Interview With Roy Streit

Stefano P. Coraluppi, *Fellow, IEEE*

***Abstract*—Roy Streit (IEEE Life Fellow and a longtime AESS member) celebrated his 75th birthday last fall. To mark this important milestone, Stefano Coraluppi (IEEE Fellow and member of the AESS Board of Governors) met recently with Roy to conduct this interview on behalf of Aerospace and Electronic Systems Magazine. The text of the interview follows.**

***Index Terms*—Information Fusion, Target Tracking, Signal Processing**

I. Interview With Roy Streit

Stefano: Roy, I am honored to be the one to conduct this interview with you. Can you start by telling us a bit about when and where you were born, and memories of your childhood?

Roy: I was born in Oklahoma, but I grew up in the West Texas oilfields (the Permian Basin, for those who know the Southwest). We lived where the big rigs were drilling, so we moved a lot. I can date my childhood memories reliably because I can remember where I was at the time. It's a little bit like archeology. My early memories are filled with desert. Heat. Sand. Sun. No open water for a hundred miles in any direction. Dust bowl like sandstorms that pitted the paint on cars. Dramatic weather. Squall lines marching across the desert, and timing when to go inside. Towering anvil thunderheads, with lightening unlike any I've seen in the Northeast. The clean, sweet smell of long dry soil moistened by the first raindrops. Glorious sunsets. Strange insects. When I got my driver's license (age 14), I would drive to the edge of the Caprock at high noon to see the horizon stretch away 40 miles in one direction and 15 in the other. Why high noon? To avoid the rattlesnakes who were smarter than me and stayed out of the noonday sun. The air was crystal and nothing manmade could be seen. This was a fantastic landscape for a kid to grow up in. The problem was that those who didn't own "mineral rights" to their land, if they owned land, were poor. Much later I realized that there was almost no middle class, just like Appalachia. I wasn't in the middle.

My parents were wonderful people. My father was very friendly and always happy to talk. He shared a warm smile with everyone he met. He could talk easily to anyone. He loved to laugh. He was down to earth. He was kind and understanding, and he accepted people exactly as they were. Not once did I hear him say a hateful word about anyone. He kept his opinions strictly to himself, but his stories spoke volumes. I loved his stories, which he never repeated even in his later years. I deeply admired his instinctive love and respect for everyone he met. My mother was a different kettle of fish. She was reserved and smiled as needed. She had opinions which she guarded closely. She had a pithy wickedly sharp tongue, but she policed it well and few ever saw it. She wanted to go to college, but she graduated high school in the depths of the Great Depression. Instead, she went to work in the local shoe factory. That left a mark, but she was tenacious. Some 20 years later, she was able to go to college and get a Nursing degree. She worked as a nurse in the local (now regional) hospital for the next 25 years. My parents both wanted to see their children get the education they could not, and to see them (in their words) "stand on their own two feet". My brother and I were not the first in the family to attend and graduate from college – that unique honor belongs to my mother. On graduation day, my father was teary, and my mother beamed. Their profound love of family and deep inner strength made possible many things that otherwise might not have been.

Fig. 1. Roy, the day the earth stood still (1948).

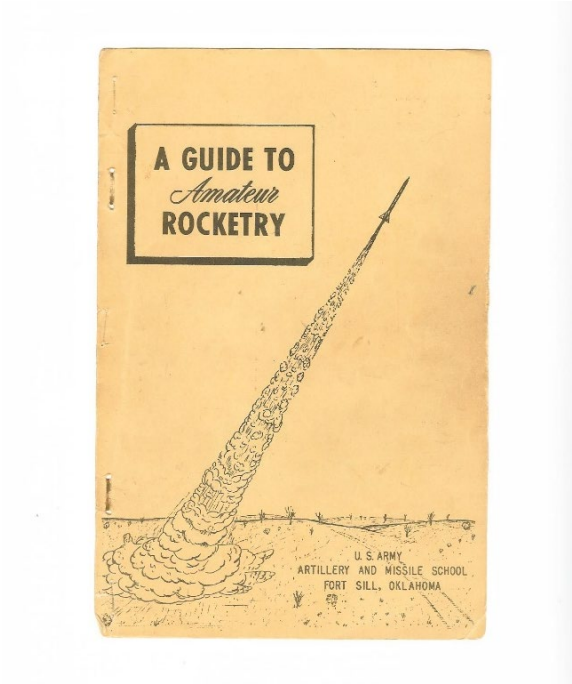

Fig. 2. Roy's sixth grade Ft. Still roadmap (1958).

Stefano: Please tell us a bit about how you first developed an interest in mathematics, science, and engineering.

