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PLANNED RADAR NETWORK IN HAIL SUPPRESSION

Bojan Lipovscak

Hydrometeorological Institut
Zagred, Jugoslavija

Summary

During the 10-year period of hail suppression based on radar measurements, the need for modern radar network came into evidence.

Operational hail suppression, due to the possibility of fault of one radar, requires a special distribution of radars in the network. The neighbouring radar must carry out the measurements and direct the hail suppression activities. A presentation of the principles of hail suppression based on radar measurements is also given.

1. INTRODUCTION

The first attempts of Cb clouds radar measurements for hail suppression in Yugoslavia were made during 1968. For this purpose the 3MK7 radars S-band with maximum measuring range 33 km were used. From 1970 to 1976 the 3MK7 radar network was developed, and supported the rocket launching stations in hail suppression operations. The first Mitsubishi RC 34A radars were put into operation in 1976, and in 1981 the EEC-made WSR 74 C and S were installed.

2. HAIL SUPPRESSION IN YUGOSLAVIA

In 1981 a territory of cca 5,580,000 ha was under the hail suppression activities in Yugoslavia. One radar centre includes 180,000 ha. Fig. 1 represents the area with hail suppression activities. The seeding of reagents on the basis of AgI in Cb clouds is carried out with rockets made in Yugoslavia, with vertical range of 3,5 and 8,5 km. During 1981 the hail suppression area was covered by 2,335 launching stations and 31 radar centres. One radar centre operates cca 75 launching stations which are connected in network to enable the multiple covering of hail suppressed area (Horvat et al., 1979), i.e. the range of one launching station is covered by at least two other launching stations. The launching station equipment consists of launching ramp, starter, radio station, shelter for storage of 15-25 rockets. The typical launching station is presented in Fig. 2 (Horvat et al., 1979).

Technical characteristics of rockets are described in papers (RHMZ 75 and Lipovscak '82).

During the season of hail suppression (from April to September) the average number of days with hail suppression activities is 40 and approximately 25,000 rockets are launched. Evaluation of success in hail suppression activities is made on the basis of Insurance Companies data, compared with historical records.

3. RADAR MEASUREMENT IN HAIL SUPPRESSION

The hail suppression is by its conception a preventive activity where it is necessary to seed the clouds with large amounts of reagents in a short period of time. Thus the number of hailstones is increased which results in the decrease of hailstone diameters. The need to act quickly on Cb clouds causes the need for early detection of hail growth areas in clouds.

The method of hail detection is based on the use of S-band radar. It is overtaken from Soviet scientists (Sulakvelidze et al., 1967) and modified according to Yugoslav climatological conditions. The probability of hail occurrence is based on radar measurements and thermodinamical conditions of the atmosphere.

The parameters for probability computation are:

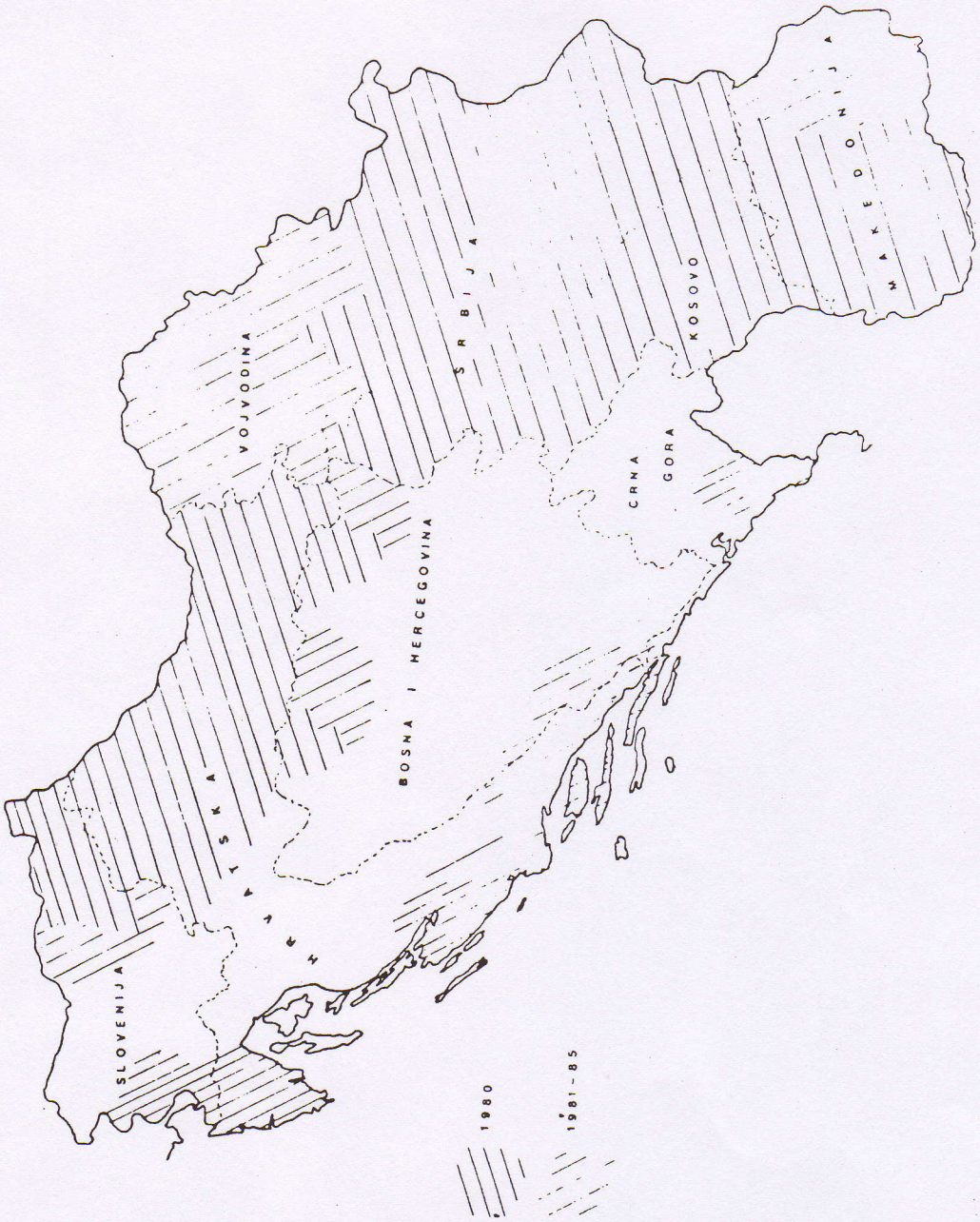


Figure 1. Hail suppression in Yugoslavia - area with hail suppression activities.

