RF Industry Icon – Alfonso Farina

Welcome to this RF Industry Icons podcast. I am Pat Hindle and today I am talking with Alfonso Farina, a well-known Italian engineer that pioneered new technology in radar systems and signal processing. He has authored about 1000 papers and noted for work to bridge the gap between industry and academy. He is a fellow with the IEEE and IET with many honors and fellow member of the European Academy of Science. Welcome Alfonso!

1. **You were born in a small town in the Rieti area of Italy, what was it like growing up there?**

I was lucky enough to be born in a village in the center of Italy. A few hundreds living beings including animals and wolves could be heard from afar when it was winter. The village is somewhat famous for the now ruined castle - that saw the tragic story of Beatrice Cenci (Rome 1577– 1599) young Roman noblewoman executed and then risen to the role of popular heroine- an artificial lake below and fresh summer air.
The village is around a square that is crossed by a road, unique at the time. In the summer, a van came with the film projector. The projector on the van was at one end of the square: I seem to still hear the magical periodic noise of the projector. The screen was on the other side of the square, in particular on the fountain where the animals also drank. All the villagers, including us little ones, used to bring their chairs or small seats from home to watch the screening. There weren't many lights, but you could see lots of fireflies and then the stars in the sky. It sounds like the history of Nuovo Cinema Paradiso (1988 film, which won the Academy Award for Best Foreign Language Film), but it was just like that.

If a rare car had to cross the square to follow the road, there was no rush: people stopped to see the film. I believe that the joy we felt has rarely been experienced by today's kids. With this childhood background, I was always looking for arenas where summer films were shown outdoors. My brother has always been a film devourer and he still is, he "drags" me to the cinema a few weekends. I bless Nicolini– politician and full professor in Architecture- for the now vanished invention of the Roman summer (1977), where the projections took place at the Imperial Forums. There was a massive and varied participation, including young mothers nursing their babies! I came directly from the office with my job bag and went to see the screenings.

However, I am going too fast.

2. **You developed a love for rocketry early on, what sparked that interest and what type of work did you do with rockets?**

My family soon moved from the village to near Rome to give us (me and my brother) the opportunity to be prepared to study at the university. I graduated from the brand-new technical institute for electronics “E. Fermi” where I had professors who came directly from university teaching.

In the meantime, “Space conquest” converted me to rocketry. So “my first publication”, dated December 1964 on “Missili & Razzi. Oltre il Cielo” (Missiles & Rockets. Beyond Sky), was about the conception, design and realisation of a 1.5m long rocket, which subsequently I successfully launched, at the age of eighteen, from shooting range of Furbara Air Force Base.

3. **You received a Doctor Degree (Laurea) in electronic engineering in 1973 from University La Sapienza in Rome and did your dissertation on the Kalman Filter – tell us about that theory and how you became interested in it?**

I should add, as I exploited this interest in the Industry and Academia.

Few years later, 1973 …. I got the Electronic Engineering Degree at Rome University "La Sapienza," with Antonio Ruberti, Professor of Automatic Controls - a leading scientist at the international level. Dissertation thesis was about the Kalman Filter (KF). Part of my professional career has been galvanized by KF, an important mathematics jewel for a huge spectrum of applications. Years ago, I had the honor of becoming a friend of Professor Kalman and seeing him and his family periodically.

It occurred that I showed a paper on the connection between KF and *golden section* (yardstick of beauty) to Rudy. He said, ok, though not big news. Eventually, I published on the IEEE Trans on Signal Processing August 2019 on extension of his famous duality theory (i.e.: the optimization in the LQG (Linear Quadratic Gaussian) frame was extended to encompass not only the guidance control law but also the radiated waveform from the radar on board of the interceptor. The optimum values of guidance law and radiated waveform are proportional to the target state estimate provided by the KF. Hopefully Rudy will appreciate this new result.

4. **What was your first job like after graduation when you joined Selenia, a Finmeccanica company then became Selex ES?**

During my military service as Lieutenant, I was assigned to the Air Force Radar Department in Rome. There, I got in touch with Air Traffic Control Systems and radar products of Selenia. I was engaged in some job interviews and then Selenia hired me. I had to study a lot: I met great masters, even gurus I would say, that I recognize as my mentors.
From the very beginnings of my working experience, I was engaged in advances topics, and I had to work hard on IEEE and IEE scientific magazines, AESS Transactions, Microwave Journal and Proceedings of Radar Conferences.
Selenia had a modern and very well-equipped library, which I visited often.