Roy: I liked history and storytelling. They made me ask questions. I wanted (needed?) to understand what I was seeing, hearing, smelling. I was very shy, much too shy to ask questions. (For those who know me now, that must be hard to believe, but it's true – I have report cards to prove it.) No one talked about what mattered to me, but even if I had asked, they would have been puzzled by my questions. A lot of them were weird. One question I fondly recall asking myself, while looking at my bowl of breakfast cheerios, "Which one is the last cheerio I will eat?" There had to be one, but only by eating the bowl could I find it. I was 4 (I remember what I saw out of the window). And then Sputnik happened in October 1957. I was in the 4th grade. We'd had a television for less than a year. They called Sputnik a new moon, and they said you could see it overhead. I went outside at the appointed time, and there it was. A bright dot in the dark sky moving fast. I remember thinking that was "almost" interesting. But in December of that same year, I watched on tv as an early Vanguard rocket rose 4 feet in the air before settling almost straight down into an inferno of flames. I thought that was *very* interesting. I recall thinking something vaguely like "they don't know what they're doing," which turned into "I want to help them."

To do that I knew I needed to learn a few things. In the sixth grade I discovered that the US Army Artillery and Missile School in Ft. Sill, Oklahoma, ran an amateur rocket testing facility. I wrote them a letter (3 cents postage), and they sent me a small booklet, "A Guide to *Amateur* Rocketry." I am reading it again, now! The chapters on propellants, rocket engine design, ignition systems, aerodynamics, launchers, and performance analysis are written for high school and college students. I understood none of it back then, but it became a guide to what I needed to learn. I did a lot reading on my own. I loved science and engineering, but math was a dull thing, until I entered Mr. Kuser's math class in the 12th grade. He was a retired Dallas lawyer who taught by the Socratic method, just as he was taught in law school. (Back in the 1930s it was common for lawyers to get dual degrees in math and law.) Very first day, he asked some poor soul, "What is the reciprocal of 5?" Answer, "it's the number upside down." Mr. Kuser went to the board, carefully drew the number 5, and then he drew it upside down. "But ..." protested the student. "You had your chance," said Mr. Kuser, and moved to the next student, whose answer was, "It's one over that number." Mr. Kuser stretched and wrote the number 1 far above the 5 already on the board. "But..." said the student. "You had your chance," said Mr. Kuser. And so it went until he got the answer he wanted. When he got to me, he asked, "What is a function?" I had no answer, and I was deeply mortified. For most students Mr. Kuser was not a good teacher, but for me he was ideal.

By Christmas I was reading an inspiring book by Courant and Robbins ("What is Mathematics?" 1941) and teaching myself calculus (Granville, Smith, and Longley). The following Christmas found me reading a little book by Kamke ("Theory of Sets", Dover edition, $1.35). Math won me over totally – for beauty's sake – and physics came along for the ride. Learning was a great joy and a consolation. It gave me the courage to keep going.

Fig. 3. The future begins (1981).

Stefano: What are your memories of your time at East Texas State (B.A. Mathematics and Physics) and University of Missouri (M.A. Mathematics)?

Roy: You didn't mention Stevens Institute of Technology in Hoboken. I was there for the summer of 1968, in between East

Texas and Missouri. Stevens sits atop a cliff in New Jersey across from midtown Manhattan. I watched as the SS United States and the SS France sailed up the Hudson and docked in Manhattan, as they did several times that summer. What a magnificent sight! I often took the tube (the name the locals give to the tunnels that carry subway trains between Manhattan and Jersey City) over to Manhattan, sometimes alone, often with other students at Stevens. I spent several delightful evenings at the Bitter End in Greenwich Village which had many folk singers. Joni Mitchell performed there one evening, and I was in sitting right in front of her in the first row. How did that happen? Pure luck and the fact that she was almost unknown at the time. Anyway, a guitar string broke, and while she was fixing it, she started chatting with me. (I like to think she was flirting, and I was too dumb to know it at the time.) I have many wonderful memories of that summer (though some are sad, like the RFK funeral at St. Patrick's.)

So how did I get to Stevens? I had a small NSF undergraduate research participation grant ($600), one that I found out about and applied for entirely on my own. Why Stevens? Because it was the only program I knew about (no internet, folks). Where was Stevens? I didn't care – it wasn't Texas. How did I get there? On my very first airplane flight to anywhere. It was also my first trip "East of the Mississippi." It was the summer of 1968. For those who did not experience 1968, be thankful. It was a Dickens's "Best of times/Worst of times" year. Stevens changed my life. East Texas (now Texas A&M University at Commerce) was not a good school at that time, and I felt trapped and more than a little bit angry. Stevens helped me escape. I made one of my professors at Stevens so annoyed he wouldn't meet with me again. (I was late for a meeting, and he missed his train home. I had no clue what that meant.) He did give me a problem to work on, a good one too. It was to prove the existence of an optimal control for a linear system of differential equations. Wow! That was *very* different from anything I had seen before. When I finally settled into the problem with a different professor, I solved the problem exactly as the first professor had outlined to me – it was my first encounter with convex functionals and Hilbert spaces. I loved it. I also wrote it up in a nice way and typed it myself, painfully, one special character at a time (this was long before LaTex.) To this day I have no idea why I did that. When I showed it to the new professor, he was shocked as he quite reasonably had expected nothing from me. My fellows in the program watched me write it and were emotionally supportive (I needed it, too). When the summer ended, I went back to East Texas, bereft at the loss of my new friends. But I had learned a lot and discovered that I had the audacity to slap a cover page in that paper and submit it as an honors Thesis. It was almost too late, and a little finagling was needed. The Department had never seen anything like it. I graduated with Honors.