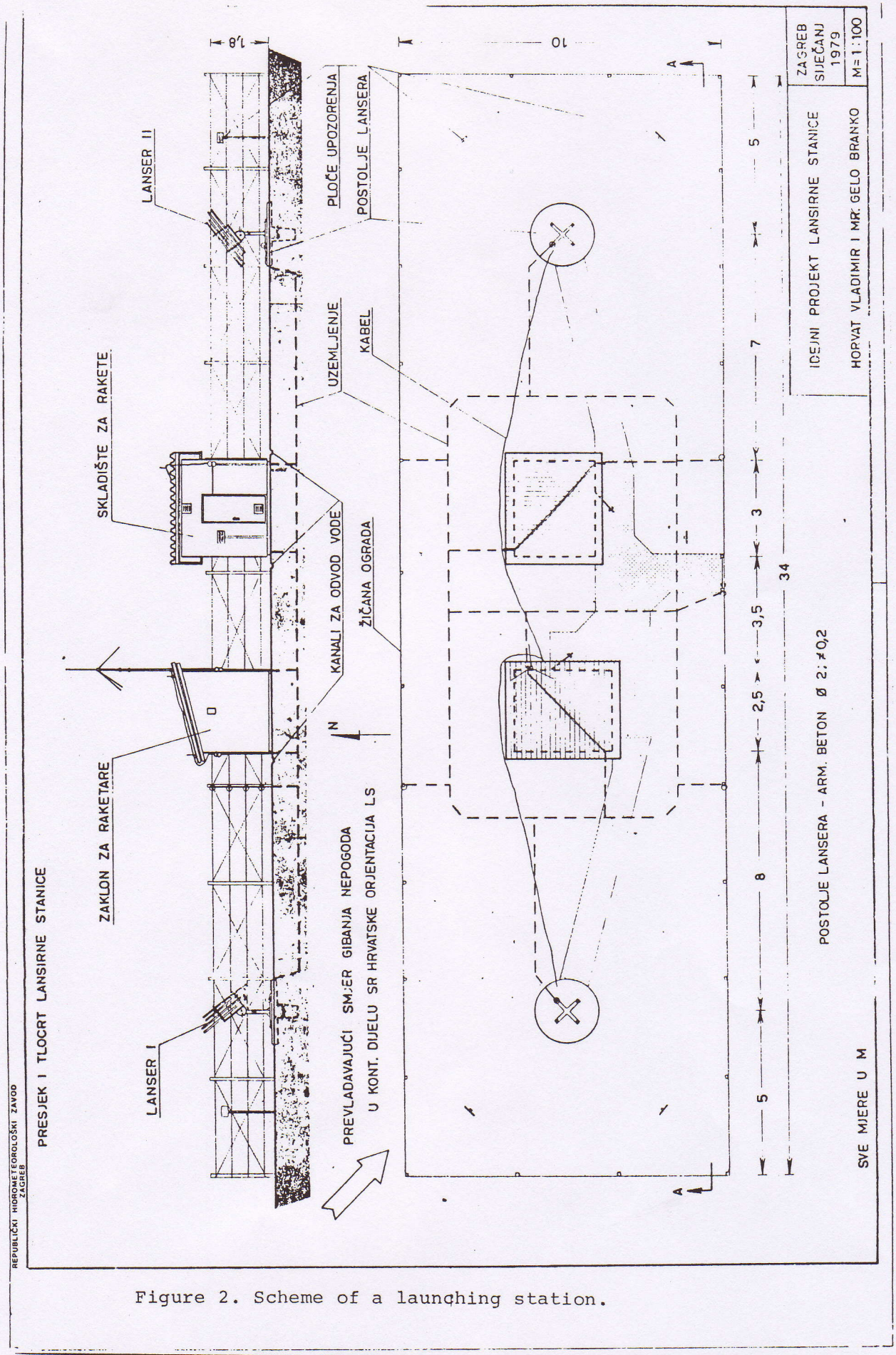


Figure 2. Scheme of a launching station.

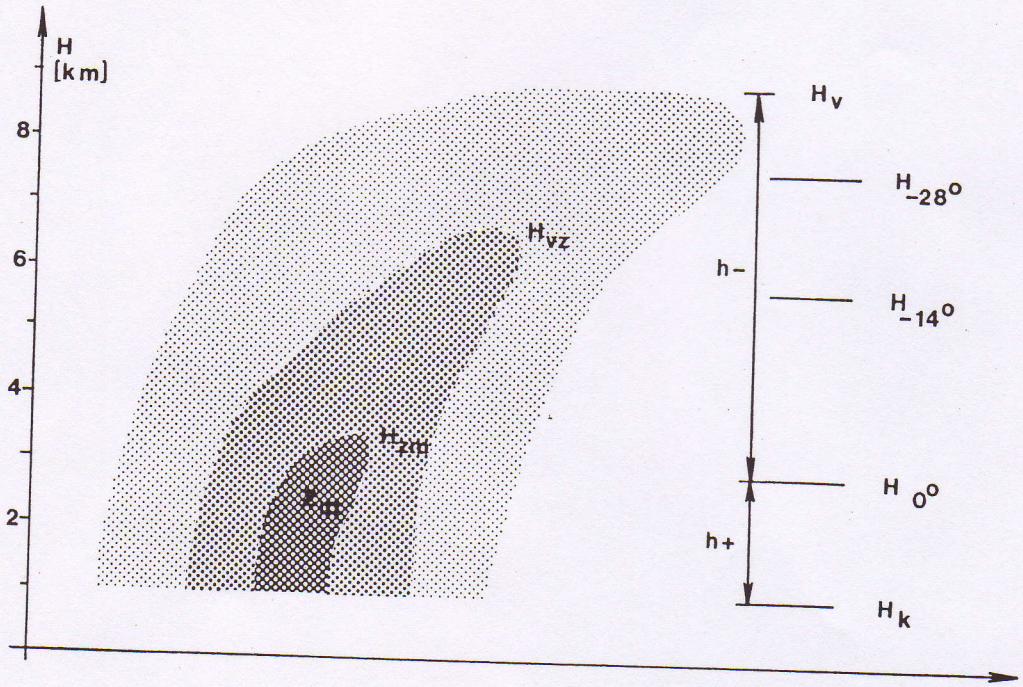
the height of the cloud top (H_v), the height of the maximum reflectivity zone (H_{zM}), the height of the accumulation zone (H_{vz} - 10 dbZ below H_{zM}), the value of (Z_M), and the ratio of the heights between the warm and the cold regions of the cloud (H_+/H_-).

