Mem. Natl Inst. Polar Res., Spec. Issue, 49, 386–395, 1994

PLAN OF DOME-F STATION FOR DEEP ICE-CORING BY THE JAPANESE ANTARCTIC RESEARCH EXPEDITION (JARE)

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Abstract: A station for deep ice-coring, Dome-F Station, is to be constructed by the Japanese Antarctic Research Expedition (JARE) on top of Dome Fuji (3800 m a.s.l.) in Antarctica, where the minimum temperature is expected to be –88°C and the mean annual temperature is –58°C. The planned station consists of two areas: a residence and a drilling area. The residence area includes living huts and a power station, to be constructed on the snow surface. The drilling area consists of a drilling trench, drill workshop and icecore and equipment storage trenches buried under the surface. To construct the station and conduct ice-coring operations, 263 t of material must be transported 1000 km by oversnow vehicles from Syowa Station to Dome-F.

1. Introduction

The deep ice-coring project on an ice sheet dome in East Queen Maud Land was planned by JARE to run from 1991 to 1997 (Fig. 1). The transportation operations and station positioning were completed during 1991 and 1992, the construction of station huts and some drilling facilities will be done in 1993 and 1994, and the coring operation will be carried out from 1995 to 1997.

The site for coring, informally named Dome-F Station, is to be constructed at the highest point of East Queen Maud Land, Dome-F (77°22'S, 39°37'E, 3800 m a.s.l.). In this report, the station design and layout conception are explained.

2. Meteorological Conditions

Meteorological conditions at Dome-F were estimated from those of Plateau Station (79°15'S, 40°30'E, 3625 m a.s.l.) 300 km poleward Dome-F. Temperature was estimated assuming a lapse rate -6×10^{-3}°C/m. Wind speed and annual snow accumulation were assumed to be equal to that of Plateau Station. These conditions are summarized in Table 1.

In Fig. 2, the seasonal variations of temperature, wind speed and atmospheric pressure are shown. Of these conditions, the most significant problem for station construction is low temperature. The estimated mean annual temperature is –58°C and the minimum temperature –88°C. To keep accommodation areas warm, the building walls must be well insulated, and sufficient fuel for heating should be provided. Since snow accumulation is not substantial, buildings need not be so strong as to last many years. Mean wind speed is not so large, about 5 m/s, whereas the maximum wind speed is 25 m/s. Therefore, the deposition of drifting snow around buildings will probably be less than at Mizuho Station

