

## 5.5A CAPABILITIES AND LIMITATIONS OF EXISTING MST RADARS: POKER FLAT

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The Poker Flat MST Radar was designed as a prototype system to continuously monitor the atmosphere up to  $\sim 100$  km. Initial funding was received from the National Science Foundation in September, 1978. The system began operations -- at a relatively low sensitivity -- some five months later. Since that time the system has been in almost continuous operation, and the sensitivity has increased steadily toward its ultimate design characteristics. Both the current and the final parameters are shown in Table 1. A more complete description of the system appears in BALSLEY et al. (1980). The current (fixed-position) antenna beams are shown in Figure 1, and a picture of the site is shown in Figure 2.

In addition to the parameters listed in Table 1, the Poker Flat radar embodies both a number of specific design features and an operating philosophy that are reasonably unique. These are discussed briefly below.

The modular system design incorporated in the Poker Flat radar uses 64 transmitting modules distributed throughout the 200m x 200m antenna array. Each transmitter is connected to four coaxial-collinear (COCO) dipole chains in one of two possible orthogonal polarizations. Each of these subsets (1 transmitter - 4 COCOs) is independently controlled from low-power RF pulse drivers located in the main building. Reception is accomplished by a similar process: the same four antennas feed a low-noise 50-MHz amplifier located at the output of the TR (Transmit-Receive) switch in the same transmitter. Each set of eight receiver outputs (i.e., one polarization-quarter) is combined in the field, so that eight separate inputs (i.e., eight separate polarization-quarters) are fed into the main building.

This modular design has a number of advantages relative to that for single transmitter/antenna systems. One of the most important advantages lies in the fact that the scientific observational program can begin with the completion of the first module; it is not necessary to await completion of the full system. A second advantage is that the probability of catastrophic failure is considerably reduced. The loss of a single transmitter, power supply, or antenna module merely reduces the system sensitivity, and the observational program can continue. For example, the loss of one transmitter in the final system reduces the system sensitivity by only a fraction of 1 dB. A third advantage of modularity is the relatively simple maintenance procedures necessary to keep the system operational. Any single transmitter, for example, can be replaced in less than an hour, and repaired subsequently (a transmitter module weighs less than 20 kgm and can be changed by one person). These and other advantages to a modular design are listed in Table 2.

The operational philosophy adopted at Poker Flat is one of continuous, uninterrupted operation. This precludes all but the most crucial "campaign-type" experiments. It also precludes -- at least for the time being -- a number of desirable long-term studies using either higher temporal or spatial resolution. This latter limitation arises primarily from the amount of taped records (see Figure 3 for an example of the taped spectra) that would accumulate at the higher data rates if data were to be taken at all possible heights: currently Poker Flat uses a single standard digital tape every two days; improved resolution studies using, say, 300 m resolution instead of the standard

Table 1. Poker Flat MST radar\* parameters

|             |                              | CURRENT (FEBRUARY 1983)     | FINAL                       |
|-------------|------------------------------|-----------------------------|-----------------------------|
| Transmitter | Frequency                    | 49.920 MHz                  | 49.920 MHz                  |
|             | Peak pulse power (oblique)   | 1.2 MWatts/polarization     | 3.2 MWatts/polarization     |
|             | (vertical)                   | 0.35 MWatts                 | 3.2 MWatts                  |
|             | Average power (oblique)      | 22 kW/polarization          | 64 kW/polarization          |
|             | (vertical)                   | 6 kW                        | 64 kW                       |
|             | Pulsewidth                   | 2-16 $\mu$ sec              | 2-16 $\mu$ sec (coded)      |
|             | Pulse rate                   | 1.2 kHz                     | 1.25 kHz                    |
| Receiver    | Noise figure                 | $\approx 3$ dB              | $\approx 3$ dB              |
|             | Bandwidth                    | Matched to pulse width      | Matched to pulse width      |
|             | Filtering                    | Bessel                      | Bessel                      |
| Antenna     | Area (oblique)               | $3 \times 10^4 \text{ m}^2$ | $4 \times 10^4 \text{ m}^2$ |
|             | (vertical)                   | $1 \times 10^4 \text{ m}^2$ | $4 \times 10^4 \text{ m}^2$ |
|             | Beamwidth (two-way)          | $\approx 1^\circ$           | $\approx 1^\circ$           |
|             | Direction                    | Oblique/vertical            | Oblique/vertical            |
| Processing  | Coherent averaging (oblique) | 58 pulses                   | 58 pulses                   |
|             | (vertical)                   | 412 pulses                  | 412 pulses                  |
|             | Spectral resolution          | 64 points                   | 64 points                   |

