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FEASIBILITY STUDIES OF DIRECT VOICE BROADCAST SATELLITES

by Perry W. Kuhns

Lewis Research Center

Cleveland, Ohio

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ABSTRACT

The results of two voice broadcast satellite studies undertaken in 1966-67 are summarized. These studies included audience and receiver analyses, conceptual spacecraft configurations, technological evaluations, cost evaluations, and data of indigenous noise surveys.

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SUMMARY

The results of two voice broadcast satellite studies undertaken in 1966-67 are summarized. These studies included audience and receiver analyses, conceptual spacecraft configurations, technological evaluations, cost evaluations, and data of indigenous noise surveys.

INTRODUCTION

During the past few years the use of satellites for direct broadcast transmission to the earth has become a matter of increasing interest (refs. 1 and 2). As part of the continuing study of communication satellite applications by NASA, voice broadcast studies were performed for NASA by the General Electric Company (ref. 3) and the Radio Corporation of America (ref. 4).

These studies had the following objectives:

(1) To determine the technological and cost factors affecting the feasibility of direct broadcast of aural programs from an unmanned satellite with a minimum expected life of two years to home receivers in the early 1970's

(2) To evaluate the technological requirements of such a mission and the extent of advances in existing technology required

(3) To determine the cost factors for such missions

The following major constraints were also placed on the studies.

(1) Broadcast to unmodified receivers only

(2) Broadcast a minimum of 1 hour per day to a given area on repeated schedule

(3) Use the following frequencies, modulations, and receivers:

(a) High frequency (HF) (band 7) 15 to 25 megahertz, AM modulation, to "short wave" receivers

(b) Very high frequency (VHF) (band 8) 88 to 108 megahertz, FM modulation, to home FM receivers

(c) Ultrahigh frequency (UHF) (band 9) 470 to 890 megahertz, FM modulation, to UHF television receivers

Major factors which would affect the characteristics and costs of the spacecraft were considered, analyzed, and evaluated. Among the factors considered were the following:

(1) Mission

(a) Audience, including receiver distribution, language differences, and geographic areas

(b) Signal quality, signal-to-noise ratio

(c) Noise, manmade and natural

(d) Broadcast frequency

(e) Broadcast time, duration, and repetition

(f) Time period for mission implementation

(2) Technology

(a) Propagation effects due to atmosphere and ionosphere

(b) Satellite antenna and transmitter

(c) Satellite prime power source and thermal control

(d) Satellite attitude control and station keeping

(e) Launch vehicle and ascent trajectory

(f) Ground-to-satellite communications

In addition to the feasibility, technological, and cost studies the contractors performed measurements of indigenous radiofrequency noise levels to aid in determining spacecraft power requirements.

The objectives of this brief summary are to make available to a larger audience the results of these studies and to reference programs in NASA which support the broadcast satellite technology. These programs ran either in parallel with the GE and RCA studies or were started subsequent to them.

FEASIBILITY STUDIES

Method

Mission, communications and spacecraft technology, and spacecraft configuration analyses were performed to define feasible spacecraft configurations capable of meeting the mission objectives. An evaluation of the performance capabilities of these configurations was made. The preferred approaches were selected, and detailed analyses of the selected configurations were carried out.

An audience analysis was performed to define representative broadcast missions. The present worldwide distributions of receivers in the three frequency bands was evaluated, and the numbers and their distributions were extrapolated to the early 1970's assuming that the number, distribution, and characteristics of these receivers were unaffected by any knowledge of a future space system. The sensitivity of present receivers manufactured in the USA and in other world areas was evaluated by using the present world standards, where applicable, and data obtained from the respective contractor's consumer products division. The time(s) of broadcast and duration(s) were used to define the required satellite orbits. These analyses, together with a study of radio wave propagation effects, were used to define the satellite performance requirements.

A technology evaluation of the various satellite subsystems was performed, and the results were used to define conceptual configurations which could meet these requirements, as well as launch date and life constraints. Preferred approaches at each frequency were selected, and detailed analyses of the spacecraft designs, performance, and cost were made.

Field Strength

The required field strength for reception is determined by the following factors:

(1) Required signal-to-noise ratio (S/N)

