INTERVIEW WITH SEAN CASEY

YOU HAD COME UP WITH THE IDEA FOR THE TIV WHEN YOU WERE LOCKED OUT OF A MINIVAN IN A STORM, CORRECT?
Well, actually, we had come up with the concept the year before, but getting locked out of a minivan with a tornado right next to us, that kind of confirms my sneaking suspicion that if we were going to be that close we should have something a bit more rugged.

WERE THERE ANY OTHER INSPIRATIONS FOR THE TIV?
Mainly it was just a feeling that, you know, there's a huge difference between filming a tornado from a couple miles away with a telephoto lens, and filming a tornado that's on top of you with a wide-angle lens. And that's really where all the action is. It's right next to the tornado. And it's close in the tornado. That's the kind of power that I wanted to capture. I wanted to get footage that really was as powerful as the subject matter.

HOW DID YOU FEEL DURING THE GOSHEN INTERCEPT?
Of course it's hard to describe. In the moment, a part of you is fearing for your life. A part of you is just overjoyed and kind of in shock. I think I was in shock at the time, really. It was such an unbelievable experience. Unbelievable to see a tornado forming half a mile away. You pick the right spot, and it's just coming right at you, and to bear witness to that. And another thing is I'm trying not to mess up. You don't want to mess up that opportunity. So I'm really focused on capturing it with the IMAX camera. And so for me not to lose my mind I'm focusing on the job at hand. And, of course, it was kind of a scary moment, too, because the turret on our vehicle, which we film out of, was jumping up and down. The turret had come off the vehicle about a month earlier, just from driving into strong headwinds, it had kind of come off the vehicle and bounced off our mast. All of sudden with the wind, it started jumping up and down. I thought, in the back of my mind, it was, we finally got the shot, but all of a sudden the turret and the camera were going to be sucked out of the vehicle. But in the moment the thing that actually happened, you know, I was actually bracing myself, my feet up against the ceiling of the TIV, wedging myself in there and gripping onto the turret with everything I had so that it wouldn't leave the vehicle. And it probably wouldn't have, but at that moment I felt that there was a danger.

WHAT'S INPIRED AND INFLUENCED YOU AS A DIRECTOR?
What was mainly on my mind was that we had spent eight years shooting dozens of tornadoes. Probably 18 tornadoes for the film. But it's also the hail footage and the beautiful storm footage. It's all this beautiful weather stuff. You know, that's the main

character of this film. And the reason why this film was made was for people to experience what it can be like in Tornado Alley. The majesty, the power, the spectacle of it.

DID YOU CONSCIOUSLY FOLLOW IN YOUR FATHER'S FOOTSTEPS?
Well, that's how I kind of cut my teeth in documentary films was in IMAX projects that my father was doing. And so over a ten-year period I kind of came up, I guess, through the ranks. When I was nineteen, I'd be carrying cases. And when I was twenty-one I was doing location sound. And then when I was twenty-four I was operating the second-unit 35mm camera. And then for "Forces of Nature" I was operating the IMAX camera. So yeah. But I'm kind of project driven. If the subject matter doesn't interest me. I don't know why you would make a film if the subject matter really didn't grab you.

DO THE CONSTRAINTS OF USING IMAX MAKE FILMING MORE DIFFICULT?
Oh, yeah. Usually when the action starts you might have between 600 and 400 feet left, so you've got roughly a minute and a half of footage left to use when things get really, really interesting. And there were lots of time when I had to change my magazine. I've got the camera down on the TIV and the TIV is busting long to stay ahead of or catch up with the tornado. And you're hearing all the oohs and ahhs from the guys in the vehicle. And a lot of times I yell at them that I don't want to hear anything that's going on outside the vehicle at that moment. I don't want to hear what I'm missing when you're changing a film. And this year when we were filming in Minnesota, that was just the chase. I actually had a camera jam, and so I had to tear apart, I was having to get into the camera, change the film, take out the bits and pieces of film that had broken inside the camera. And we were tracking along with this massive, mile-wide tornado. And you glance out the window and you see this big, black, massive thing right next to you and then you're having to change the film in the camera, it's just, you know, it's the stuff of nightmares. It's not only the nightmare where you're at school naked, but your hair's on fire, too. It's just awful.

ARE THE DROP-DOWN SKIRTS ON THE TIV MADE OF STEEL?
Those are aluminum. We tried to build things as light as possible. And so the skirts and around the engine compartment is all aluminum. And it's pretty thin. Because we don't really care if a tree or telephone pole goes into those areas. It's around the cab where the people are where you have two-inch thick composite armor. It's aluminum. Then it's Kevlar. Then it's aluminum.Then it's steel. Then it's rubber. Then it's half-inch polycarb. Then it's rubber. Then aluminum. So around the people there's a lot of stopping power.