\*Location  $65^\circ 07' 58''$  N,  $147^\circ 21' 30''$  W

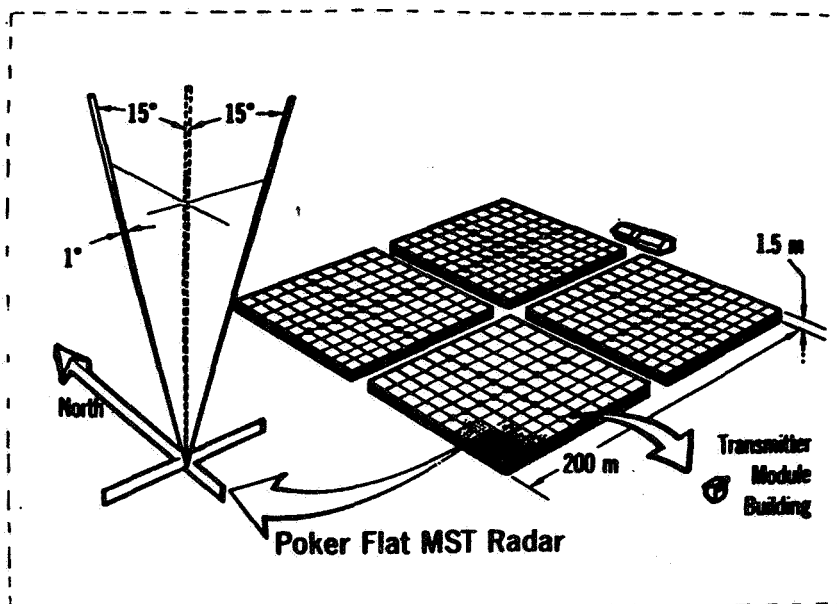


Figure 1. Showing the current three fixed-beam arrangement of the Poker Flat MST radar.

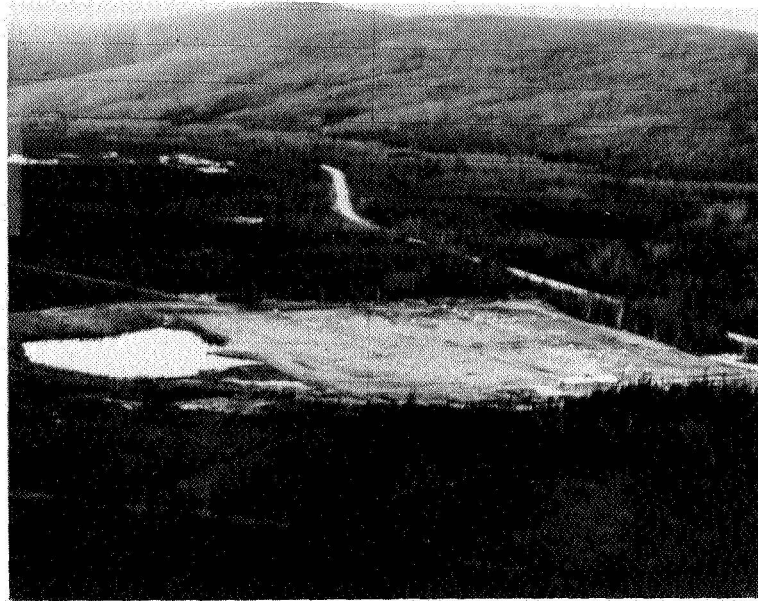


Figure 2. Aircraft view of the Poker Flat radar (foreground) and the University of Alaska Geophysical Institute's Poker Flat rocket range (upper left area). View looking approximately WNW.