(2) Receiver sensitivity or gain

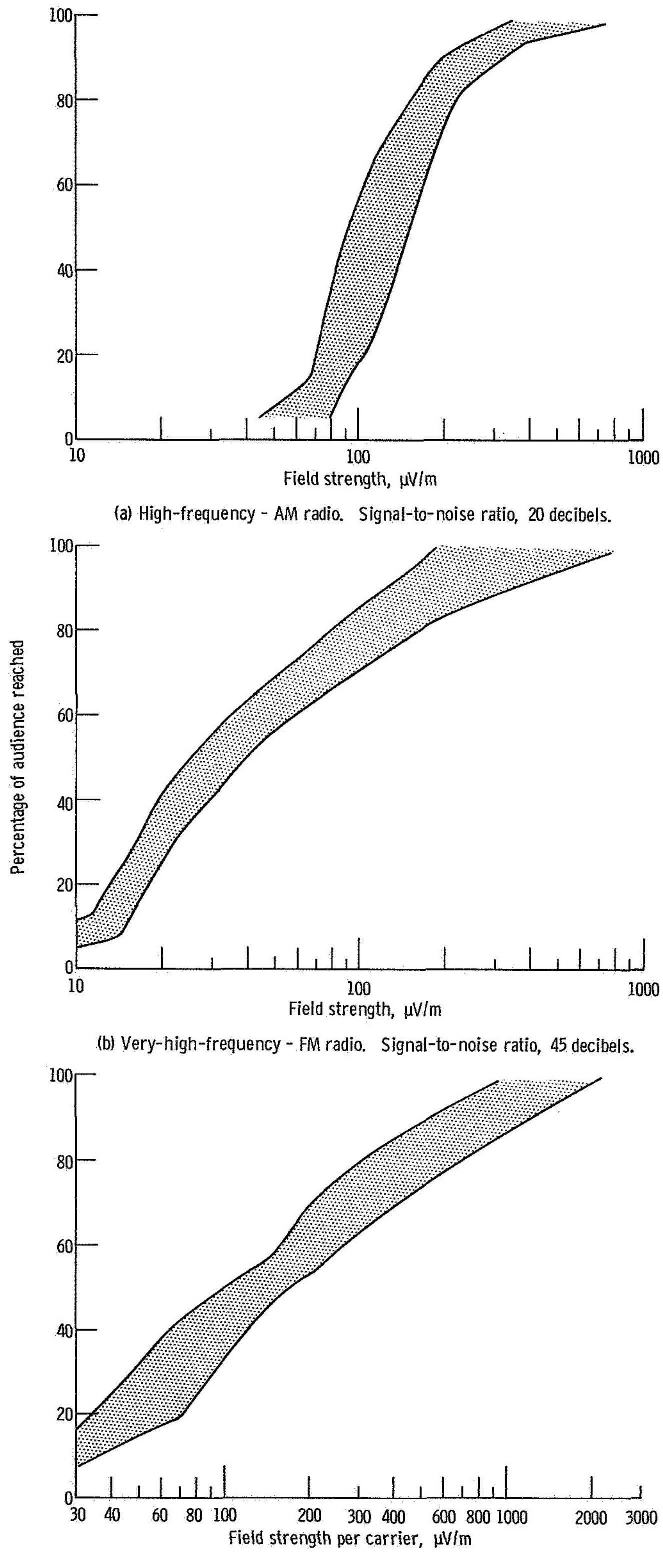
(3) Antenna gain

(4) Building attenuation

(5) Indigenous noise

To be viable the broadcast satellite service must offer to the listener a quality of reception equal to or superior to that now received using terrestrial services. Using information from domestic and international sources the contractors determined that the HF service, which is primarily voice, should have a signal-to-noise ratio of 20 decibels or above. The same information sources were used to determine that the VHF, which contains a high percentage of musical content, should have signal-to-noise ratios above 40 decibels, while UHF services should have signal-to-noise ratios equal to or above 30 decibels.

To design a spacecraft which will be the most cost effective in reaching a chosen audience it is necessary to know not only the values of the above field-strength factors but also the statistical weighting of these factors and their geographical and economic distribution. While these factors are known or can be determined to a degree of certainty, the weighting and distribution of the factors depends upon detailed inputs which were considered to be beyond the scope of these studies. However, considering many likely



(a) High-frequency - AM radio. Signal-to-noise ratio, 20 decibels.

(b) Very-high-frequency - FM radio. Signal-to-noise ratio, 45 decibels.

(c) Ultra-high-frequency - FM television receivers. Signal-to-noise ratio, 30 decibels.

Figure 1. - Percentage of audience reached as function of outdoor field strength.

missions an envelope curve of audience reached can be constructed. Both contractors did this using slightly different approaches.

Figures 1(a) to (c) summarize the results of both contractor's estimates as to the percentage of audience reached as a function of outdoor field strength. For all cases table model receivers were assumed. The quality of receivers varies from expensive table models with high-gain outdoor antennas in a rural environment at the low-field-strength end to inexpensive table models with low-gain indoor antennas located in an urban environment at the high-field-strength end. The field strength per carrier required for UHF audio reception by television sets using intercarrier sound systems is given. Calculations by the contractors determined that in this case it is necessary to broadcast equal strengths on the video and audio carriers.

The envelope curves of figures 1(a) to (c) are for a given signal-to-noise ratio. The effect of a signal-to-noise ratio above those given on the required field strength and audiences can be estimated by the relation

$$\text{Field strength(in } \mu\text{V/m)} \propto \sqrt{\text{antilog S/N (in db)}}$$

A lower signal-to-noise ratio for FM receivers may require operation below FM threshold. In all cases the number of available listeners may decrease because of the poorer quality of reception. This may be especially true for HF broadcasting where surveys have indicated that many listeners tune to the least noisy station with little regard for program content.

Propagation Effects

The four major propagation effects due to the ionosphere were determined to be scintillation, attenuation, reflection, and Faraday rotation. Scintillation is due to scattering by irregularities in the ionosphere and causes fading of the received signal. Attenuation is due to collisions of free radiofrequency-excited electrons in the ionosphere with atomic and molecular constituents of the atmosphere causing a transfer and absorption of energy. Reflection occurs when the electron density is such that the critical frequency exceeds the radiation frequency. These three effects are so deleterious at HF that some broadcast areas, times, and frequencies are excluded. At VHF and UHF the total of these effects is a propagation loss of less than 1.0 decibel. Faraday rotation causes a rotation of the transmitted radiation in the plane of polarization as it passes through the ionosphere. It was determined that transmission using circular polarization would be necessary at HF and VHF because of Faraday rotation. This would mean an

TABLE I. - SUMMARY OF MAJOR CHARACTERISTICS OF SELECTED CONFIGURATIONS

Characteristic	Band 7 (15 - 20 MHz)		Band 8 (100 MHz)		Band 9 (800 MHz)	
	Configuration					
	A	B	C	D	E	F
Orbit	Medium, 4.8 hr	Medium, 6 hr	Geostationary	Geostationary	Geostationary	Geostationary
Mass, kg	2140	2500	1180	1090	500	1320
Prime power, kW	15	15	11	5	2.5	10
Antenna type and size, m	Array 30.4 × 30.4	Vee-booms, 60.8 long	Array 15.6 × 15.6	Parabola, 23 in diameter	Parabola, 6.72 in diameter	Parabola, 9.15 in diameter
Antenna gain, db	14.4	15	26.9	25	33	35
Transmitter output, kW	8.8	9.0	7.07	2.5	1.15	4.0
Transmitter type	Solid state	Solid state	Solid state	Solid state	Tube	Solid state or tube
Power supply type	Orientated solar array and batteries	Oriented solar array				
Attitude control type	Three-axis, active					
Effective radiated power, dbW	52	54.5	65	59	64	71
Field strength, $\mu V/m$	158 to 433	150 to 430	204 to 273	100 to 140	99 to 144 per carrier	200 to 250 per carrier
Potential audience in 1970	300×10^6 Home receivers in the world		98×10^6 Home receivers in the world		67×10^6 television receivers in the United States	
Area of coverage	5×10^6 sq km		Continental United States continuously except when spacecraft in shadow		United States by time zone, 5 hr to each time zone each day	
Percentage of audience reached	13 Maximum in four areas of the world	5 Maximum in one area of the world	90 of the United States	65 of the United States	35 of the United States	55 of the United States

additional 3-decibel loss since the receiving antennas at these frequencies would be plane polarized.