During all those years, I had the opportunity to work on international teams and programs; I met colleagues from companies all over the world. The top management of Selenia engaged me in relevant programs and gave me key roles in Radar and Command & Control Systems of international programs.

I had responsibility of departments of different industrial sites, being head of System Analysis, Chief Engineer and Senior Vice President Chief Technology Officer of my company. Notwithstanding the bureaucracy to manage, I've never given up in technical cooperating, shoulder-to-shoulder, with my colleagues.

5. **You became an expert in many areas of radar technology and pioneered Track While Scan technology, can you tell us about the development of that technology?**

Looking back, the story is quite adventurous. I was about taking my specialization on stochastic filtering theory, when my brand new FIAT 500 car was stolen together with my leather bag, containing my dissertation.
Long story short, once in Selenia I rewrote my dissertation from scratch and this gave me the opportunity to conceive a brand-new tracking algorithm to exploit, in a pulse-Doppler radar, the measurement of Doppler frequency, which is related to the radial speed of the target. I proposed this new approach for mono-radar as well as multiradar tracking (MRT) for fast-track initiation, to avoid track swap when target paths come closer, to mitigate the birth of false tracks.
In addition, I refined the adaptive logic to improve maneuvering target tracking. I introduced into practice one of the first combinations of Interactive Multiple Model (IMM) and Multiple Hypotheses Tracking (MHT) for suitably performing multi-target tracking, and the variable-state IMM (VS-IMM) for Advanced-Surface Movement Guidance and Control System (A-SMGCS).
These algorithms have been pillars of Track-While-Scan (TWS) in clutter environment, helping in maintaining a complete situational awareness.

With a bunch of colleagues (remarkably Sergio Pardini and Antonio Graziano), we worked to have these tracking algorithms on board operational land and naval systems for civilian as well as defense systems.
This effective cooperation led to the conception and practical implementation of the algorithms and processing architectures of the novel -for that time, early 80's- MRT, one of the first realized, at least in Europe, for Air Traffic Control and defense systems. As time passed, it was suitably upgraded with the advent of modern technology and additional sources of information (GPS data, geography, and GIS data for instance) and it continues to be in operation today as a key component of the international air traffic management here in Italy.

The late Dr. Flavio Alessandro Studer, a bright colleague and great friend, followed me into a foolhardy enterprise: to write the first book (1985-1986) ever published about Radar Data Processing, translated also in Russian and Chinese in addition to publication in UK and US.

6. **Passive radar is another area of work, you don't see much talk about this in the US but seems more prevalent in Europe – can you tell us about passive radar technology and it advantages?**

Thank you for this question, Patrick.
About passive radar technology, a good starting point could be my plenary talk "Green Radar State of Art: theory, practice and way ahead" available on IEEE TV, recorded in 2014 during IEEE International Conference on Acoustic, Speech and Signal Processing held in Florence. This talk is counting 1600 views: this is a reference to the increasing interest about this topic.

This conversation with you, Patrick, is a good occasion to me for highlighting the role that radars will have to play in creating a greener, more sustainable and fairer economy.

The point is that, now that radar technology, more than ever, is interacting with many other rapidly developing areas of technology, those of us involved in developing and producing it must combine innovation with responsibility.

From this perspective, passive radar is an interesting technology that may find new and more numerous applications since it has the advantage of not needing to generate and transmit its own radiofrequency signals.
Passive Coherent Location (PCL) is based on locating objects with electro-magnetic transmissions already existing in the environment.

I promoted a development project for a PCL radar at a time when few believed in its potential. In fact, the AULOS® radar that we developed is a so-called 'green' radar that does not emit a radio frequency. It comprises two circular array antennas mounted on a telescopic mast: the first is used to detect flying objects via the reception of FM radio frequencies, while the other one uses DVB-T (or digital video broadcasting) signals. The project began in 2004-2005, and since then, AULOS® has demonstrated the ability to monitor air traffic up to 200km away, proving that it can also be used to track maritime traffic or even drones in flight.