As you can tell, I don't particularly enjoy speaking of East Texas State University. The University of Missouri is a very different story. I spent the first year (1968-69) making up deficits caused by East Texas, but the next year was a treasure. I spent the summer of the in-between year (1969) in New London, Connecticut. I'll talk about that in a moment. The second year (1969-70) at Mizzou (what they call the state University in Columbia) was special, and challenging. I got A's from professors who very rarely gave A's. I loved analysis, but group theory with its upper central descending series was a bore. Lots of good memories. One story I rarely tell is my involvement in a student demonstration following the Kent State murders. A large group of students assembled in the Quad. There were a couple of hundred, which was very large by Missouri standards. It was tense. Students were really angry. The Quad happens to be next to the residence of the University President. At one point someone shouted, "Let's go talk to the President" and headed that way. I was first in line behind him. Being too naïve for words, I really did want to hear what the President had to say. We arrived on his porch and stopped at the front door. The porch was filling up behind us. What now? We looked at each other. We had a choice – open the door or ring the doorbell. He rang the doorbell. The President opened the door himself. I learned two things instantly: one was that I was a very lucky young man, for behind him and nearly out of sight were four state troopers, armed. The other was that the President was a remarkable man, with no small measure of courage. We talked and disbursed, all very peacefully. I soon found out that someone took a picture of me sitting on the porch and it was published in a local paper of some kind. I never saw it myself, but it seemed like everyone else did. I graduated in 1970, in part because a man rang a doorbell. Had he opened the door instead, the state troopers would have pounced. Enough said.

Fig. 4. First born, a bridge, and Stanford (1982).

Stefano: What brought you to NUWC in 1970 and what are your best memories of your time there? What were the major challenges? Tell us a bit about the projects on which you worked.

Roy: Well, you won't be at all surprised to hear me say that I got there by accident. I had two summer intern jobs, the first was the summer of 1969. One evening in the spring of that year, I was wandering around Jesse Hall (the admin building at Mizzou) after hours with more than one beer in me. How did I get in? The door was unlocked! Anyway, I bumped into a set

of mail slots and grabbed onto a brochure from the "US Navy Underwater Sound Laboratory" (USN/USL) in New London, Connecticut. It was a summer intern job. In that state I recall thinking it might be fun to work underwater. I knew better the next morning, but I applied anyway. They accepted. I had $50 to my name, so I used the offer letter to borrow enough money to get me to my first paycheck. You won't be surprised by now to hear I didn't care for the job, but the size of my first "real" paycheck astounded me. This was the summer of 1969. I watched the moon landing from a tv in the common room of a women's college dormitory. I nonchalantly relegated this astonishing feat of astronautical engineering to the category of "of course they can do it" because I somehow thought that would impress the ladies. My penance for that bonehead comment, which betrayed what I really thought, was to spend my career working with engineers. Summer of '69 over, I returned to Mizzou.

By the time I graduated from Mizzou in 1970, I knew that I liked having money in my pocket and needed a break from being a student. The booming economy of the 1960s had gone bust, and finding no jobs, I reluctantly returned to NUWC for my second summer intern job. I told myself that by the end of the summer I'll find a permanent job. That did not happen the way I expected because no one was hiring. My NUWC supervisor noticed me though and noticed that I could write well, so he was able to convert my summer intern job into a full-time position. A hiring freeze hit two weeks later. Once again, I was very lucky. I could not have found a better job, but it took me several years to figure that out, and many more years to fully appreciate my good fortune. The men (yes, all men) were tough but fair, and tolerated sloppy work very poorly. I wasn't very likable, but I was able to do what they wanted done *and* write about it clearly too, which I think surprised them. The first two years or so I was doing raytracing for underwater acoustic propagation. It was my first encounter with asymptotics. I recall too well the sad day I suggested the speed profile should be modeled as a random variable. Enough said. I moved on to more open-minded groups. In time there came the magical day when I found I could do things others did not know how to do. This led to an encounter with a man who all feared. He was an exceptionally talented structural acoustician. I was warned that he was combative and ran over people who he felt didn't measure up. I was sent to talk to him, not knowing what to expect. He looked me up and down (I was 26), chomped on his lit cigar (allowed in offices in the 1970s), and growled that he never expected to need a mathematician to do his job. To which I replied instantly that I never thought I'd need an engineer to have a job. At that, he bit his cigar practically in half. He took a moment, grinned in a devilish way, and invited me into his office, whereupon I was gifted with a marvelous one-hour extemporaneous lecture on structural acoustics. (It was a kind of an in-depth interview, but I passed.) His engineering vision was blocked by the need to solve certain large dense generalized Hermitian eigenproblems. In those days most numerical analysts thought that an order 10 matrix was pretty big, but his problems were of order several hundred. Solving them with the available computer resources was fun. We were friends to the end of his days, though after a few years we never worked together again. After that, I was no longer the man who was going to leave next year.

