

Flight Lab: Skies of Tomorrow

Building the Future

They look for survivors in earthquakes...they spy on enemy territory...they even deliver packages in the mail! Drones are the tech of the future, and they'll change the sky as we know it. But to get there, we need to develop the technology first. Hannah and her team at the flight lab are on the job.

by Davia Luke
illustrated by Christopher Ables

GR

Nonfiction: Narrative
000 Total Running Words
Level Z

Heinemann
DEDICATED TO TEACHERS™

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Trim size: 8" x 10.75"

Text Elements
Genre: Narrative Nonfiction
Form: Graphic
Text Structures
Main: Chronological Sequence
Embedded: Categorical, Temporal Sequence, Cause/Effect
Text Features: table of contents, headings, photos, captions, illustrations, speech balloons, diagrams, sidebars, maps

Flight Lab: Skies of Tomorrow

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Heinemann

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www.heinemann.com

Offices and agents throughout the world

Fountas & Pinnell Classroom
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ISBN-13: XXX-X-XXX-XXXXX-X

Design and Production by Dinardo Design LLC
Editorial Development by Kelly Robinson

Credits

Illustrations: Christoper Ables

Printed in China

19 20 21 22 23 24 RRD 8 7 6 5 4 3 2 1

Chris Lum: To help illustrate this point, Hannah recently got a job at Amazon where she will be working on drones for package delivery.

Pioneer Partners

Scientists like the ones featured in this book are pioneers—their discoveries and innovation help companies, governments, and the public adopt new technologies or solve problems. Their work doesn’t happen in a vacuum—science, industry, and government often work hand in hand. Many times a company will partner with a science department at a university. The company provides funding for new computers, software, and other materials, and the university leads the work. Students like Hannah get real, hands-on experience, and companies get extra help designing new technology. And many times, students go on to get a job with their company partner. Everybody wins!

Acknowledgments

The author and editors of this book would like to thank Hannah Rotta and Christopher Lum of the Autonomous Flight Systems Laboratory at the University of Washington in Seattle. (The Lab works closely with industry partners and funding agencies that help enable its work.)

The Joint Center for Aerospace Technology Innovation (<https://jcati.org/>) – Funding Agency
Hood Technology (<http://www.hoodtech.com/>) – Industry Partner

Advanced Navigation and Positioning Corporation (<http://www.anpc.com/>) – Industry Partner

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Sagotech (<https://sagotech.com/>) – Industry Partner
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—Davia Luke

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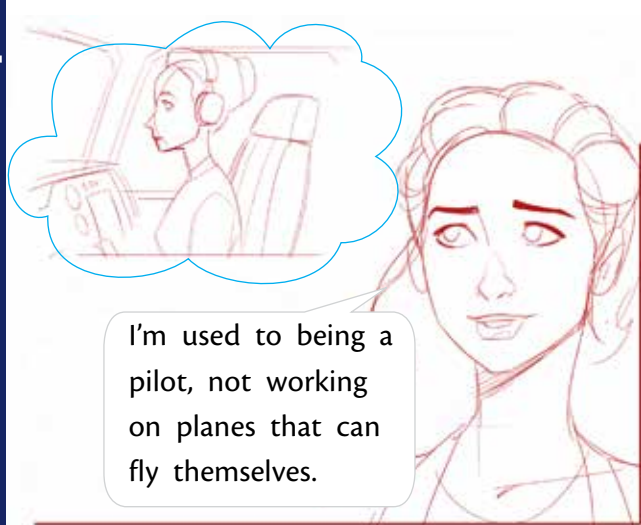
Hannah Rotta scans this most unusual classroom. Wings, motors, and other parts of what look like toy planes are strewn across the tables. This isn't just any classroom, it's a flight lab.

Welcome to the flight lab, Hannah! We're excited to have you join our project.

Thanks, Professor Lum.

Chris Lum: This is a relatively minor point but while some of the systems we use might have origins as toys, the majority of them are aerospace quality components and subsystems.

1A: artist will fill details of classroom in the background.



I'm used to being a pilot, not working on planes that can fly themselves.

Not to worry. Your experience as a pilot will be really helpful. We're trying to find the best way to fly unmanned planes. These drones are the cutting edge of technology.



Every day we work on new ideas for technology that everyone will use one day.

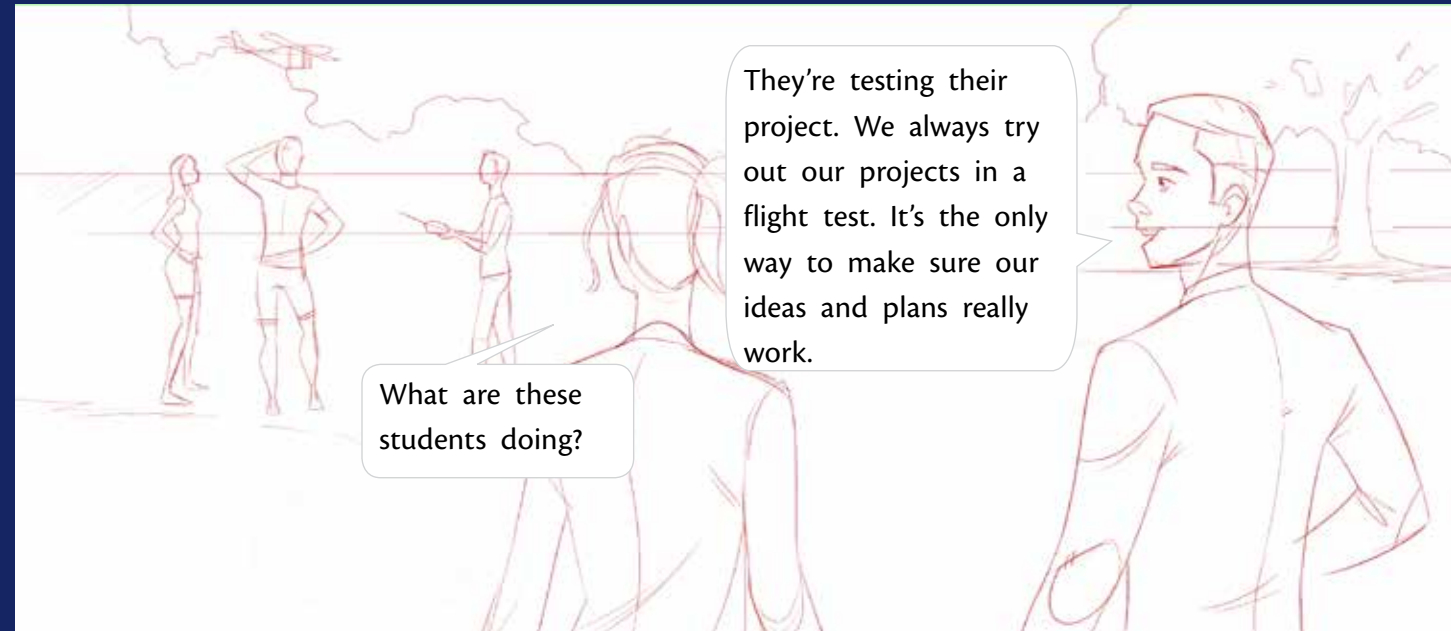


So the sky is literally the limit!