All calculations were made for a period of low sunspot activity. Broadcasting at HF during a period of high sunspot activity would be technically difficult and costly from the standpoint of necessary transmitted power.

Configurations

During the early part of the studies a number of configuration concepts were considered for each frequency based upon broadcast time, orbit, and audience. From these concepts four configurations of each contractor were chosen for more detailed study. A summary of the major characteristics of three of the four selected configurations of each contractor is given in table I. Shown in figure 2 is a size and shape comparison of

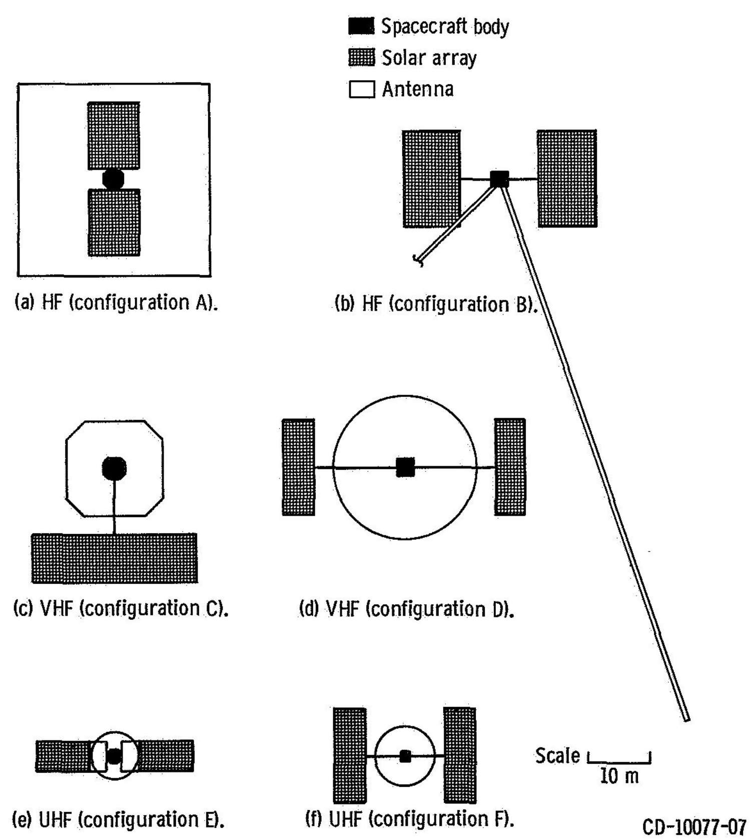


Figure 2. - Size comparison of voice broadcast satellite configurations.

these configurations. The other configurations, which are not reviewed, were for a subsynchronous altitude VHF satellite, which while inexpensive could neither fulfill all the goals of the study nor compete economically with the synchronous VHF configurations.

HF configurations. - These configurations were designed to broadcast for a minimum of 1 hour to selected areas on a daily repeat schedule. A sketch of one of the configurations is shown in figure 3. Weight optimization of the configuration with orbit altitude as a variable determined the optimum orbits to be in the medium-altitude range. Since continuous transmission was neither necessary nor possible, energy storage batteries were used in one configuration (A) to lower the size of the solar array and the attendant costs.

Scintillation, absorption, and reflection effects limit most of the broadcasting to the upper portion of the HF band where only a small fraction of present "short wave" receivers are usable and to those receivers located between latitudes of 45N and 45S. The result is that although these satellites may be capable of reaching 80 percent of the total receivers in the selected areas at a signal-to-noise ratio of 20 decibels under favorable conditions, the actual percentage of total receivers reached much of the time

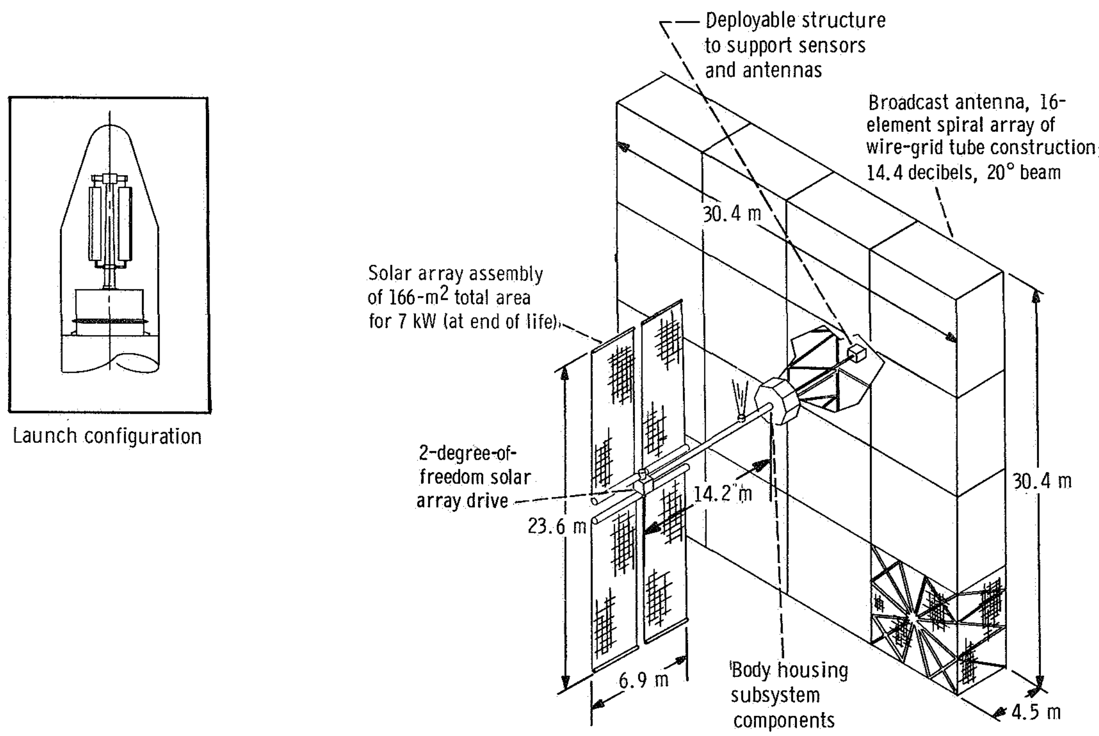


Figure 3. - High frequency (configuration A). Carrier frequency, 15.1, 17.7, 21.45, or 25.85 megahertz; radiofrequency bandwidth, 10 kilohertz; modulation, AM; effective radiated power, 1 decibel referred to 1 watt; satellite weight, 2140 kilograms. (From ref. 3).

