Oral History of Stan Honey

Interviewed by:
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Recorded May 24, 2018
Mountain View, CA

CHM Reference number: X8646.2018

Rino: Today, May 24th, 2018, at the Computer History Museum in Mountain View we have the pleasure of recording the oral history of Stan Honey.

Honey: Hello. I'm Stan Honey.

Rino: Stan led the development of the ETAK Navigator, which was the first practical navigation system for automobiles, but his contributions are more widely known through sports television. The company Stan cofounded, Sportvision, was responsible for putting the first-and-ten line marker on your TV screen, miraculously appearing without obscuring the players. It all started with tracking a hockey puck, and finally graphically enhancing televised coverage of sailboat racing, making ahead-behind distances, laylines, and the wind visible which greatly enhanced viewer appreciation. Regarding sailboat racing, it's not uncommon for the icons of Silicon Valley to take up sailboat racing to demonstrate their mastery of extreme challenges, but with Stan it was quite different. Stan started sailing when he was very young. He mastered sailing and has held just about every major sailing award. It was through his mastery of sailing that he made the connections that-led to what we now recognize as augmented reality, another fascinating chapter in the history of computing. So, start from the beginning and tell us your story.

Honey: Well, you kind of gave a quick overview. I went to Yale for my undergraduate degree. I was on the sailing team and studied engineering and applied science. I wanted to go to Stanford for graduate school, so I only applied to companies in the San Francisco Bay area that participated in the Stanford Honors Co-op program. I ended up working at SRI International, which was my lowest offer, but the interviews at SRI made it clear to me that it would be the most interesting place to work. I largely went there to work with guys like Walt Zavoli and Alan Phillips because I was absolutely staggered by my interviews with those guys. I was at SRI from '78 through '83, working on over-the-horizon radar, underwater optics, and radio positioning systems. They put me through the Stanford honors co-op program so I ended up with my master's at Stanford. In 1983 I cofounded ETAK with SRI colleagues Alan Phillips and Ken Milnes. We then hired several others from SRI: George Loughmiller, Jamie Buxton, and Jerry Russell. Walt Zavoli joined us somewhat later, Larry Sweeney joined us a number of years later. So, there was definitely an SRI technical core at ETAK. Marv White was a critical early employee of ETAK on the mathematics and digital maps side. Marv came from the U.S. Census Bureau where he helped pioneer topologically structured digital map storage. That was the original core technical group at ETAK. ETAK did derive from the sailing side to some extent in that the original concept and seed funding came from my being asked to navigate Nolan Bushnell's ocean racer, Charley, in the 1983 Transpac Race.

Rino: Tell us a little more about that early background. Your parents were sailors?

Honey: My dad was a sailor ever since he left the Navy after WWII. We generally had a boat or there was a boat we could borrow. We'd often sail to Catalina on the weekends. I grew up in Southern California, sailing and racing out of Los Angeles Yacht Club, which was the center of ocean racing in Southern California in those days. I was active there as a junior, racing in all size boats from eight-foot Guppies, to14-foot Lasers, to crewing on 50-foot ocean racers. I developed an early interest in navigation resulting from my father and Godfather's (WWII navigator in B17's) stories about navigation. I was also interested in technology, becoming a ham radio operator as a teenager, and building my own radios. My interest in navigation was somewhat different at the time because navigation then wasn't technical, it wasn't electronic. It was just the interesting mathematics of dead reckoning and celestial navigation. By the time I was a teenager I was being asked to navigate in races to Mexico and to Hawaii. But again, in those days navigation was traditional dead reckoning and celestial navigation. Of course, through the years, navigation became more high-tech and more based on electronics, so my interests in technology and navigation eventually merged.

Rino: Okay, and your decision to go to Yale was also motivated in part by the sailing that was there?

Honey: Yale had the best sailing team in the country at the time. When I was accepted there I got anumber of phone calls from the guys on the sailing team encouraging me to go. It was irresistible to go to a terrific school, with the best sailing team in the country.

Rino: So, they already knew you.

Honey: Sailing is a small world. I knew of the guys on the team although I'd only actually met a few of them. Some of them knew me. When they called encouraging me to come, it was irresistible. I'd never seen Yale. I had never done the tour of colleges that kids often do nowadays so my first time in New Haven was when I showed up in September. The winters were a shock to a Southern California kid, but it was a fabulous experience. Yale was ranked first in the nation in college sailing throughout the years that I was there.

Rino: So, you have to adapt to East Coast sailing?

Honey: It's very different. There is more focus on short courses and tactics, and generally shiftier winds. I was on the team with Peter Isler, Steve Benjamin, and Dave Perry. Peter, Steve, and I were roommates for three of the four years that we were at Yale and lived out at the yacht club at the beach for three years. We remain very close friends. In fact, I'm going to Peter Isler's wedding in Spain in a few days.

Rino: So, from the sailing now back to ETAK.

Honey: I was asked to navigate Nolan Bushnell's boat in the Transpac in 1983.

Rino: Is that how you met him?

Honey: Nolan had decided to try to win the Transpac and had hired some local guys, Bruce Munro, Steve Taft, and Jon Andron, to get a boat designed and built, and a crew collected, with the objective of being first to finish in the Transpac. Bruce and Steve in turn hired me to navigate —because I navigated the boat that was first to finish in the '79 Transpac. I was an electrical engineer so they also asked me to sort out the electronics on the boat. That is how I met Nolan. In preparation for that race, Ken Milnes and I designed and built a performance assessment, competitor assessment, and weather data processing, computer system for the boat that analyzed the boat's performance as a function of wind speed and wind angle. That system helped me determine the fastest course given the forecast, the performance ability of Nolan's boat, and the analysis of the performance of other competing boats.

Rino: What computers were you using at that time?

Honey: That was based on an NSC-800, which was a National CMOS version of the Z-80. Ken Milnes and I were both at SRI at the time. Taylor Washburn, the vice lab director at SRI also wrote some of the software.

Rino: The right connections.

Honey: The same people weave in and out. We ended up being first to finish in the Transpac. It all worked out perfectly.

Rino: Was there any question about the legality of using sophisticated computers for enhancing the sailing or anything like that?

Honey: The rules have changed through the years. Of course, I've never done anything that's not been permitted by the rules although I've done things aggressively once they are permitted, early on in racing you were limited to only using celestial navigation and RDF. At some point in the late 70's and early '80s the rules were changed to permit the use of transit satellite navigation and then ultimately GPS. There was a period where you couldn't use programmable computers on board the boat, but you could use a calculator. Those boundaries got hard to define with time as calculators become programmable. By 1983 the rules had changed so there is no longer any limit on what you could do on board in terms of computer processing. The only limit today is on what you can receive from outside the boat. You can receive data from outside the boat but only if the data is free and available to everybody. Racers are not permitted to get custom advice from off the boat.

Rino: So, you can use radar for surface monitoring?

Honey: Yes, we can use radar.

Rino: That's okay now.

Honey: I think radar has always been legal for use on boats. We sometimes use it to detect ice, to detect squalls, and to detect fishing boats to avoid collisions. We also use it to track nearby competitors.

Rino: Were these just conventional shipboard radars that were being used or were they--

Honey: X-band radars are used on racing boats because they are smaller. Ships generally use larger S-band radars when offshore in order to have longer range. Yacht radars are mostly pulse magnetron but recently FMCW chirp radars have been introduced. The FMCW radars that are available now have better resolution but shorter range at which they can detect weak targets relative to the older pulse magnetron radars.