WHAT LEVEL OF TORNADO IS THE MAX THAT YOU THINK THE TIV COULD WITH WITHSTAND?
They go by the EF now. So it's the enhanced Fujita scale. It's a difficult question to say what winds you could survive, because it's not really the winds. It's what in those winds. And even if there's no big debris, if you have a lot of dirt picked up, all of a sudden that wind has got mass. It's the equivalent of walking through water or walking through mud. All of a sudden the wind has got a thicker mass. So we've always felt comfortable with maybe 175 mph winds. And if the tornado wasn't picking up a lot of debris then maybe 200 mph winds. But, then again, which directions are you going to get hit by those winds? If they're head-on, we have a profile, rather than taking a broadside wind.

HOW MANY OTHER IMAX CAMERMEN WERE SHOOTING FOOTAGE, OTHER THAN YOU?

We had three other camera operators at times out there. Jack Tankerd, Peter Rubi, and Tom Camarda. The other camera people. I feel a strong connection to the communities I work in. Providing critical data and capturing rare footage of these ominous storms will hopefully lead to better warning systems and more respect for natural forces and processes.

INTERVIEW WITH JOSHUA WURMAN

WE'D LIKE TO MENTION YOUR HAVING INVENTED THE DOPPLER ON WHEELS. WAS THERE A EUREKA MOMENT?

I was working at NCAR, up here in Boulder, developing a different kind of radar system that I had invented. Something called Bi-Static Radar Networks. And I was reading some literature about how tornado research was being done. At the time, I was not doing tornado research, but I was reading some of the technical literature about how some research was being done. And clearly scientists were working to chase tornadoes, but the instrumentation that they were using, the technology they were using, seemed primitive. Not ambitious enough, to me. And so, basically, what I thought was, great idea. You know, getting up close to them is a great idea, but wrong toys. Right idea, wrong toys. And that this could be done just, you know, not just a little more ambitiously, but really much more ambitiously. Ten times more ambitiously than had been done before. So my idea was why don't we take what I'll call a real radar, somehow get it onto a truck, and obviously we had to do a lot of technology development to make something like that work on a truck. But why don't we really try, sort of from the end want a real uncompromising radar near a tornado. And so, starting from that end, to basically get real radar stuff, which I knew a lot about. And try to compress some of it, modernize some of it, toughen up and harden a lot of it, to get it onto a truck platform and then test it, it was tough going for a while, because there was, I think, great skepticism. There was great skepticism that this could be done. And the senior people in the field, both meteorologists and radar engineers, basically tried to convince me that it wouldn't work. You couldn't put that kind of technology on a truck and expect it to work. The truck would tip over.. The radar would break. The computers would break. There were a hundred reasons why you couldn't do it. But I was young an uninformed, so I didn't listen to those ideas that much. You know, I was young, ambitious, and arrogant, and thought, hey, why can't I do this? I just was in the middle of a project on these bi-static networks where I'd kind of been told a lot of the same things. Hey, this can't really work. But I'd gotten it to work, so I thought, hey, maybe they don't really know everything.

I THOUGHT IT WAS FUNNY THAT, BECAUSE YOU'RE INSIDE THE D.O.W., YOU RARELY EVER SEE THE TORNADOES.

I've been near. About 170 now. A hundred and seventy tornadoes. With the D.O.W. So the D.O.W. has basically collected data on about 170 tornadoes. However, I've seen, personally with my own eyes? How many have I seen? I don't know. Ten or twenty of them. The problem is right at the moment that would be most interesting to look out the window is the busiest time for me inside the truck. Because we're getting the data. We're trying to

make sure we're getting it right. I don't want to look outside the truck, see the tornado, and then have the radar shut down. I did that once, in 1996. I actually got out of the truck. Everything looked like it was working. I got out of the truck. I looked at the tornado for a minute, and I hopped back in, and the second I hopped out the computer had crashed. And so I lost a minute of data. The only reason we're out there---we're not out there to look at the tornadoes. We're out there to get data and science. So, yeah, I don't get out of the truck anymore, unless somebody else is in there watching the computer.

HOW PACKED FULL IS YOUR TRUCK?

The IMAX team filming, they were not really that intrusive. Sometimes it was a pain, just ferrying on off days, and they want to get a shot, you know, an aeriel shot from us, on days when we'd like to be resting, or we'd just like to get to another hotel or something like that and we're doing some of those kinds of shots. The aerial shots or the driving under a bridge kind of shots. But when we're in action, basically, we don't do anything for them, and we don't let them get in our way. So it's very non-obtrusive. We're just going about our business. But, what was I going to say? I'm sort of rambling here. But the IMAX team, they don't get in our way because we don't let them get in our way, and the ground rules are all pretty set. Because we really have a science mission. And that's the top priority. The ground rules are they're filming us doing our science mission. We're not making a film. We're not actors for a film.