will be 10 percent or less. In addition, the total number of receivers in areas selected represents only 5 to 15 percent of the known world total in 1970. One contractor gained a larger potential listening audience by broadcasting to four areas per day and by including frequency diversification in the configuration.

In order that the solid-state output devices would operate at the highest efficiency, digital switching techniques for amplitude modulation signals were used.

VHF configurations. - These configurations were designed to broadcast simultaneously to VHF-FM home receivers in the United States of America for a minimum of 22 hours daily. A sketch of one of the configurations is shown in figure 4.

It was determined from receiver growth studies that the United States would contain 98 million, or 75 percent of the world total of, FM home receivers in 1970, of which a substantial fraction (65 to 90 percent) could be reached by these configurations at a signal-to-noise ratio of 45 decibels. In addition, a substantial number of inexpensive transistor AM-FM portables could be reached when they are used outside.

Propagation losses are negligible at these frequencies; however, as stated before, because of Faraday rotation in the ionosphere a 3-decibel loss was accepted for using linearly polarized antennas to receive circularly polarized radiation.

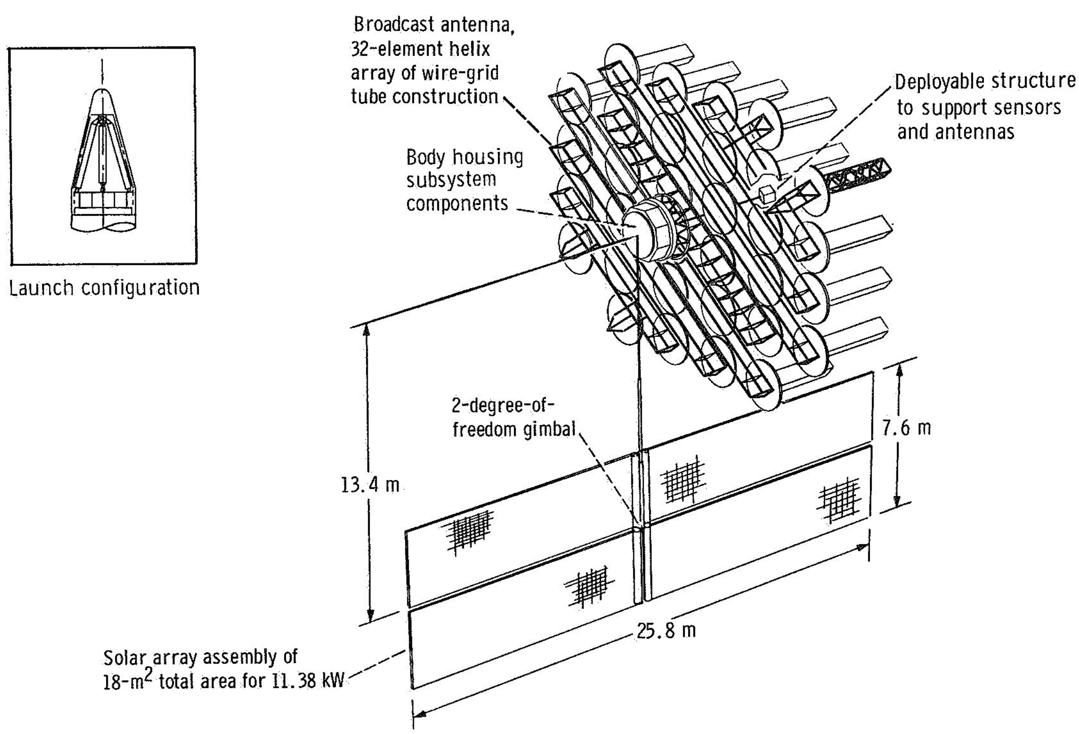


Figure 4. - Very high frequency (configuration C). Carrier frequency, one channel in 100- to 108-megahertz band; radiofrequency bandwidth, 180 kilohertz; modulation, FM; effective radiated power, 65.4 decibels referred to 1 watt; total weight, 1180 kilograms. (From ref. 3).

UHF configurations. - The UHF configurations were designed to broadcast audio material to unmodified television sets in the United States. The instantaneous coverage area is a single time zone with each of the time zones covered sequentially. Broadcasting is continuous except when the satellite is in the Earth's shadow. Because the vast majority of television sets in the United States use intercarrier sound IF amplification, both the video and audio carriers must be transmitted. This results in a fourfold increase in power over the usual audio FM transmission. A sketch of one of the configurations is shown in figure 5.

From receiver growth analysis it was estimated that the United States would contain 67 million UHF television sets in 1970, about 55 percent of the world total at that time. The UHF satellites configured were expected to be able to reach 30 to 55 percent of this audience with a signal satisfactory for an unweighted signal-to-noise ratio of 31 decibels.

Again, propagation losses are negligible but a 3-decibel loss was accepted for circularly polarized reception by linear polarized antennas. At these frequencies helix antennas could be manufactured at moderate cost, negating the 3-decibel loss.