Rino: Yeah. That's a whole separate topic, so coming back to ETAK. So, when did ETAK get started and what kind of technical challenges did you have to overcome in ETAK?

Honey: It was during the Transpac and the practices leading up to it, that I got to know Nolan Bushnell. Nolan is a fascinating guy, in fact we remain friends today and I see Nolan every year or so. Nolan has always been interested in technology and particularly in technologies that could have a consumer market. Nolan and Al Alcorn had founded Atari and invented Pong, the first video game. After Atari, Nolan founded Pizza Time Theater. Nolan was in the middle of Pizza Time Theatre during the Transpac and the preparation for it. During the times that we spent together before the race and during the race, Nolan would ask me what kinds of things I was working on at SRI, and whether there were consumer applications. Nolan was intrigued by the navigation computer that Ken and I built for the Transpac on his yacht, but Nolan wasn't interested in the business of providing computers for ocean racing; that was a market that was too small.

Rino: Too small.

Honey: The market for yacht racing was too small and he had no interest in it. But nevertheless he kept asking, "What else could you do-- where do you think there's a technical ability to do something for a consumer market?" My lifelong interest has been in navigation and so I had thought about it a lot. I told him that it was possible to build a vehicle navigation system without waiting for the GPS system to be introduced. In those days GPS was still a number of years away. My proposal was to build a navigation system that could dead reckon, measuring the distance and direction that you travel, but then it would figure out where you are, and eliminate the accumulation of error by cross-correlating your measured path against the available roads in the digital map database that are in the vicinity. Given the fact that drivers tend to drive on roads, it would figure out where you are by cross-correlating or matching between the pattern you'd driven and the available paths in the map database. It would use that cross-correlation also, to improve the calibration of the sensors. Nolan is really a smart guy so he instantly saw how that would work and he instantly saw the synergies, that you need the digital map database anyway to display to the viewer and find destinations. That digital map database could also be used to solve the navigation problem with map matching. You didn't have to wait for GPS. Nolan was excited. During the race he offered to provide the seed money to start a company. That is what enabled Alan Phillips, Ken Milnes, and I to leave SRI and found the company that later became named ETAK, although the basis of that name is another story.

Rino: Yeah. In fact, you might tell us what ETAK means.

Honey: This is a long story… When you start a company, all you really need right away is office space, computers, work benches, oscilloscopes, coffee machines and Xerox machines etc. You don't need a name, so we didn't name the company. We had gotten the map matching navigation to work, and we got the map display to work. We assumed that the maps should be north up because all maps by convention are north up.   J. B. Alegiani and George Loughmiller, two of the engineers, decided to try a map display where the map rotated and scrolled so that the car symbol would always be in the center, heading up, and the map would scroll and rotate as the car drove and so the map would rotate to line up with the world outside the car.   I was unconvinced on the concept, being a traditional navigator, but within 20 seconds of driving in a car with a rotating map everybody, including me, became instantly converted. It became immediately apparent that the car-centered map that was rotating to stay heading up, was the only way to go. When you're driving, the visual clues to your orientation are so strong that a north-up map really doesn't work. People rock their head to interpret it. Astonishingly we were able to patent that and that became a very valuable patent through the years.   But you asked about the name of the company. Some time after JB and George figured out the heading-up rotating map we had to come up with a name for the company. I recalled a paper I'd written at Yale in an anthropology class. Given my interest in navigation I wrote the paper on Micronesian and Polynesian navigation. I remembered that there was a Micronesian cognitive mapping approach called ETAK where the Micronesian navigators imagined their canoe in the center of the world and then as they sailed they imagined that islands move past the canoe. If you showed a Micronesian navigator a chart of the South Pacific they would struggle to name the islands. But if you asked them to hold out their thumb and you told them what direction their thumb was moving, and you pulled the chart under their thumb they could name the islands as they went by. It is a very different cognitive view of the world where you stay at the center of your world as you travel, and landmarks move past you, rather than imagining the world in a spatial layout. I remembered that Micronesian cognitive approach to mapping where the canoe is always at the center of the world. The Micronesian term for that approach is ETAK and so we decided to name the company after it. Only two individuals ever recognized the name. One was Ken Farmer from GM Research who was a really good human-factors guy who called me up out of the blue and said, "Perfect name." Another guy was Nainoa Thompson who is the legendary Polynesian navigator who currently navigates the Polynesian voyaging canoe Hokulea. Nainoa was surprised that we not only knew what the term "ETAK" meant but had actually named a company after it.

Rino: Did he read the newspapers to find out that the company had been founded or--

Honey: I went sailing on Hokulea for an overnight trip with him when working on a Disney sailing movie and got to know Nainoa as part of that project.

Rino: Okay. There's one aspect of the Navigator that's really interesting, this business of the criticality of the maps. Now you were working at the time when digital maps weren't even in GPS coordinates. Is that correct?

Honey: We started with the Dual Independent Map Encoding (DIME) file developed for Census Bureau. The DIME file provided a major head-start for us because it contained street names and address fields, as well as rough coordinates. The Census Bureau-- for reasons that are hard to understand from today's perspective, hadn't maintained high resolution in coordinates. The data included NAD27 coordinates of latitude and longitude but only had rough coordinates, which of course is all the Census Bureau needed to manage a census. So, a large part of the early development of ETAK's database was the task of taking the Census Bureau data, which had good address fields and street names and boundaries associated with the two-cells like zip codes, city park, water, and other characteristics of two-dimensional areas. We would conflate that data with the accurate coordinates that we were able to measure off of either aerial images or other accurate image sources such as the USGS quad maps. We developed a very efficient computer graphic approach where we would overlay a plot of the database over an aerial or USGS quad image, allowing a digitizer to efficiently move the zero-cells into place and to add new zero-cells to pick up the curvature of a curved road. It was a very efficient way of improving the coordinate accuracy of the DIME file.

Rino: But you wanted true distance on a flat map fundamentally.

Honey: The earth isn't flat and the ETAK navigator must navigate on the earth, so we had to deal with the shape of the earth properly. The world is an oblate spheroid. The ETAK Navigator's wheel sensor calibration was accurate enough so that we needed to accurately model the shape of the Earth as an oblate spheroid. We couldn't use a spherical approximation for the earth. We had to actually do the calculations properly, taking in account of the actual shape of the Earth. The base map coordinates were stored in latitude and longitude.

Honey: The ETAK navigator used a 8088 running at 4.88 MHz, so to minimize calculations we would do local navigation calculations in a small plane surrounding the car's location. Similarly, we had to take the model for the magnetic fields, which is a reasonably complicated model around the world and changes with time. We calculated the variation for each variation area in which the car was driving.

Rino: Yeah, and that's because you were using a magnetic compass to determine direction.

Honey The magnetic compass is influenced by variation which of course changes depending on where you are, but also is influenced by huge amounts of deviation that come about due to the car itself. The car gets magnetized when you slam a door or when you drive over a new bridge where there is a very strong incident field due to recently welded steel. The Etak Navigator software had to constantly learn the deviation of the car. The compass also was influenced by deviation caused by the flux focusing from the soft iron in the car. The software also had to learn that, but at least that part stayed constant. So it was a very sophisticated self-calibration routine.