THE BENEFITS WILL PROBABLY OUTWEIGHT THE HASSLES, OR THE RISKS?

Oh, and look, it's good for us. Publicizing our science is useful. It's good for our ego to see ourselves up on the screen. It's good for our funding agency, NSF, to see our work up there. We probably get brownie points with our funding agency. It's generally in our benefit to get that stuff publicized. It's not like it really translates to more grants and more funding, but certainly it's not a negative thing to have this kind of coverage. It's a positive thing. But my personal feeling is that nearly everything we do is tax dollars. And so when documentary companies like this, or even just a local reporter from Podunk, Kansas, wants to interview us, his tax dollars are paying for those trucks. I think, in some sense, we owe it to them to explain what we're doing.

THERE WAS A FUNNY COMMENT YOU MADE THAT SUICIDE BY A TORNADO WOULD BE VERY INEFFECTIVE.

I do say that sometimes. Well, it's true. Tornadoes are actually a very small risk to people. My point about the suicide by tornado is that it's hard to get hit by a tornado even if you're trying. And, in fact, the TIV has been trying for years and years and years to get hit. And it's a very rare thing that they get hit, because it's very hard to do, even if you're really good, really experienced, and in a tank and trying hard.

IT'S VERY IMPRESSIVE, AND I IMAGINE IT MUST BE DIFFICULT TO BE AWAY FROM HOME FOR SO LONG.

Yeah, being away from my family, the whole time I've been chasing I've had family, and that is a challenge. You know, every night we're in a different hotel is miserable. One thing that I've made a big effort to do, because I do it every year, is during down times, there's always several day down times, or a week where there aren't going to be tornadoes, so I've become

really adept at bugging out, getting back home for a few days, touching base with family, and then coming out again. Usually about three times during the season, every two or three weeks or so, I'll come home and visit, so the kids know who I am.

YOUR KIDS PROBABLY BRAG TO THEIR FRIENDS THAT THEIR DAD'S A STORM CHASER.

I don't know if they brag about that, or if they're horrified. I don't know if having a dad as a tornado chaser wins points with the teenage-girl mall crowd. Who knows?

INTERVIEW WITH KAREN KOSIBA

HOW DID YOU GET INVOLVED WITH THE MOVIE?
Well, I guess just to start, I've been involved working with Josh Wurman at the Center for Severe Weather Research since 2004. I was just doing volunteer stuff out in the field while I was getting my PhD. And Sean Casey was always working with Josh a few years before that on another IMAX film that he was doing. And they were just people that I kept working with. Like I said, I worked with Josh. And then Josh and Sean worked together. So I've just kind of been involved in helping the two with their weather instruments and that kind of stuff. I've known Sean for a while, and like I said, I've helped out getting stuff, weather instruments, tracking stuff, you name it. So, yeah, I've worked with him and Josh for five years.

WERE THE IMAX CREWS WITH V2 DURING YOUR ENTIRE MISSION?
All these people we've picked up in the vehicles run together. I know they were filming stuff from the beginning. And, in terms of when they, it was probably somewhere in the middle of the season, I think? That they were getting out all their equipment and getting into the trucks. So probably sometime in May. Actually, though, they were filming us as we were preparing for stuff out in Boulder, when we were out getting the radar trucks ready, the mesonets ready, so they were there then.

WAS IT DISTRACTING TRYING TO DO YOUR WORK WITH THEM THERE?
No. Once again, that's something you start to get used to. I think I haven't not had a film crew out there since I've been doing this. Yeah, I've been more than happy, honestly, to have the media with me. All the different forms and flavors from all the different countries. People out for a short amount of time. Some for a long amount of time. The funny thing about the IMAX crew is you know their film is really, really expensive. All their shots are five seconds, or six seconds, so when you're rolling you're like uh oh. This is a real expensive shot coming up right now, as opposed to the people who are just using a digital camera or even news or documentary crews.

WHAT ARE YOUR MEMORIES OF THE GOSHEN EXPERIENCE?
Well, we've got a lot of memories. Particularly in 2009, which seemed like a very slow start to Vortex 2, and Goshen was just, yup, finally, we had this very slow-moving tornado. And we didn't have that many road options, so there weren't that big of logistical decisions to make at that point. So it was just a nice set up. It was, like, thank you! Because once we got out and deployed and we got this really nice integrated data set on a long-lived tornado. The Goshen one, everything just came together.

WHAT WILL YOU GLEAN FROM THE DATA? LONGER WARNING TIMES, MAYBE?
In terms of the Goshen one, everybody's still in their preliminary analysis stages. And the lengthening of the warning time really has to do with identifying stuff we haven't identified yet. That sounds really vague. It's learning more about the science, and once we learn a little bit more about the science, we can apply that to forecasting warning signs. But that stuff, the forecasting warning signs, is very far down the road, compared to gleaning what new knowledge we can gain, in terms of the physics and that kind of stuff.

