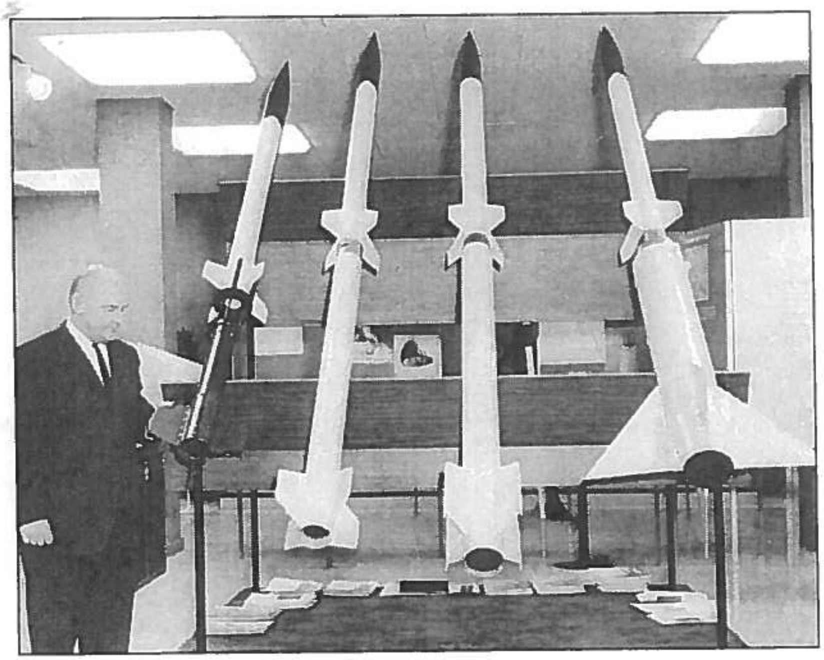
BOOSTED ARCAS

The first effort to boost a conventional meteorological rocket to higher altitudes began in 1960 when the U.S. Army Electronics Research and Development Activity (USA ERDA), White Sands Missile Range, funded Atlantic Research Corporation to provide a booster motor for the Arcas. However, since the ARC booster provided only a 10 to 20 percent increase in altitude, it was determined that a more powerful booster would be required, preferably at a lower cost. In 1962 the U.S. navy at Pacific Missile Range (PMR) and USA ERDA entered a joint program to stage the Arcas with HVAR and Sidewinder five-inch aerial rocket motors as boosters. The U.S. Navy and PMR designed the interstage coupling and launch rail. Flight tests were conducted at WSMR. Because of possible grain retention problems in the standard Arcas, the system was designed for simultaneous burning of both stages, as with the ARC booster. On a later Sidewinder-boosted Arcas firing conducted at White Sands Missile Range used an improved method for head-end bonding for retention of the grain, and a successful flight using a delayed second stage ignition was achieved.



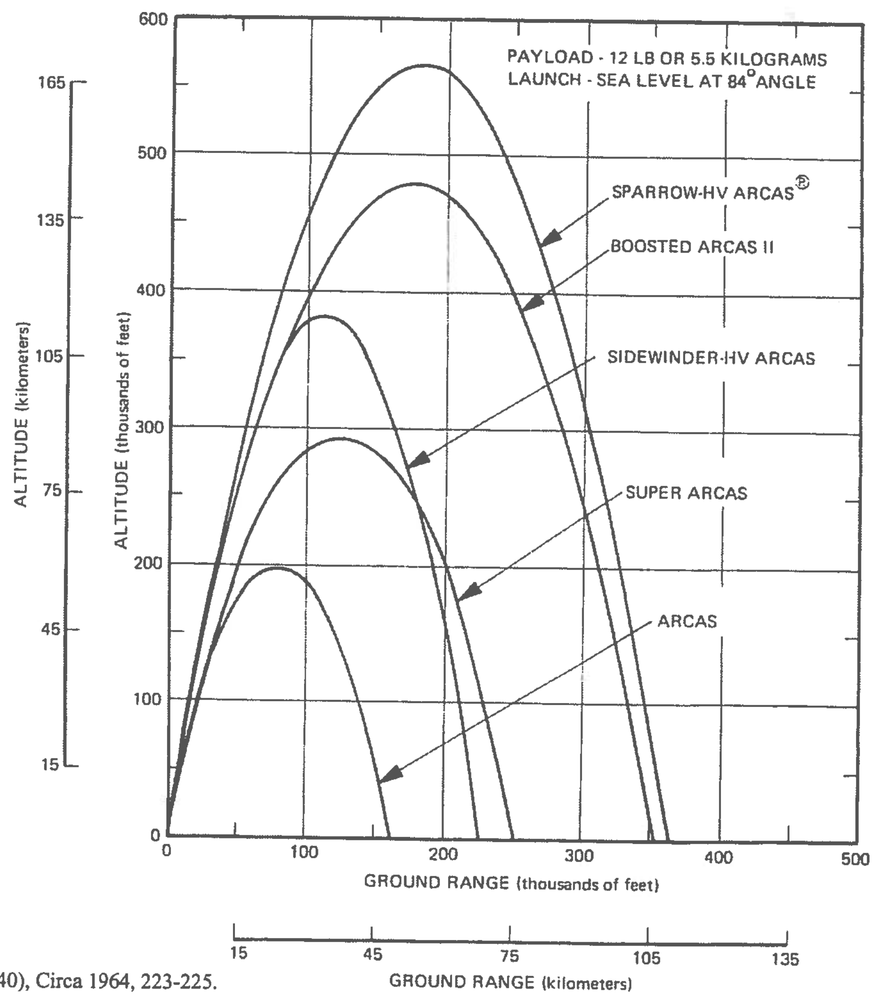
BOOSTED ARCAS Sounding Vehicles
Photo courtesy of Chadwick Coombs