Rino: Yeah. That's remarkable, yeah. Okay. So, you got the map part of it down. Now the whole business then of finding an optimum route from point A to point B. Was that a--

Honey: That came quite a few years later. The initial Navigator would show you where you were and keep track of where you were as you drove by measuring your distance—

Rino: Oh--

Honey: --and then it would remove accumulation of uncertainty and error by the cross-correlation. It would allow you to find a destination by putting in an intersection of two streets or a street and address and it would show you the destination. The initial Navigator left the user on his own to zoom in and out and figure out how to get there. For the most part it worked pretty well because if you zoomed out you'd see the high-priority roads— which makes sense to use to get into the vicinity of the destination. Then as you get closer you'd zoom in and you'd see the residential roads and you'd find your way to the destination. There was occasionally a problem that we called "Loughmiller's dilemma" named after George Loughmiller, who is the one the guys that originally joined us from SRI. Loughmiller's dilemma was the situation where you could see where the destination was but if you zoomed out far enough to see the destination you couldn't see the roads to take. But if you zoomed in to see the roads you couldn't see the destination, and so then the dilemma was you had to just trust that you'd somehow figure it out as you get closer. Occasionally that would get you in trouble. Later, after we did a license deal with Robert Bosch and Blaupunkt, we developed a routing algorithm that allowed the system to recommend a complete route. That was originally developed by Tsia Kuznetsov. The routing first appeared commercially in the TravelPilot, which ETAK developed for Bosch Blaupunkt. Tsia sensibly took advantage of the inherent prioritization of the map database. The routing algorithm would climb up the tree of priorities to get to the major roads, find a route to the vicinity of the destination and them climb down the tree of priorities to get all the way to the destination. And so, by taking advantage of that prioritization that's inherent in the way we stored the database, Tsia was able to come up with a routing system that worked quite efficiently even in the days when the map retrieval was quite slow.

Rino: That's fascinating. Okay. Now there were several other things I guess in the course of putting all that together. You had the display unit you had to deal with and making it rugged, the tape drives that you were using; the cassettes that stored all that information had to be redesigned, some of the details of that.

Honey I'll take the display first. Memory was really expensive so the first Navigator used an 8088 with only 128 kilobytes of random access memory. When we were developing the display we could not pay for enough memory to do a bitmapped display. The other problem was that the display had to be viewable in direct sunlight and at that time we had to use a CRT. If you had a bitmapped display on a CRT the beam spent most of its time scanning the whole surface of the screen and the beam actually wasn't turned on that much of the time so you couldn't get much average beam current and therefore brightness. If you tried to turn up the peak beam current too much it would bloom so that wasn't a solution. We found a solution to both of those problems and it was largely recommended by Al Alcorn and Nolan Bushnell. They suggested that we consider a vector display. Anybody that used oscilloscopes in those days would understand exactly what I mean but instead of having the CRT beam scan the whole surface of the screen, the CRT beam would instead spend almost all of its time turned on and it would actually draw the roads on the map and actually letter the street names. Oscilloscopes used to work in this way where they'd put the labels on the top and the bottom by actually drawing them with the beam. The beauty of that approach is that it didn't take much memory because you didn't need a bitmapped display. You could leave the beam on 95 percent of the time because the beam's spending most of its time actually drawing. The display could be much brighter because you get a lot more photons due to the much higher average beam current, without having a ridiculously high peak beam current. It was a really nice solution to both problems of having an inexpensive display and having a display that was extremely bright using affordable small CRTs in the day. Alan Phillips and Jamie Buxton came up with a very clever charge pump running an integrator so we were able to generate the analog voltages to drive the beam around without even having an expensive D to A converter. It was a very clever solution at the time. Of course later systems ended up with LCD displays which became cheap.

We had a similar cost problem on the data storage. We knew when we started ETAK about CD-ROMs and we knew that eventually that was going to be a good approach, but they weren't available when we started. So we had to design a tape drive. The tape drives that you could buy were too expensive and they couldn't survive in the temperature of a car. Cars get really hot when they're parked on asphalt on a shopping center in Arizona in the middle of the day. We had to build a tape drive that could survive the temperature of a parked car. The cassettes had to be made from Lexan to survive the temperature. We needed to move the tape very quickly, so we couldn't use a capstan drive. We used a direct hub drive. We read all four tracks at once. We had to come up with a complete custom digital tape data storage system including our own tape drive operating system and tape motion control. Details included the need to move the tape so that the tape isn't sitting against the head when the car is parked. We had to move the tape to a place where there was a place for the head to rest where it wouldn't wreck the tape. We were forced to do a very clever job of storing the map database because the tape is fundamentally a linear medium and a digital map is fundamentally two dimensional or three dimensional if you look at priority. Therefore you can't avoid long seeks and there's occasionally going to be some boundary that you drive across and you're going to have to move the tape a long way. But we could minimize the number of times that that happened by doing a really efficient job of storing the map data on a tape. Marv White led the development of a carrier structured hierarchical approach of storing the map data where we would use the inherent priority of the roads themselves to divide the database into regions. Marv's approach to map storage became a valuable asset for ETAK for years to come because even when you ran on mini computers and mainframes ETAK software could access the map data much more quickly than conventional software because of this sensible priority-based structure to the map data.

Rino: Yeah. So how many patents were actually spun out of ETAK? Do you know a rough number?

Honey: About 30 total.

Rino: Fascinating, yeah, and some of them never even made their way back into ETAK. Was the gyroscope--

Honey: We had three or four patents that developed a significant amount of royalty income. I recall that those patents were on map matching, heading calculation, and the rotating map.

Rino: Okay. There is something you must have appreciated at the time. The GPS was becoming more and more affordable. You must have anticipated there's a time where this whole operation is going to get absorbed with a totally different technology. Did you anticipate that, or did you see growing into it or--?

Honey: We knew about the development of GPS of course and Brad Parkinson was part of our larger community given that we were from SRI, associated with Stanford. So we certainly knew of the development of GPS. I was also a close friend of Charlie Trimble dating back from sailing where in the early days Charlie would lend me his various products including Loran C. We knew that GPS would have a large eventual effect. We assumed that GPS would replace map matching and that all the work we'd done to develop the map matching solution would be set aside, and that a GPS receiver would replace it. It turns out that we were wrong. What happened instead when GPS came in was that map matching continued to be used. The reason was that if you used GPS alone, it would look sloppy to the driver because the car would be wandering around, and it wouldn't stay on the roads, and you'd turn a corner, and the car would overshoot or undershoot and look messy. The vehicle navigation companies continued to use map matching. They used map matching for the precise positioning, and they used GPS to make sure the map matching didn't get completely off the rails and to keep the car location close. To our amazement, the map matching patent ended up one of the most valuable patents that the company ever developed. The other one that also amazed us was the rotating map patent.

Rino: Okay. I guess now we've come to Etak. Etak was eventually sold, and companies evolved from it, so that the Etak technology, is going to give way to another system-- the GPS-based system. And then what you're saying, I think, was the Etak technology that went on was the map matching, rotating map, and things of that sort.

Honey: Etak was sold in '89 to News Corp. Rupert Murdoch acquired it; he was very farsighted. He was already thinking about the need for something like Google Maps. He was already thinking that someday people would want to ask the question, "Where is the nearest, and how do I get there?" He acquired Etak because in '89 Etak had the highest-quality digital map of the U.S. and for a large chunk of Europe. When News Corp got into a bit of a debt problem after a few years, Rupert asked me to stay on as Head of Technology for News Corp, but he asked me to sell Etak. Etak was bought by Sony. Sony was interested in consumer products for vehicle navigation. Subsequently Sony merged Etak into Tele Atlas. Then Tele Atlas was bought by TomTom. I think the size of that transaction was about five or six billion.