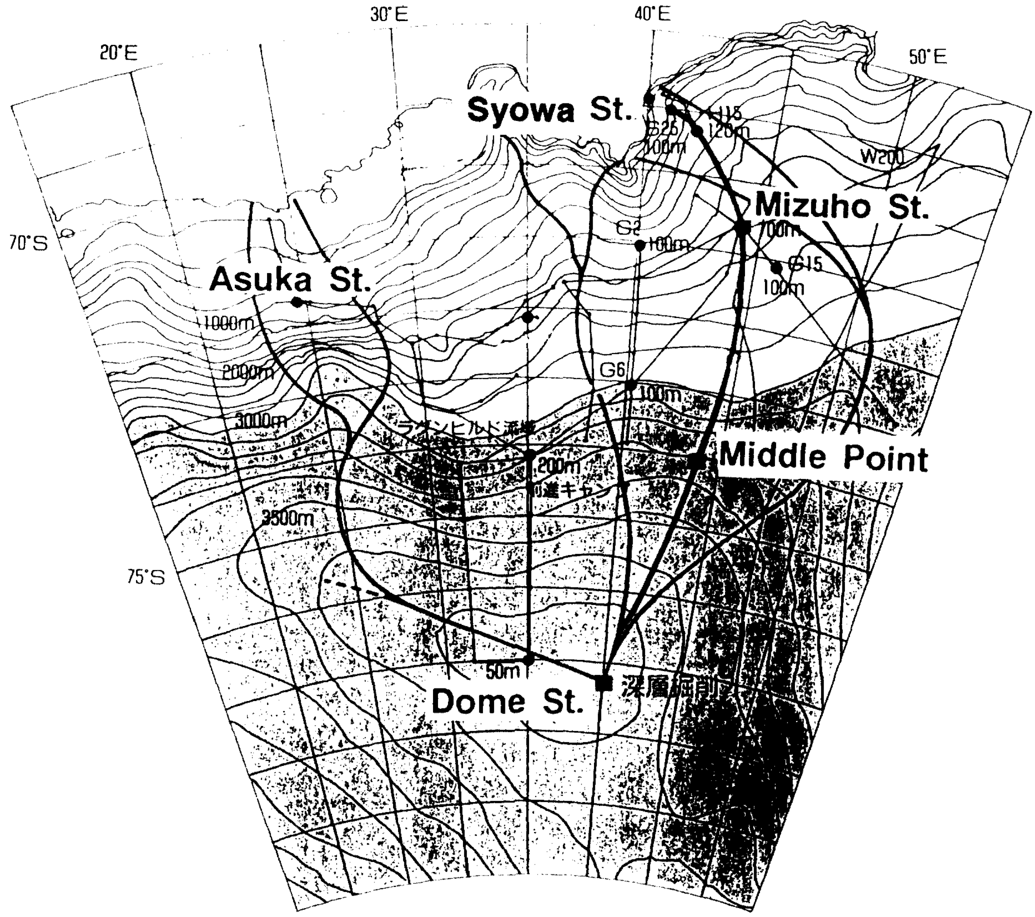

Fig. 1. Location of Dome-F Station in East Queen Maud Land. The Deep Ice-Coring Project will be carried out at Dome-F Station (77°22'S, 39°37'E, 3800 m a.s.l.).

Table 1. Conditions at Dome-F Station.

Location	77°22'S, 39°37'E
Altitude	3800 m a.s.l.
Ice thickness	2800 - 3000 m
Maximum temperature	–20°C
Mean temperature	–58°C
Minimum temperature	–88°C
Annual snow accumulation	32 mm/a (in water equivalent)
Mean wind speed	4.9 m/s
Maximum wind speed	25 m/s
Mean atmospheric pressure	590 hPa

and Asuka Station. Another problem is low atmospheric pressure, about 590 hPa, at which the power loss of generators and oversnow vehicle engines occurs. For example, power output of our 28 kVA generator will be reduced to 22 kVA.

3. Station Layout

The outline of Dome-F Station is shown in Fig. 3. The station consists of two areas: a

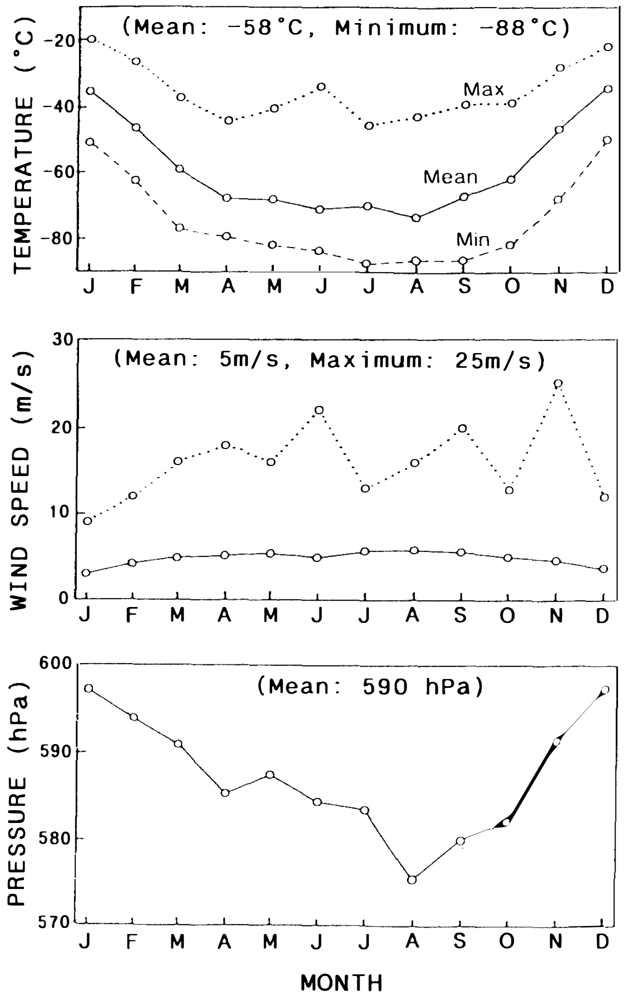

Fig. 2. Meteorological conditions (temperature, wind speed and atmospheric pressure) at Dome-F Station estimated from those at Plateau Station.