Fig. 5. What matters most (1993).

Stefano: What led to your choice to pursue the Ph.D. in Mathematics (University of Rhode Island, 1978)? Was it difficult to perform coursework and research while maintaining your position at NUWC? What was the focus of your dissertation? Do you recommend advanced studies while employed, or would you recommend a different approach?

Roy: As I have said, lack of resources drove me out of academia in 1970. My accidental discovery of USN/USL meant that I suddenly had money in my pocket for the first time. I liked how that felt. But to escape the sound propagation group, if only for an afternoon, I started taking one-off courses at URI. Why URI? Because it was closer than UConn. I wasn't planning to get a degree, as I was still "leaving the next year" to get a degree somewhere else TBD. But inertia comes from investment, and I was getting old (I was 25), so URI it was. My topic was approximation theory, which had an appeal to me, and for which I found applications in beamforming. For my year "in residence" at URI, both NUWC and URI considered me full time. I did that by working too many hours. By doing that, the rules being what they were at that time, I graduated no time commitments – I was free to leave, as I always dreamed of doing. And then I didn't. Why I didn't leave had to do with the structural acoustician story, and the fact that the job market was still awful. Large eigenproblems had morphed into large constrained optimization problems for compact high power steerable active arrays, and I found a way to study the project for a year at Stanford University in the Operations Research Department, where I learned many of the tools of the trade that are useful in machine learning. I remained a full-time NUWC employee for that year, but I (we, as I was married with a one-year-old baby boy) lived in Palo Alto. I personally thought of it as a kind of postdoc, but Stanford called me a Visiting Scholar. It was a very good year. It was my first year away from NUWC. I discovered I could leave without leaving.

Stefano: During your time at NUWC, you had several extended stays around the world including Stanford University, La Spezia (Italy), and Adelaide (Australia). The longest visit

was in Australia, from 1987 to 1989. Please tell us a bit about these visits and how they contributed to your personal and professional life.

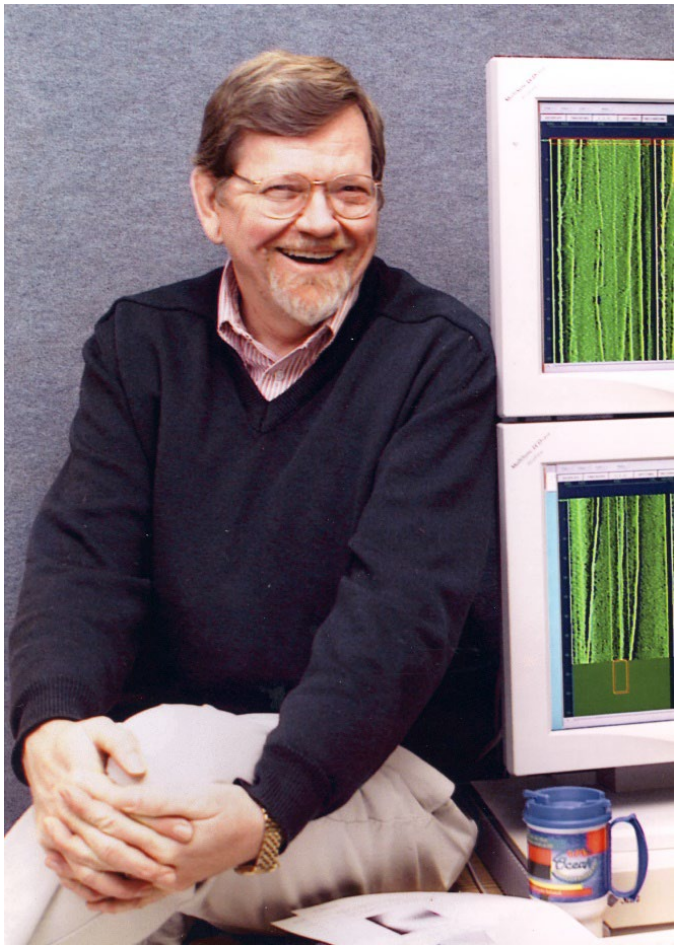

Fig. 6. Roy in the lab with lofargrams (2000).

