3

Designs That Take Flight

Jamy Drouillard

Key Concepts
from Previous Chapters

- 2 Engineering Design Process
- 2 Criteria
- 2 Constraints
- 2 Prototype

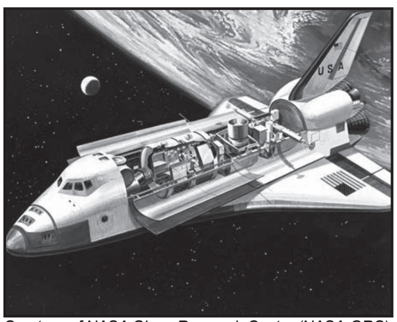
I'm an aeronautical engineer, which basically means that I design technologies that can fly. I know the charcoal briquette project did not involve any flying technologies, but like any engineering project, it did involve the design process, which is something I've had plenty of practice using.

My name is Jamy Drouillard, and I come from Haiti, which helped a lot during the trip to Maissade. Every day our team needed to communicate with the native people, especially when looking for new materials. Having spent the first 12 years of my life in Haiti, I speak Haitian Creole. But even beyond that, I understand people in Haiti. They trusted me to communicate what they wanted to say to the other students. Of course, I had never learned to talk about engineering in Creole, so I had some challenges translating what the students wanted to say. In the end, we learned how to ask the right questions.

You may wonder how I ended up at MIT. While I was growing up in Port-au-Prince, my parents taught me that education is important. Time and time again, they had witnessed how those who received a good education had better chances at creating prosperity for themselves and their families. By the time I was twelve years old, Haiti was in the midst of major political upheaval. Our president, Jean-Bertrande Aristide, had been forced into exile during a violent military overthrow of the government. The future felt uncertain for Haiti, and I remember that school was often canceled due to widespread violence. As a kid, I'd celebrated the extra days off. When I look back now, I realize that those were days I could have been in school learning.

My parents longed to find a more stable situation for me to get my education. My sister lived in Philadelphia, so I came to the United States to live with her. My mother moved here so she could work and support me. But my dad stayed in Haiti with the rest of the family, and he traveled back and forth often. I did well in school, but it wasn't easy, especially at first.

I attribute most of my success in school to my early interest in engineering. Back in Port-au-Prince, I loved watching *Buck Rogers* or *Lost in Space,* two popular sci-fi TV shows. I was also good with my hands. I could fix clocks or get our cable connection working. In Philadelphia, I went to a school that focused on science and math. I liked school, but I really enjoyed an after-school program called "SPARC!" That program showed me that creativity and fun are a big part of engineering. On some days, we'd pretend we were on a mission to Mars, and we'd build a mission-control room with lights and computers. We'd make space suits and act as if we were NASA engineers and astronauts. We even created our own astronaut-training program.



Courtesy of NASA Glenn Research Center (NASA-GRC)

I didn't realize that what seemed like fun and games back then would lead me down my career path, but that's when I decided I wanted to build flying machines. I looked into several engineering schools. There are hundreds of schools and each has something unique to offer. I decided that MIT was the best fit because I liked what I'd heard about the aeronautics program. I spent four years getting my undergraduate degree in aeronautical engineering at MIT. I got to work with teams to design and build different kinds of airplanes and rockets. The experience was not unlike those early SPARC! days. In college, of course, we were trying to make real machines that actually worked. But the fun and excitement were still there for me—even more so.

Now, as a graduate student at MIT, I'm trying to solve a different problem: building a small helicopter as a class project. It's nothing like the fuel problem I worked on in Haiti, but it does use the design process. I'll take you through my process:

1. Define the problem.

For any engineering project, you must be clear about what problem you're trying to solve. On television, broadcast news channels are always trying to find the newest, most cutting-edge camera angles at fast-moving basketball games so they can attract a larger share of the television-viewing audience. We determined that a flying machine carrying a camera might be a great solution to this problem. The technology would have to be capable of flying around a court, controlled by radio, and sometimes navigated by itself. The flying camera would need to be able to follow a fast break while remaining a safe distance from the players and the audience. The machine should also take the camera up to the stadium ceiling for a bird's-eye view of the action on the court. The technology would also be designed to dispense coupons to spectators during halftime. The technology must not be too big or too heavy. If a heavy machine were to crash, a spectator or a player could be injured.

- **Problem:**
  Sports news channels want a new way to capture basketball games on camera so they can attract more viewers. (While most people use the word "problem" to describe something bad or troubling, engineers often use the term to describe a need or desire that a new technology is designed to satisfy.)
- **Criteria:**
  The technology must be able to carry a small camera, track a player, make maneuvering decisions on its own, and be radio-controlled. It must also be able to dispense coupons. Its design must minimize the risk of injury or damage if it falls or malfunctions. It must be able to fly for seven minutes at a stretch and carry about a quarter-pound of weight.
- **Constraints:**
  The device can't be larger than 1.5 feet long and 1 foot tall or weigh much more than 6.5 pounds.