residence area and a drilling area. The residence area includes two living huts, a research hut, a dining hut and a power station, all of which are constructed on the snow surface. The drilling area consists of a drilling trench, drill workshop and icecore and equipment storage trenches buried under the surface (Fig. 4). The detailed areas are shown in Table 2.

According to the transportation schedule, the total amount of materials to be taken to Dome-F Station is 263 t, including fuel and drilling machinery. Of this, 30 t is for station construction, including the buildings, generator, communication facilities and roof materials for the drilling trench.

At Mizuho Station, the annual mean wind speed was 11.1 m/s and the annual drift transport rate was 3×10^6 kg $m^{-1}a^{-1}$ in 1982. TAKAHASHI (1988) obtained a relationship between drift transport rate Q (kg $m^{-1}d^{-1}$) and wind speed V (m s^{-1}), where Q is proportional to $V^{5.17}$. According to this relationship, the annual drift transport rate at Dome-F is roughly estimated as 1.5% of Mizuho Station from the annual mean wind speed of 4.9 m/s at Dome-F, although the calculation needs daily wind speed data. The estimated snow drift transport by the annual mean wind speed is small, but the expected maximum wind speed

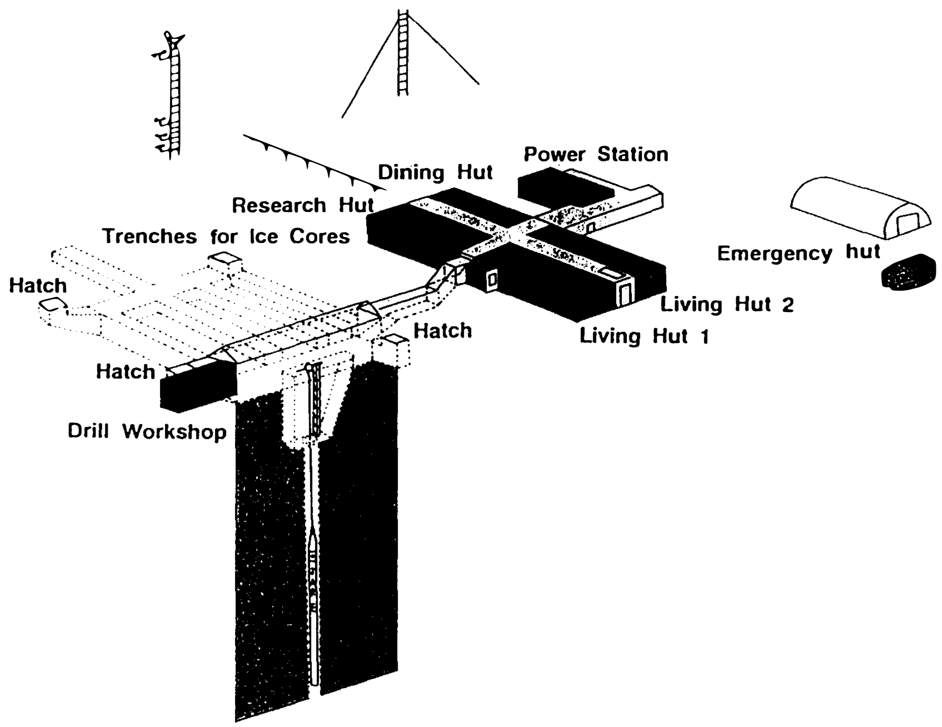

Fig. 3. Outline of Dome-F Station. The residence area is on the surface and the drilling area is under the surface.

