

Interview with Chris Hadfield, Canadian Astronaut

Chris Hadfield, NASA Astronaut and **Terry Orlick** Interviewer,
University of Ottawa

In 1995, Major Chris Hadfield flew aboard the space shuttle *Atlantis*. He was the first Canadian to fly as a mission specialist, to pilot a docking with the Russian space station and to operate the Canadarm in space. He has worked in Houston as a CAPCOM, the voice-link between astronauts in the shuttle and mission control on the ground, and is currently preparing for a mission which involves extra-vehicular activities in building the Space Station.

Abstract

Chris Hadfield is one of the most impressive performers I have ever had the pleasure to meet or interview. The quality and detail of his mental preparation for training and space flight is nothing short of amazing. In this interview he discusses his extensive use of mental imagery, his ability to control distractions and connect totally with his task, and how he acts on his commitment to ongoing learning. There are many insights and practical suggestions raised in this interview that can be applied to virtually any mission or pursuit.

Terry: From your experience, what do you think is required to excel?

Chris: In order to get to the level where people are considering that you have excelled, you need to clearly understand where it is that you are heading and really have a good feel for what it is that you are trying to accomplish. If you have a shotgun of things that you are trying to do it is very difficult to excel at all of them - maybe you will have one or two highlights or mountain peaks. To excel you need to focus on what it is you want to do. In my case I need to visualize several routes to get there whether it is climbing a mountain or winning a particular race or succeeding on a certain space flight or getting something built in orbit...something that has never been done. You need to visualize all the different ways that you can get there easily and then visualize the ways that you can just barely get there when things are breaking. Once you have figured out what it is you are

trying to do and you really have a clear picture of that, you develop a clear picture of what you can do for all the possible things that can go wrong. Then of course the hard part is sorting out your training and how you're going to realistically prepare for all of that. How are you going to get yourself ready so that when the moment comes you're ready to come out of the shoot and do it?

It's very much a long term focus issue, keeping that long term goal that you've defined in mind, thinking about the route and how you're doing on that road, and then keeping yourself moving incrementally along. It can be something you want to do in an hour, like one hour from now I want to do this ... and this how I am going to do it. Or it can be something for your whole life, I want to accomplish this by the time I'm 90 and these are the things I'm going to do to get there. The most important thing in the training is to have representative, environ-

mentally situated training, enough training that when you get to the real test that you have seen something that was close enough or you have been able to extrapolate to it so that it becomes familiar. So you aren't relying on chance when it really comes down to it, so that it becomes familiar and you can just focus down and get this job done and it's within the scope of what you've seen before.

Terry: What is it that keeps you going after those goals over the long term?

Chris: It is very much a retention of purpose throughout your entire life. There will be insurmountable setbacks if you set yourself any sort of difficult goal. You will get to a stage where the whole horizon is black and you don't see anyway through. That happened several times to me. I chose as a kid to be an astronaut when I grew up. It was a black horizon from the beginning, there was no way - it was impossible at the time. But things always change, given time. There are always new possibilities. The important part in achieving, or even coming close to what you dream of doing, is a retention of purpose. Everyday you're going to have a choice to go a little bit closer to where you want to get, every single day. Then there will be some break points in your life where you really fundamentally choose whether you're going to head that direction or not. And if you don't make that choice, if you don't change direction you will end up where you're headed. Guaranteed. So you need to fundamentally choose which direction you want to go and start heading that way and maybe you'll get to where you want to go.

I think the purpose that I chose for myself, the goal I wanted to achieve as an adult, I internalized deliberately at 9 years old - I am by no means a robot that headed that way, but I always had choices and I thought,

"Well someday, maybe I'll get to be an astronaut and if I am, I really should know about this, I better study this, I should do this". I was just lucky enough that when I got to the point in my life where I was qualified, where if the opportunity was going to come along, I'd gotten myself to the level where, "Hey, this body and this brain, this is about all I can offer". I was lucky enough that at that stage in my life the opportunity arose and I was in a position to take advantage of it. So I think that basic retention of purpose through a whole life, not only gets you to your goal but makes life more interesting and fulfilling because you're headed some direction that you like. And your life loses its random and therefore unfulfilling nature. I really enjoy it.