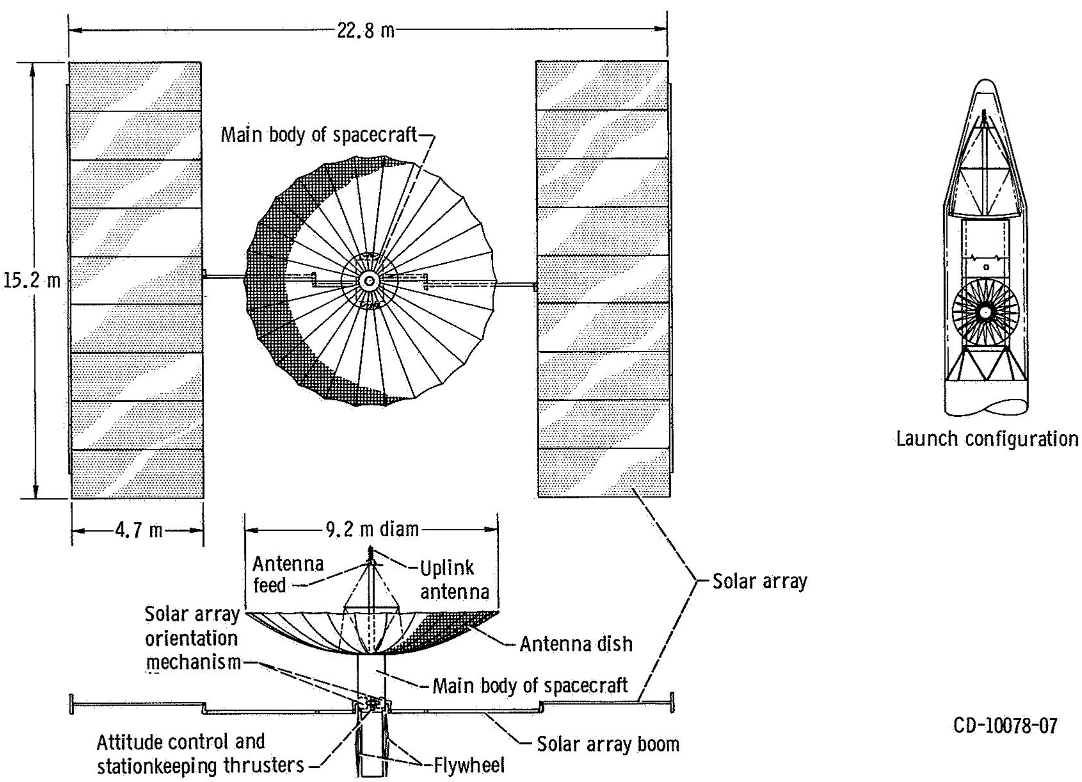


Figure 5. - Ultra-high frequency (configuration F). Frequency, 800 megahertz; modulation: audio carrier, FM; video carrier, unmodulated: coverage, United States by time zone; total weight, 1320 kilograms; effective radiated power, 71 decibels referred to 1 watt. (From ref. 4).

TECHNOLOGY EVALUATION

As part of the studies the present and projected (to early 1970's) technology status of the various satellite subsystems was evaluated. Several subsystems were found to require either a substantial extension of the present state-of-the-art or a long lead time for design, construction, and testing.

Prime Power

All types of prime power systems were considered, including nuclear, solar electric, battery, solar thermal, and fuel cell. The weights of the systems considered as a function of power level are shown in figure 6.

From cost, weight, and technological evaluations of the systems, solar arrays were determined to be the only practical power source for all the configurations (ref. 5). The high power to be used on all these configurations necessitates the lightest possible solar array that is consistent with deployment reliability and two-year life.

One contractor used a lightweight rollout array, deployed by means of extendable tubes, which mounts standard silicon cells on a thin flexible film. The other contractor

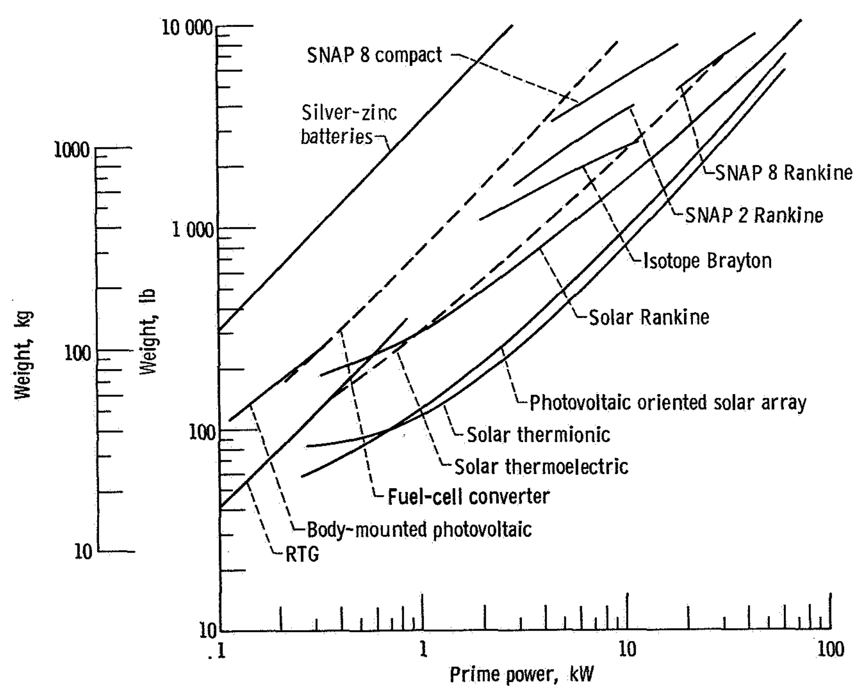


Figure 6. - Estimated weight against prime power for power subsystems. (From ref. 3).

used a lightweight foldout array. Both of these array types have packaging, deployment, and thermomechanical problems which must be solved by full-scale modeling and testing before they can be considered reliable enough for space use. Although space-tested solar arrays are limited to less than a few kilowatts, extension of present solar arrays to the 2.5-kilowatt array of UHF configuration E would be practical. Also the weight penalty placed upon this configuration by the use of a less advanced array would be too severe.

The NASA is at present sponsoring a number of studies on lightweight arrays which would be applicable to broadcast satellite missions (refs. 6 to 9). These studies are centered about arrays using standard cells on lightweight support structures. The NASA also is sponsoring efforts for the development of thin-film solar arrays (ref. 10) which could further lower array cost and weight.