Roy: Well, I think I just said the how and why of Stanford. That year opened my mind to many things, but I was blind to other things. It was 1982/3 and I had an offer to get in on the ground floor of computer games. I declined, lack of imagination on my part I suppose. When I returned to Connecticut, I was blessed – a stronger word than fortunate – to move into a group that was everything I wanted. It was called the Towed Array Group. One section designed arrays, another built prototypes, and a third evaluated them in sea tests at AUTEC. The group did the full arc from theory to test to evaluation, and I was part of all of it for five very happy years. I could talk about that period in my life for hours.

It is relevant to my life's later trajectory that I was just beginning to explore modeling spatially nonhomogeneous self-noise in towed arrays using hidden Markov models (HMMs), being inspired to consider them by their use in speech processing. Then out of the clear blue sky came an opportunity to go to Australia for a year, all expenses paid. It was too good to pass up, but still I refused to go until and unless I was guaranteed a return to my beloved Towed Array Group. They agreed. My family and I packed up (we now had two boys) and we went and had a grand time in every way imaginable. Our third child, Katherine, was born there.

Before I accepted the posting, the Aussies sent along a rank ordered list of about ten topics they might ask me to work on while I was there. The last item was tracking. I read all such lists in reverse order, an old habit which is ofttimes very revealing. So it was this time. Before I went to Australia, to be frank, whenever I was in a meeting and the subject of tracking came up, I did my best to leave as quietly as possible. Tracking was not in my list of interesting topics. Three weeks after I arrived in Adelaide, however, I realized that by swapping a space variable for a time variable, the HMMs I had begun to study back in the states were models for tracking.

Australia was a watershed. After concluding my posting to DSTO in Australia, we stayed on for four more months in Adelaide. Our house in Connecticut was still rented, so why return early when we could live in this idyll in Australia? I had saved a lot of my vacation time, so I used it. Free and clear – no obligations to "The Man" for four whole months! Adelaide University offered me an office (which I declined) and access to the library and Faculty Club. I spent my time studying artificial neural networks (NNs) on my own and totally self-supported. It was liberating. I moved fast and in those few months developed what I later turned into three NN patents, all assigned by me (not the Navy). It was 1989, and the AI winter was coming but no one knew that at the time. These NN ideas came back in a totally unexpected new guise five years later (PMHT).

Stefano: Before continuing the technical discussion, I would like to ask you to talk to us about your lovely wife Nancy, who many of us know from her frequent participation at the FUSION conferences and other events, as well as your children Adam, Katherine, and Andrew, and their families.

Roy: Ah, the joy and delight of my life. We had one and only one opportunity to meet and that singular moment was in January 1976, in JFK Airport about 3PM. Talk about luck. We've been together ever since. We are very different people united by deeply shared values of every kind -- personal, family, social, professional, religious, political. Nancy started coming to FUSION conferences because of the wonderful venues. After I retired from NUWC and was finally able to participate actively in ISIF, her attendance became regular and is now expected. We bring our children when we can, especially Andrew who still lives with us. It has become a family affair. Our other children attend when they can, and our grandchildren (Anna and Clara) will soon be attending their first in Charleston. Good conferences can be family affairs. The stronger the bonds, the more productive the conference.

Stefano: In 2005, you made a significant career move in leaving NUWC, where at this point you had reached the level of Senior Executive Service and joined Metron. Please tell us about this time in your life and what motivated this transition. Looking back on those days, do you think this was the right career move for you? Take this opportunity to talk more broadly about career choices and what advice you might have for our listeners and readers.

Roy: Leaving NUWC and moving to Metron was absolutely the right move. I was at NUWC for 35 years, but it wasn't as if

I had the same job all that time. In fact, I had at least five very different jobs, and unlike nearly everyone who works there, I switched departments at least four times, not counting my two long term assignments (Stanford for a year and DSTO in Australia for almost two years). With each switch, I gained experience and learned new things. I learned to avoid working in groups whose supervisor functioned as an administrator and not a Leader. When I had to choose between two technical jobs, one that I deemed safe and within my skill set and another one just outside what I knew, I learned to make the riskier choice. Not once did I ever look back with regret.

I stayed in my final position at NUWC for about five years. I was at the top of my technical career ladder, and further promotions were not possible. My position was on the technical side of the SES, which few are aware of, and it came with little intrinsic authority. I could have stayed in it for many years, and part of me wanted to do just that. It was demanding in several ways. I had to deal with internal politics, which is hugely important, and I hated it. I had skillfully managed to avoid it before then. Upper-level management often doesn't like change. (John Milton wrote of one tragic figure who declared, "Better to rule in hell than serve in heav'n.") I also had to engage with a larger Navy community external to NUWC via a program called APB (Advanced Processing Build). The best of APB reminded me of my treasured earlier years in the Towed Array Group.