Terry: You mentioned that during your last space flight nothing went exactly as planned, yet everything had been prepared for. Could you talk a little about that?

Chris: Yes, everything that we had thought about prepared us for the flight. And we were audacious enough to make-up a plan, minute by minute, of how the whole flight was going to go, down to 5 minute increments through the whole 8 days, of what we expected to be doing every minute. We call it a flight plan. Of course nothing went exactly according to that plan but everything was somewhere within the scope of things we had seen while we were training. That is what you need in that preparation phase. As an example, in docking with the Russian space station, timing was critical, and yet when we got to 25 feet away we had three different sensors and we were sure two of them would agree. Well one of our sensors said 20 feet, one 25 feet, and one 32 feet, and depending on which one was right would make all the difference as to whether we could dock on time or not. So there we were in a situation that we had never directly practiced for, we

had never assumed that the sensors would all disagree and so we had to go with the only one that couldn't lie to us, which was really visual, eyeball - "The docking module is 15 feet long so that's another 8 feet above so okay, we're about 23 feet away, go with that". You know, go back to the absolute basics of what you've seen in training and what you've practiced for as a contingency. And we ended up hitting it 3 seconds early, basically right on time having had enough depth of training that you've covered the whole scope so that you could do the job with the real time deltas when you had to get there.

Terry: So what would be the price of error in that situation?

Chris: If we had been wrong, if we had guessed wrong, if we hadn't been prepared for it, we would have had to back away from the Russian space station for at least 24 hours because the world is turning underneath you and you have to wait until Russia gets underneath you again. So we would have had to wait 24 hours which means you are using up consumables, you're using up fuel, you're running the risk of something breaking, you're analyzing what was wrong, "What's going to be better next time?" You know you are going to have the same problem. So we ran a risk of total mission failure based on that. You are always having to work around those things one domino at a time to get the whole thing through.

Terry: In terms of preparing for that docking about how many times would you have actually simulated it or run it through your head?

Chris: An actual full crew simulation of the docking I would guess we did 250 times. And then myself simulating stages of it, or complete bits of it in my head, I couldn't

count the number of times. I sat out on my deck at home at night, and thought through it and practiced with it. In the simulator we're using a big hand held laser, of course in the simulator a hand held laser doesn't have anything to range off of. I used my workbook which is about the size of a hand held laser, and every time I used that laser I would physically hold that up and count the 5, because that's how long it's going to take to do a laser mark, to make it as realistic as possible: to block the commander's view of what was going on, to simulate the time it takes to actually get a mark, to miss some of the marks. You know just trying to put in as many realistic obstacles as possible so that when we did it for real we would go, "Yeah, that's just what we expected. It was easy". Because that's what we had planned.

Terry: When you are doing that kind of preparation in your mind what do you experience? Can you describe what it is? What is the detail? Do you feel things in your body?

Chris: I learn things better if I understand how I am physically going to interact with them. When I want to learn about the shuttle's thruster system I have an actual picture of the thruster control panel in what I call my brain book. And I work through that. I will research every single thing that switch does; how it effects the whole system, how it all works, interacts, so that as a straight tangible reminder when I'm reaching for that switch and touch it, the actual physical action is a reminder to me of all of the study and all the background and everything that led up to what that switch does. And that's true for all of the switches in the cockpit. I spend time thinking through a checklist or a cue card as well. I have taken one of those cue cards and written a thousand notes around the outside so that when I get to the actual cue card there's a whole pyramid of information below each

thing that is there, that I've tried to spend the time preparing for beforehand. So the few cues that you're actually interacting with real time are all based on a much wider base or depth of information that you might have from before.

Terry: So is your brain book those notes, or is it in your head?

Chris: My brain book is... I will try to condense everything that I need to know about a certain idea onto one piece of paper, like a cheat sheet basically. I have an entire book of cheat sheets about my next flight, and it allows me a couple things. It allows me to coalesce my thoughts. By going through the process of making up one of those sheets you tend to drive home in your mind how you're going to remember this stuff. When I am having a simulation the next day it also allows me to have a one page reference for all of the key stuff. And as an added benefit, we're allowed to take one small book up to space with us and I have this thing photocopied and put on the flame proof paper and I bring these notes up with me to space. But I didn't check those notes even once on my last flight because the act of developing them, studying them and then using them in training is enough to internalize it so that I don't need them real time although they're there as a security blanket.