Meet Hannah

Hannah comes from a family of pilots, so it was only a matter of time before she got her own pilot's license. She loves everything about planes and flying, so she came to the flight lab to learn about the exciting new technology of drones. Drones don't need onboard pilots to fly them. But Hannah thinks it's great to be on both sides—as a pilot, she understands how planes fly, and she can help shape this exciting new technology.

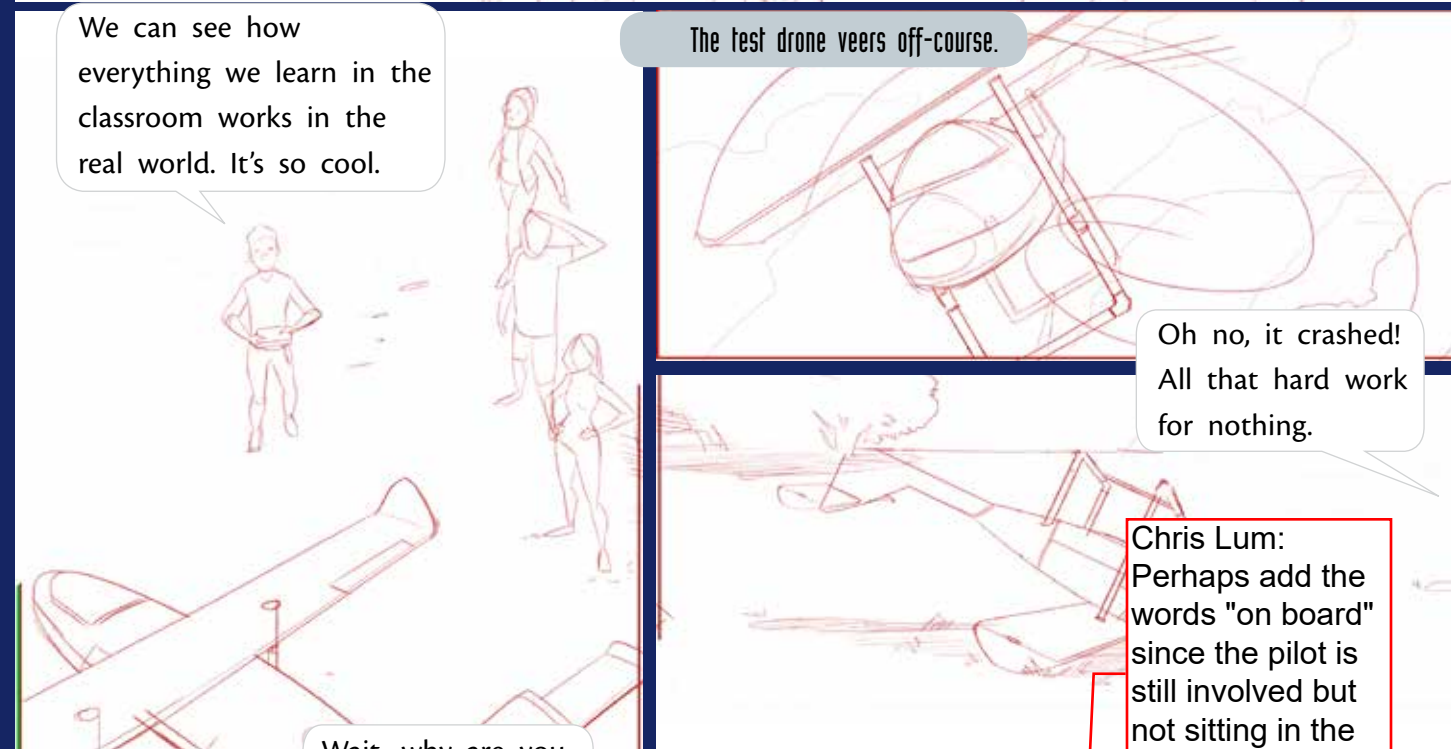


What are these students doing?

They're testing their project. We always try out our projects in a flight test. It's the only way to make sure our ideas and plans really work.

We can see how everything we learn in the classroom works in the real world. It's so cool.

The test drone veers off-course.



Oh no, it crashed! All that hard work for nothing.

Chris Lum: Perhaps add the words "on board" since the pilot is still involved but not sitting in the aircraft.

Wait, why are you all smiling? Wasn't the test a failure?

Yes—and no.

Now we know exactly what we need to fix.



The Sky's Next Big Thing

Drones fly in the sky—but they don't need a pilot. They can be operated by a pilot on the ground, like a remote-control plane, or by an on-board computer via autopilot. Drones can be so tiny they fit in the palm of your hand, or they can be as big as a full-size jet. These unmanned fliers can be very useful for mapping, delivering supplies to remote areas, and more. They can go places humans can't and perform dangerous jobs like search and rescue.

[panel 2A art: Perhaps full measure view to establish the setting of a bustling classroom/tech lab. Papers and diagrams fill white boards on the walls. There should be a big window with a field outside, as this will appear later as the flight testing space. Groups of students cluster around different tables—some working on a motor, some putting drone pieces together, such as wings and body. Off to one side are a computer or two with students working together while looking at a screen. Should convey bustling activity and students working collaboratively. Should look enough like a classroom to be familiar to readers, but then have these hands-on things happening that might seem surprising in a classroom. Hannah looks like a student, Professor Lum wears a button-down shirt and tie with sleeves rolled up. She is taking in this scene in wonder, and he is welcoming her.]