I discovered that Milton's tragic figure lives also on the technical side. Gaining acceptance of new ideas in established programs to try to meet the larger needs of the APB program was a challenge. Getting technical groups to cooperate that have never previously worked together, and passionately do not want to do so, was another. In large spiral programs like APB, competing institutional interests add a special spice to the program (cayenne, Jalapeño, habanero). The APB program was fortunate to have good Leadership at NAVSEA and good engineers throughout. For five years I found it rewarding and fascinating to watch the spirals in the program evolve, but it was also often frustrating, and I slowly began to recognize the signs – it was time to move on, but this time it meant leaving NUWC.

It turned out to be psychologically harder to leave than I thought it would be: "As you bend the twig, so grows the tree." In terms of the work, though, moving to Metron was easy because I went back to doing the kinds of work that I like best. I am fond of telling all who will listen that my intention was to stay at Metron for about five years and then slow down. I made no secret of that when I accepted the offer. That was 18 years ago. This story is my way of saying that I believe that Metron is a great small company with all the right values. It highly esteems good work and strongly supports its employees. Moving to Metron began a whole new phase of my career.

Stefano: You are perhaps best known for your co-development of the PMHT along with Tod Luginbuhl at NUWC. Please tell us about this this work and how you view the PMHT today.

Roy: That is an interesting story. I mentioned my NN patents earlier, the ideas for which I developed in Australia. They were based on Gaussian mixtures. I trained them using the expectation-maximization (EM) method, which was rarely used outside of statistics at that time. The algorithm didn't use HMMs because I didn't need them. On my return to NUWC after Australia, word about my work on NNs got around, and I was asked to do some work with them for classification. It was a perfect application of my patents. Tod and I, and others too, developed these ideas further, with a special eye on dimensional reduction which included aggregating training data over a time window. One day, someone complained that these models were static, meaning the NNs were time independent. Sure, I said, so you want them to evolve? By this time Tod and I had a close working relationship, and a quick glance told us that we both knew how to do that. Well, we knew what it was we wanted to do, which was to "put the Gaussian mixtures in motion," but the technical details eluded us for a while. To make things easier, we decided to make the Gaussian mixture have exactly one term. That is when the connection to multitarget tracking became obvious – our classes were targets, and our aggregated-over-time data were sensor measurements. We had a sliding window multitarget tracker. What's more, we didn't use the "at most one measurement per target rule" because we used EM. The technical details were finally ironed out when we used what is today called a graph-based model to elucidate the conditioning, and then we had the first PMHT filter. It did not come out of the tracking community, but from the classification community. Today one might say that it was AI inspired, but 30 years ago during the AI winter, that would not have been a good thing to say.

Fig. 7. Granddad trying to be a tree (2017).

Stefano: In more recent years, particularly since your move to Metron, you have contributed to the area of label-free tracking methods. This is the realm in which the PHD filter was developed, along with many of its more recent versions and extensions (including labeled tracking). How do you view this subfield in the tracking community? How does your point processes approach differ from the PHD? Should practicing engineers be interested in these methods as design alternatives to more established methods such as PDA, MHT, etc.?

Fig. 8. The gang's all here (2020).

Roy: I had no interest in what you call label-free methods until 2008. When I began (belatedly) to read what was out there, I found exceedingly poor mathematical discussions that were written in what struck me as a newly invented jargon that failed totally to acknowledge connections to established mathematics. That puzzled me then, and it puzzles me still. Finite point processes and random finite sets (as defined by the Vo's) are the very same thing. The intensity function of a point process is identical to what is called a PHD. Many today still do not acknowledge these facts. Those who claim there is a difference are either just plain wrong, or they are using Mahler's flawed definition of an RFS that does not make sense on discrete spaces and has theoretical problems on continuous ones.

These methods have been extended to tracking labeled targets. On the very face of it, labeling the targets in an unlabeled filter would seem to give up the very advantages that are touted for the unlabeled filter. In my view, labeled versions of the PHD intensity filter are a limited subclass of MHT trackers. It is regrettable that the advocates of labeled methods are oblivious to the obvious connections to MHT. This posture is at variance with the entire body of scientific thought. By inference, this is also a sad statement about the quality of editorial and reviewing oversight in our journals and transactions.

Stefano: While active scientific discussion is of great benefit, the subfield to which the PHD filter belongs has led to many, sometimes acrimonious discussions within the tracking community. Is there anything you would like to share with us here? What lessons can we learn from this for ongoing research endeavors?

Roy: Your words "sometimes acrimonious" do not begin to describe it. I was amazed at the animosity that permeated the entire subfield for many years. It was far and away the most egregious unprofessional behavior I have ever witnessed. Deep personal hostility was directed at anyone who gave alternative technical formulations that differed from the Accepted Doctrine of RFS. The overt hostility drove established researchers out of the field, and motivated others to avoid studying it. It made some students shift fields after graduating. It is pointless to go into the details. In short, it sullied the reputation and academic standing of the field in the eyes of many. For several years, as a friend of mine once said, its reputation was "lower than pond scum."