Terry: So when you're writing and reading, or referring to those note or checklists, does that create images or actions in your mind?

Chris: Definitely, yes. I think through the whole thing in a sequence of actions and responses. I'm always trying to understand completely how these things affect other things. You know, "When we do this, what is really happening? What effect is it going to have on other systems?" When we did the second Hubble space telescope repair we

put a new airlock on the shuttle. Of course the astronauts get into the airlock, close the hatch, and then they have to vent the air. Well, the new airlock had a new air vent and people had thought about various things but nobody had thought, "What happens when you vent this air? Is it going to go up and impinge on the big solar rays of Hubble?" And when they released that air the solar rays got caught in the rushing air and spun around 1 1/2 times and we were lucky not to rip it right off of Hubble. There was something, where we had almost thought through it far enough, but not quite. And we came so close to wrecking the Hubble telescope because of one tiny missed detail of "Exactly what is the angle of that outrushing air?" So our whole job as the crew on board is to think through and visualize the real world, three-dimensional effects of all of these tiny little pieces and view them as a whole. Nobody looks at it like astronauts do, because we're the people there, we're not just the reaction control system expert or the docking system expert. We are the people who see the whole thing as a piece and so the responsibility really falls to us to amalgamate it and think it through as a one piece unit, or as one sequence of events.

Terry: When you run these things through your mind so many times do you end up feeling like you can do them without thought? Do they become automatic or instinctual most of the time?

Chris: If at all possible I would like to make it instinctive. When I'm doing a complicated flight in an airplane like an F-18 I will actually get a map of the ground and I will draw, even though it's a flight and I'm never going to see the ground, I will draw a map with a line on the map where I'm going to go, which navigation aids I'll be able to tune in. I think about what that means for switch throws in the cockpit,

where I'm going to go here, the type of things I'm going to need. I'll get out my checklist; I'll have the pages marked. Just so that when the real moment comes it's something you've done before. In my business you can't have too much detail in preparation. The only mistake is when you don't have quite enough and you've missed one key little factor that can make or break the whole experience. So we are real detail people, and we have to be.

Terry: Can you tell me a little about preparing for the William Tell fighter pilot competition that you won before becoming an astronaut?

Chris: We had a minimum time to intercept as part of that competition. You're simulating sitting on the ground on alert and someone is coming into your airspace and you have to minimum time to get up, fly your airplane, get up on their wing and identify it. They have markings on their airplane, so you have to read down some colored patch or something, and identify the type of airplane. So you are sitting on the ground cold and you have to get your airplane going, get your systems running in minimum time. So it's a race and detail makes a huge difference there. We looked into all of them, working every detail. How can we shave 10 seconds off getting the airplane going, off getting the inertial navigation system running? How can we taxi out to take-off the quickest? How can we perform the jet so that you go from a dead stop on the runway to supersonic at 35,000 feet? What's the quickest you can get up there, really? What method do you follow? Let's say my lead's radar is bad. OK, how are we going to work this if lead's radar is bad, or my radar is bad? We address every possible detail coming through this whole thing so that we can get to a fairly clearly defined task, given a bunch of variables that we may not be able

to control. It is very similar to what we do in space now.

Terry: What would you say is the main benefit of detailed preparation?

Chris: The main benefit of detailed preparation is success; that's the short answer. The long answer, the main benefit of detailed preparation is confidence and lack of fear. I'm always fearful when I haven't had time to prepare or when I don't think I know what's going to happen, or I have no ability to control what's going to happen. So I try and keep myself out of those situations. One way to do that is to study the heck out of something beforehand and to do everything you can to get yourself ready. Especially when it's a clearly defined task, why not? Don't leave it to chance if you don't have to. If you want to win at something then put the time in beforehand so that when it really happens, you're confident. You're not scared of it, you're not worried about it, you're just ready. Probably the biggest indicator of readiness for space flight was that the overriding emotion on launch is not one of fear or nervousness, it's one of relief. Because finally, after all that preparation, and everybody being at the Cape and ready for you to go, you finally are actually going. And when those engines light, you look down and you've got 3 good engines and the solids light and you're leaving the pad, it's like, "All right, we're going at last - relief". That's the emotion, not the fact that you're sitting on a million pounds of explosive or that you've got 7 million pounds of thrust. Those things are not what are shaping your day at that point. You are prepared for that. That's the situation I would really like to be in for all watersheds in my life.

