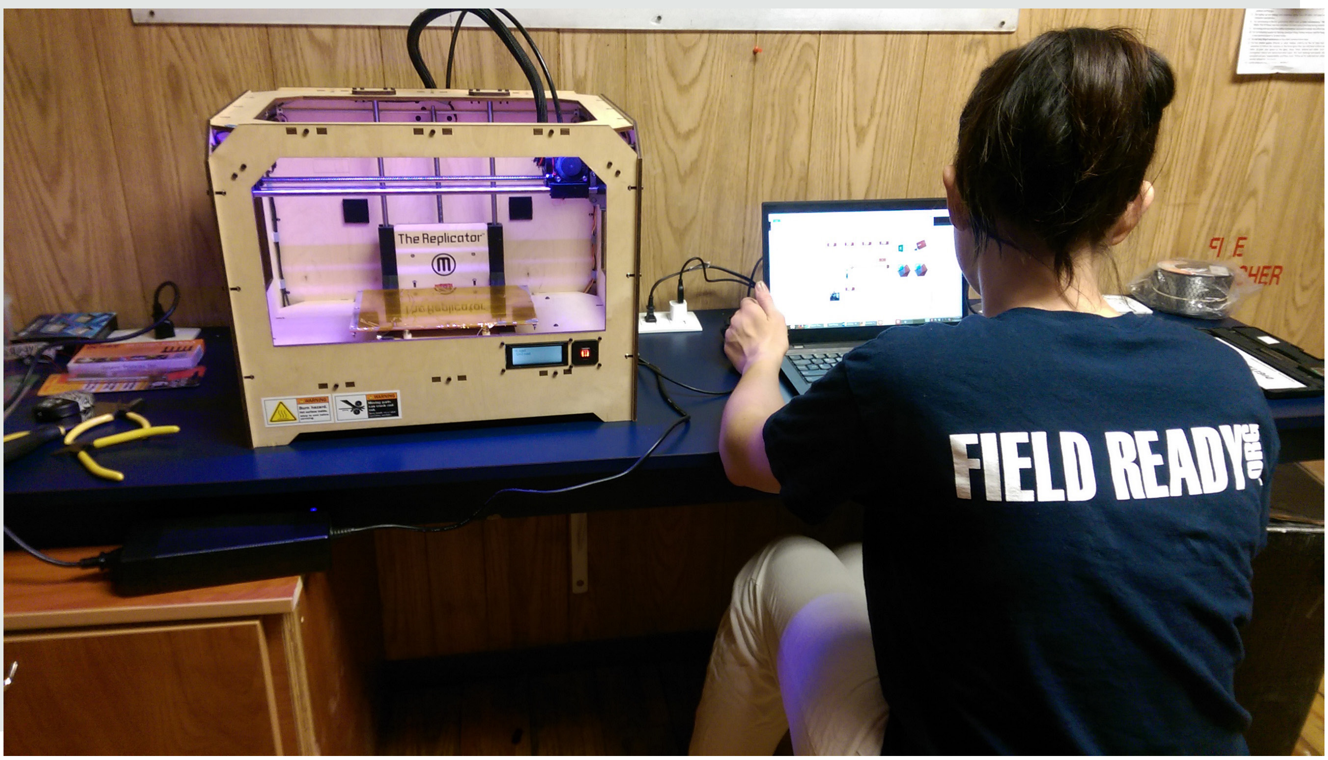
Small clinics in rural Haiti often have no access to sterile medical supplies. Many of these supplies are unavailable, while others are too expensive for many of these clinics to afford.

One example is the clamp used to close the umbilical cord during delivery. The lack of sterile clamps poses a health risk to mothers and babies. Neonatal sepsis, a type of infection that can originate at the umbilical cord, is one of the leading causes of death among infants in the region.