Power Conditioning

The power-conditioning equipment must supply the power (which may be as high as 15 kW) to the final stage of the transmitter amplifier and approximately 300 additional watts for housekeeping. The power conditioning is greatly simplified in those cases where the final output stage is a transistor array, as the supply voltage will be at or near the solar array voltage. In cases where tubes such as klystrons are used, the supply voltage will have to be in the thousands of volts. These high voltages may necessitate new and unusual construction techniques for the power-conditioning equipment. A diagram of the power subsystem of one of the configurations (configuration E, table I) is shown in figure 7.

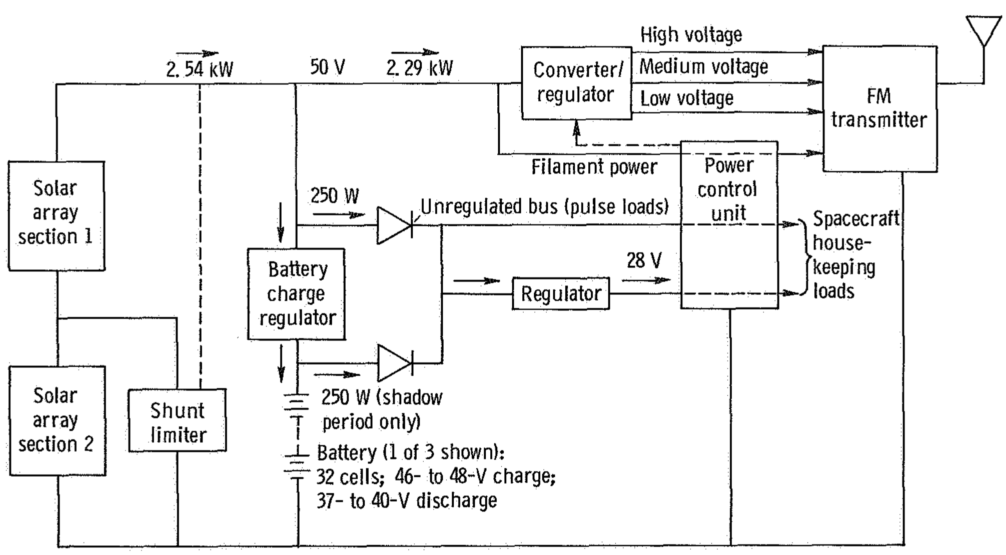


Figure 7. - Power subsystem block diagram for UHF configuration. (From ref. 3).

Transmitter Output Devices

At HF and VHF frequencies all configurations used solid-state devices in the final output stage. The estimated power output capabilities of such devices as a function of time and frequency is shown in figure 8. The devices with output powers in the hundreds of watts would be arranged in arrays mounted on either the spacecraft body or the antenna. For HF-AM a method of digital synthesis of AM signals, as shown in figure 9, was used so that the transistors would operate at all times at the highest possible efficiency.

At UHF, the triode, the klystron, and solid-state devices were all choices for the output stage (refs. 11 and 12). While triodes and kylstrons would have higher efficiencies than solid-state devices, the lower voltage requirements of the latter make them attractive.

Because the efficiency of the output device determines to a large extent the total spacecraft electrical efficiency and thus the spacecraft solar array power, the devices whether tube or solid state must have the highest efficiency which is achievable and consistent with a 2-year life. Output tubes of present satellites operate below 100 watts. Solid-state circuits of the same power level have been built and demonstrated on the

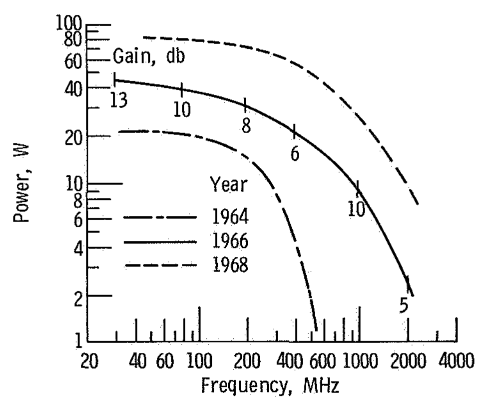


Figure 8. - Transistor power output as function of frequency and year. (From ref. 4).

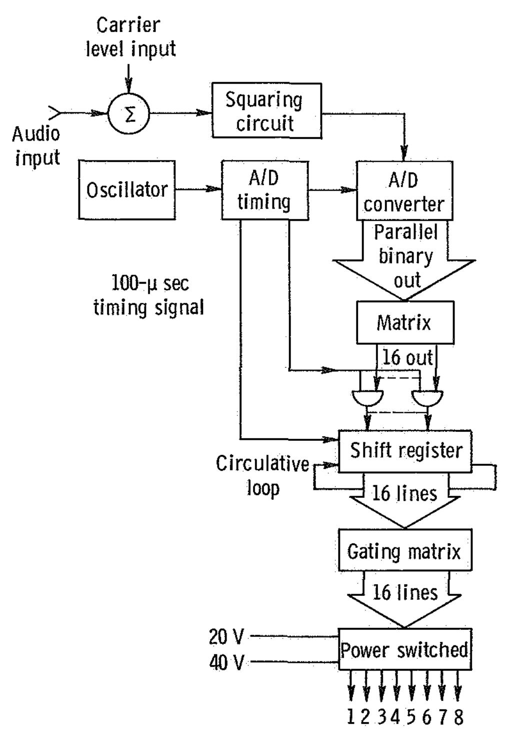


Figure 9. - Digital synthesis AM modulator to modulate each of 16 individual HF transmitters. (From ref. 3).

ground. Thus, the power output for the future voice broadcast satellites represents a 10- to 100-fold increase in output power. This increased power plus the desirability of high efficiency and long life necessitates a strong development and long-term life testing effort for either tube or solid-state devices.

Because of the importance of output devices to all space communication systems, the NASA is engaged in a program of improving solid-state devices, joining of these for higher powers, and designing high-efficiency, reliable, high-power space-qualified tubes.

Thermal Control

The two critical areas of thermal control are the control of heat in the solar array and antenna structures and the rejection of heat generated in the radiofrequency output devices, expecially if tubes are used. The problem in the first critical area is amenable to solution by passive methods used today on a smaller scale and would be evaluated by large-scale testing of the components. Solid-state output devices also present no great problem as they would be dispersed over a large area.