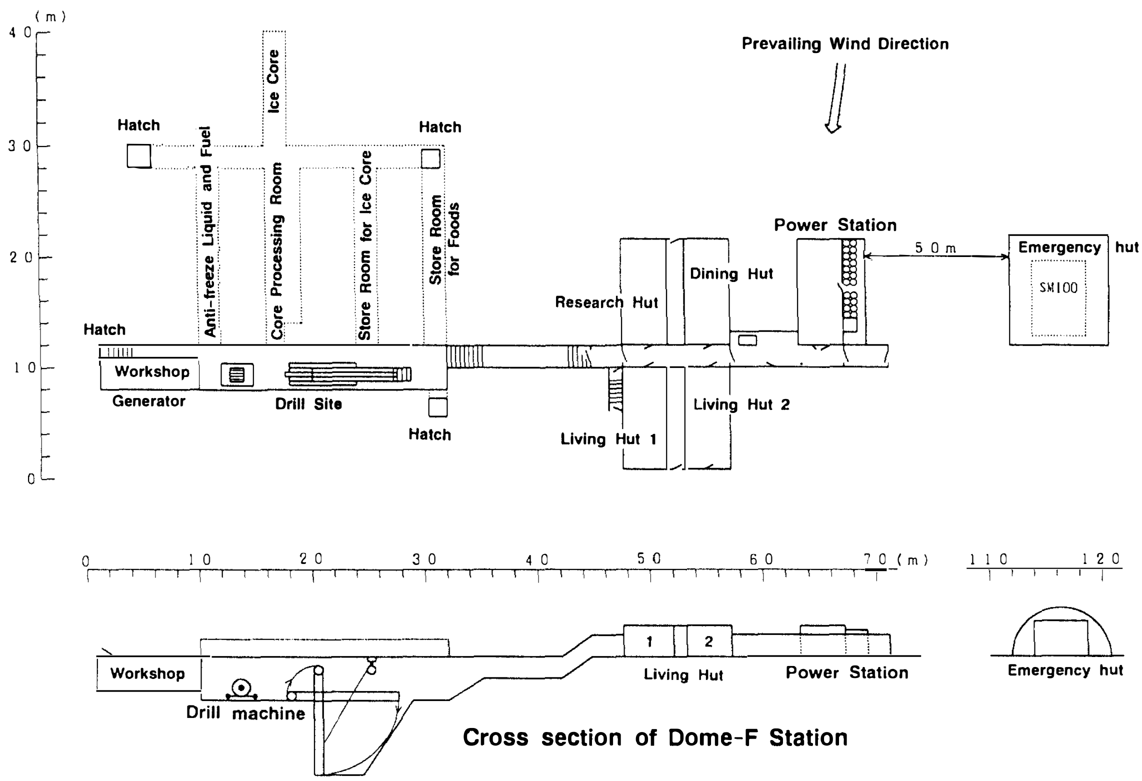

Fig. 4. Plan of Dome-F Station.

Table 2. Outline of Dome-F Station.

Division	Area (m^2)
(Residence area)	(208)
Living hut	32×2
Dining hut	32
Observation hut	32
Power station	32
Corridor	48
(Drilling area)	(276)
Drilling site	112
Work room	24
Core-analysis room	48
Core-storage room	40
Storeroom for anti-freeze liquid and fuel	32
Storeroom for machines	20
(Emergency area)	(90)
Garage for oversnow vehicles	90
Total	574 m^2