The Field Ready team interviewed personnel at a number of clinics, which led to the identification of various immediate needs. One clinic, for example, needed birthing kits to give out to pregnant mothers because, often times, women who go into labor may be five or ten miles from the clinic with no means of transportation. After assessing multiple clinics and learning more about the delivery process in Haiti and the needs of these rural clinics, it became clear that expanding access to sterile items like clamps would significantly improve the health of mothers, babies, and medical personnel.

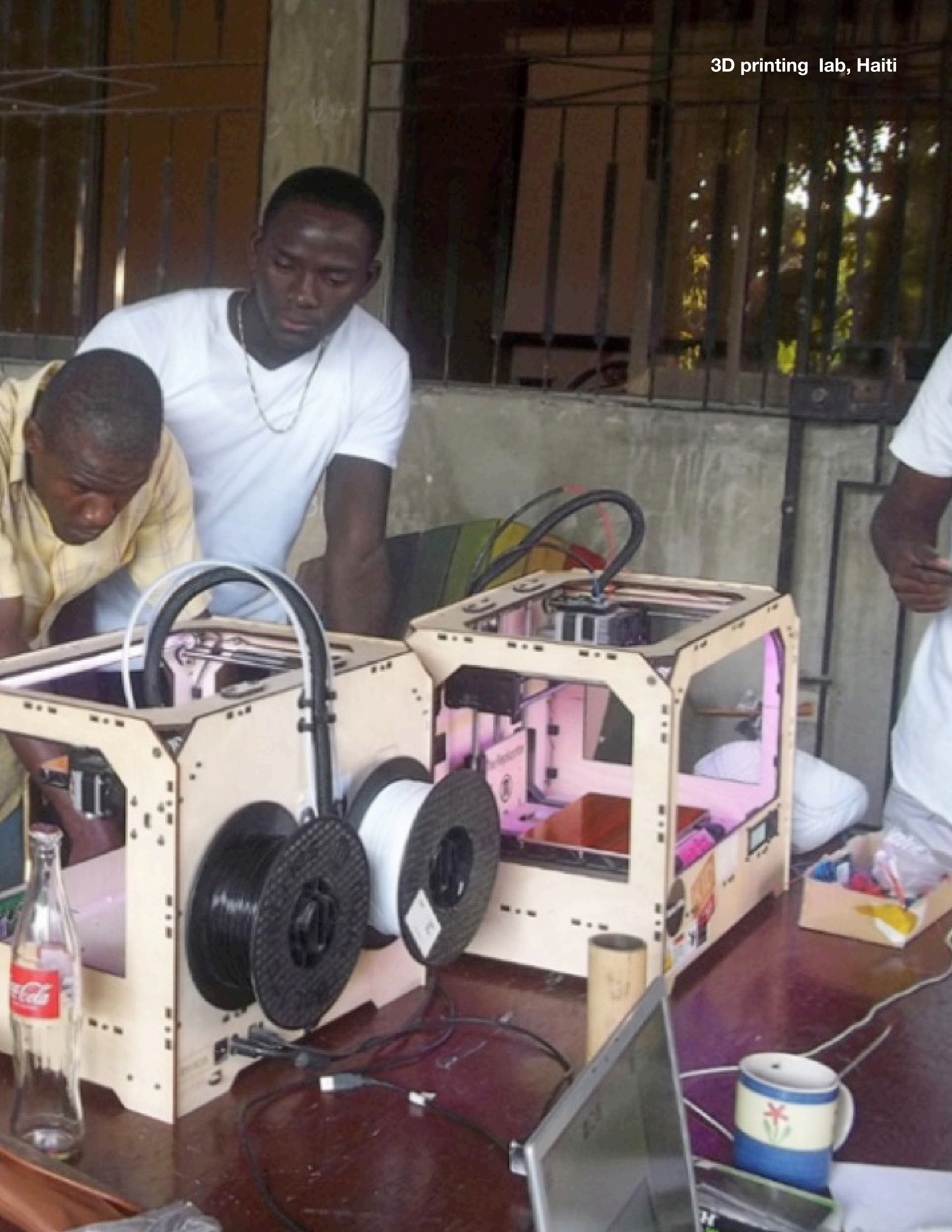
The Field Ready team set out to design an umbilical cord clamp that would fulfill the following requirements:

- The clamp must be sanitary and should not be reusable. Therefore it was designed to break after the first use.
- It needed to be intuitive and easy to grip.
- It needed to be easy and cheap to produce. This meant coming up with a design that minimized amount of material.
- Must remain on the baby for three to five days.
- Preferably made from a non-porous, medical grade material to minimize the risk of bacteria and infection.