Rino: Now, TomTom had a navigator at *some* point in the market, did they not.?

Honey: Yeah. TomTom was in that business.

Rino: They were a competitor?

Honey: TomTom was a competitor in building vehicle navigation systems, but the reason for the acquisition of TeleAtlas was mostly for the map database.

Rino: Okay, so we're at News Corp now, and concepts are being developed at News Corp that lead to your sports enhancement, or what's the trajectory there?

Honey: When Etak got acquired, I had been the CTO of Etak. Early on we hired George Bremser to be the CEO, who was terrific and became a kind of a godfather to a number of us. When we sold Etak to News Corp, Rupert Murdoch asked me to run it as the CEO. As the CEO of Etak, an operating subsidiary of News Corp, I was asked to attend all the management conferences with all the other CEOs. Etak was this tiny little navigation and digital mapping company in Silicon Valley, and the other companies were companies like TV Guide, HarperCollins and Fox, e.g. significant media companies. The other CEOs got to know me, and they realized that I was an engineer who could explain technology to them. So they could ask me questions that were timely, in those days, like, “What is encryption?” And, “What is conditional access?” And, “What’s the Internet?” And, “What does Bill Gates want to talk to me about in this meeting in two weeks?” They started asking me to attend meetings with them, and support them, because they found that I understood the technical issues, and could explain them. That may be a benefit of an engineering education at Yale, because you learn to speak and write well, in addition to the technical stuff. By the time I was asked to sell Etak, I was probably spending half my time on News Corp work going to meetings with Rupert and executives from the other NewsCorp companies answering questions on technical issues. I ended up as VP Technology for News Corp somewhat prior to selling Etak. During that period that I figured out that to stay sane I needed to continue to be involved in development projects. I got to know David Hill quite well. He was founding Fox Sports at the time. David asked me to have lunch with him once a week, and each week to brief him on something technical that could impact the televising of sports. During one of these lunches, I explained to David that it was just becoming technically possible, with the most powerful SGI computers available, to compute simple computer graphics fast enough so that you could position them in an overlay on live video, and position them correctly, relative to the image of the real world in the live video, so that they could appear to be *in* the real world. The example I used to explain this to David was that you could insert a billboard. And you could put a billboard someplace where it couldn’t actually be, like on the grass or in the stands, or you could replace an existing billboard. David said that that was the stupidest thing he’d ever heard, *but* if you could put something in the real world, his question was, could you do something useful? David asked, “Could you put a trail behind the hockey puck, and show where the puck was?” I was pretty confident from my SRI background, that we could track the puck. I responded, “You could do that. You couldn’t afford it, but nevertheless, it would be possible, to both track and then put a trail behind the puck in live video. But it would be an SRI level of development for the tracking, and then it would require the most powerful SGI computers to do the computer graphic overlay. It would be possible, but not affordable for TV.” David observed that I probably didn’t understand the economics of TV, and asked me to write him an e-mail, telling him what it would cost. I figured it out and sent him an email estimating that it would cost $2 million and take two years. I sent that e-mail to David Hill, and in about 10 minutes I got a phone call from Rupert Murdoch. “David Hill tells me you could highlight the hockey puck for the All-Star Game two years from now, for $2 million.” I said, “Yeah.” And he said, “Do it.”

Rino: <laughs> That’s beautiful.

Honey: And so, at that point, I started the News Technology Group. I stole some of the key guys out of ETAK and created a technology group, and we set up here in Mountain View-- in fact, very close to where we’re talking now, just around the corner. We set up a group to develop the FoxTrax system that would track and highlight the hockey puck. We started work in ’94. Rick Cavallaro was absolutely central to that development. And several the other ex Etak and ex SRI colleagues worked on it, Alan Phillips, Jerry Russel, Phil Evans, Hal Guthart, Alan Burns, Jud Heinzmann.

Honey: Terry O’Brien did the mechanical engineering. Phil Evans did the IR sync system, Alan Phillips designed the puck circuitry, Alan Burns did IR engineering, Jud Heinzmann developed a RF puck transponder. Tim Heidmann and Wade Gillam and J.R. Gloudemans were key guys on the software side. Rick Cavallaro was the overall project engineer without whom the project never would have even started.

Rino: But you said something that caught my attention: that you knew you could track the hockey puck. How did you intend to do it, at that time?

Honey: At the time, we figured we would try three different approaches, and we would see which one came easiest. And, as you know, that's how we've done a lot of things at SRI. When you're trying to do something that hasn't been done, you play your hunches, and you try a couple of things, and see what turns out to work more easily. We started a couple of different initiatives in parallel. One initiative we came up with was to do an FMCW radar transponder in the puck. We worked with Jud Heinzmann on that. We did get it to work. The problem was that the pucks were expensive. And at a hockey game, in those days, the nets didn't extend up, and the pucks would go into the stands, and you could *never* get the puck back from the stands. And so you'd go through 30 pucks a game, and it was becoming clear that it was going to be an expensive operating cost, to have to lose 30 pucks a game with the FMCW transponder.

Rino: You actually put a transponder in there?

Honey: Yes. So it was a full off chirp radar. We would transmit a chirp, and then we would measure the response, and compute range. We had to range-gate, because indoor stadiums rang like a bell. So you'd have to range-gate to not listen to the reflections, but we got it to work. The cost was a wrinkle. Another approach we looked at early on, but set aside very early on, was a retro-reflecting puck. The problem was, the surface of the puck is really important to the game, and you really can't change the properties of that rubber, because the way the puck behaves. So that was one that we were able to set aside very quickly. The approach that we ultimately used, was to have a puck where we embedded a lithium battery, an accelerometer, so the puck could figure out when it was in play-- a ceramic oscillator-- and then we had infrared emitters all around the puck, on the edges and the top and bottom. They IR emitters would emit 100-microsecond pulses of infrared, 30 times a second. Alan Phillips designed the puck. Phil Evans built a system that would synchronize to the puck, so we knew when the puck was pulsing. We had image sensors around the arena that were cameras, but they had cavity interference filters in front of them, so they were only sensitive to the very narrow spectrum of the infrared emitters. The shutters were synchronized to the puck, so the shutter was only open during the 100 microseconds that the puck was pulsing. So, because the camera was only sensitive to that spectrum and at that timeslot, we had huge signal to clutter, and it was really easy to track the puck. You couldn't do it with image processing in the visual image alone, because a hockey rink has too many things that are black and three inches across, like sticks and elbows and ankles and forearms and skates.

Rino: Do I remember right that the tracking was actually done with metric stereo, where you had two cameras?

Honey: We often had about six image sensors around the rink.

Rino: But each camera was a pair, or--?

Honey: Each camera was just by itself.

Rino: It was a single camera.

Honey: Yeah. We looked at an approach, and we tested an approach, where we would do frame differencing. We'd take 200-microsecond exposures, one after the other: one during the pulse of the puck, and one adjacent in time but *not* during the pulse of the puck, and we'd subtract the two to subtract out any CW infrared sources that would appear in both images, whereas the puck would only appear in one. That approach was hugely effective, but we didn't need it, because just the combination of the cavity interference filter, and then the opening the shutter just during that 100 microseconds of the pulse, gave us enough signal to clutter.

Rino: That's good. So, you got the detection problem solved. Now the business of calculating where that puck is, and getting that information into the video stream, wasn't exactly a back-of-the-envelope competition.