Terry: Can you tell me a little about your views on the importance of focusing on the

essentials and letting non-essentials go when performing different tasks?

Chris: Not only is preparation important in studying details but you need to understand what you can ignore. When you're flying an airplane at 500 miles an hour there are all kinds of things that don't matter, and there are a few things that really, really matter. What's in front of you for the next kilometer really matters because you're going fast and in a few seconds you're going to be there. It doesn't matter what's going on with your car at home or what just happened 30 seconds ago, or whatever. What really matters is what is going to have the biggest impact on you in the next 30 seconds. And in an airplane things happen quickly, especially in a high performance airplane when you're flying down low or flying with another aircraft. So you need to completely compartmentalize, and just be ready to disregard things that don't matter and worry about them later. Even though it may be life or death later, for now it doesn't matter and you can't pay attention to it. You need to focus on the immediate things in front of you that really matter.

When we docked with the Russian space station, of course it was very focused and a lot of people were working real hard especially with the problems we'd had in sorting out the real time ranging and such. We had a video camera running on the flight deck and I watched the video afterwards. All of us are working hard, scrambling, and we get ourselves docked and then we're running the mechanism and no one says a word. And it's probably 5 minutes later that one of the guys turns around and says, "Hey, we did it!" Five minutes! Because we were so focused on task specific things that absolutely had to be done or it wouldn't succeed, that there wasn't time to celebrate the forest. We were dealing with trees, right there, and that's all we had time to deal with.

Later on you could start to realize the significance and the bigger impacts and all the rest of it. There are times when if you don't focus right down to the critical items right there, you don't give yourself a chance. You have to learn to put things into their boxes and drawers and compartments to be able to succeed.

Terry: How do you think you've learned to do that? How do people learn to get that kind of focus - let's say people who aren't there yet - how do you take those steps?

Chris: I think I learned it incrementally over my whole life. I was a downhill ski racer as a teenager and there's a lot of it in that. I grew up on a farm working with large machinery and when you're moving something along that's big and heavy you need to be right with your machine, right there. It's an extension of your body. In downhill racing you have the next 30 seconds, either you're getting a medal or you're falling and breaking your leg, and you've got 30 seconds to do it right. So that's a good reason to focus. For developmental purposes I think you can do it on a very small scale, focus for this length of time to get something done that's difficult to do. Challenge yourself to do something that you can just barely do and then learn how to focus on it until you can do it well. Then slowly expand that. Start flying a glider and then fly a piper cub and then something a little bigger and a twin and then a small jet, and then a big jet, and then a space shuttle. That's all the same idea of training yourself and developing the skill set and the confidence and the ability to focus and strip away irrelevant things. No matter what your field of study is that same idea applies.

Terry: Can you tell me what you do in simulations and how you entrench those lessons through debriefing?

Chris: We simulate a tremendous amount in preparation for space flight and we try and make our simulations and our simulators as realistic as possible. We work very hard to set up a scenario that is realistic, that is credible so the people in the shuttle simulator feel like they're in a shuttle, the people in mission control feel like they're controlling a real shuttle. So there's a lot of air of realism to it. Then we will set up the malfunctions so that you drive the system to its edges, try and get into a grey area, "What if this failed and this failed? Do our rules cover us? Would we know what to do?" And so we try and drive ourselves to the edge, and hopefully during the sim we'll get into a situation that we've never been in before and figure our way through it.

That's all good real time, but only a few people in that room will benefit for a short-term unless you somehow entrench the lessons that come out of it. The way to do that is in a debriefing. We debrief in exhaustive detail. The way it runs is the person who was running the simulation, the flight director or the shuttle commander, has kept major event notes through the whole exercise, whether it's 4 hours or an 8 hour simulation or a 36 hour simulation, whatever. They will have hit the highlights from all the different things that they think are unseen things in the past, or points that need to be reemphasized or new things for the shuttle. They will hit every single major event during the simulation and what went right, thank the people that did it right, or if there was a new way of doing something that worked better and then definitely get into the details of what went wrong or what was inefficient. They will take it through the whole thing asking pointed questions of every expert that was involved and it's a cast of 100 people involved with a simulation. Then they give the microphone to every single person, everyone has a chance to pipe

up, how they saw it from their console, what they got out of it, what interaction they had with other consoles. Then actions are given to everybody, basically, "OK, take an action to put that into the flight rules. Put that into the training from now on. Let's expand our collective brain power here. Let's learn from this thing".