7. What other areas did you work in (SAR, ECCM, Quantum radar, etc.)?

For sure, the Synthetic Aperture Radar Laboratory (LABSAR) experience deserves some words. I coordinated LABSAR together with my colleague, Dr. F. Vinelli, collecting pioneering efforts from different groups in Finmeccanica company to build up technical expertise in the field of SAR for remote sensing, both for civilian and defense applications.
Competence was capitalized on SAR image formation from recorded raw data, platform motion compensation, SAR signal simulation also in the interferometric mode, speckle filtering, fusion of images from different carrier frequencies, polarization and platform sensors, Electronic Counter-Counter Measures (ECCM), and detection and imaging of moving targets by means of the conception, with Prof. S. Barbarossa, of the space-time-frequency algorithm, etc.
Funds were granted by the European Community on an ESPRIT-1 (European Strategic Program on Research in Information Technology) remote sensing project: it was our first success in 1985 in that context. A fund from an institutional organization was earned to support the feasibility project of a miniaturized SAR on board a Remotely Piloted Vehicle.

Concerning ECCM, my involvement dates back to the '70s and it proceeds for years to move from analogue Side Lobe Canceller of a two-dimensional long range surveillance radar to a fully digital parallel technology for adaptive directional interference mitigation in a modern multifunctional phased-array radar today in operation, also on-board foreign navy ships. Successful cooperation with Dr. Luca Timmoneri and other colleagues was pivotal to reach theoretical and practical results. Needless to say, that I am quite proud to have contributed to ECCM chapters, invited by Dr. Merrill Skolnik, in the second and third editions of the Radar Handbook.

I am happy to share also a few words about quantum technology.
In 2008, Professor Seth Lloyd at MIT– who I personally met in 2019 at Waterloo University in Canada- wrote an article on the use of the so-called phenomenon of 'entanglement' between photons for low-light quantum target identification applications using an 'entangled' pair of photons. In theory, the very close correlation created in this case between a pair of photons, which is a purely quantum effect, can be exploited to obtain advantages to identify a target. One photon is transmitted towards the target, while the other is held back in order to measure the correlation at the moment when the transmitted photon returns.

A gain in the order of six decibels in the signal-to-noise ratio has been estimated, which is far from trivial. The quantum regime also gives protection from any interference precisely due to the close correlation between the photon sent and the one held back.

Huge difficulties nonetheless need to be to overcome: the first demonstrator was built with an operative range of fractions of a meter and is not yet capable of measuring distance, speed and angular position. For the system to work, the correlated photons must be generated at temperatures close to absolute zero.

To provide a state of art snapshot, I have co-edited two special issues on Quantum Radar published on IEEE System Magazine in April and November 2020. These reviews open with the key article by Professor J. Shapiro (MIT), a distinguished colleague since 1982.

The potential of quantum technology seems more exploitable in terms of secure and encrypted communications, since any attempt at intrusion is immediately apparent: the mere observation of the quantum state irreversibly alters it, highlighting any attempt by an attacking party to detect the information being exchanged.

8. What lead you later to become a professor at University of Naples and teach?

Since my first day in Selenia, I remember that the cooperation with universities across Italy was very active. Also at times, university professors came from a previous career within the company and continued to share professional interest in radar and to teach courses related to radar.

Personally, I have always promoted this sort of cooperation. Often, I say that half of my “heart” beats for university still today. So, along with my job in Selenia, I had a simultaneous academic role as a professor at the University of Naples. I remember this formal and successful cooperation began in the ’80s.

More recently, I was instrumental in enfolding a framework agreement between the company and Universities to sponsor PhDs on radar studies. The results have been very positive for both sides in terms of technology transfer, formation of young engineers and PhDs, some of which are hired by these companies. Creation of university spin-offs were also achieved. To reiterate the mutual benefits: industry faces concrete technical problems; the University shares mathematical and theoretical means. Jointly we can find advances solutions. I also strongly believe in cross-disciplinary work, a motivation that has led me to cooperate with mathematicians, physicists, and neuroscientists.

I am honored to have been recently appointed President of the Radar & Sensors Academy of Leonardo which is an active bridge between industry, academia governmental institution and customers nurturing continuous professional education within the company.