Thermodynamical parameters are determined by radio-sounding, and they are: the height of isotherms 0, -14, -28 degrees Celcius and the condensation level.

The combination of radar and thermodynamical parameters results in a complex hail probability factor.

$$P = P(H_v, H_{-28}, H_{vz}, H_{-14}, H_{zM}, H_o, Z_M, H_+/H_-) \qquad (1)$$

Fig. 3 represents the scheme of Cb cloud defined by the above mentioned parameters.



The cloud cell is defined as a hail cell if it is fulfilled

$$P \geq 50\%,\ H_{zM} > H_o,\ H_{vz} > H_{-14},\ H_v > H_{-28},$$

$$Z_M \geq 35\ \text{dBZ},\ H_+/H_- > 0.5 \qquad (2)$$

During 1982 the criteria suggested by Waldvogel was used on two radar centres:

$$H_{45} > H_o + 1.4\ \text{km} \qquad (3)$$

This means that if the height of the 45 dbZ contour is more than 1.4 km above the 0°C level, the cell is a hail cell. The criteria was shown to provide useful results (Bizic, 1982).

The number of rockets (N_R) needed for seeding one hail cell is a function of zone accumulation volume (V) and reagent efficiency (E).

$$N_R = N_R\ (V,\ E) \qquad (4)$$

The calculation of the necessary number of rockets is made by analogue computer (RHMZ 75).

4. RADAR NETWORK IN CROATIA

The obsolescent radars suggested the need for a project for radar modernization and the existing S-band radar network was defined (Lipovscak et al., 1979, Lipovscak, 1981).

Hail suppression activity requires a special distribution of radars in a network. It is essential that the whole experiment area be twice covered by radar observations, in case one radar is out of order. The existence of sidelobes and the characteristics of digital video integrator and processor (DVIP) mean that no measurements can be performed within a distance of 5 km in range. On the other hand, the distance between radars should not exceed 150 km in order to minimalize the number of cases where radar beam passes through the melting layer with zero degree antenna elevation.

The existing network of 10 S-band radars in inland Croatia will be reduced to 4 S-band and 2 C-band radars. In the coastal area the setting up of 3 S-band and 1 C-band radars is planned, Fig. 4. The main task of S-band radars is hail suppression and of C-band radars the precipitation measurements.

Fig. 5 shows a scheme of equipment of one radar centre. The computer consists of HP 1000 F model with 512 Kb high performance memory, magnetic tape unit, disc unit, line printer, video and printing terminals. The radar picture integration is performed at the centre and the integrated picture is radio-linked to the neighbouring centres and to the central network computer in Zagreb, Fig. 6.