ACTUAL PERFORMANCE OF THE BOOSTED ARCAS

Booster Type	Payload Wt. *(Lbs)*	Effective QE *(Degrees)*	Peak Altitude *(Ft)*	Peak Time *(Seconds)*
ARC-booster	12.0	84	324,000	156
HVAR-booster	10.5	85	385,000	155
Sidewinder booster (Simultaneous burning)	12.0	83	424,000	175
Sidewinder-booster (With second stage coast phase)	12.25	83	490,000	190
Sparrow-booster	15.2	83	520,000	205 [149]

BOOSTED ARCAS
Vehicle Performance Comparison,
Atlantic Research Corp. Brochure

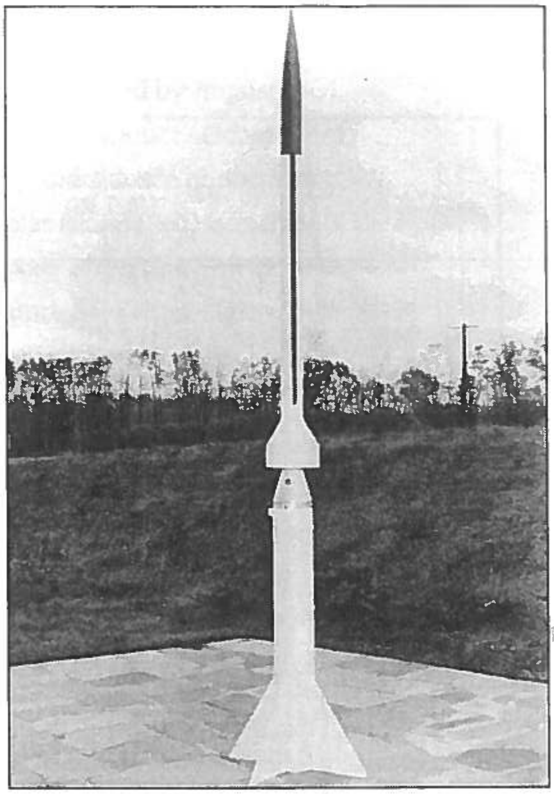
Courtesy of Betty Flowers
Wallops Island, Virginia



149. Thiele (Report N65-33640), Circa 1964, 223-225.

6. DENPRO (SPARROW-HV-ARCAS) VEHICLE

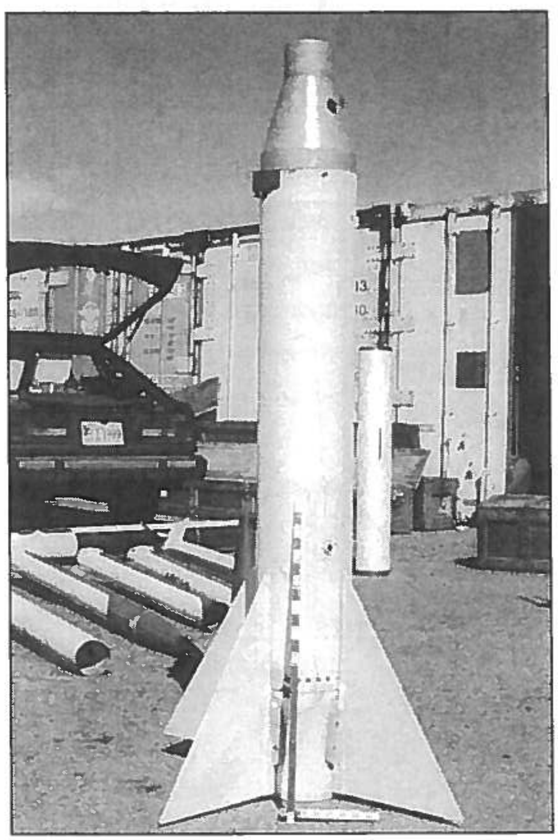
The Sparrow-Arcas combination was originally developed for the Pacific Missile Range Density Probe (DENPRO) program. The vehicle's performance capabilities and reliability for probing the mesosphere and lower ionosphere were demonstrated by both navy and air force experimenters at several U.S. ranges.