Honey: You calculate where the puck is with the angles from the six cameras. Every time they open their shutters, they all measure an angle. You compute where it is, with a standard calculation to figure out the most probable position, given that they don't all cross at a point. You know where the broadcast cameras are. You measure their pan, their tilt, their zoom, their focus. You measure the distortion of the lens, as a function of zoom and focus. And then, for every field of video, you compute where the puck should appear, in each of the broadcast cameras. There's a lot of coordinate transformations, and there's a lot of mathematics, but we never saw that as being a real risky part of the project.

Rino: Yeah, just do it.

Honey: You've got to get all the math right. And it's a great example, even for kids today, of the importance and the usefulness of mathematics. Because kids will look at the yellow first-down line, and say, "Cool." And you say, "See? That's why it's important to know math."

<both laugh>

Rino: It was always interesting, but sometimes you could see the puck behind a barrier.

Honey: Yeah.

Rino: <laughs> Because...

Honey: Yeah, we didn't key it. So in those days, the overlays were on top of everything in the video. We did use a different symbol when the puck was behind the boards to make it clear that you were seeing the puck "through" the boards. We used what we called the x-ray puck symbol and hoped that viewers would see that as a feature.

The trick was to get the calculations done in time, because of course they don't stop hockey games, for the graphics to catch up. You have 60 fields of video, and they're roaring along non-stop. As each field of video comes along, you can delay it a second or so, if you must to calculate the graphic overlay, but you must keep up in real time, meaning you need to emit 60 fields of video per second with a graphic on top. In the early days of the puck, we delayed the video for two seconds. We'd have to get all of our calculations done in time, then we'd have to tee up the graphic overlay and have it sitting there, ready to get slapped on top of the output video field that was two-seconds delayed, and the timing had to be perfect; meaning, when we measured the pan and tilt and zoom and focus of the camera, we had to make those measurements at the instant that the shutter was open, and overlay the resulting graphic overlay on that exact field, so that when the cameraman is panning and tilting very quickly, the graphic stays exactly on the puck. Otherwise, the blue highlight would move around relative to the puck

Rino: Wasn't there even an issue with the fact that the union rules said that the operation of the cameras had to be done by union people, and to calibrate the arena, and all those issues, or...?

Honey: That is a good question. The integration with the broadcast TV compound was critically important. And none of us knew anything about field TV production. TV production has a culture as strong as offshore racing. They have their own terminology, they have their own traditions, and they don't like guys showing up with lab coats and telling them what to do. That wasn't going to work at all. I knew enough about the challenges of TV production, having worked at News Corp, as Head of Technology, to tell David, I can assemble a team to track the puck, and compute overlays, but there's no way my team can figure out how to integrate this into a field TV production compound." David introduced me to Jerry Gepner, who later became one of the cofounders of Sportvision, with Bill Squadron and me. Jerry Gepner was the Head of Field Operations for Fox Sports, and he had a wonderful breadth of experience and interest. Jerry was a legend in TV field operations. Everybody in the business knew Jerry. But he was also a guy who was interested in technology. Jerry was delighted to be involved in the development of the puck. Later as one of the cofounders of Sportvision, Jerry helped us through many cultural and technical issues. Cameramen are super-highly skilled professionals. You can't mess with them. You can't get in their way. And you can't even make their job the slightest bit harder. If we're going to have them use our instrumented pan tilt head, it must be a specific type of head, a Vinten head, because that's the best in the industry, and that's the only gear that they will use. Similarly, for our equipment in the TV truck, nobody's going to care what we use for computers. But these TV engineers are going to come into our truck, and they're going to look at our video path, because that's *their* video signal/product that's going through *our* truck. And if we're going to run their video through our systems, it must be *the best* equipment. We need to buy *this* delay line, we need to buy *this* keyer. And if they come in and they see that brand name, they'll say, 'Okay. You guys get it.' And if they see any other brand name, they won't accept it." Jerry knew how to handle all those details so that we fit into the field TV production culture.

Rino: Were they concerned at all about what it was doing, or just the brand name?

Honey: The storytellers and the producers and directors are interested in the creative part, and how to tell a story, and what the effects are. But the TV field production people are interested in the quality of the signal. They do a first-class job, they want to see that their signal is only going through the absolute best electronic path.

Rino: Okay, that's the motivation for it.

Honey: Jerry briefed us on the terminology, on what to wear, on who to talk to, who not to talk to, how to not appear like you're a scientist at a broadcast event. How to appear that you are part of the field crew. There is a lot of culture and traditions. When we finally showed up at sporting events, we were accepted as people who got it because Jerry had educated us. It was critical that we were able to find a guy like Jerry, who was interested and willing to help us figure it all out. Jerry knew that we needed to have a TV truck that would look like a TV truck. So he bought an old CBS TV truck that we named the Puck Truck. It was a truck that people in the industry knew. We gutted it, and we put in the FoxTrax Puck system. When we showed up at a TV compound, it looked as if we knew what we were doing, and increasingly we did, because of Jerry. Jerry did one other thing that was astonishing. Our first game was scheduled to be at the All-Star Game in '96. That was Fox's very first hockey game to air. But we needed to test the system. Jerry was able to convince the previous NHL broadcaster's field crew to let us show up with our truck, to put our heads under their cameras, and to let us operate the puck highlighting system; not to air, but to let us operate it in the background for testing.

Rino: Just to test it out.

Honey: To test it. And we were doing this in a broadcast compound that was working for a competitor to Fox. And we were putting heads under their cameras. The only reason they let us into the compound, provided power to our truck, provided us the video feeds, let us put our heads under their cameras, was the fact that everybody knew Jerry. Operators in that compound figured that, sooner or later, they'd be working for Jerry again. And so when Jerry asked for a favor, they were willing to help. Arranging for the testing at real NHL games was something that we never could have done without Jerry being involved.

Rino: Okay, so the hockey puck is working, and you had your big debut. <laughs> I guess you could tell us a little bit about that.

Honey: Well, it was hairy. It's a big system, with a lot of parts, and a lot of telemetry around the stadium-telemetry wires to the broadcast cameras, to our puck image sensors, and to the detectors all over the stadium, with wires to all of them. The last problem we had was, from time to time, our telemetry would get noisy, and we'd start getting very flaky telemetry. When the telemetry was good, the system would work solidly. But every now and then, the telemetry would just go bad. And we were struggling off and on with this problem, right up until a half an hour before the All-Star Game. The guys were asking me, "Should we call it off? Should we tell David?" And I said, "No. Not until the end. We got to keep trying to find this damn thing." And we *did* find it, and it was just shortly before the game. We had a defective dimmer on the lights in our production truck that was causing enormous interference.

Rino: Oh, gee.

Honey: This defective dimmer put out noise like a leaf blower on the powerline, when the lights were dimmed. Whenever we were trying to debug, people would turn the lights fully up so we could see what we were doing, and the dimmer would go quiet. Whenever we went into operating mode, they'd turn the lights down, so that the operators could see the screens better, and then this noise would come in. Finally, we correlated it: And then, of course, once we found the problem it was easy to fix. That's an example that when you're working on new systems, there's just always something to torture you.

Rino: Yeah, at the last minute.

Honey: It did work at the very first game, so when Rupert and David Hill said, "Can you get it working by the All-Star Game?", we did. And it was 2.2 million, instead of the 2 million we'd estimated.

Rino: That's not bad.

Honey: It was on schedule, it worked, and was within 10% of the budget. Fox used it for two or three seasons but branded it very strongly: FoxTrax. When ESPN took over the contract, they didn't use it in part because it was so strongly identified with Fox.