[panel 2B art: close-up on Hannah. Thought bubble shows her in the pilot seat of a small Cessna type plane smiling. She should clearly be the pilot]

[panel 2C art: close-up on Professor Lum. He's holding a drone/model up in his hand while he talks]

[panel 2D art: Hannah and Professor Lum together. He is showing her around the lab. Perhaps they've paused to look at a cool model]

[panel 3A art: Hannah and Professor Lum have stepped outside the lab into an open field space—open green grass with a distant ring of trees. A group of 2-3 students are testing a drone by flying it with a remote control]

[panel 3B art: Professor Lum and Hannah have come up to the student testing group, and they're all looking up at a drone hovering overhead]

[panel 3C art: Close up on the drone in the air. The drone goes veering off—it should look like it's turning and wobbling—something is clearly amiss. This could be broken up into one or two small panels with no text to show motion. The students are chasing it and/or run over to it where it lands.]

[panel 3D art: the drone has crashed or landed awkwardly (it doesn't look broken).]

[panel 3E art: the students gathered around the drone on the ground, with Hannah and Lum looking on. The students and Professor Lum are smiling and congratulating each other; Hannah looks on confused]

Hannah meets the team she'll be working with. The students are already knee-deep in an important drone project.

Welcome to the team, Hannah! We're happy to have your pilot's eye.

The team is trying to solve a big problem for drones.

Student 3

Professor Lum

Drones fly by GPS. Satellites in space send GPS signals to a receiver on the drone. They tell the drone where it is.

But sometimes a drone loses the GPS signal, like when it flies in the woods.

It's just like when a cell phone loses its signal.

Global Positioning System

And without a GPS signal, there's no way to steer the drone.

Student 5

Student 4

Yeah, that sounds like a problem alright. So what can we do about it?

Hannah

Steering by GPS

GPS stands for "global positioning system." It's a map on a device, you know where you are. That's GPS at work. Satellites in space send signals to a receiver in your device, and that receiver uses the signals to calculate your exact position. It works the same way with drones, and since there's no pilot to navigate it, this location information is critical.

4

Chris Lum: "navigate" might be a better word instead of "steer". Many systems can still steer themselves (ie hold a desired heading) without GPS using a magnetometer or compass. Navigation without GPS is the real problem. The word "navigate" might line up better with the side panel discussion in the bottom left of the page.

Instead of a satellite sending a signal to the drone, we can have the drone send a signal to a receiver on the ground.

Through a transponder—that's the thing that sends the signal out.

A ground antenna picks up the signal from the transponder, see?

Student 5

Student 4

Artist will show Student 4 pointing to the diagram.

And then a computer can tell from the signal where the drone is.

Student 3

Wow! No GPS needed.

Hannah

Design note: Artist swapped Students 3 and 4 on this spread; we can ask him to change their positions but this part of the text is not necessarily specific to each student in this panel.

This is the team's plan.

DIAGRAM

And we're actually going to build this? Us?

And if the team's idea works, there's a good chance it will end up in real drones and planes.

Yep. This lab isn't just any old classroom.

Hannah

Student 3

5

Electronic Calling Card

A transponder is a small piece of equipment used on many commercial planes. It sends out a signal broadcasting the exact position and altitude of the aircraft. Air traffic controllers and other pilots can pick up the signal and know exactly where the plane is.

[panel 4A art: Professor Lum is introducing Hannah to her team—a couple of other students who are smiling and taking a break from what they're working on. They are back in the lab]

[panel 4C art: Hannah up close, looking concerned]

[panel 4B art: Hannah's team are gathered around a diagram on a whiteboard or a more formal looking poster on the wall showing how GPS works, called "Global Positioning System." It essentially shows a GPS signal represented by wifi-type lines such as))))) going from a satellite to a drone. Student 3 is pointing to the signal marks. Student 4 or 6 could be expressively gesturing to show this is a problem.]

[panel 5A art: Same group of students and Professor Lum around a drafting table, with a large drawing/diagram spread out on it (representing the diagram shown in panel 5B. Student 3 points to drawing.)

[panel 5B art: close-up of the students' diagram/work plans, which are on the table. This should function like an actual diagram for readers.]

[panel 5C art: close up of Hannah and Student 4. Hannah looks amazed.]

[panel 5D art: close up of Professor Lum talking]

It's time for Hannah to get down to business. The team works in two groups: software and hardware. Which group will she join?

This group over here works on the software side of things.

Professor Lum

Student 1

The software group is writing the computer program for the drone to send and receive ground signals.

I'm in this group because I'm good at coding.

Me too. But I've never used my coding skills like this before. Check it out!

The software group's coding looks like this:

Strings of numbers, letters, and symbols make up commands that will tell the drone what to do.

We're making a drone do something it's never done before.

Awesome! So what's the other group working on?

Student 3

Hannah

6

The hardware group works on the drone itself.

Professor Lum

Hannah

I've been designing the shape to make sure it can fly.

Student 4

I'm good at wiring so I put the pieces together.

You see, Hannah, everyone has different skills and strengths. And in our lab, we need all of them.

I work on the outside, he works on the inside.

Professor Lum

What about you, Hannah?

Well, I think like a pilot, so...

Hannah

Student 4

Sweet! We want Hannah in our group.

No, way! We do.

Professor Lum

Student 1

Settle down. Hannah will work in the software group. But don't worry, we all work as one team.

Hannah

Student 5

Mad Skills

Students of all ages and backgrounds come to the flight lab. They all have different skills and experiences, so they approach a problem from different angles. But they all have something in common: dedication and determination. They're not afraid to make mistakes, learn from them, and try again.

[panel 6A art: Hannah, Professor Lum, and Students 1 and 3 gather around a computer or row of computers. The screens are full of code, and there are papers strewn everywhere, in a deep-in-work kind of way, perhaps with drone drawings and notes pinned to the wall]

[panel 6C art: close up of a computer screen full of programming code]

[panel 6B art: close up of the two students]

[panel 6D art: back to the group from 6A]

[panel 7A art: Hannah, Professor Lum, and Students 4 and 5 stand with a test drone on a table. Student 4 is holding or pointing to papers including a schematic drawing of the drone on top, needs to look like a drawing or blueprint, with some indistinguishable notations or arrows, but it should be based on a Skywalker 1900 drone.]

[panel 7B art: same as previous, or a focus on elsewhere on the same tabletop, with Student 5 pointing to or holding a device that goes inside the drone, with associated wiring. See reference images. Could look like the transponder]

[panel 7D art: close up of Student 4 and Hannah. Perhaps now she has a poster behind her showing a plane in the sky]

[panel 7E art: wide shot of the lab and whole group of Hannah, Professor Lum, and several students from this spread]

[panel 7C art: close up of Professor Lum speaking a spreading his arms wide, as if to indicate the whole lab]

The two groups have been hard at work on their parts of the project. They test and retest everything they do, every step of the way.