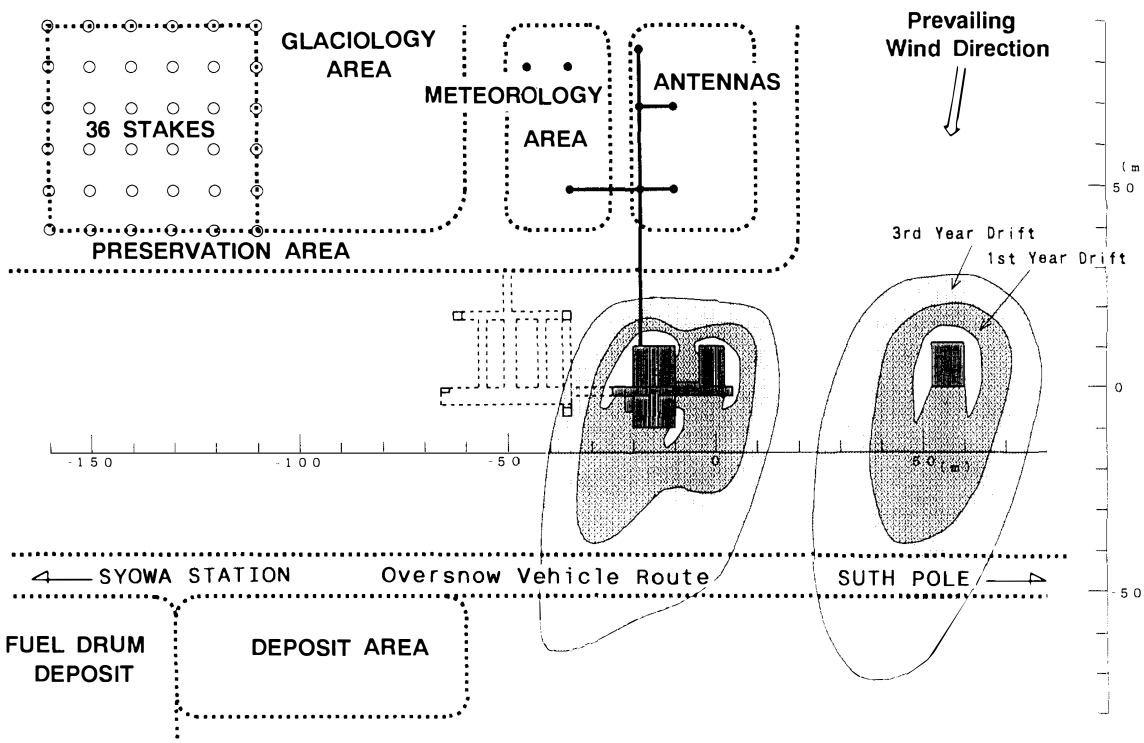

Fig. 5. Layout of deposit areas and research areas around Dome-F Station. The dark shaded area is the estimated distribution of drifting snow deposited in the first year after building construction; the light area is that in the third year.

of 25 m/s can cause much snow drift around buildings, so we should be prepared to deal with drifting snow.

To avoid drifting snow piling up around the buildings, it is better to place nothing on the snow surface, and therefore the drilling facilities are to be buried under the surface, as at "Little America" in Antarctica (BYRD, 1930). However, considering fire safety, the residence facilities will be constructed on the surface.

Assuming that snow drift will extend to a distance of three times that of building height in the windward direction and ten times in the leeward, the distribution of snow drift around buildings was estimated and the station layout was planned to avoid drift effects as much as possible, as shown in Fig. 5. The residence area and the drilling trench will be placed in a line perpendicular to the prevailing wind direction. The preserve areas for glaciological and meteorological researches are located windward of the station, and the deposit areas for fuel drums and other materials are on the leeward.

4. Residence Area

In the residence area, five prefabricated buildings will be constructed on the snow surface. They include a research hut, two living huts, a dining hut and a power station,