The reputation of the field of unlabeled target tracking has improved somewhat in the last few years, which is good because it has real value. The recognition of earlier scholarly research in other countries may improve its standing further. For example, a 1976 paper in Russian by Bakut and Ivanchuk (translated into English the same year) derived – as a special case – what is called the PHD intensity filter. This paper was merely one of a series of papers inspired by the work of giants in statistical physics.

Before I became interested in the subject, I saw everything only from outside. That changed in 2008, when I presented an alternative derivation of the PHD intensity filter at the FUSION conference in Cologne. I had not yet realized that alternative derivations were "not allowed." I was not naïve and fully expected some strenuous technical exchanges, but I was amazed at the animosity. The attacks started immediately and persisted for years. My papers were misrepresented in print, and the misrepresentations were attacked. Some authors were "ordered" by anonymous reviewers to remove references to my papers as a condition for acceptance. Some reviewers, in the second round of reviews, attacked other reviewers who, in the first round of reviews, had offered objective criticism. On learning I had a paper that was still under review, an individual wrote to the Editor *demanding* to be made a reviewer, and they were. I could go on, but eventually one individual involved in this unprofessional activity was publicly sanctioned by the IEEE for violating its ethical standards.

Do you mean lessons learned about myself, or about how professional societies can fail their membership? For myself, I discovered that I am still that young kid in West Texas who

didn't let what others thought and said change my thinking unless and until I was convinced by fact and careful discussion. I am not easily overwhelmed by lies and distortions.

As for societies, I do have a few heartfelt thoughts about Associate Editors (AEs) and the important role they play. The big one is that, in my opinion, many do not fully understand one of their most important roles, perhaps because it so rarely needs to be exercised – they are responsible for protecting the integrity of the blind review process. As I have learned firsthand, and from others who have been victimized this way, bad actors can and will find ways to abuse this process. Why wouldn't they since, after all, they can attack cowardly from the dark, anonymously, in novel ways? They expect AEs to be confined behind a code of silence. In truth AEs have a choice – they can stay silent, and risk being accused of violating ethical standards, or they can act to control the abuse, and risk being accused of violating the blind review process. It requires courage and sound judgement on the part of AEs to do their duty and not abdicate it. Undoubtedly some AEs (and there are often 50 or more nowadays) need training to understand how to exercise their authority. Do they get this kind of training? I think not.

Fig. 9. NATO Lecture Series in Rome (2022).

Stefano: Your most recent work has been in analytic combinatorics (AC). Please tell us about this work.

Roy: Until very recently, say the last ten years, I would have never believed I would be interested in this subject. I was the kind of guy who enjoyed seeing answers to combinatorial problems but had absolutely no interest deriving them. That's because I cannot count worth beans and worry that I have overcounted or undercounted. AC is really a subject for younger minds, but hallelujah here I am. The subject liberated me—I no longer worry about counting because I am confident that I can differentiate correctly. That only makes sense in AC because—magically—the terms in the derivatives map one-to-one to combinatorial configurations in the problem. Problems are reduced to modeling the functionals to be differentiated, and—yet more magic—the governing functionals are derived from first principles, just as things are done in physics! All the standard tracking filters such as PDA, JPDA, IJPDA, multiBernoulli, PHD, JiFi, and more can be formulated in this way. The functionals that describe them are very compact, concise, complete, and exact. Moreover, these functionals are closely related and can be used to organize the filters into a beautiful family tree. But I digress. There are other reasons to be interested in AC too, and these have to do with higher level information fusion. I feel lucky to have been blessed to have discovered such interests, especially now. They help me feel young at heart.

Stefano: What are you most proud of in your technical accomplishments?

Roy: I cannot talk about many of the things I am most proud of, but I know of them, and that is enough. There was a period of about ten years starting about 1985 that was especially exhilarating. For me personally, all I can say is that I am very grateful to have been so lucky. I have already talked about those years. When I mentioned my last five years at NUWC, I neglected to say that I was part of a small but determined team that was dedicated to getting things done. What an incredible team they were to work with. It is always an honor to work with extraordinarily talented people. I was heart-broken to leave the team when I left NUWC, but I am very proud of the work we accomplished.

Stefano: Tell us about the most memorable work-related travel experiences, at conferences or lecture series.