The software group has been writing code that will allow the drone to receive position information back from the ground, telling it where it is.

Hannah

Hi, team. What do you have planned for today's test?

Professor Lum

We need to make sure the drone is getting its location signal from the ground.

How will you know it's working?

Professor Lum

Student 1

This dot represents the drone. Hannah's going to walk around with the drone, and hopefully the dot will move as she does.

Then we'll know we are tracking the drone's exact location.

Hannah

Okay guys, let's give it a try.

Hannah

I'm making a lot of moves...

Hannah

The blue dot begins to move on the screen, matching Hannah's movements outside.

Now we need to make sure the drone's flight controller can use this location signal to steer itself.

Bench Testing

For every step, students at the flight lab conduct bench tests. Bench tests help tell whether a string of code, a set of wires, or a specific piece of equipment is working. They're like quizzes along the way, before the team puts all the pieces together in a full flight test.

Student 3

And we're tracking them all.

The software is working. Yesssss!

Student 1

Design note: artist will fill in left side of panel.

We did it! So what's next?

Student 3

Let's get back to coding.

Student 1

Meanwhile, the hardware team is working out a way to attach the transponder to the drone.

Hey, hardware team. What are you guys working on?

We're figuring out how to attach the transponder to the drone.

Nice. That sounds easy enough.

Hannah

Student 4

You'd think. But we've had to design a box to hold it, and the size and weight have to be just right. It's like a puzzle.

We're using this 3D printer to print the box. We've already tried four times to get the shape right.

Student 5

The team tries one more time with the new box.

Okay here we go....
Drat, it still doesn't fit.

Looks like we need to shave off another millimeter right here.

Student 5

Student 4

Well, at least you know what to fix, right?

You're catching on, Hannah!

Hannah

Student 4

Need a Part? Just Print It!

A 3D printer doesn't print words on paper—it prints out an entire object! A 3D printer works by making a model out of plastic, "printing" the plastic layer by layer. 3D printers have been used to print everything from machine parts to human organs to clothing. The flight lab team uses a 3D printer to make parts for their test drones.

[panel 8A art: Hannah, Students 1 and 3, and Professor Lum gathered around a computer (note all should be wearing different clothing to indicate a different day). Not much focus on the computer yet, but if the screen is visible it should show the mapping program described below]

[panel 8B art: close up of Professr Lum, Hannah and Student 1 looking at the computer screen. On-screen, we see Google Maps-like software with a blinking/glowing blue dot that will move around. The "map" it's moving around on should be fairly abstract but loosely represent the lab classroom with the testing field just outside. Focus should be on the dot, not the map. Student 1 is pointing to the dot.]

8B art spec calls for Hannah, Professor Lum, and students in front of detailed screen. Artist rendered only the screen. To maximize space, we could have the voices coming from outside the scene, or combine panels 8A and 8B, or rever to original spec.

[panel 8C art: Hannah wearing a headset and heading out the door to outside, with the test drone in hand and maybe waving back to the group]

[panel 8D art: Hannah walks/runs around outside while holding the drone. She talks into the headset—could b holding the microphone piece to emphasize this]

[panel 8E art: Students 1 and 3 are gathered around the computer with the blue dot moving around on-screen, perhaps with dashed lines indicating its path. The students look excited/triumphant]

[panel 8F art: Hannah back inside with the other two students. They are high-fiving each other triumphantly]

[panel 9A art: Students 4 and 5 working on a drone on a table. Paper/plans, screwdriver/screws, bits of wire, a wrench, etc. are on the table to suggest work in progress. See photos for location of exposed parts (transponder, radio), tape, wires and such that show this is a test/active project. Hannah approaches the team from one side.]

[panel 9C art: 3D printer finishing printing another plastic cradle. Perhaps Student 5 is leaning down, at eye level with the printer, looking on]

[panel 9E art: Close up of Hannah and Student 4. Hannah looks like she's encouraging the student.]

[panel 9B art: Close up of top-down view of drone, with a hole where the plastic cradle holding the transponder will go (see reference image). On the table next to the drone we see a black electronic looking box representing the transponder, and next to that a plastic cradle with a hole the shape of the transponder. It should be clear that the transponder will go in the plastic cradle, and then the plastic cradle will go in the drone. The student speaking is pointing to the cradle.]

[panel 9D art: Similar to first scene. Student A is holding the cradle with the transponder inserted, and is inserting it into the hole in the drone. It's stuck halfway because it doesn't fit. Student 5 is pointing to one corner/edge. Both look mildly frustrated. Hannah looks on. Transponder/payload is black box labeled "Pixhawk" as well as the unmarked black box beneath it. These fit inside the payload bay of the aircraft. The antenna is mounted to the tail.]

After many months and dozens of lab tests, the team is finally ready to test the whole system with everything put together.

Today's the big day—your first flight test.

Professor Lum

Don't be! It may not go as planned, but it's always a learning experience.

I think I'm nervous.

Hannah

It's true. You never really know what will happen outside until you try it. Are you ready?

The team launches the drone by hand, like throwing a paper airplane.

Ready when you are.

Here goes...

Hannah

Student 4

We have lift-off! Now it's your turn, Hannah.

Student 4

As the one pilot on the team, Hannah uses a remote control to steer the plane once it's in the air.

This sure is a different way of piloting!

Hannah

How's it looking, software team?

Professor Lum

The drone is sending and receiving location signals.

Student 1

Thumbs up!

Student 3

Now let's turn on the automatic flight controller and see if it can use the location signals to steer.