On a 4 hour simulation you can have a 1 hour debrief, typical 8 hour simulation you debrief for an hour and a half, on a 9 day space flight you will have a month of debriefing afterwards. Everyday. You just debrief on everything: How was the food? What was good? What was bad? What kept? What didn't? What did you like? What did you throw away? How was the packaging? It sounds trivial but it makes a big difference when you're building a space station. You know, "What is efficient?" The reaction control system people, the guys that gave you the clothes, the flight dynamics officer, all those people want a complete debrief so that they can do it better next time. We've gotten to the point now where we've flown the shuttle 91 times and we've made it look effortless. Whereas 91 times for any complicated vehicle that is still in its infancy is quite an accomplishment. That is purely through accurate simulation and then incredible attention to detail in learning every lesson you can from every effort and rolling that back into the training flow so that the next one is even better or optimized or every crew benefits from experiences they didn't have to have personally.

Terry: Do they take those lessons and act on them immediately, for another crew that is preparing?

Chris: Yes, we implement things as quickly as possible. If it's something that is critical, we'll turn it around in a day, put it in the simulator, run it and come out with the change the next day. We'll do that in

support of a flight in progress if something develops for a shuttle that's up there, we will find the problem, we'll run off and simulate it all night, and come up with new procedures, verify the procedures, have a bunch of people look at them and send them up in the shuttle the next day; a whole new set of procedures based on something that's developed that we've had a chance to simulate and enact real time. Yes, sometimes we can turn it around right away. Some things you want to run through a peer review board because it may seem like a great idea in this circumstance but you may need a bigger picture than the group that was there for the debrief. So we have a flight rules control board that meet every couple weeks and they go through all the new proposals to changes for flight rules that have come through and gotten everybody to weigh in on them. And you have joint rules where you have the Russians and the Americans and everybody all working together to come up with a new set of flight rules.

Terry: Can you describe what space flight is like in comparison to your expectations?

Chris: Space flight is one of the few things that is better than you dreamed it would be. I don't say that to be self-serving, it really truly was. I just couldn't believe how magnificent and fulfilling the whole thing was. Of course being an engineer fighter pilot kind of guy I tried to figure out, "Why? Why did it have this effect?" When you go see the Grand Canyon you say, "There's the Grand Canyon. It's beautiful but it's sort of like I expected". Why was this better? I think it was a combination of things. One, it is something that you've been dreaming of doing for a long time and you're actually finally getting to do it. So there is that feeling like going to Disneyland or something, it is like, "OK, we're actually doing this thing...cool". So there's that

whole anticipation part. Then when you get there you have a continuous string of successful completion of steps. So you have a building momentum of success and pride of, "Hey, we're getting this thing done, this is actually working". So you have this upwelling of confidence as the mission is going on.

But on top of that there are a couple of things that you just can't prepare for that are delightful. And that is you are weightless the whole time, so someone has just taken away the rules. They've put you on the best ride at the fair and it's permanent - you can float weightless, you can just touch off the wall and tumble and you can float someone your book or bounce a Smartie off the roof into your mouth. It's just a constant delight; it's just a beautiful change of rules. Then coupled with the whole thing is every time you go over to the window the world is rolling by underneath, the whole planet, every place you've ever read about. You look down and there's Lake Victoria, there's the Nile all the way to the Mediterranean. People gave their lives trying to find the source of the Nile and you can see it out your window, you look down and see the Himalayas as a place. And every place you've ever read about or dreamt about is just rolling by underneath you. So it's just an overwhelming experience of expectation and success and stimulation and change of rules, so that you just come back addicted. This is such an amazing experience and you want to tell people about it. You want to go back to space yourself of course, and you want to try to contribute to a situation where more people can come up and break the bonds that are holding all of us here sitting in our chairs, and go and see what is possible. It's just an amazing experience.