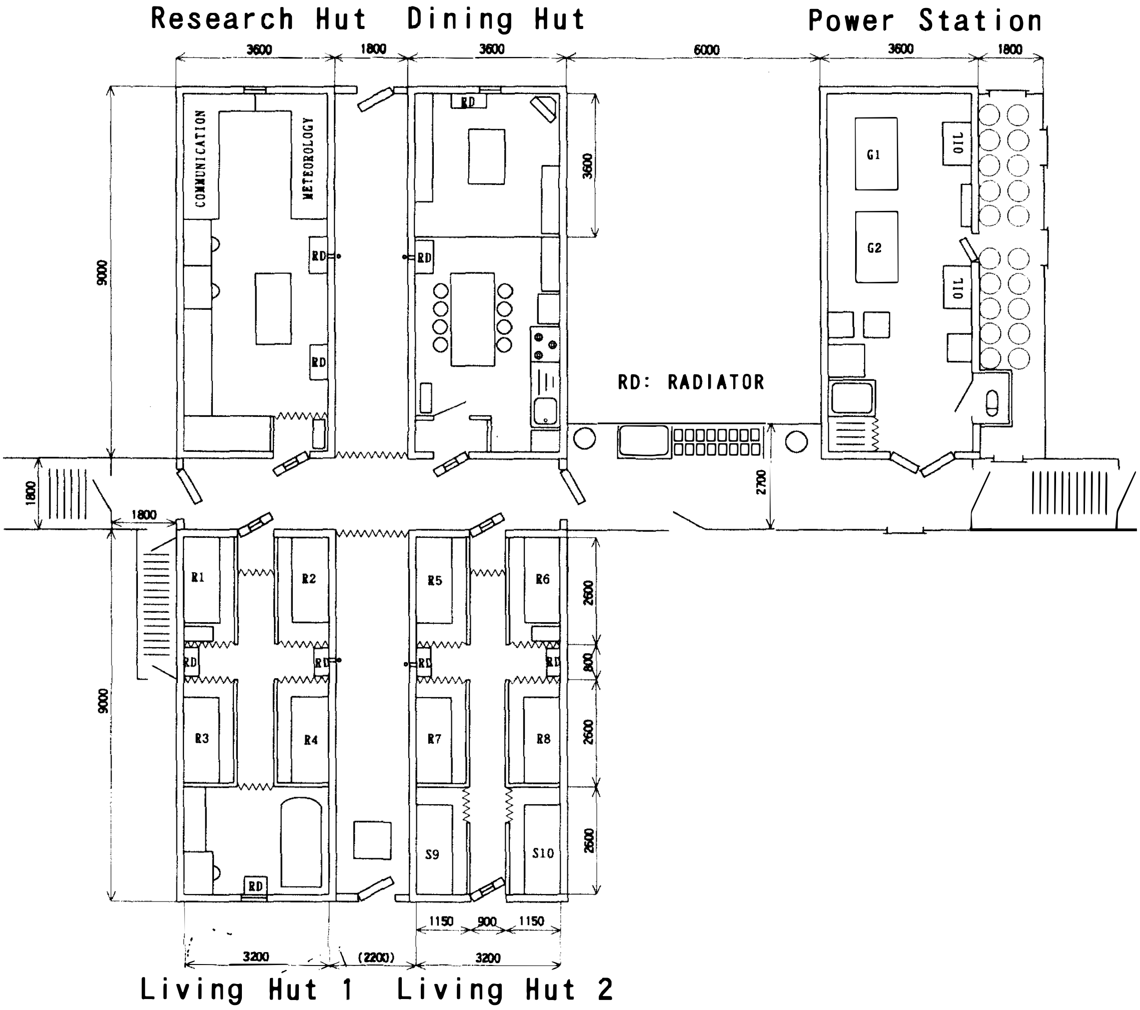

Fig. 6. Detailed plan of the residence area.

each of which measures 3.6 m (W) × 9 m (L) × 2.5 m (H) (Fig. 6). Walls of the huts will be 10 cm thick with additional 10 cm thick insulated panels attached from inside.

Close to the power station, fuel drums will be placed for temporary deposit. A toilet and a bathroom are to be installed in the power station. The toilet disposal system is a type of burning by electrical heat.

An emergency hut, 9 m (W) × 10 m (L) × 4 m (H), will be placed 50 m away from the residence area. The emergency hut will house a oversnow vehicle which is to be preserved ready for immediate start in case of emergency.

5. Drilling Area

The drilling area consists of a drill site, a workshop, a core-processing room and icecore storage trenches. The drill site is a trench, 22 m (L) × 4 m (W) × 4 m (H), with an insulated roof. At the drill site, a 10 m-high drilling machine will rotate from a horizontal position to the vertical, taking ice core in the vertical position. Therefore a narrow trench, 6 m (L) × 1 m (W) × 6 m (H), is to be dug into the drill site base for use as a rotating space.

A workshop, 8 m (L) × 3 m (W) × 2.5 m (H), will face the drill site, in which work machines will be used to maintain the drill machine and a generator.

Connecting to the drill site, four tunnels are to be dug for use as a core-processing room and three store rooms for icecores, anti-freeze liquid drums and other items. Above the trenches, several hatches will be made for emergency escape and/or supply and personnel entrances.

6. Generators and Heating Systems

Three 28 kVA generators will be installed in the station: one is for station maintenance, the second for drill operation, and the third for preparation of the both.