Student 1

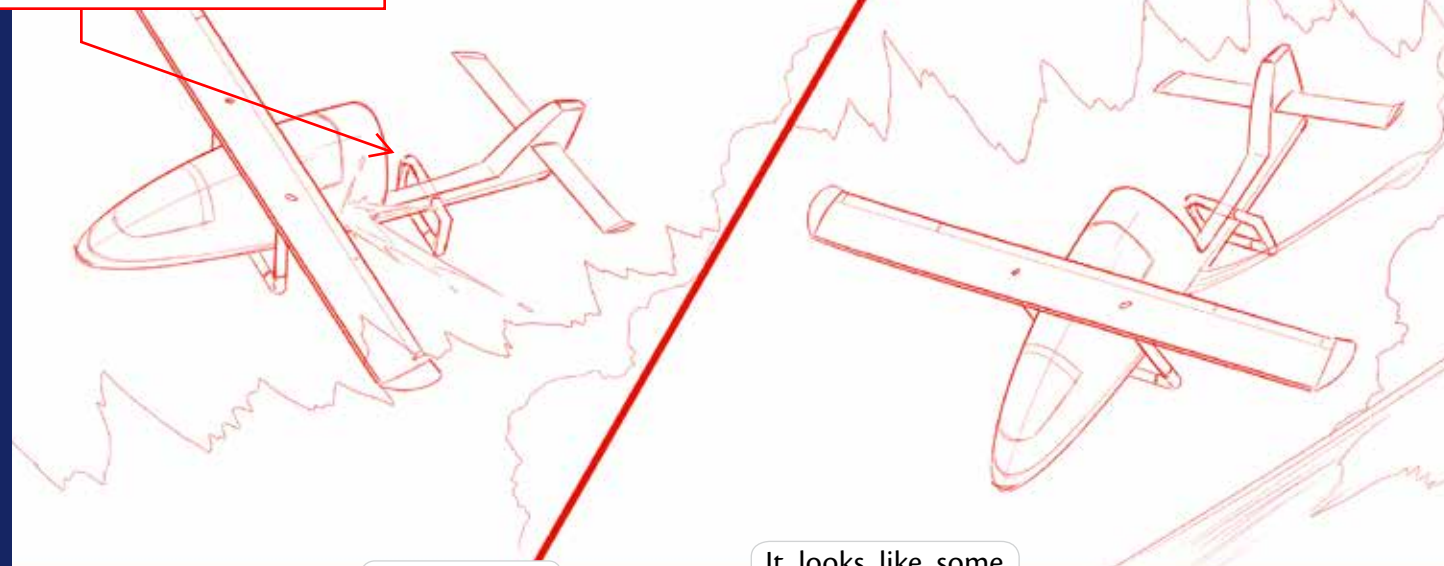
Professor Lum

Copy that. Let's see if this baby can fly itself.

Chris Lum: I'm not sure what this box around tail boom is. It is not on the actual aircraft and doesn't appear in other illustrations.



Also, perhaps the propeller should be drawn? We do remove the prop from the aircraft when it is on the ground (for safety) but it is the primary propulsion mechanism for most drones.



Oh no! What happened?!

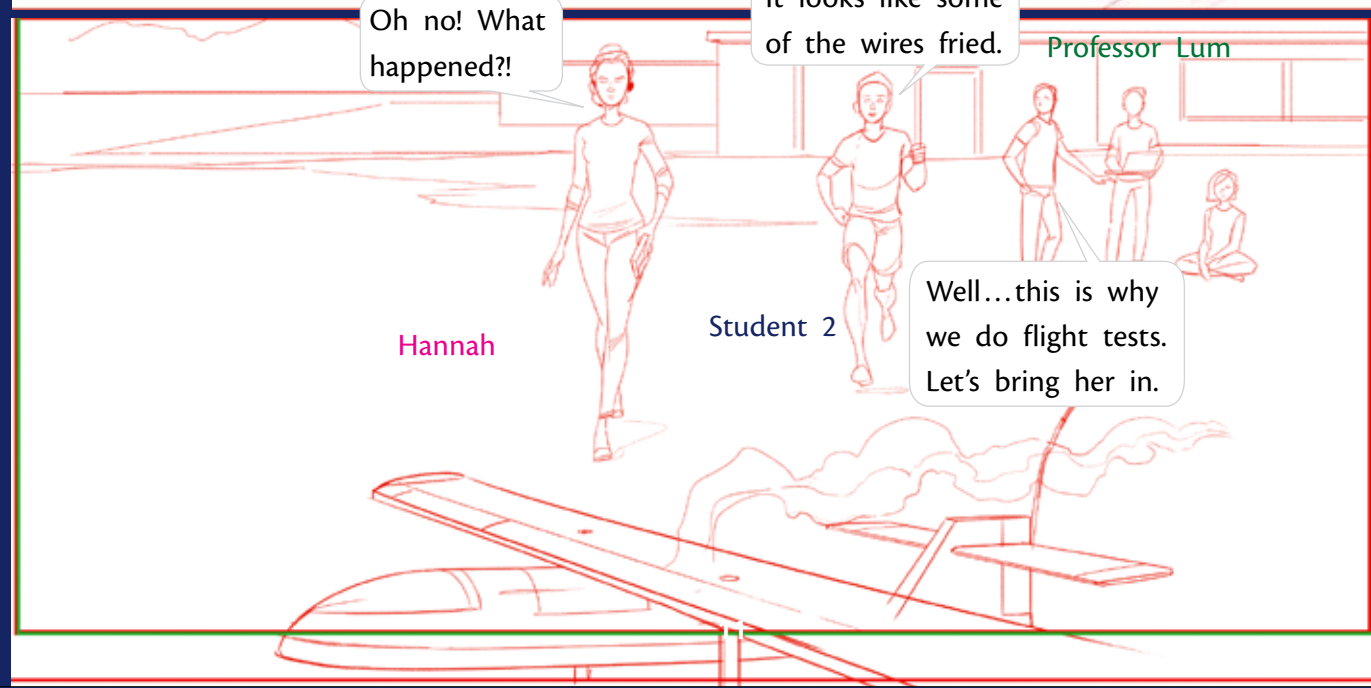
It looks like some of the wires fried.

Professor Lum

Hannah

Student 2

Well...this is why we do flight tests. Let's bring her in.



[panel 10A art: Hannah and Professor Lum on the test field next to the classroom. Perhaps students in the background are gathered around the drone. Student 4 approaches holding the drone, and conversation expands to include him/her. NOTE: different day; months have passed, maybe clothing shows a change of seasons?]

[panel 10B art: Hannah stands with Student 4. She is wearing a headset and holding a remote control. Student 4 is throwing the drone into the air to launch it. See reference images.]