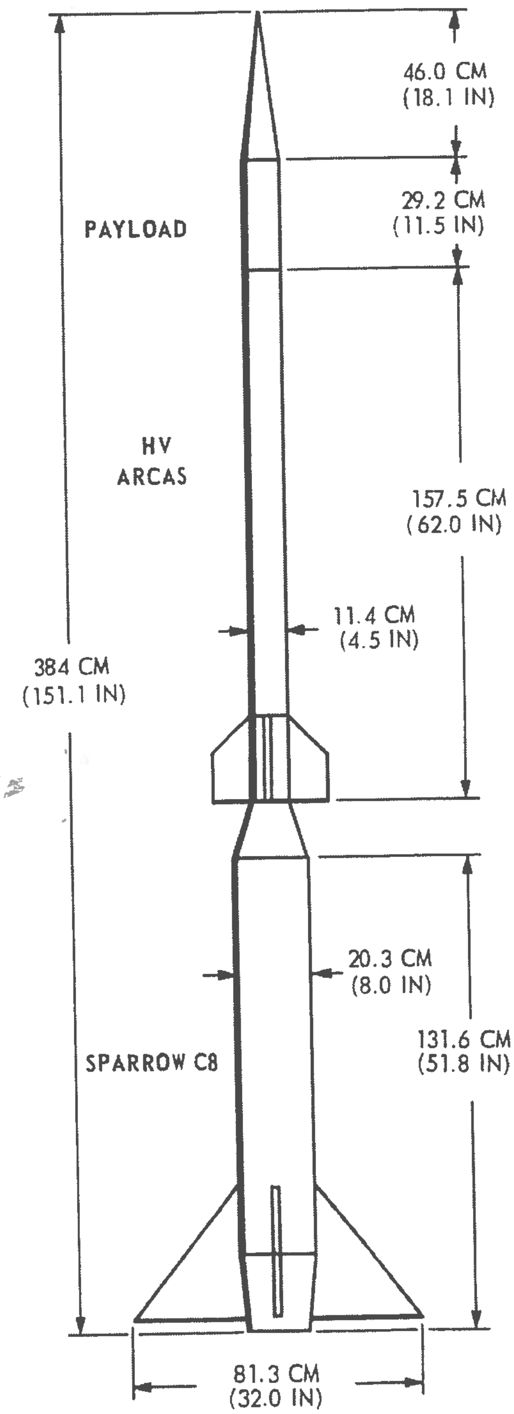
SPARROW-HV ARCAS
Coloring: Sparrow booster-white; interstage coupling-natural aluminum; HV ARCAS motor & fins-white; payload, nose-red; two body stripes 180° apart-red

Photo courtesy of Lt. Col. Roy F. Houchin II

Efforts were made to scale down the Nike-Cajun vehicle and the measurement techniques associated with it. A small program using developed vehicle hardware was undertaken. The Sparrow Mk 6 Mod 3 navy-developed rocket motor was selected as the booster. A standard Arcas, strengthened to withstand the acceleration of the Sparrow booster, was selected as the sustainer motor. Modifications to the Arcas were special grain wrapping and head plate bonding to overcome the initial *g* forces of liftoff and shroud-mounted titanium fins to withstand the increased aerodynamic stresses.



SPARROW BOOSTER at Atlantic Research Corporation storage containers
Photo courtesy of Lt. Col. Roy F. Houchin II



SPARROW-HV-ARCAS
General Dimensions
Atlantic Research Corporation Marketing Brochure

The purpose of this development was:

1. To use existing proven gauge techniques to provide density measurements on the ascending leg of the trajectory.
2. To retrieve the telemetered meteorological data and ranging information through modified AN/GMD ground equipment.
3. To put together a vehicle capable of carrying the selected gauge payload or the sphere developed for the PRESS program at Kwajalein.

The Nike-Cajun served as the workhorse for many years in the scientific exploration of the stratosphere, mesosphere, and ionosphere after its development for the International Geophysical Year (IGY). But 10 years later, the Sparrow-Arcas required less sophisticated range facilities making it more suitable than the use of the Nike Cajun for gathering data for the MRN. The experiments and payloads carried by the Nike-Cajun and later by the Nike-Apache vehicles pioneered the direction in which hardware would be developed for the smaller meteorological rockets. Two such payloads were the inflated falling sphere and pressure/density gauges.