2. Research the problem.

There are many ways to research this problem. We watched some videotapes of basketball games to determine how players move around a basketball court. We went to several basketball stadiums to take measurements of the court, the stands, and the space between the court and the stadium ceiling. We even talked with stadium managers and news camera operators to learn more about what other technologies are currently used to record games.

Next we looked at how other people have solved similar problems. Sometimes small blimps are used to distribute coupons to audience members, but they move too slowly to keep pace with a fast break. And there are quite a few small and maneuverable remote-controlled helicopters already on the market, though none of them are used to hold cameras at sports events. We decided to build one of these helicopters to see how well it met our requirements.

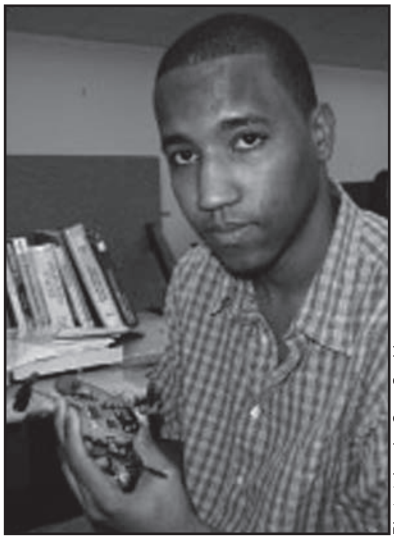


Photo taken by Cary Sneider

We built a small, remotely operated helicopter from a kit. Building the helicopter was a great way for me to learn more about the science principles behind how helicopters operate. It's essential for an engineer to understand the science concepts relevant to his or her design projects. Otherwise, the engineer would have to rely exclusively on trial and error to develop an improved design. By understanding the science, an engineer can make a good prediction about whether a particular design will operate the way he or she intends.

The model helicopter works just like a full-size helicopter. It is lifted off the ground by the main rotor, which has four blades, each of which is like a small airplane wing. The helicopter's engine spins the rotor, pushing air downward, which lifts the helicopter. This upward lift can be explained by a fundamental physics concept: For every action, there is an equal and opposite reaction. It's not unlike when you do a push-up on the floor: When you push down on the floor, your body is lifted in the opposite direction with the same force. In this case, the rotor pushes air toward the ground and is lifted toward the sky. Asa soon as the helicopter leaves the ground, however, the machine's body tends to spin in the opposite direction as the rotor for the same reason. To prevent that from happening, a smaller rotor is mounted on a boom—a long arm that extends from the body. This rotor pushes air in the opposite direction of the spin, which counteracts the body's tendency to spin.

Photo taken by Cary Sneider

Jamy creating a cardboard model.

After building the first model, we discovered that the design had some serious drawbacks: It was too heavy, and in the event of a malfunction, the large rotor could injure someone. In addition, this helicopter was very hard to control. This helicopter clearly did not meet our requirements, but because helicopters are easily maneuverable, move quickly, and can carry weight, we decided that some type of helicopter still might work.

We looked at other small helicopters on the market. My professor found some toy helicopters that had three or four main rotors rather than just one. Helicopters with three or four main rotors work a little differently from conventional helicopters. Each of the small rotors on the top provides lift. The tilt of the rotors has an effect much like a boom, giving the helicopter stability. The rotors are small, making it less likely that someone would be injured if the helicopter fell, a big advantage from our team's standpoint. And these helicopters seemed to be much more stable. However, none of them were powerful enough to carry a small camera. Most of them could just lift their own weight.

Toy helicopter with three main rotors

3. Develop possible solutions.

After some thorough research, our team felt convinced that a helicopter design would work. We developed a handful of possible solutions. Most of the designs were helicopters, larger than the toy helicopter but smaller than the model helicopter, with three or more small rotors instead of one large one. Each design used a different material. One design had a durable plastic for the body of the helicopter, for instance, while another used a lightweight aluminum frame.

4. Choose the best solution.

To compare and choose the best possible design, I created a computer simulation of how these helicopters might fly. I could simulate how the helicopter would handle in tight turns or chase a player to the other side of the court. In this way, I "experimented" with different designs before spending the time and money to build a prototype.

I also created some simple cardboard models. Building these simple models really helped me see how the different designs might work. Of course, engineers can never be sure they've selected the "right" design—there's always a design that might be better. At some point, an engineer must make an "educated guess" and choose one solution.