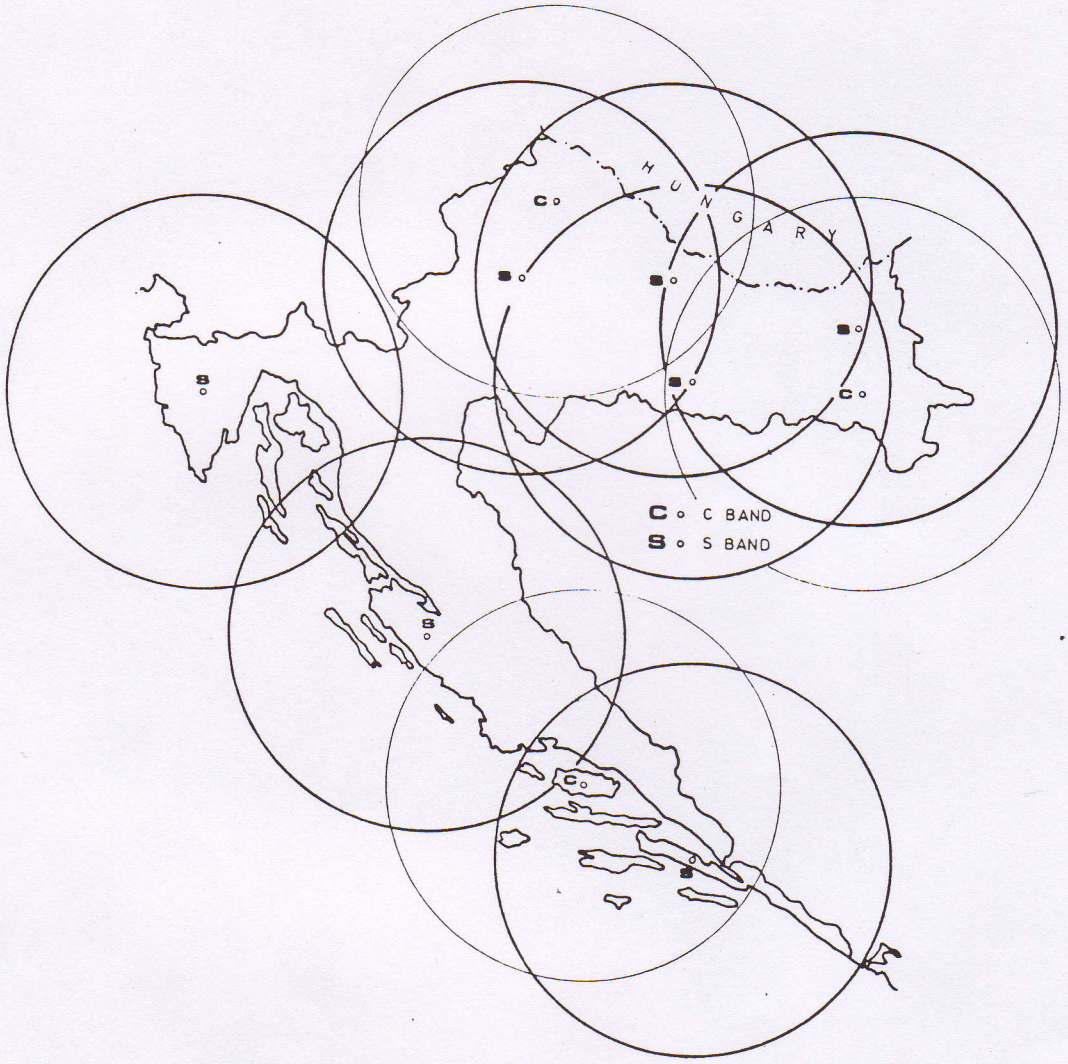


Figure 4. Planed WSR-74C and S radar Network in Croatia

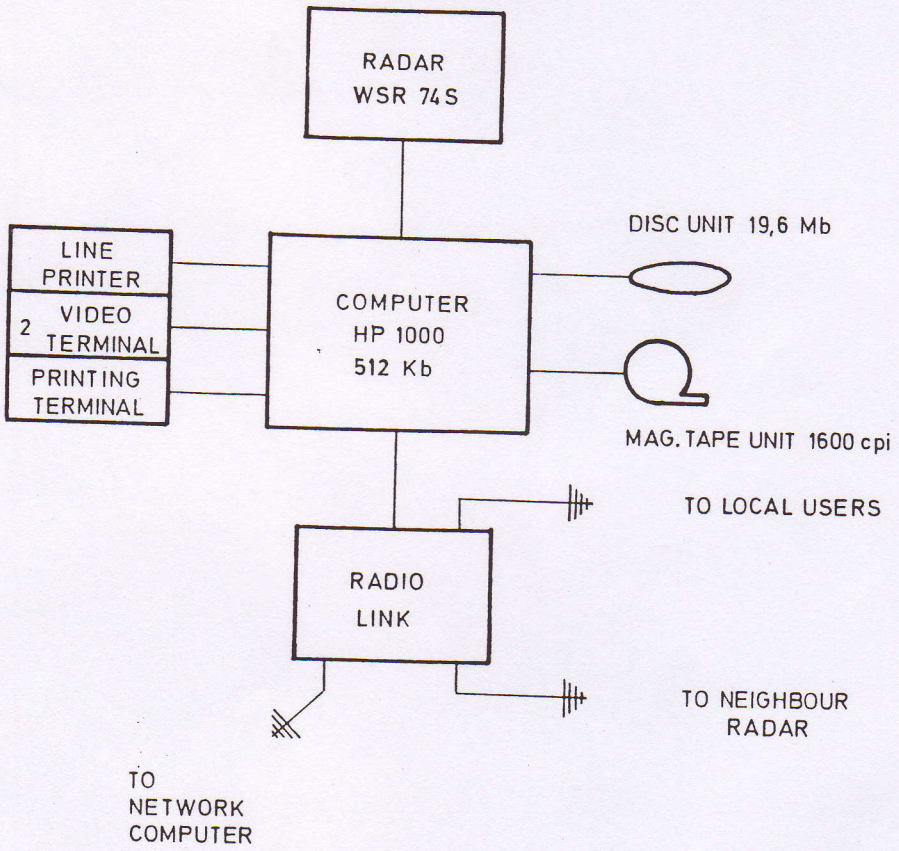


Figure 5. Scheme of equipment of one radar centre.