The problem of cooling tubes is best solved by using more unconventional methods. The contractors suggested using heat pipes or an active system with a redundancy in mechanical pumps. The heat-pipe system is to be preferred. Heat pipes have been tested in a space environment (ref. 13), and NASA has, at present, a study program on the use of these devices for cooling higher-power tubes in space.

Another even less conventional method for cooling tubes is by means of direct radiation to space (ref. 12). This method was considered by the contractors but not adopted. However, it may warrant further consideration.

Antennas

To concentrate the radiofrequency power to the desired coverage areas on earth requires very large antennas at the frequencies considered. The major problems associated with these antennas are packaging for launch, weight, deployment, structural stability, beam guidance and shaping, and high-power handling. The great size of the antenna and the competition of the packaged antenna with the solar array for space in the launch shroud necessitated optimization of packaging and weight at some sacrifice of structural stability.

One contractor used a long "vee" boom for HF (fig. 2(b)) and lightweight umbrella deployed parabolas for VHF and UHF (fig. 5). The other contractor decreased weight and increased packaging density further by using inflatable grid structures for an array of 16 spiral elements at HF (fig. 3), an array of 32 squared helical elements at VHF (fig. 4), and a parabola at UHF. A drawing of an element of the wire-grid VHF array is shown in figure 10. The wire grid is attached to a tube of thin film. The tubes are inflated, deploying the grid structure and stressing the grid beyond the wire elastic limit so that the structure will remain deployed after the pressure is released.

Packaging, deployment, and thermomechanical problems of all the antennas considered must be solved by large-scale modeling and testing before use in space can be considered practicable.

The NASA has at present two programs for large erectable antennas which, although concerned with different antenna types, would be applicable to some broadcast missions. One program is concerned with the design, fabrication, and demonstration in space of a 10-meter erectable parabola of the petaline type (ref. 14). This antenna may be tested in space in the early 1970's. The other program is concerned with the study of a metal-tube-truss-backed 30-meter antenna with a high packaging density (ref. 15).

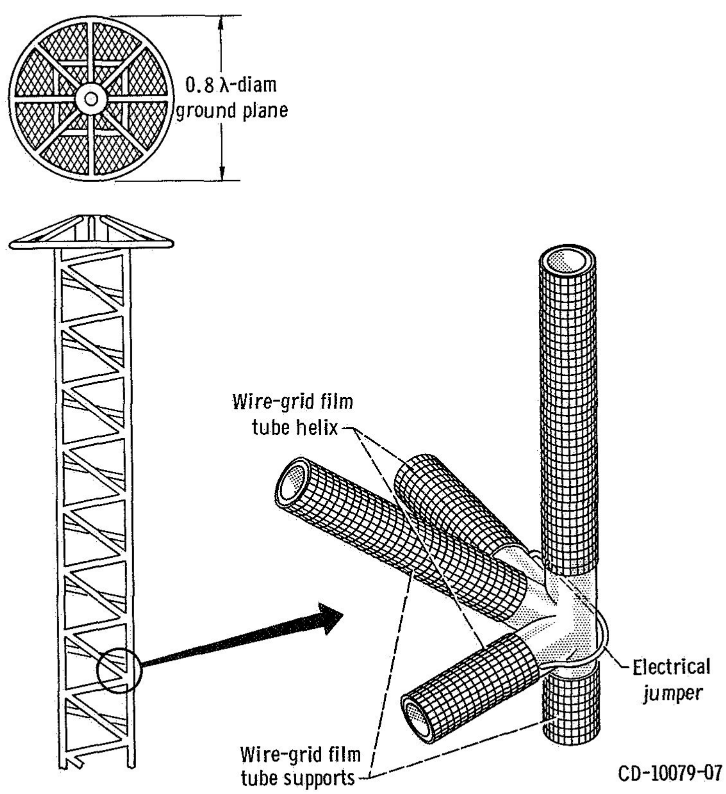


Figure 10. - Wire-grid tube element of VHF helix array (configuration C, ref. 3).

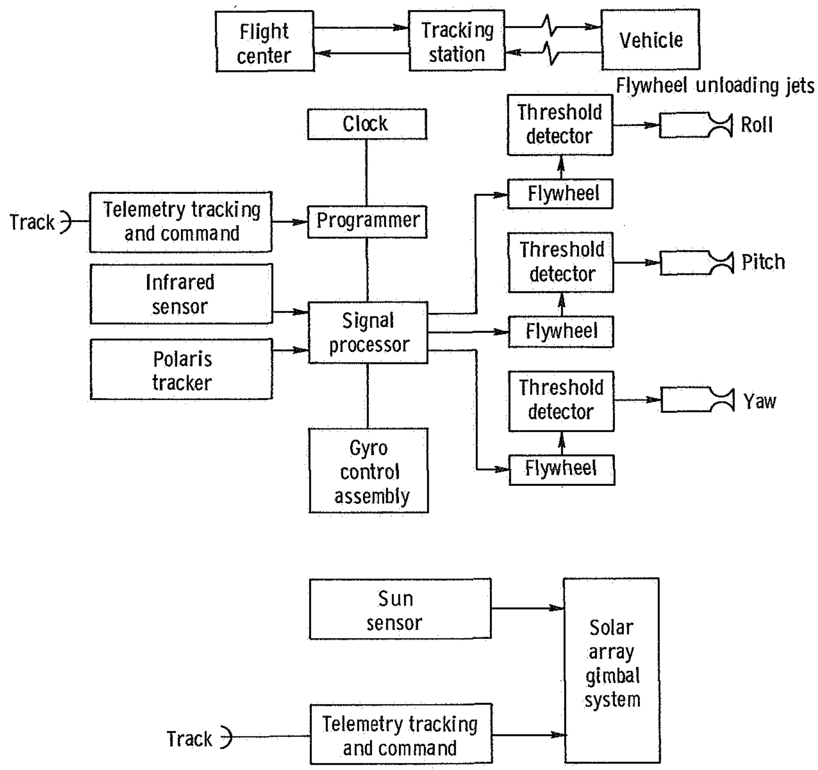


Figure 11. - Very-high-frequency attitude control subsystem block diagram. (From ref. 3).