Roy: There have been many. An especially treasured moment was meeting the legendary Paul Erdös at the 1978 World Congress of Mathematics in Helsinki. There was a queue of people wanting to ask him a question. I joined the queue and asked my question, he listened, smiled at me with extraordinarily kind eyes, and directed me to speak to a man sitting on a low wall. I hadn't noticed the wall until that moment, but arrayed along it were about 20 people, all world class experts in their own fields, who were there to support Erdös. Another incredible meeting was in 1999 in Paris at a workshop on tracking organized by the late Jean-Pierre LeCadre to mark the five years since PMHT was invented. A third was the Fusion Conference in Florence that you, Stefano, helped organize in 2006. There was the Fusion Conference that I co-chaired in Istanbul in 2013, which was held shortly after the riots in Taksim Square near the conference venue and during which Ramadan began. Finally, and more recently, the several

NATO lecture series that I have been honored to be part of on multiple occasions has led to lasting friendships and working relationships. As I said, so many wonderful experiences, and after I joined Metron in 2005, I was able to share many of them with my family.

Stefano: Do you have any further words of advice for young researchers in our field? How should they navigate important career choices? What are some open problems that you believe are most worthy of investigation?

Roy: Trust yourself. Go where your intellectual interests are, if you can. Remember that hiding inside every problem that someone else is having difficulty with solving, there resides a real problem, and it is often interesting. Take ownership of it, and you may be rewarded. When in time you believe you can "feel the boundaries of the job you're in," maybe it is time to think about doing something else but be patient. Opportunity comes to the well prepared. When given career choices, go to the boundaries of what you know, assess the choices, and take the riskier one, provided it is not too risky. What do I mean by risk? Well, risk is in the eye of the beholder. Given my lack of resources when I was younger, my appetite for risk never included financial risk. Professional risk, sure, but I am fairly confident that I can contribute if I put my mind to it, whether or not I like the work at first. Often as not, the core problem will seduce me and, if not, I have always found that another opportunity will pop up. So here I am, nearer the end of my career than the start of it, and I find myself interested in analytic combinatorics. The amazing thing is that over the last two years AC has stimulated in me a deep and growing interest in quantum computing. Inquiring minds walk through many doors.

I have little to say about navigating the choice between technical and corporate career paths. As your experience grows over time, it is inevitable that you will move into ever more senior positions. At some point a corporate opportunity may tempt you. All I can say is to try to be prepared for that moment. There is no one right choice. All I will say is that good leadership is quite rare but priceless, and poor leadership is vastly overpaid (and poorly respected).

Some open problems are purely technical and scientific, and I see little need to talk about them here. However, I will venture to say that many important problems are only partly technical. They arise from the ever-increasing abundance of mis- and disinformation, much of which can now be generated automatically without cost. Its purpose is to sow doubt and uncertainty about all kinds of facts, to say nothing of half-truths, distortions, and lies. It spreads with astonishing ease on social media. Contributing to the problem are the "echo chambers" that are enhanced by automated methods (that I imagine are akin to reinforcement learning). There are grave societal risks if we completely ignore these problems. And there are grave societal risks if we go to the other way and overly regulate the space. Finding a middle road will be a serious challenge and, like the problem itself, finding it will be partly technical and partly not.

Fig. 10. Roy and Stefano in Charleston (2023).

Stefano: Please share with us any further thoughts that we have not had a chance to discuss. Also, please tell us a bit about any plans for the coming years.

Roy: I am looking forward to clamming this summer up in Maine. But I have no plans to retire, at least not fully, if that is what you were asking. Too many exciting things are happening to leave the playing field just when things are heating up. I think I could go on and on from here, but I have said enough.

Stefano: Thank you, Roy, for spending time for this very interesting and enlightening discussion. And, on behalf of our tracking and fusion technical community, thank you for your significant contributions and service over so many years. Best wishes for the years to come!

II. Forthcoming Recognition

Roy has been selected to receive the highly prestigious ISIF Yaakov Bar-Shalom Award for a Lifetime of Excellence in Information Fusion. Yaakov Bar-Shalom was the inaugural winner in 2015, and the award now carries his name. Only three other individuals have received the award since that time. Further details may be found at https://isif.org/isif-yaakov-bar-shalom-award-lifetime-excellence-information-fusion. The award will be given at the ISIF/IEEE FUSION conference in Charleston SC, USA, in June 2023.

Stefano P. Coraluppi (M'92–SM'08–F'21) is a Chief Scientist at Systems & Technology Research (STR).

He received the B.S. degree in Electrical Engineering and Mathematics from Carnegie Mellon University in 1990, and M.S. and Ph.D. degrees in Electrical Engineering from the University of Maryland in 1992 and 1997.

He has held research staff positions at ALPHATECH Inc. (1997-2002), the NATO Undersea Research Centre (2002-2010), Compunetix Inc. (2010-2014), and STR (since 2014). His research interests include multi-target tracking, multi-sensor data fusion,

distributed detection and estimation, nonlinear filtering, and stochastic control. He has served as Associate Editor-in-Chief for the IEEE Transactions on Aerospace and Electronic Systems, and now serves as Editor-in-Chief for the ISIF Journal of Advances in Information Fusion. He serves on both the IEEE AESS Board of Governors and the ISIF Board of Directors.