[panel 10C art: Wider shot of the field with drone flying overhead. Hannah and Student 4 stand together, and all the other students and Professor Lum look on. Everyone is looking up, maybe some are shielding their eyes. To one side are two students from the software team, one holding an open laptop]

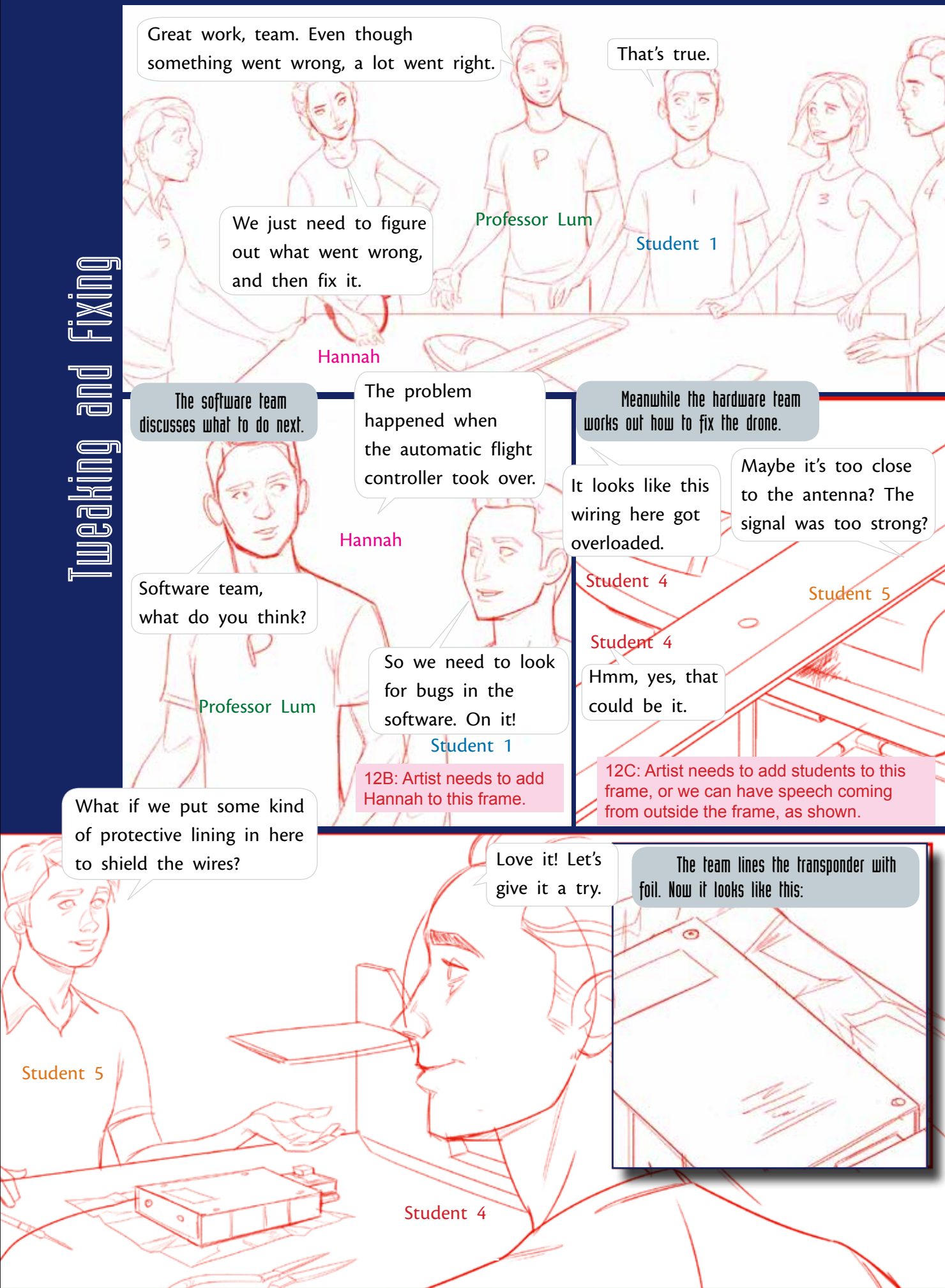
[panel 10D art: close up of Hannah flying the drone by remote control]

[panel 11A art: scene continues from previous page. Focus is now on the students with the laptop, and Professor Lum calling over or walking up. Student 1 is looking at the screen and Student 3 is flashing two thumbs up; both are grinning]

[panel 11B art: close up of Professor Lum bending down/looking over the shoulder of Student 1, both looking at the laptop screen as they speak]

[panel 11C-D art: we see a small spark and a thin string of smoke. The drone flips upside down and then plummets straight into the ground. These can be shown over a series of frames as needed to convey motion and drama]

[panel 11E art: Hannah, Professor Lum, and a few other students crowd around the drone on the ground, with a burn mark around the antenna and looking a bit beat up but not broken]



[panel 12A art: Wide shot of the group of students, Professor Lum, and Hannah around a big work table in the lab, with the damaged drone in the middle of the table, as if they're examining it]

[panel 12B art: Perhaps half the previous shot, showing Professor Lum and software team students. Or they can be grouped around a computer as in previous spreads.]

[panel 12C art: close up of the damaged drone on a table with a couple of students from the hardware team]