Rino: Oh, that's interesting.

Honey: Sportvision has provided a subsequent system that has been used a few times since, but it isn't as necessary with HDTV. With HDTV you can generally see the puck because it's very high-contrast.

Rino: Okay. So we go from there to Sportvision?

Honey: At that point we were hoping to do the yellow first-down line as the News Technology Group. We thought it was a pretty approachable problem, if we could get the keying solved. J.R. Gloudemans, was fortunately hot on the trail of proving that his solution to keying would work. We caught News Corp at a bad time, however. News Corp was again in a cash crunch, so David Hill and Rupert Murdoch didn't want to field the yellow first down line right away. They wanted to go slow for a year, and maybe field it in a year or two. So Bill Squadron, Jerry Gepner and I made a proposal to Rupert Murdoch, that we spin the News Technology Group off and start a new company, Sportvision. But to do that, the new company would need the patents, and we would need the equipment. Rupert Murdoch made a deal with us that was extremely fair. He gave us the Puck Truck and all the equipment, the office lease, the furniture, the test gear, our employees; and rights under the patents, in exchange for which he kept 10 percent of the equity in the new company. But because of the current cash crunch, he couldn't help us with any operating capital. At the time, I was navigating for Roy Disney on *Pyewacket*, and at the time, Bill Squadron was good friends with Fred Wilpon, from the Mets. And so we raised a round of funding that included Roy Disney's Shamrock, Fred Wilpon, other VC's, some friends and family, to give us the operating cash that w Jud Heinzmann e needed. With that first round of financing we modified the Puck Truck to do the first-down line.

Rino: That was the same... yeah, the same operation.

Honey: The first year of the first down line we used the same truck, the same SGI computers, and the same tricky requirement for telemetry wires to all camera locations.

Honey: The software was quite a bit different because it had to deal with the crown of the football field, and we had to key the line around the athletes, which was JR Gloudemans insight and solution. We introduced the yellow first-down line for Jed Drake at ESPN in the early part of the 1998 season. The puck had always been controversial. It earned high ratings for Fox, because non-fans watched hockey who normally hadn't. But diehard hockey fans hated it. Whereas the yellow first-down line was widely loved and appreciated. I don't think there was a single criticism of it. Part of the positive reception may have been the fact that we keyed it around the players. So it just wasn't possible to argue that it got in the way of watching the game, or that it was distracting because It didn't move. It was stationary on the grass. It was keyed around the players. It was underneath everything. And yet, it did something that we discovered, in hindsight, was important in *all* the later systems that we did. For an augmented reality system to make a positive contribution to sport, it must take something that's important to a game, hard to see, happens a lot, and make it easy to see. The first do Jud Heinzmann won line was a great example of that, because the first down line is the objective of almost every play. Yet, once the camera has zoomed in on the action, and you can't see the chain gang on the side, you can't see the objective of the play. But with the first-down line, you could. Jed Drake also did a very interesting thing with the introduction. Jed didn't preannounce it. He tortured us by bringing us to every game and having us operate the system at the venue. He would look at it, and he would say, "Well, I'd like the color different, or it wiggled too much here, and I need the edges softer." And every week, we'd go back, and we'd make improvements, and come back. He didn't know when he was going to introduce it, because he wasn't sure when we would get it good enough, and so he didn't announce it. Jed drove us crazy with his requests for improvements but in hindsight Jed was exactly right to get it right. Finally we found a bug in our timing calculations and things got much better. Not long after that, I think it was in Baltimore, in October, at halftime Jed just calls the production truck, and says, "Take it to air." And so the yellow first down line just went to air.

Rino: So nobody expected it? <laughs>

Honey: The journalists were mystified and asking, "How the *heck* do they do that?" Everybody watching the game on TV knew that it was indicating the first down line, that was immediately obvious, but nobody could figure out how it was done, especially keeping it stationary on the grass, and underneath the athletes.

Rino: Oh, sure. Yeah.

Honey: Times change. Today nobody cares how things work. Everybody assumes that, with a computer, you can do anything. But in those days, people still were interested in understanding how stuff worked.

Rino: Like they said, it miraculously didn't obscure the players.

Honey: People were calling up, saying, "Is it on the grass in the stadium? Are they laying it out with chalk and vacuuming it up, or... and if they do it electronically, how does stay still and not go over the players?"

There was a huge hubbub of discussion, trying to figure out how it was done. But it is an interesting sign of how times have changed, because now, everybody expects that anything is easily doable with computers, and they don't try to make sense of it, to see how it works. But in those days, people really *did* want to understand how it worked.

Rino: That was beautiful.

Honey: So it collected a ton of interest.

Rino: So, with that success, then, you take on something like baseball?

Honey: It was so well received that we had a major project on our hands to make it affordable, without a production truck at every game, without the dedicated telemetry wires to every camera, and not needing 6 people to run it for the next season. So we had to develop whole new camera sensors that didn't require us to run wires to every camera. We needed to pass the camera pan/tilt/zoom/focus data down the triax that's a part of every stadium and used for the TV cameras. We had to move to more affordable computers. We had to get that all done by the next season, so that the next season, we could roll out to do more and more games. It was a major project, to get it to where it was economically possible to do lots of games. Within a year or two-- it grew to where it was done on every televised game, both NFL and NCAA. Sportvision did every game on every network except CBS. PVI, who had been working on billboards and product insertions, got in the business competing with Sportvision and did CBS.

The next year, Jed Drake, the ESPN head of production who introduced the first down line and earned the Emmy for it, came up with the concept of the K-Zone baseball tracking and highlighting system and asked us to develop that for him, earning yet another Emmy.

Rino: How were you tracking the baseball?

Honey: The problem with hockey was that the field of play is so complicated: all these sticks and ankles and elbows that are black and about three inches across, and lots of occlusion from the athletes, so we had to put IR emitters in the puck. In baseball, if you have high cameras, the background for the baseball is this stationary field of grass, with no occlusion. So we didn't need to put anything in the baseball.

Rino: That's a good thing. <laughs>

Honey: We could take just images of the baseball from cameras at high home and high third

Rino: I think it was done optically. Yeah.

Honey: We track the baseball optically using frame differencing to detect motion.

Rino: Frame differencing. Yeah.

Honey: In summary you subtract adjacent frames from one another. Everything that's not moving subtracts out and turns to black. Two balls become visible, where it was, and where it now is in the most recent frame we could measure the ball very accurately, 60 times a second, from about a meter after the pitcher let go of it to just before the plate. And then we would extrapolate it across the strike zone. Having measured the entire flight of the ball we understood its dynamics, and then we could accurately extrapolate it to the plane of the strike zone.

Rino: Did it bother the umpires?

Honey: The umpires were opposed to it, until about two weeks after it was introduced. Then the umpires became advocates. It turns out that the system revealed something that few had expected, which is, the officials do a much, much better job than anybody had imagined. Most of the TV cameras from the outfield weren't centered up right over the pitcher, so there was a bit of confusing perspective in most baseball broadcasts. The K-Zone system solved that and showed exactly where the baseball crossed the plate. In fact, the officials asked that the sensors be installed at every ballpark, even when the K-Zone isn't used by the broadcaster.

Rino: Just to calibrate the umpires.