Prototyping station


FIRE

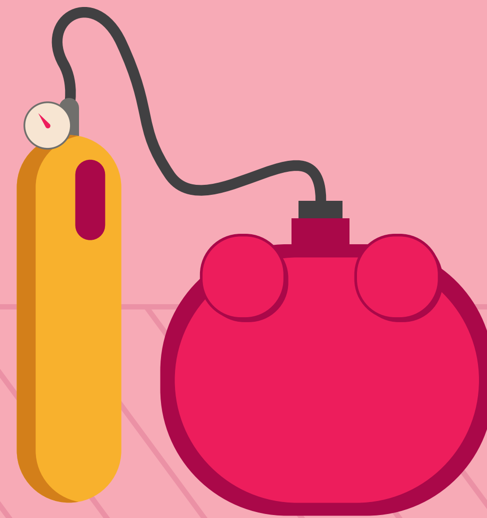


3D printing lab, Haiti

Case Study

Rescue Air Bag

Syria



Goal

To invent a device for rescuing trapped people in destroyed buildings, which can be produced in the field.

Problem Framing

The Syrian civil war has claimed many lives and caused untold human suffering. Urban warfare means that people inhabiting multi-story buildings are at risk of becoming entombed in structures that have been directly hit by artillery, aerial strikes and ‘barrel bombs.’ People trapped by rubble and collapsed buildings can survive the attack but frequently don’t because they cannot be rescued in time.

The extremes of the war make rescuing trapped civilians a nearly impossible task. To lift heavy debris, such as concrete slabs weighing several tons, special equipment is needed. While lifting airbags are available to well-supplied search and rescue teams worldwide, these can cost up to $10,000 each.

Working with a number of excellent partners, Field Ready identified the specific parameters needed – **small, portable, easy-to-use, robust and inexpensive** - using sketching, photography and prioritization tools. We followed the widely used “British Standard” for rescue airbags to develop a workable solution that can be implemented within the limitations of cost and the combat zone.

Early prototypes of the rescue air bag

Tech

The Field Ready team set out to design a reliable lifting air bag that could be produced from readily available, inexpensive materials.

Using an iterative design process, a number of air bag prototypes were created and tested. The initial model involved using a reinforced vehicle tire inner tube. The second and third prototypes refined this idea, but were still not ideal, so the team prototyped alternative models using thick rubber flooring mats. Along the way, the team created a testing rig capable of applying thousands of pounds of pressure with supplies and compressed air procured locally.

Results

The final prototype was positively received by search and rescuers in northern Syria. With a final go-ahead, an initial batch of 100 rescue airbags was manufactured and distributed wherever these tools were needed. Following this experience, locally made rescue technology can be used worldwide to directly save people's lives.

Load testing prototypes

Final air bag prototype

Glossary

ABS: Acrylonitrile Butadiene Styrene is a type of plastic. It is made out of oil-based resources and it has a much higher melting point than PLA plastic (it also produces harmful fumes when used in 3D printing). Because it is stronger and harder than PLA plastic, ABS is widely used for injection molding objects ranging from car bumpers and motorcycle helmets to musical instruments and Legos. It is not suitable for contact with food.

Additive manufacturing: A process by which machines create new objects by in layers (i.e., by adding or 'printing' material one layer at a time). Complex shapes and forms can be made this way. 3D printing is a type of additive manufacturing.