Attitude Control and Station Keeping

The contractors evaluated active, passive, and hybrid attitude control systems and concluded that active systems using momentum storage wheels with jet unloading would be preferable for all configurations. A typical block diagram of such a system is shown in figure 11. This system has been partially demonstrated in space, but further development and testing would be necessary.

If the satellites are going to have useful lives beyond the two-year limit used in the study, jets of high specific impulse, such as ion engines (ref. 17), must be used or the propellant weight allocated for station keeping becomes excessive.

The contractors considered that a problem which needs both analytical and experimental study is the question of the effects of the interacting motions of two large, lightweight, semiflexible structures such as the solar array and antenna.

COST EVALUATION

In estimating the costs of the programs leading to a voice broadcast satellite it was assumed that all necessary research and development and all hardware not presently available were chargeable to the mission, with the exception of development of necessary launch vehicles. Two costs are of interest, the research and development cost and the operating cost effectiveness of a fully developed voice broadcast satellite system.

The research and development costs included the costs of increasing the technology to the required level, testing and modification of components, test facilities, and mechanical and thermal test models of the satellites. It did not include the costs of building the launched satellite. Although there was a wide variation in this cost, due to the contractors differing opinions as to the extent of development and testing necessary, the average development cost was approximately $25 million plus $4000 per kilogram of final configured satellite.

The cost effectiveness of a broadcast system can best be measured against similar terrestrial systems. For this, three terrestrial system operating costs were available to the contractors:

(1) The estimated operating cost per receiver-hour of the HF broadcasting system of the United States Information Agency (USIA), 0.002 cents per receiver-hour

(2) The estimated operating cost per receiver-hour of terrestrial FM broadcasters in the United States, 0.0025 to 0.006 cents per receiver-hour

(3) The estimated operating cost per receiver-hour of terrestrial band 8 television broadcasters in the United States, averaged at 0.065 cents per receiver-hour

The operating costs per receiver-hour of the configured satellites (assuming a two-year life) were estimated to be

(1) HF configurations, 0.15 to 0.30 cents per receiver-hour

(2) VHF configurations, 0.002 to 0.004 cents per receiver-hour

(3) UHF configurations, 0.015 to 0.035 cents per receiver-hour

NOISE SURVEY

A limited program to measure manmade noise at the frequencies of the broadcast satellites was conducted as part of the voice broadcast mission study to confirm and update existing data. A summary of the results is shown in figure 12.

One program consisted of measurements of absolute and relative levels of manmade noise in urban, suburban, and rural sections in the Philadelphia area. Noise discrimination by home antennas was also evaluated.

The equipment used for these measurements was the Noise Amplitude Distribution Measurement Equipment (NADME), which consists of eight solid-state amplitude detectors and counters preceded by a receiver with approximately 10-kilohertz bandwidth.

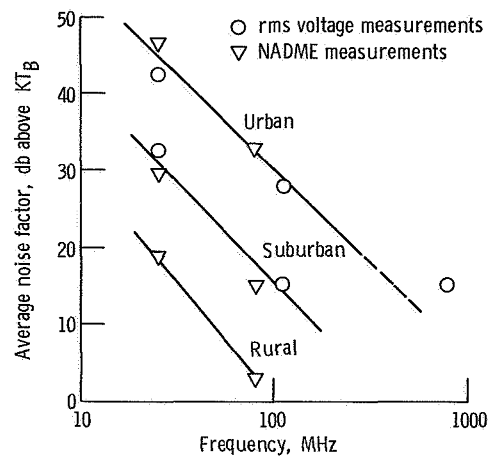


Figure 12. - Results of noise surveys.

Each amplitude detector was adjusted to respond when a preset amplitude was exceeded. The average number of noise pulses above a preset amplitude per unit time was then calculated and these values were converted into rms noise. The dipole antennas used were mounted 20 to 40 feet above the ground plane. These measurements were made at 25.8 and 90.4 megahertz over a two-week period at each of three sites; downtown Philadelphia (urban), Valley Forge (suburban), and near Bucktown, Pa. (rural). Measurements were made during both daytime and nighttime hours.

The other noise survey was performed at six major sites chosen in the New York - New Jersey metropolitan area. The sites varied from suburban (New Brunswick, New Jersey) to urban (midtown Manhattan). Standard communication or RFI receivers were used with 6- to 20-kilohertz bandwidths at 20 and 109 megahertz and a 300-kilohertz bandwidth at 800 megahertz. The noise parameters measured were true and weighted rms voltage from the detector output at the receiver. Both dipole and directive antennas were used and were mounted 10 to 20 feet above the ground plane.

Results of antenna discrimination measurements indicate that a high-gain antenna elevated at 45° above the horizon may provide a reduction in manmade noise of approximately half the forward gain in decibels (an antenna with 10-db forward gain has 5-db noise discrimination).

CONCLUDING REMARKS

It is evident from the cost evaluation and the coverages that the HF broadcasting satellites are not economically competitive with terrestrial systems. In addition, the large size and complexity of these satellites necessitates the use of the most advanced technology.

The VHF satellite systems are cost competitive with terrestrial systems. The best use for such satellites would probably be in broadcasting to the increasing number of low-cost, small, and inexpensive portable AM-FM receivers. These satellite configurations are also large and complex due to the low frequency used.

While at first glance it would seem that the UHF satellites are cost competitive, the terrestrial costs shown are for broadcasting a video rather than an audio signal. Because of the use of intercarrier sound reception in most television receivers these satellites suffer a factor of 4 power penalty. The higher power UHF configuration could thus better be used to either broadcast UHF audio signals to special low-cost receivers (not using intercarrier sound IF amplification) in emerging areas or to broadcast television to homes which would have low-cost antennas and preamplifiers mounted on the roofs.

In general, the studies concluded that the voice broadcast missions were feasible from the technological standpoint for a launch in the early 1970's providing effort on items needing long development and testing times are started in the immediate future.

As part of a continuing study of communication satellite applications, the NASA is presently conducting similar studies of the feasibility of television broadcasting from space.

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