Honey: Because they wanted to understand how well their umpires were doing and have their own quality control. Various folks have asked the MLB, "You know exactly where the ball is. Will you ever use this instead of the official?" Major-league baseball had a very insightful answer to that, which is, "No. Today, there is a very strong culture of the game, this three-way battle between the official, the batter, and the pitcher. The official's not always right, but he's always right according to the rules and that's an important cultural and traditional part of the game." The K Zone was just a system to allow the viewer to see. Major-league baseball also said that they're aware that, as the decades go by, they may change their approach. There will come a time when future fans are not willing to accept that a mistake influenced a game, given the fact that the data was right there. So they say that sometimes they might choose to gradually address the fact that the fans are changing, and there'll come a time when the new fans are less tolerant of avoidable errors in officiating.

Rino: Who is it that does the tennis in-and-out judgment, that when the ball is a millimeter off, the... <laughs>

Honey: That's one of the first systems where the measurements were used for the official call. LiveLine, that we did for sailing, is another example where the tracking measurements were used for official calls.

Rino: But who did it? That wasn't FoxTrax, is it?

Honey SMT, the outfit that acquired Sportvision is now in the Tennis business, but Sportvision wasn't the first to innovate that. It was first introduced by Hawk-Eye.

Rino: Okay. Yeah.

Rino: So, what other things are they looking at, that might be enhanced? What about golf? I mean, is there any interest in tracking a golf ball, to see where it's--?

Honey: Quite a bit has been done in golf. Ken Milnes has led several golf projects at Sportvision, and then SMT, to both track and highlight the ball. SMT also does augmented reality from shoulder cams on cameramen.

Rino: Put them all together, yeah.

Rino: So... okay. So, we've come through now. What is your transitions, now, from Sportvision? You-- are you still...?

Honey: We did NASCAR in 2001.

Rino: Oh, yeah. I forgot about that. Sure, yeah.

Honey: -- The NASCAR project, Race F/X was led by Ken Milnes as the chief engineer. We had to do GPS tracking to Real Time Kinetic (RTK), carrier phase, precision, specifically two-centimeter precision. In the day when we started that, RTK, carrier-phase tracking-- was common for surveyors but they would set up an antenna on a tripod, and back away for 10 minutes, and then you'd have a two-centimeter position. Our challenge was to get a two-centimeter position on 43 racecars that are going 200 miles an hour under a metal fence, so they could only see half the sky at any one instant. The half the sky they could see changed every minute, as they went around the track, so every satellite would come and go in visibility every minute. It was a huge challenge. Ken Milnes was critical as the chief engineer for it. We eventually closely coupled the GPS with an inertial measurement unit. So when the car went under an overpass, or the car temporarily lost the satellites, the car would know where it was, within a couple of centimeters, as it reacquired the satellites, and it wouldn't have to go through the whole computational process of figuring out, what are the ambiguous possible solutions? It could immediately track the actual carrier phase solution.

Rino: So, you were using commercial GPS receivers?

Honey: We were working very closely with NovAtel, Pat Fenton and Tom Ford were critical engineers in this at Novatel. NovAtel closely coupled the GPS with the IMU. We also surveyed the ribbon of track that's suspended in three-space, and we would only consider--

Rino: Okay, then you'd know exactly where that was.

Honey: -- We would only consider the subset of ambiguous solutions that were on that ribbon of surveyed track. When you normally do an RTK lock-in there's a bunch of ambiguous possible solutions. But with time, they drift out, and most of the ambiguous solutions become clearly crazy. But we didn't have a lot of time with the system running on racecars. If you just took an off-the-shelf RTK receiver that would be used by surveyors, and you put it on a 200-mile-an-hour racecar driving under a fence and overpasses, it wouldn't ever lock in. In fact, if you took a *consumer* GPS-- you know, your Garmin-- and put it on a racecar driving under a fence and overpasses, it would never lock in. So we had to find a way to maintain RTK centimeter lock at 200 miles an hour, under this fence. NovAtel was critical to it, — integrating the survey data of the tracks, and closely coupling with an inertial measurement unit. The close coupling between a GPS and an IMU is one of those technical marriages made in heaven, because both systems gain. When the GPS *is* in lock, you're able to remove all the biases and offsets from the inertial measurement unit. And then, when the GPS loses lock, you have this extraordinarily accurate IMU, because it's been calibrated up to a fraction of a second ago, and you're only needing to dead-reckon using that IMU for a second or two, to get underneath some overpass. And so then, when you come out from under that overpass, you have your position nearly as accurately as when you went in. And so it's one of those beautiful combinations of technologies.

Rino: Yeah. I think there's a notion that, at some point, inertial navigation will replace GPS, but using them together seems to be the future.

Honey: There was a fascinating argument between the MIT inertial group and Brad Parkinson's GPS group. Brad sat right on the fence between them, because he was originally from the MIT inertial group, and then he became the program leader of GPS. I think one of Brad's major contributions was. mending that fence and making it clear to everybody that both technologies had something to offer, especially when used together. Inertial navigation, at the end of the day, no matter how good it is, you're going to have some accumulation of uncertainty and error. And GPS can lose lock from interference and blockage. The marriage of the two works well.

Rino: Yeah. Well, this is a-- yeah, this is really a beautiful connection, because we are starting, in the museum, to pick up some of the layers of GPS. And I think starting with you, with this development, is a nice point to jump off, because every single one of the things you've said are all related.

Honey: Well, get Charlie Trimble in.

Rino: Yeah. I'd very much like to do that.

Honey: In fact, I still see Charlie three or four times a year, or-- we serve on a board of directors together at KVH. And I discovered that I still had one of the original Trimble Transpacs, which was the consumer C/A Desert Storm GPS receiver that ended up being used a lot even by the US military. A few weeks ago, I gave that old Trimble Transpack unit to Charlie, and he was delighted to have one. <laughs>

Rino: That's nice. Okay, so we've come all the way, to finishing up with Sportvision. What's going on in Sportvision right now?

Honey: I left Sportvision in 2004. I got the opportunity to navigate the 2005-6 Volvo Ocean Race on ABM AMRO One. Ever since Yale I had been navigating professionally, but only part time. I was navigating part time for guys like Nolan Bushnell, Larry Ellison, Richard Branson, Steve Fossett, Roy Disney, and then later Jim Clark and George David. But the Volvo Ocean Race is the pinnacle offshore race in the world and I couldn't pass up the opportunity to navigate a boat in it.

Rino: But you always race monohulls?

Honey: No. In those cases, *PlayStation* was a 125-foot catamaran. I also navigated for Franck Cammas on *Groupama 3* in 2010, when we set the round-the-world nonstop sailing record from France to France, around the great capes and the Southern Ocean, in 48 days.

Rino: Now, see, to bring technology back into it a little bit, am I correct in saying that you'd really mastered the art of collecting all of the weather information you can get your hands on, make projections of what the conditions are going to be for the race, and then maybe, literally, use that to give you the boost to surf a gale across the ocean, or something like that?

Honey: That's broadly what I do, and that's what competitive navigators do, also. We compete on the precision with which we can characterize the performance of our own boat in different wind angles, wind speeds, and sea states, and then we also compete in our ability to characterize the strengths and weaknesses and characteristic errors of the different weather models. There's a lot of risk assessment, in this situation where you're basing your calculations on data that's decreasingly dependable with time. There's a lot of judgment that you must bring to bear. You do the best you can at analyzing the performance of your own boat, you do the best you can at making sure you have the best weather models, you compute the various optimum courses, but then you have to decide between them, based on where your competitors are, based on the characteristic mistakes that you think might be in those models. You must run experiments-- speed up a model, slow down a model, start earlier, start later, force it to go this way, force it to go that way-- until you understand where the likely pitfalls are.