CAD: Computer Aided Design, computer software used in designing models used in manufacturing.

Calibration: the process of marking an objecting with a standard scale of readings using a gauge or instrument.

CNC: Computer Numerical Control is means in which a computer converts the design produced by CAD software into numbers (like plotting coordinates of a graph) which then control the movement of cutting/shaping devices. Often used to refer to the machine itself used in creating a range of items such as molds as well as solid objects.

Code: The instructions in a computer program. These instructions are written by a programmer in a programming language often called source code. The code used in CNC and CAD files to control the movement of manufacturing equipment is known as preparatory code or "G-Code."

Community forum: A group of people on the internet who discuss topics. Reddit is a popular site that hosts numerous community forums.

Design: an approach to complex problems that focuses on solutions (particularly related to technology), actions and users of solutions. It is generally used where human interactions are important and involves a process of understanding and constructing (as opposed to analyzing and deconstructing).

Extruder: an essential part of a 3D printer in which molten manufacturing material (e.g., plastic) is forced or thrust out ('extruded') to form with a desired shape to create an object.

GPS: the Global Positioning System refers to a handheld electronic device that receives coordinated satellite signals to indicate the users exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Iterative: the repetition of a process used in a design process. The back and forth of iteration produces different ideas and allows for creativity, learning and improvement.

PLA: PolyLactic Acid is a type of bio-degradable plastic that is manufactured out of plant-based resources such as corn starch or sugar cane. It is less durable than ABS but generally easier to use in 3D printing.

SD Card: a Secure Digital card is a small, postage-stamp sized flash memory card designed to provide high-capacity memory for digital cameras and other devices.

Silicone: a synthetic polymer compound which is insensitive to temperature changes and commonly used to make rubber, plastics, polishes, and lubricants.

Solution: a means of solving a problem or dealing with a difficult situation. At an early phase, a solution may appear to answer a problem but fail with further testing which is common during the iterative phases of innovation.

STL: STereoLithography is a CAD software file format created by 3D Systems. It is widely used for rapid prototyping, 3D printing and computer-aided manufacturing

Resources

Design Thinking

Design Kit by IDEO
designkit.org

Development Impact & You (DIY) Toolkit
diytoolkit.org

Stanford Univeristy Design School Methods
dschool.stanford.edu/use-our-methods

Design Thinking for Educators
designthinkingforeducators.com

Problem Identification

Handbook on Participatory Methods for Community-Based Projects
uwyo.edu/girlmotherspar/_files/pubs-handbook.pdf

Participatory Methods Toolkit: A Practitioner's Manual
archive.unu.edu/hq/library/Collection/PDF_files/CRIS/PMT.pdf

Tools for Assessment, Planning and Participatory Development
toolkit.ineesite.org/toolkit/INEEcms/uploads/1033/Participatory_Development_Tools_EN.pdf

3D Printing

3D Hub
3dhubs.com

America Makes
americamakes.us

3D Model Libraries

Thingiverse
thingiverse.com

GrabCAD
grabcad.com

McMaster
mcmaster.com

Wevolver: Open Knowledge & Files for Engineering project
wevolver.com

3D Content Central: Free 3D and 2D CAD Models
www.3dcontentcentral.com

Youmagine: share, remix and 3D print
youmagine.com

Cults3D
cults3d.com

Pinshape: Free 3D Printable Files and Designs
pinshape.com

3D CAD Software

OnShape
onshape.com

Blender3D
blender.org

Autodesk Fusion 360
autodesk.com/products/fusion-360/overview

Ethics

Principles for Ethical Humanitarian Innovation
oxhip.org/assets/downloads/Principles_for_Ethical_Humanitarian_Innovation_-_final_paper.pdf

Humanitarian Organizations

Field Ready
fieldready.org

Humanitarian Makers
humanitarianmakers.org

Response Innovation Lab
responseinnovationlab.com

"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

-R. Buckminster Fuller

FIELD READY