Table 2. Poker Flat MST radar

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Advantages

Modular Design

Allows operation using only a portion of the system  
 No catastrophic failures (distributed elements)  
 Easy maintenance  
 Beam switching using very low power phase switching  
 Air-cooled (not water cooled) transmitting tubes  
 Heat exchangers not required  
 Small spare parts reserve (~ 10%) relative to single unit system  
 Lower feedline costs (not major)  
 No moving parts (i.e., dishes, mechanical switches)

Continuous, uninterrupted operation (> 4 years)

Virtually unattended (except for maintenance)  
 Reliability (> 90%): no start-up problems  
 Cost effective  
 Operates well in climate extremes (+ 30°C to - 56°C)  
 Power supply "bleeder" resistors heat main building

Miscellaneous

Remote site: less man-made interference (RF, aircraft, etc.)  
 Proximity to University of Alaska rocket range (Met rockets and balloons and experiments)

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POKER FLAT, ALASKA  
18 February 1982  
10<sup>h</sup> 48<sup>m</sup> - 11<sup>h</sup> 48<sup>m</sup> AST

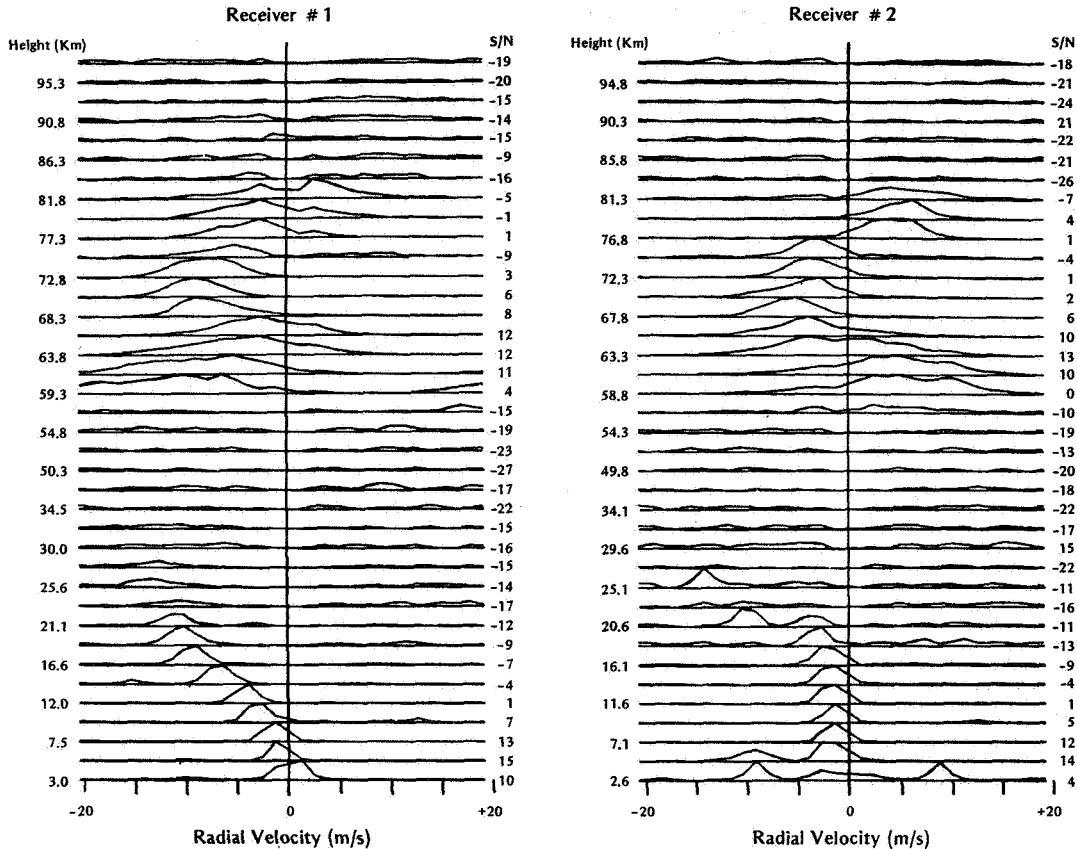


Figure 3. Example of the spectral information obtained from Poker Flat taped data. Shown are one-hour averaged values of normalized Doppler power spectra for "EAST" receiver (#1) and "NORTH" receiver (#2). S/N values are printed on right of each spectrum.

2.2 km resolution would require three tape changes per day. While this is not an unreasonable rate for a few days, it becomes prohibitive for long-term studies. In the final operational mode at Poker Flat, however, such data will be obtained using a separate recording system with minimal interruption.