It's a funny thing that I've navigated for a lot of these guys I've mentioned, like Richard Branson and Steve Fossett and Roy Disney, and Larry Ellison, and they're all businessmen. When they see what I do, they all uniformly observe that it is exactly what *they* do in business; meaning, they're forced to make decisions based on information that's decreasingly dependable with time. My currency is miles; we all know the shortest course is a great circle. You can always sail the great circle and sail minimum miles. Instead, you sail a longer course, because you have developed the expectation that you're going to get there faster. So what you're doing is you're investing extra miles, with the expectation that you're going to be repaid by more than the time it took to sail the extra miles. There are also risk assessment decisions, like... if you have a big lead, do you want to invest all that lead to have 100-percent certainty of beating the next guy? If you could invest your 20-mile lead, and have a 100-percent certainty of beating him by a meter, should you do so? And there's fascinating questions that come up, but all these business guys are good at that kind of--

Rino: And this teeny little bit about whether you're putting up a spinnaker as quickly as you can, is coming into the equation.

Honey: Oh, certainly. And you wouldn't ever re-invest an entire 20-mile lead all the way away to a meter, because you need to keep some margin. I'm just using that as an example.

Rino: Yeah. Sure. I understand. It’s a beautiful story.

Honey: But nevertheless, if you have a 20-mile lead, and all you’re trying to do is be first to finish, you probably *are* willing to invest a good chunk of that, to almost eliminate the possibility that the next guy could find a way around you. Business guys have good instincts on that.

Rino: Yeah. Sounds fascinating. So we have augmented reality, and now sophisticated decision-making.

Honey: But decision-making in the presence of data that’s decreasingly good with time is a fascinating problem. Generals and admirals are good at that, too. That’s what *they* do as well in wartime. They have *some* information, and they don’t know what the other guy’s doing, but they must make a decision.

Rino: So, well, tell us a little bit about the augmentation of sailboat viewing. I mean, that was... to watch a sailboat race, when all the boats are going every direction, you have no idea who’s in the lead to...

Honey: —The LiveLine system came out of an odd sequence of events. I navigated for Larry Ellison in ’95, on *Sayonara.*I got to know Larry, because at the time, I was Head of Technology for News Corp. Larry was aware of what I was doing at the time, on the hockey puck, and in the development of the yellow first-down line. The first-down line hadn’t been introduced, but I’d described it to him. Larry asked, “what would you do for sailing?” —This conversation happened in ’95. I responded to Larry, that sailing would benefit more than almost any sport. Because in sailing, there are lots of items that are important to the event, but hard to see. Examples include who’s ahead, who’s behind, what the wind direction is, what the current is, where are the laylines, and where are the marks? And so what you would do is, you’d get video from a helicopter and you’d put in ladder lines, so you can see who’s ahead, and you put in laylines, and you’d highlight the marks. I described that all in ’95, but I also mentioned that this is expensive, and the sport of sailing probably can’t afford it.” *During* the round-the-world record that I was navigating on *Groupama 3* in 2010, *Fortune* magazine interviewed Larry who had just won the America’s Cup. They asked, “So, you won the America’s Cup. You’re going to put on the next America’s Cup. You say you’re going to improve TV. What are you going to do?” And Larry said, “Well, I’m going to look up an old sailing colleague, Stan Honey, and we’re going to put ladder lines and laylines and mark circles.” He was referring to a conversation we’d had 15 years before. Meanwhile I was in the Southern Ocean on *Groupama 3*. We’re setting the round-the-world record. My wife Sally saw this interview and sent it to me by satellite. I was amazed that Larry remembered the conversation. It was a rare opportunity, as a freelancer, where you get a hunch as to what you might have a chance to do next. When I got in from setting the round-the-world record, there were e-mails from Jimmy Spithill and Russell Coutts, working for Larry. They wanted to investigate doing what became the LiveLine system; meaning, from the helicopter video, putting in the ladder lines and the laylines, and all that. I mentioned what I’d told Larry 15 years earlier: that we could do it, and it would work, but it would be expensive, and systems that are that expensive normally only makes sense for major sports, like football, baseball, NASCAR. They asked what it would cost. So I dragged in Ken Milnes, as always, and we figured out an estimate of what it would cost. It was $5 million and would take two years. We summarized that it would work but it will be very expensive. You must have RTK tracking on all the boats, and marks. You must have an extraordinarily good INS in the helicopter, to measure its angle to a hundredth of a degree and its position to 2 cm. But you can do that. It’s just money. And then you must develop a telemetry system that cover this entire very large field of play, that's much bigger than, say, a NASCAR track." We said, that we didn't think that it would make economic sense, but we could do it and it would work. Larry and Russell decided to proceed. So we did it, and it came out exactly on budget, and exactly on schedule, and everything worked, and it was a terrific contribution to the sport of sailing. We also built the electronic umpiring system and electronic race management systems, that used the same tracking and telemetry, and were used to officiate the event and to manage the races and course.

Rino: Never thought that was possible.

Honey: It will eventually get affordable enough to be useful for the rest of the sport of sailing, because technology always drives things down in cost. But at the time we did it, it was really expensive to do, because of the cost of the sensors and the telemetry.

Rino: Well, there was a system out there that would tell you where the boats are, and things like that, you could subscribe to.

Honey: There are various subscription systems that provide occasional GPS positions of racing boats. Some are use AIS VHF telemetry, some use 3G mobile phone telemetry, and some do telemetry by Inmarsat or Iridium satellites. There are race viewers on the web that show the position of the racing fleet using these tracking data. Most of those fleet viewers are virtual reality, where everything is rendered graphics. LiveLine uses augmented reality, where we insert graphics over live video. There are tradeoffs. With virtual viewing you can look from any angle, any time. With augmented reality you can see the real boats and the real wind on the water. LiveLine is, so far, the only system that tracks racing boats to RTK 2cm precision and so can be used to umpire a race.

Rino: Well, let's see. We've covered a lot of territory, I think; put your story together very nicely. Is there anything else we should add?

Rino: I have one item, but you could tell me yours first.

Honey: Why don't you do yours first? I'll think.

Rino: Okay. Well, you mentioned Sally. Could you tell us the charming story about how Stanley met Sally?

Honey: <laughs> Sally is a legend in sailing. Sally was one of the few women who competed in open sailing competitions in 505s against men. Sally won the North American's and was one of the top competitors in the 5-0-5 class for years. Sally was twice the USA Yachtswoman of the year. Sally's career was working as a sailmaker. She started her own sail loft, and then was head of spinnaker design for North. I met Sally when I was at Yale. I was crewing in 505s for Steve Taylor, who was Sally's boss at North Sails. Ultimately, I started sailing *with* Sally. If you can't beat them, join them. When I graduated from Yale and moved out here, I talked Sally into coming with me. Once in Palo Alto, she started her own technical sewing business...

Rino: Do you have family? Children?

Honey: One son, Tam, who lives in Portland, Oregon.

Rino: Oh. Okay. Is he a sailor?

Honey: He's a recreational sailor, and he does some light racing. He in IT. Tam is married to Jenell who also works in IT.

Rino: Okay. So, well, it's been a great pleasure to hear your story and bring it into the computer history literature, officially, so... well, thank you.

Honey: Well, it's a pleasure. I can't imagine anybody easier to talk to about it than you, Chuck.

Rino: Well, thank you. Appreciate that.

END OF THE INTERVIEW