Estimated electricity consumption for station maintenance is 8 kW in the steady state and 18 kW in the maximum, while for drilling 11 kW in the steady state and 16 kW in the maximum. The generators may lose some power due to low atmospheric pressure at the high altitude, but their power, 28 kVA, will be sufficient for the consumption. Considering a consumption rate of light oil at 0.344 *l*/hour for 1 kW, the daily fuel consumption would be 66 *l*/day for station maintenance and 47 *l*/day for drilling.

The residence area will be heated by a circulating hot-water system, with heat supplied from the generator cooling system and an additional kerosene heater. Assuming a heat loss from each hut of 3774 kcal/h, it is projected that 10.8 k*l*/a of kerosene will be

Table 3. Fuel for station maintenance and drill operation.

	JARE-36 (1995)	JARE-37 (1996)	Total
Light oil	45.4	42.4	87.8
Kerosene	16.4	13.5	29.9
Total	61.8 k*l*	55.9 k*l*	117.7 k*l*

necessary for additional heating.

Table 3 provides a list of the necessary fuel, including reserve fuel. Total fuel for two wintering parties is 117.7 k*l*.

7. Communication

HF radio transceivers are used for communication between Dome-F Station and Syowa Station. Two 600 W sets are installed in Dome-F Station, and several 100 W sets are on oversnow vehicles.

VHF radio transceivers of 150 MHz are used for short distances between oversnow vehicles and for personal communication.

Satellite communication by Inmarsat is planned between Dome-F Station and Japan. The vertical angle limit of antenna direction for good quality communication is above 5°, and the angle at Dome-F Station to the satellite is about 3°. Though the angle is smaller than the limit, communication will be possible according to other examples at such high latitudes.

8. Transportation

It is necessary to transport to Dome-F 263 t of materials for two winterings (Table 4). Materials include buildings, the drilling system, scientific instruments and fuel. Since the 1000 km distance from the coast to Dome-F is too far for the aircraft of the wintering party (Cesna A185F and Pilatus Porter PC-6), all materials must be transported on the surface by the oversnow vehicles which includes the SM-100 (Power: 280 PS/2000 rpm, track ability of 72 sledges), SM-50 (156 PS/2400 rpm, 3 sledges) and Snow Tractor D40PL (8 sledges).

The transport schedule is shown in Fig. 7. Transport traverses will be done twice or three times a year between 1991 and 1994, and wintering at Dome-F for the drilling operation is to be done in 1995 and 1996. In each traverse, four or five vehicles will pull a train of sledges. For transport efficiency, several traverses will be made from Syowa Station to Middle Point, 600 km from S16 on the coast.

Table 4. Materials for transport to Dome-F Station.

	JARE-36(1995)	JARE-37(1996)	Total
Buildings	32		32
Facilities	16		16
Light oil	46	42	88
Kerosene	16	14	30
Oil	3		3
Drill system	12		12
Anti-freeze liquid	30	20	50
Instruments	6	2	8
Food	12	12	24
Total	173 t	90 t	263 t

