There Is Always A Beginning

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This historical narrative reviews the initiative of a small group of innovators over thirty-five years ago. The result of their efforts was the construction of a laboratory model of the first sidelooking airborne radar to be flown in the United States. At that time there were many doubters, so the principle had to be proven.

Since that time there have been many technical papers and published results of very advanced designs. It is not believed that any data in my report could have a military security classification in view of the great length of elapsed time and the open publication of the details of very advanced designs.

Every engineering project or endeavor has a beginning. Unfortunately some are lost in the mists of time and there are many reasons for this situation. However, it is not the intent of this note to delve into the matter. The real purpose is to establish a starting point for a branch of research and development and to acknowledge the efforts of many persons that contributed to this genesis. The author, having had at that time a direct responsibility for a search radar branch at the Wright-Patterson Air Force Base, Ohio, is presenting this historical resumé as an engineering report for the record.

The high resolution airborne radar program at that time (1950) was classified and it is not known if any of the data to be discussed are still available for detailed analysis. The writer retired from government service (USAF) in 1970 and does not have the resources to defray the cost of reestablishing the myriads of technical details. The purpose of this note is to encourage innovation wherever it may arise.

During WWII, research sponsored by the US Army (Air Corps and Signal Corps) and The National Defense Research Committee resulted in the development and production of an airborne radar AN/APQ-7. Briefly, this equipment was a forward scanning (plus or minus 30 degrees) set operating in the X Band and employed a 16 foot linear array. The antenna was mounted in an airfoil on a B-24 airplane and was scanned by a mechanical phasing device.

In the post World War II period (1946-50) a continuing investigation of techniques for higher resolution airborne search radars was conducted. The very beginning of proving the feasibility of side-looking techniques goes back to 1949-50 (almost 40 years) when W.J. Sen and Carl Wiley (Pioneer Awardee in 1985, posthumously) proposed flying a 50 foot y band linear array in a side-looking mode. The establishment of side-looking as a viable technique led to the later important development of the synthetic aperture radars. The early linear array SARs were developed because they could provide in-flight processing for real-time reconnaissance data. Installation of a linear array into the leading edge of an airplane wing was aerodynamically, mechanically and electrically not feasible. It seemed plausible, at that time, to mount a linear array into the side of an airplane fuselage and allow the forward motion of the plane to provide one dimension of the scanning while the pulsing of the transmitter would provide the other dimension. Thus, a continuous rectilinear display or strip would be provided. A number of objections were raised but they could be overcome by careful design. First, the antenna beam must be normal to the ground track, or the radar return data must be corrected for crab angle on a continuous basis. For example, if the range is established at 15 miles for a recording media of 3 inches in width (5 miles per inch) then the speed of the recording must be varied such that 3 inches of the media will have passed through the recorder while the aircraft has traveled 15 miles. It is obvious that similar equipment could be provided on each side of the aircraft such that a 30 mile strip could be mapped. The familiar attitude hole would become an altitude "track" or gap.

Attempts were made to simulate the "side-looking" idea in an Ultrasonic Trainer AN/APQ-T1 that was used in WWII for training B-29 air crew members. The scale factors were such that this approach was not feasible.

A flying full scale model was constructed with components on hand in the laboratory. An APQ-13 Transmitter-Receiver was coupled to a 16 foot linear array as previously described. Not having ground track stabilization on such a crude design, the airplane pilot would be asked to fly at zero crab angle and minimum roll angle. The recorder proved to be a problem. Several film strip cameras were available from a photographic reconnaisance laboratory but would require extensive and time-consuming modification. Then, it was decided to use a commercial facsimile printer since its speed was easily adjustable and a direct readout would be provided, that is, the line scan could be viewed simultaneously with the range scan of the radar while flying. A serious objection was the lack of data storage as would be provided by photographic film. The exact numbers cannot be recalled, however, the transmitter pulse repetition rate was many times the line scan rate of the printer, such as, possibly 1000 to 1. Thus, only a small fraction of the return signal would be utilized, the remainder being wasted. For the purpose of proving or disproving a principle the printer would be satisfactory.

Numerous radar engineers doubted the usefulness of side-looking radar even if the system performed satisfactorily. It was agreed that the usual bombing and fire control requirements could not be met with side-looking. What was propopsed: a reconnaisance and mapping technique, useful at night and above cloud cover, and in the presence of haze or fog. It was not proposed to replace aerial photogrpahy but to supplement that technique to aid in interpretation. Also, it was believed that important geophysical features could be determined.

The side-looking test model was installed in a B-29 airplane and a flight was made over the Detroit area in early 1950. To the amazement of everyone concerned, the "lashup" worked on the flight and the first flight in the United States. The aircrew members were immediately aware of the excellent results due to the employment of the facsimile printer. The results were so gratifying that further research and development was undertaken. The objections to side-looking radar had vanished.

Research models operating in X, Ku, and Ka bands were constructed during the succeeding three or four years. All these systems used linear arrays of from 16 to 50 feet in length. Synthetic aperture side-looking radars entered the picture in the late 1950's.

In the ensuing 35 years the state of the art for side-looking radar has advanced to the extent that the public press has reported its use in space by several countries. Certainly, airborne side-looking radars are probably in extensive use. If the reader is interested further the following references should be examined:

"Side-looking Airborne Radar," **Scientific American;** Vol. 237, pp 84-95, October 1977, H. Jensen, et. al. (Good discussion of the principles as well as of coherent optical processing techniques)

Aviation Week, May 8, 1967 (Excellent photographs of side-looking radar results utilizing linear arrays—Westinghouse)

Goodyear Aerospace-Arizona Division has distributed pictorial results from their synthetic aperture radar at technical meetings.

From the 1989 ***IEEE Directory:***

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