The general specifications for the Sparrow-Arcas combination required that the payload carried be capable of measuring density by the Pitot tube gauge technique on the ascending leg of the rocket trajectory between altitudes of 140,000 and 350,000 feet. The Denpro Payload sealed the sensing element during prelaunch operations and vehicle ascent, exposing the sensors only at a predetermined altitude. The selection of the capacitance diaphragm gauge governed the requirement that the rocket must have a velocity of approximately Mach 4 through the region of measurement. Furthermore, the rocket had to have a stability factor that provided less than a 10-degree angle of attack at 350,000 feet.

Ten flights of the Denpro vehicle had been conducted by August 1964. The first two flights were conducted by the Environmental Sciences Department at WSMR in October of 1963 to verify vehicle velocity and altitude performance. The next eight were conducted from the Saint Nicholas Island (SNI) launch pad, at an elevation of 700 feet above sea level. The purpose of the first four of these latter flights was to check the vehicle performance under sea-level flight conditions and to determine the angle of attack by a differential pressure gauge probe, which was substituted for the density probe. The payload in these flights simulated the final density payload as closely as possible. Telemetry packages were operated to determine if they would survive the shock imposed by the launch. The telemetry package transmitted the differential-pressure measurements which provided information on the angle of attack. Ranging for velocity and position measurements of the probe was not included in the first four flights. The gross payload weighed 12.7 pounds, and the coast time between the booster burnout and the sustainer ignition was six seconds.

Two complete density payloads were flown on May 1 and 8 from SNI. Ranging data were obtained on both flights and both vehicles were tracked to splash by the AN/GMD-2. The AN/FPS-16 did not track the payload beyond 200,000 yards slant range. The gross payload weight of the Pitot tube probe was 14 pounds.

Another phase of the program was to substitute the Nike-Cajun 26-inch diameter inflatable sphere as a payload in the nose cone of the HV-Arcas. This was accomplished on flights 7 and 8 from SNI. The payload weight and center of gravity (cg) were identical to those of the density probe payload. The first flight from which the sphere was ejected was successful. The radar acquired and tracked the inflated 26-inch metalized sphere. Density and temperature data were derived from the radar track on both the up leg and the down leg trajectory.

The last and eighth flight of the series at SNI was not successful because of a malfunction of the HV-Arcas sustainer rocket. Observers reported that it appeared that the sustainer motor stopped burning after about four seconds. While there was no solid evidence to substantiate the cause of this apparent failure, there was a definite malfunction of the sustainer vehicle[151] All told, there were probably 50 Sparrow-Arcas vehicles flown. [152]

151. Masterson and Wallston, Circa 1964.
152. Coombs (*AIAA paper*), 1998.

VEHICLE DATA

FIRST-STAGE MOTOR (*MK 6 Mod 3 Sparrow C-8*)	
Principal diameter	8.0 in
Overall length	51.8 in
Igniter type	glow plug
Recommended firing circuit	30 amp
SECOND-STAGE MOTOR (*MARC 2C1 HV ARCAS*)	
Nominal performance rating	29-KS-324
Principal diameter	4.5 in
Overall length	62 in
Igniter type	pyrotechnic with 8-second delay squib
Recommended firing current	7 amp
WEIGHTS (LESS PAYLOAD)	
Gross launch weight	206.0 lb
Second-stage ignition	67.5 lb
Second-stage burnout	24.4 lb
Maximum altitude (12 lb payload, 84 ° QE, sea-level launch)	570,000 ft
PAYLOAD CAPACITY*	
Weight	10-30 lb
Diameter (maximum)	4.25 in
Length (nominal)	26.0 in
Volume (nominal)	305 in^3
Maximum acceleration	39g
Burnout velocity (second stage)	5500 ft/ sec
Time to apogee	212 sec
Gross launch weight (less payload)	206 lb
Overall length	151.1 in

*The payload length and volume capacities stated were those for standard vehicle hardware. Longer and larger-volume payloads could be flown. Payload weight limits were fixed by vehicle stability requirements and included the weight of the nose cone and cylindrical payload housing section (approximately 0.9 kg). Fin assemblies were preset to provide approximate spin rates of 8 or 20 rps at second-stage burnout. The launch system was a 15-foot-long rail assembly designed for mounting on an adjustable-boom launcher of the type available at most launch sites. Assembly and launch preparation required no special handling equipment and could be accomplished by a two-man crew. Power for ignition of both stages was provided by a ground source, a motion switch completing the second-stage firing circuit only after positive booster ignition. A delay squib in the second-stage igniter allowed for a coast time of 6 seconds between burnout and second stage ignition.[153]

153. Atlantic Research Corporation, Propulsion Division, Upper Atmosphere Sounding Vehicles, Vehicle Data, Sparrow-HV-Arcas.