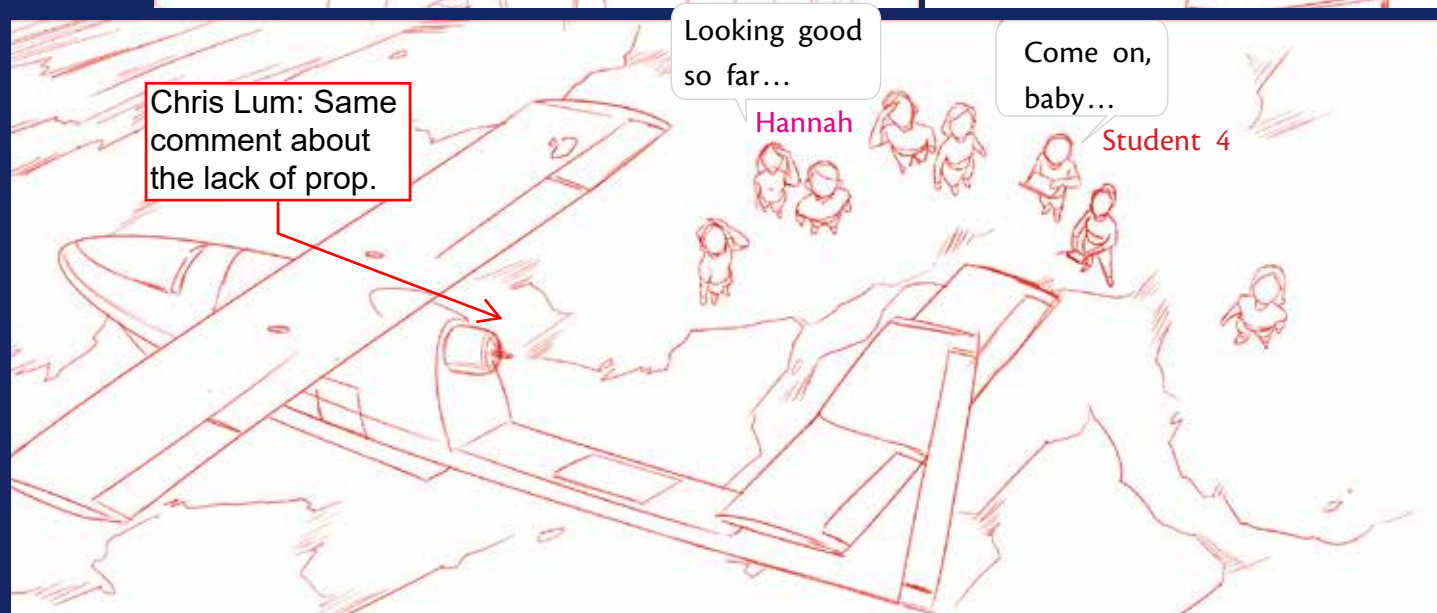
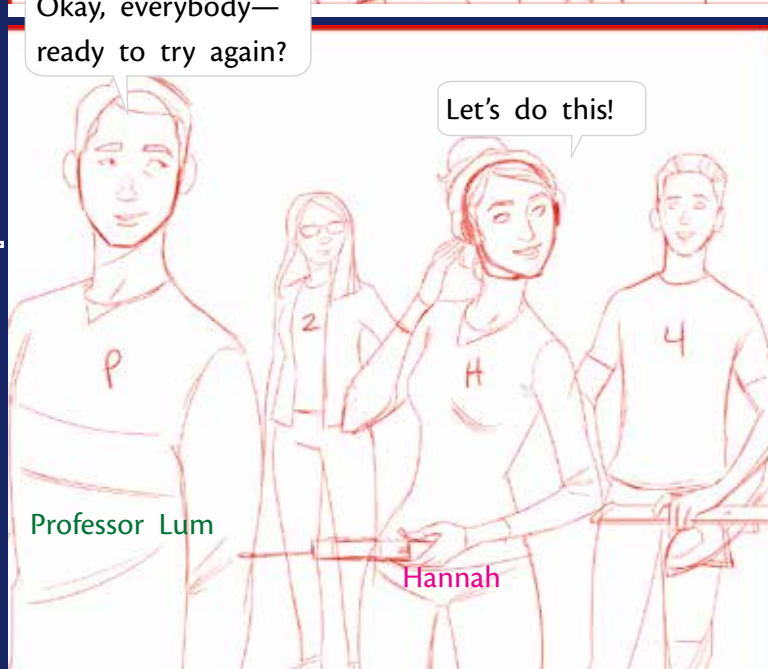
[panel 12D: close up of the student with the transponder open on the table, pointing inside. Transponder box is white, as in photos.]

[panel 12E: close up of same transponder, only now the interior/edges look covered in silver foil, rather than white]