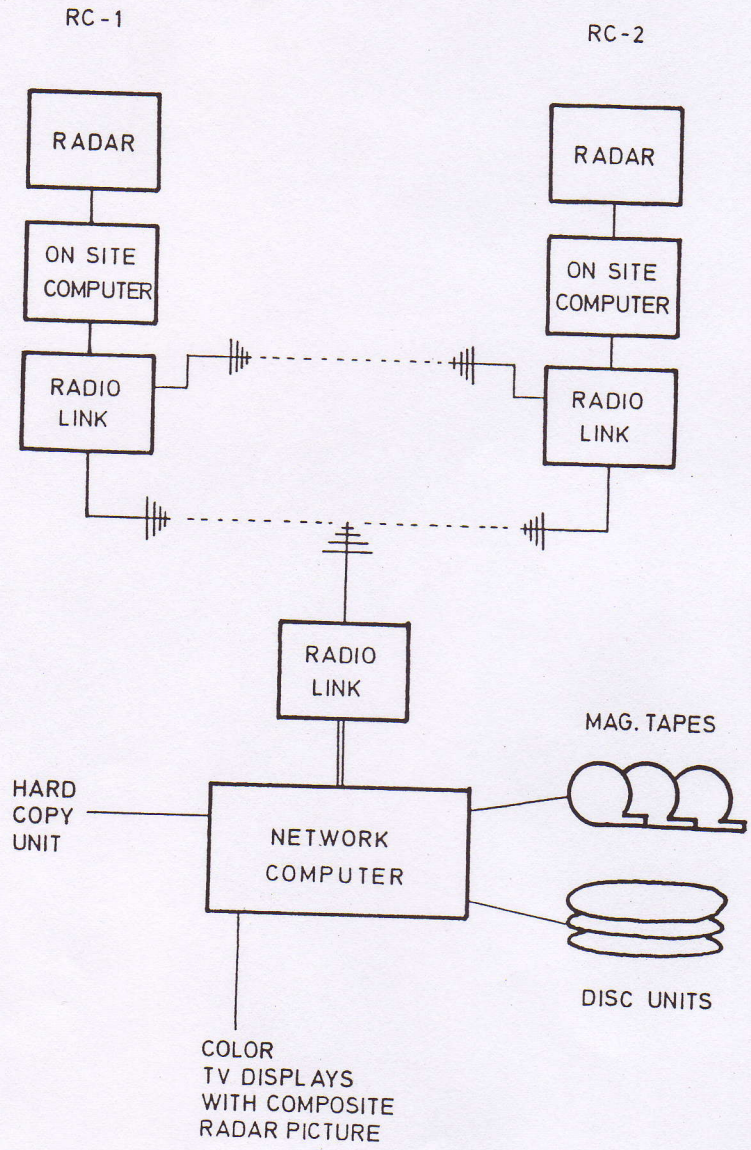


Figure 6. Scheme of equipment of radar Centres and network computer.

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