Continuous operation has a number of advantages. For example, continuous operation combined with every-two-day tape changes enables an essentially unattended operation (except for maintenance tasks and special experiments). It also results in a cost effective operation and an enhanced reliability (owing in part to the lack of normally expected "turn on" problems). As an example, during 1982, the system was operational ~92% of the time, with much of the off-time arising from tape changing discontinuities. Figure 4 shows an example of the percentage of echoes received at Poker Flat versus height and time. Also, although the ambient temperature during this period ranged between about +30 °C and -56 °C, the system operation was not affected. This can be attributed in part to the continuity of data taking. These advantages, along with other less-important ones, are listed in Table 2.

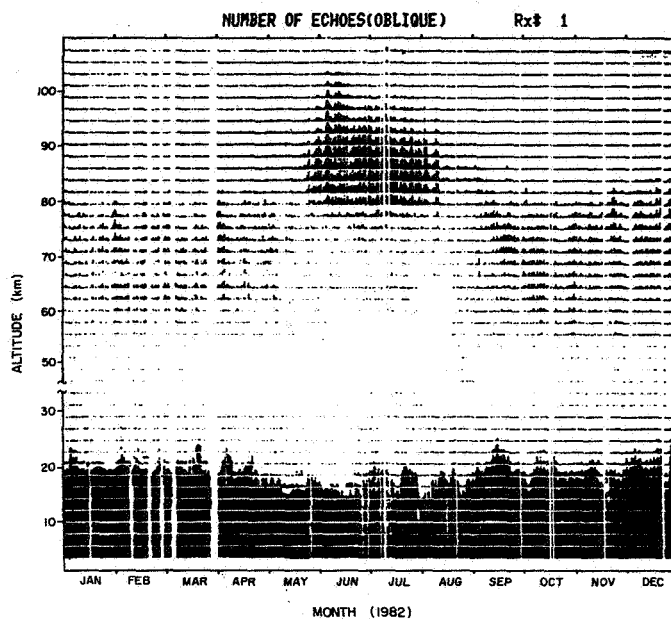


Figure 4. Example of the continuity of the Poker Flat observations (R. Garelo, private communication). For each height, the percentage of possible echoes for each hourly averaged period is scaled in terms of the full height range at that time and height (e.g., the full-height lines for all seasons below  $\sim 12.5$  km indicate 100% echo rate; half-height lines at 23.3 km in mid September indicate 50% echo/no-echo rate). Note the seasonal change in the mesospheric echo heights and occurrence rates. The relatively darkened lines that maximize at  $\approx 92$  km arise from meteor echoes.

Table 3. Poker Flat MST radar

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Disadvantages

Not-Yet-Finished Problems

- Not yet steerable (3 fixed beams)
- Three-quarters of antenna only on oblique beam
- One-quarter of antenna only on vertical beam
- Continuous observations with  $< 2.2$  km resolution requires separate tape unit
- Preprocessor unit (for maximum sensitivity) under construction
- Current reliable peak Tx power  $\leq 60$  kW
- No ancillary measurements on-line yet
- Full sensitivity on vertical to "see through" still in the future

General Problems

- Reasonably expensive operation (power bill  $\sim \$10^5$ /year)
  - Remote site (cold in winter, muddy in spring, mosquitoes in summer)
  - Continuous operation mode precludes some special studies
  - Not portable
  - Mountain echoes added to atmospheric echoes below  $\approx 7$  km
  - Moose in the (fenced-in) antenna array
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The disadvantages of the Poker Flat system are shown in Table 3. Many of the current disadvantages stem from the fact that the system is not yet completed. For example, maximum sensitivity in the vertical will not be realized until the full system is steered between vertical and oblique positions (this will allow us to examine the region of weak echoes near 45 km with full system sensitivity). Also, higher resolution studies not currently possible will be enabled with the advent of an additional recording system and a digital "preprocessing" system currently under construction. We also lack a series of ancillary measurements (surface wind, temperature, all-sky camera, riometer, airglow, etc.) at the site, which will be eventually included on the standard data format. Finally, the system is some 5-1/2 dB below the final sensitivity. This is due in part to transmitter tube HV arc-over problems, to the (current) lack of a fast preprocessor, and to the fact that only three-quarters of the full antenna is currently used for oblique operation. Additional disadvantages along with those mentioned above, are included in Table 3. (The reference in this paper is included in the Publications listed below.)

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