WOULD YOU SAY THE GOSHEN POD DROP WAS YOUR MOST SUCCESSFUL?
Yeah. It's actually remarkably hard to get something hit by a tornado. It really is. And especially something that you can't keep moving. I mean, the TIV, obviously, has an advantage where it just keeps adjusting. And I think even if you watch the TIV footage, you'll see that they adjust a little bit last minute. So you just have the advantage of him, you know. You need to get them deployed and then leave. And unfortunately with the pods we did pretty good. But the tornado changed paths right as it was coming towards the road. But we still got good data right around the tornado's core, but the actual passage of the tornado, it was so nice, I mean, it was so linear, and then all of a sudden it makes this sharp right turn as it came towards the road. And at a certain point there's nothing you can do about it. You can only move the pods back and forth for so long.

INTERVIEW WITH DONALD BURGESS

YOU FOCUS ON TORNADOGENESIS – HOW DOES THAT WORK?
That's right. We're trying to understand, and these radars are, again, particularly well-suited, that's why we put them in the groups that we do, and then we have these deployment plans and we hopscotch to keep the data going, because the storm's moving all the time. So there's all this detail, but in general the radars are broken into groups. My group is the meso-cyclone scale group, along with two of Josh's three radars. Josh's other radar is a tornado-scale radar.

WHAT ARE YOUR HOPES FOR THE DATA SET THAT THE MOVIE SHOWS BEING CAPTURED?
I think that the situation is that there is no one piece of evidence, no one shining diamond that's out there and you find and, eureka, that's it, and then you understand. Doing science, it's usually much more complicated. There's probably more than one mechanism of tornadogenesis. You say our goal is to increase lead time. Well, perhaps that's the ultimate goal, but I think, really, our main goal is to understand—to better understand—this process of tornadogenesis. So even if we completely understand the Goshen County storm, it may not be the only way a tornado can get born. So we need to continue to study.

But it will be a great increase in our understanding if we do come to a complete understanding of tornadogenesis for that storm. Now this process is kind of long and the idea is to have all these sensors out there, which means that when you do the analysis you have to integrate the data from all of the sensors. And you have to do it in the correct scientific manner, or you can get incorrect results from incorrect data, or data that's manipulated incorrectly, analyzed incorrectly. So that's why it takes a long time, and we're certainly not through, but the process is ongoing to analyze that data. But then we have a number of other cases.

And I'll tell you what I predict: when it's all said and done, because this is the way it's been for these forty years that I've been involved, these processes are like onions—tornadogenesis, the organization of storms, or whatever—and those onions are full of layers. And you keep peeling back the layers. Every time you do, you find there's another layer. So we're going to increase our understanding, but that increase in understanding is not going to be absolute. It's not going to be complete. And what we then now will get as new knowledge will just raise questions about things that we don't know, which means we'll need to collect more data, do more analysis, do more numerical modeling, as time goes on. The numerical models are going to get better and better at helping us to

understand some of these questions. So in this step-wise process, then, that we will get better at warnings and lead time. It will probably be with computer-generated warnings that we'll get these long lead times that we're after.

SO AT THE END OF THIS ANALYSIS, HOW WILL THIS HELP REGULAR PEOPLE?

We have a long-term project. And NOAA, Research Site of NOAA, the National Severe Storms Laboratory, and their partner, the University of Oklahoma, that I work for now that I'm retired, and it's called Warn On Forecast. Right now, the process is to warn on detection. We use these Doppler radars, which are great tools. And we see the circulation forming inside the cloud. And then we issue the warning. And that gives us a lead time of 10 to 15 minutes. But it's hard to get a longer lead time, because that's just how long the circulation is going before the tornado occurs. And so what we're really after to get the long lead times is this understanding of the process, knowing what to look for in the model, making the models better, and then initializing the models with radar data earlier in the storm's lifetime, and then running a forecast out, thirty, forty-five minutes, or an hour, and seeing if the model produces a tornado. If it does, that's when we can issue the early warning. So this warn-on-forecast process is going to try to do that. The data from Vortex2 are very important in that research. But the whole process may take as much as ten, fifteen, twenty years to make those kinds of things happen.

THERE WERE DEFINITELY LOTS OF HOLLYWOOD MOMENTS.

One thing I'm learning, and I guess I realize it more now with this *Tornado Alley* film project, some of us are doing this advising and consulting with the film. I've been struck, and I think I understand even more now than I did before, that it has to work as entertainment. And if it doesn't, then we're not going to get across our points of science, cause nobody's going to come and see it and try to understand these things, so it has to be entertaining.