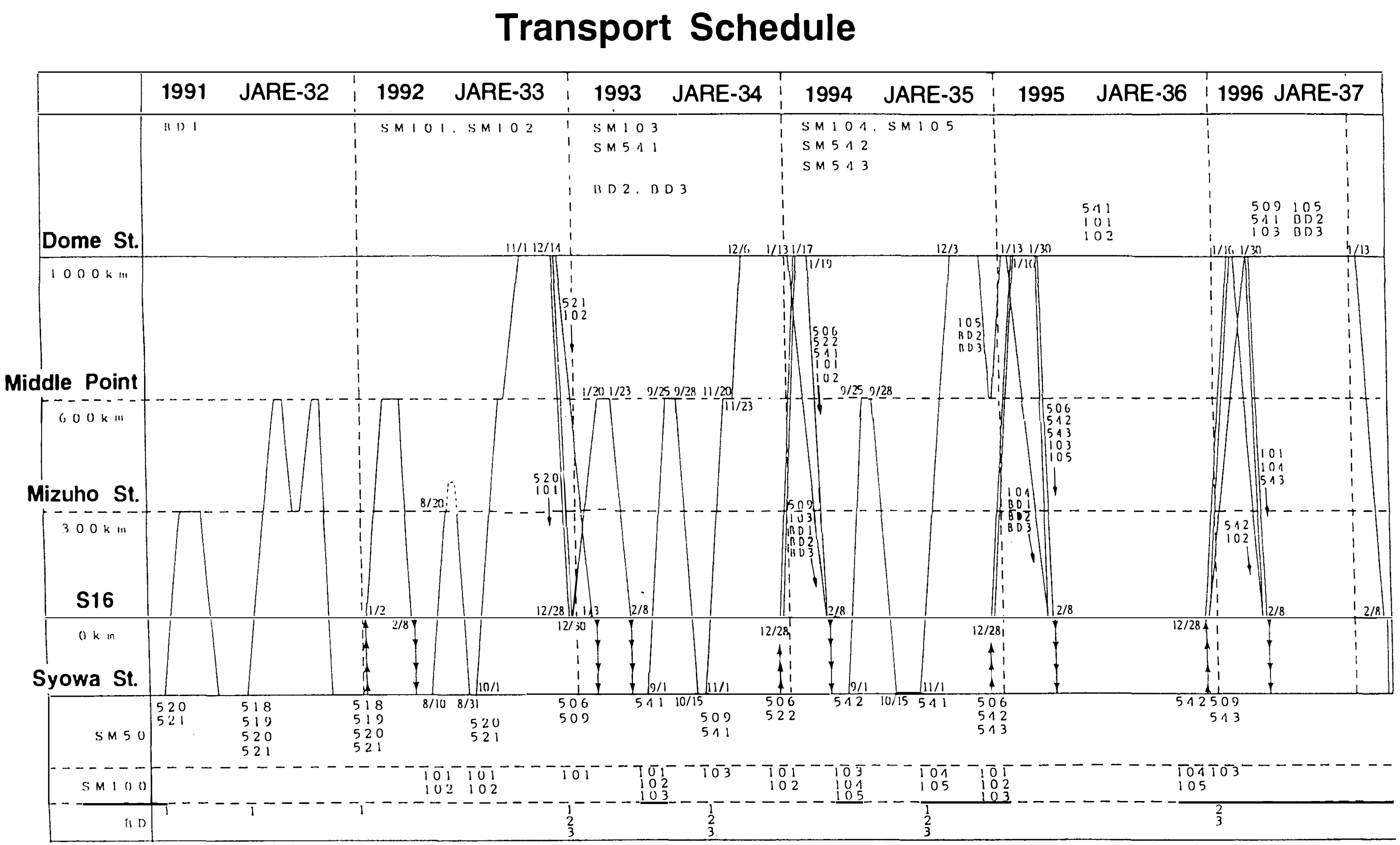

Fig. 7. Transport schedule for the Deep Ice-Coring Project at Dome-F. Solid lines indicate the movement of oversnow vehicles. Arrow lines between Syowa Station and S16 indicate flight access, when oversnow vehicles cannot pass a strait in summer.

9. Concluding Remarks

For the Deep Ice-Coring Project between 1991 and 1996, Dome-F Station is to be constructed by JARE on top of Dome Fuji in Antarctica. The station will consist of two areas: a residence and a drilling area. The residence area includes living huts and a power station, constructed on the snow surface. The drilling area consists of a drilling trench, a drill workshop and icecore and equipment storage trenches buried under the surface.

The minimum temperature is expected to be –88°C. To maintain warmth, the living huts will have 20 cm thick walls and will be half-buried with snow.

Three 28 kVA generators will be installed: one for station maintenance, the second for drill operation, and the third for preparation. Heat for warming each hut will be supplied mainly from circulation of hot-water from the generator cooling system, with additional heat supplied by a kerosene heater.

To support the ice coring operations, 263 t of materials must be transported 1000 km by oversnow vehicles from Syowa Station to Dome-F. The transport period is between 1991 and 1994, the station construction period is from 1993 to 1994, and the ice-coring period at Dome-F Station is 1995 and 1996.

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(Received October 4, 1993; Revised manuscript received January 19, 1994)