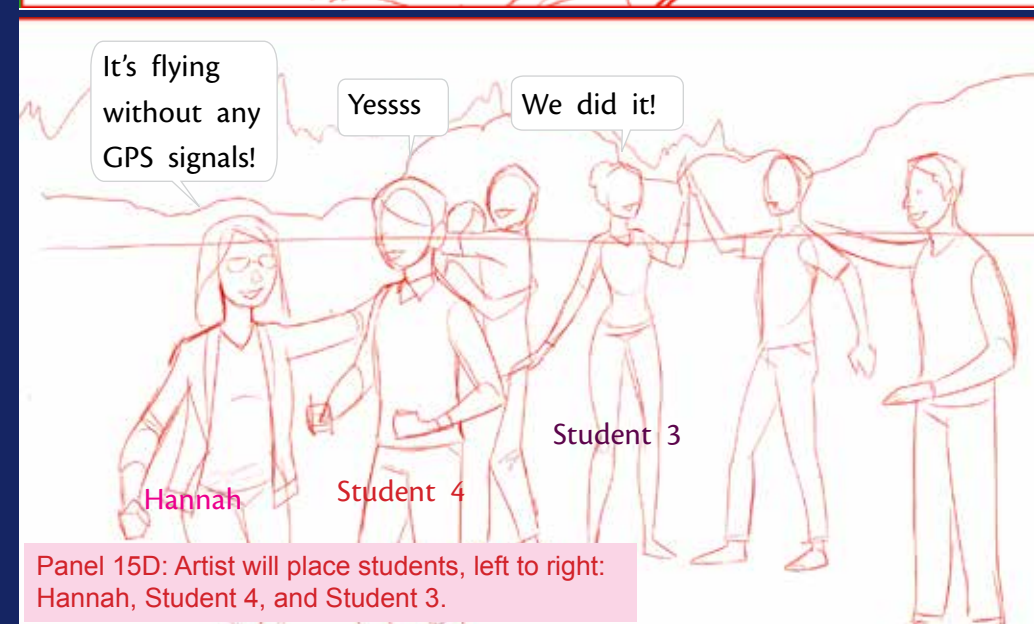
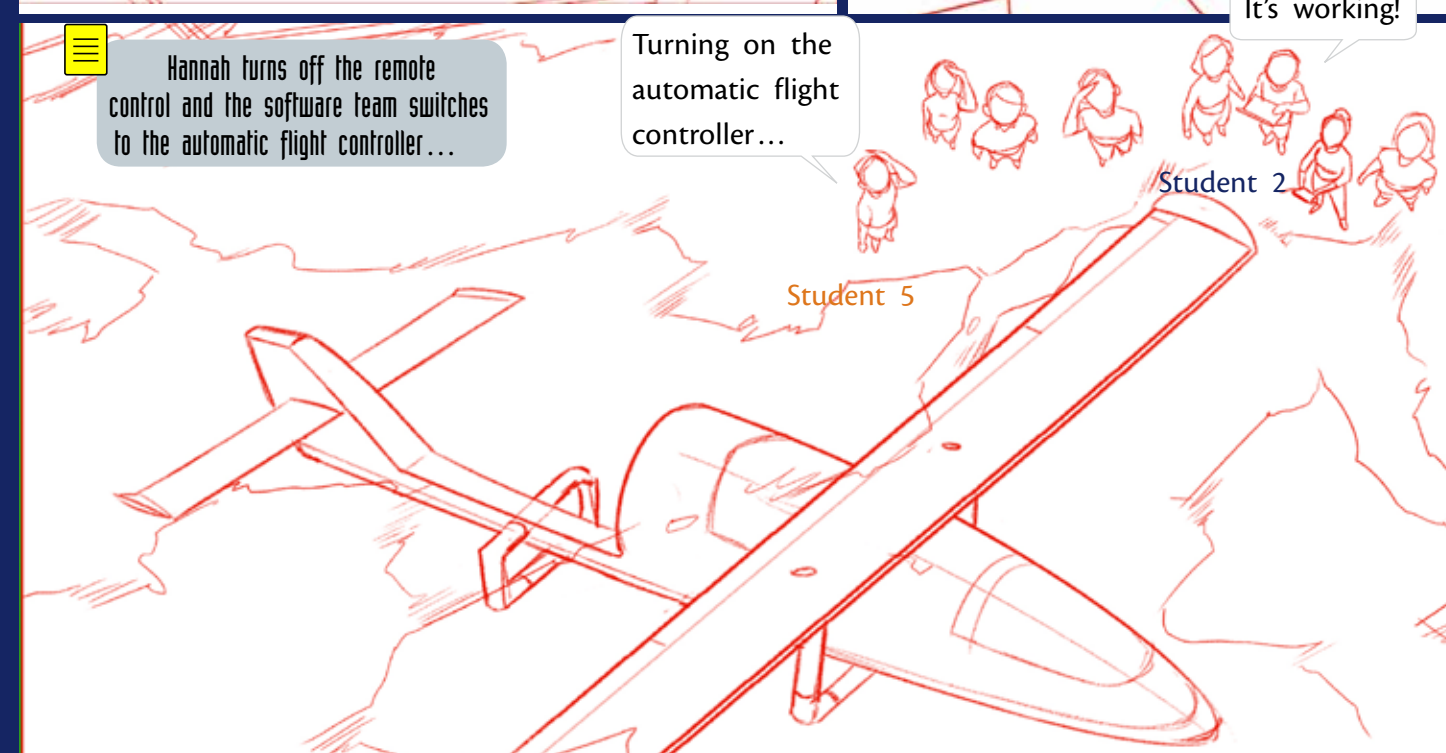
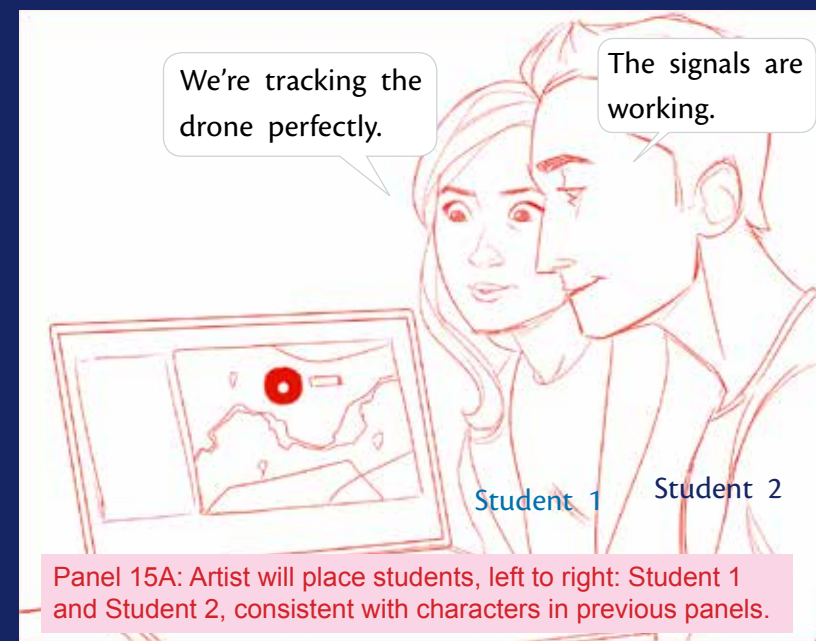
[panel 13A art: Wide shot similar to 12A, only now the drone looks fixed and undamaged. It's two months later so clothing should be seasonally appropriate, based on earlier clothing.]

[panel 13B art: large panel showing a close-up of the drone on the table, with the parts labeled as in the reference photos. Have dialogue associated with each part, without showing the speaker. The goal here is to show all the parts of the drone]

The team has fixed all the problems they found, and now they're ready for another flight test.



14



Time to Get It Right

At the real flight lab, Hannah's team spent more than three years developing a drone that can fly itself without needing GPS signals. They ran hundreds of bench tests and dozens of flight tests to get everything working just right.

[panel 14A art: Wide shot of the students, Hannah, and Professor Lum on the field, similar to previous flight test scene]

[panel 14B art: Professor Lum, Hannah and Student 4 as they prepare to launch. Hannah holds the remote with headset and Student holds the drone, as in 10C]

[panel 14C art: Close up as student launches the drone like a paper airplane; no text]

[panel 14D art: The drone sails overhead as students look up. Perhaps show a the drone in the sky wiht voice coming from outside panel, or show sides of two faces in lower part of the panel with the perspective looking up.]

[panel 15A art: close up of software students with computer showing map and tracking dot, similar to 11A and B]

[panel 15B art: close up of Professor Lum, maybe talking as he's looking up at the drone and shading his eyes]

[panel 15C art: wide shot of drone circling above the students, similar to 14D]

[panel 15D art: focus back on the students. They're jumping up and down, cheering, high-fiving each other]

This isn't just a story. Hannah, Professor Lum, and the team at the flight lab have been working for many years on their project. Students like Hannah get hands-on experience that will help them land internships and jobs in the aerospace industry. And the industry—companies that build drones for things like search and rescue—will benefit from the technology that Hannah's team develops.

Hannah and the team know that more flight tests and more failures are to come. But every setback is also a step forward; every problem is an opportunity for improvement. And every flight test will one day enable drones to keep flying when they lose a GPS signal. The team is helping to shape the future of this exciting new world in the sky.

[PHOTO TK showing Hannah, Professor Lum, and their real test drone (other students are ok too)]

[CAPTION TK but should identify Hannah and Professor Lum, and state that today Hannah is in charge of flight operations for the lab]

[PHOTO: if possible also show a commercial or real-world drone that might one day have the type of tech the flight lab is developing. May need to ask them for a reference]

Christopher Ables