Also, my current role as Visiting Professor at University College London, Department of Electronics, and at University of Cranfield, witnesses how much I still believe in collaboration between industry and university at international level.

9. **You have been very active with publications and societies like the IEEE and traveled around the world to share your knowledge, what were some of the main activities you lead and awards you won?**

My first technical publication dates back to 1977 on IEEE Transaction on Aerospace and Electronics Systems. Subsequently I have published more than one thousands of papers on journals and conferences. Among these I am pleased to say that about 20 publications are on Microwave Journal and Conferences. During one of these conferences, the 2017 edition of Electronic Design Innovation Conference in Boston, we met again with you, Pat, and we jointly rewarded Eng. Caterina Rapisarda with Outstanding Paper Award entitled "Innovative Algorithm for Wideband Digital Signal Processing in Modern AESA RADAR Architecture".

For my work, I have won numerous national and international awards, I would like to mention some of these.
Young Engineer of the year award, the first Italian to receive it. Subsequently, a few more bright Italian radar researchers received the same honor.
In 2004, I was the recipient, as the team leader, of the first prize in 1st edition of the Finmeccanica Group Innovation Technology award. The winning project was on the practical and successful application of adaptively to an advanced phased-array radar in operation.

Lastly two events, which I am pleased and fortunate to remember, are related to award ceremonies for their relevance, the distinguished celebrities I had the honor to meet, and the gorgeous places where they were held.
The first is the Royal Academy of Engineering International Fellowship award, received from Prince Philip, Duke of Edinburgh.

The other is the D. Picard medal I received at the IEEE Honour Ceremony in Montreal (Canada) in 2010. It was a wonderful week spent with my wife Franca in that beautiful city. At the award ceremony, Dr. Picard, honorary CEO of Raytheon Co., was so kind to write me a letter that was read at the ceremony. It was touching for me because Selenia Company in its beginning cooperated with Raytheon Co. 2010 marked the 50th anniversary of Selenia! What a remarkable coincidence.

10. **What are some of the traits that have made you so successful?**

No doubt: first of all, the supporting love and patience of my beloved wife, Franca. It is the seventh year that I lost her. The loneliness at home is hard to mitigate especially in this pandemic period. However, I feel fortunate. I am still passionate and curious about life. I think that key traits in my life have been exactly these: passion, curiosity and perseverance.
I have been always fascinated by "complexity" which resonates with the visionary statement of S. Hawking: "I think this century will be the century of complexity" (*Complexity Digest 2001/10, 5 March 2001*).

I also commonly blend mathematics, technology, engineering and the history of the People who have made it possible to achieve the results which are crucial for the progress of humanity.

11. **What advice would you give young engineers coming out of university now?**

To the new generations I recommend the power of culture, of knowledge, the wisdom in using them and the ability to cooperate and to seek cross-fertilization. The truth seems omnipresent. Try to challenge yourself by looking for a piece of it.
Let me remember the IEEE Motto: “Advancing Technology for Humanity”. The world in which we live is beautiful but not perfect and often quite unfair. Radar engineers, all humans, and we in general, should do our best to turn the IEEE motto into reality, also thinking to unconventional solutions to solve emerging pressing problems. I try myself to put into practice this approach.

Last March I gave an unconventional point of view about radar system at the IEEE radar conference in New York City: during my plenary speech, entitled “RADAR TECHNOLOGY AND SUSTAINABILITY: How to conjugate innovation and social duties” I illustrated how radar technology – used to be associated to military applications- can contribute to some of the 17 Sustainable Development Goals (SDGs) recommended by United Nations.

As Carl Sagan (1934 -1996) said during his speech in 1994 on “Pale Blue Dot” at Cornell University, Ithaca, NY: “it underscores our responsibility to deal kindlier and compassionately with one another and to preserve and cherish that pale blue dot [the earth], the only home we've ever known”. He referred to a wonderful image captured by Voyager One camera in 1990, at six billion kilometers from earth.

Thank you, Alfonso for joining me today to discuss your career and technology developments. I learned a lot about radar technology and great appreciate you sharing your accomplishments and insights from your life and career. For our audience, you can find more podcasts at podcasts.microwavejournal.com and thanks everyone for listening.