5. Create a prototype.

My team is still in the process of selecting a "best" solution. Then we'll actually build our design to see if the idea will work. As Shawn commented, the first prototype rarely works as expected, but they are an excellent method of showing where a design fails. As an essential part of the design process, prototypes let you discover design problems early on.

6. Test and evaluate the solution.

Our team will have to build and test several prototypes before we get one that will work. For those early tests, we'll probably tie different weights to the prototype to see how much weight it can carry. Then, we'll test it somewhere it can't hurt anyone if it fails—maybe in a big, empty gym. If it doesn't pass the test, we'll have to go back and work on the prototype some more or try an earlier idea. With the engineering design process, you can always go back to an earlier step.

7. Communicate the solution.

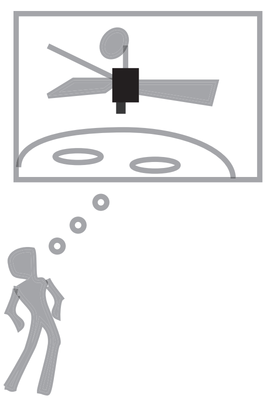
After we think we have found a good design that meets our criteria and constraints, we'll need to communicate the solution. When I was an undergraduate, I would usually make a class presentation to communicate my solution to the teacher and the other students. However, if we get this design working well, we may want to patent it and maybe even present the idea to a company that would manufacture and sell it.

Communicating the idea to others in a clear and persuasive way is just as important as every other part of the engineering design process. If people don't understand your idea or don't think it's important, they won't use it.

8. Redesign.

It's a safe bet that whatever we develop will need improvement. As people begin to use the technology, they'll encounter flaws in the design, parts that break, or new features they'd like it to have. Of course, before we make any changes, we'll need to be clear about what needs to be changed and why, which means we'll start defining the problem again. Because the engineering design process is cyclical, you can always return to an earlier step. I think you shouldn't jump steps, but not all engineers share this opinion.

During the engineering design process, an aeronautical engineer—in fact, any engineer—needs to consider all of the negative consequences of a new design. You wouldn't want to create problems that are worse than those you're trying to solve. That's one reason our team must be so careful about making sure our helicopter cannot possibly hurt an audience member or a player—even if it malfunctions and flies directly at someone! We also have concerns that the helicopter might distract players or get in their way. We're trying to predict any negative consequences so that we can lessen the chance of their happening. It can be frustrating to toss out months of work because a promising solution turns out to have an unanticipated negative consequence.



Keep a Notebook.

As with every engineering design process, we keep accurate notes and ensure that we record this information in our project notebook.

Future Projects

When I look into the future, I don't see myself fooling around with toy helicopters forever. My dream is to work on space vehicles. I want something that I designed to hover over a Martian landscape. But, as we learn from the design process, we have to take one step at a time, right?

Jamy's Comments on the Engineering Design Process

Define the Problem	Problem definitions must include requirements for the solution, such as criteria and constraints.
Research the Problem	Researching the problem often includes looking at how others have tried to solve the problem before.
Develop Possible Solutions	Getting creative new ideas isn't always easy.
Choose the Best Solution	I can never be sure I've selected the "right" design...but I have to stop fiddling at some point and choose what I think is the best solution.
Create a Prototype	The first prototype rarely works as expected, but it's a great way to see where it fails.
Test and Evaluate	If it doesn't meet the test, we'll have to go back and work on the prototype some more, or try one of the earlier ideas.
Communicate	Communicating the solution is as important as every other aspect of the design process.
Redesign	It's a safe bet that whatever we develop will need to be improved.

What's the Story?

1. What problem is Jamy trying to solve?
2. How does Jamy research the problem?
3. Jamy was a member of the team that went to Haiti. What else did he contribute besides his engineering skills? How did his contributions help the team?

Connecting the Dots

4. How is designing a helicopter similar to designing a new cooking fuel for Haiti?
5. Like Shawn, Jamy talks about the importance of communicating the solution. But the two engineers must communicate their solution to very different audiences. Who is Shawn's audience? Who is Jamy's?
6. Jamy says that engineers should always follow the steps of the design process in order, even though the engineers can go back to earlier steps and start over if necessary. Would Shawn agree with that? Which engineer is right?

What Do You Think?

7. Jamy thinks it's a safe bet that whatever his team develops will eventually need to be redesigned. Why do most technologies need to be redesigned?
8. Every engineer has different motivations. Jamy loves the creative aspects of engineering. To him, developing a new technology is fun, sort of like playing a game. Amy Smith and Shawn Frayne are motivated more by a desire to help improve the quality of people's lives. What might motivate you to learn about or develop new technologies?