GENERAL REQUIREMENTS OF A SATISFACTORY OVER-SNOW MACHINE

by

R. A. Work
Senior Irrigation Engineer and
Supervisor of Snow Surveys
Soil Conservation Service
U. S. Department of Agriculture
Medford, Oregon

A universal purpose mechanized over-snow vehicle for use in snow surveys must have certain characteristics. These principal characteristics are later listed in a rating table. The suggested relative numerical rating for each is based on the writer's experience of several years with various machines.

It should be remembered that a machine ideal for snow survey purposes might or might not be equally well adapted for commercial or military over-snow use.

Discussion of the thirteen basic characteristics follows:

1. The ideal vehicle for specialized over-snow use in snow surveys must above all be mechanically dependable. A vehicle lacking mechanical dependability cannot be counted upon to execute long or difficult trips, nor can such a vehicle safely be reckoned to displace costly shelter cabins which must otherwise be provided for men traveling on foot, nor can it be counted upon with assurance to replace many men traveling slowly but surely by ski. Mechanical dependability is achieved through proper design, skillful workmanship and correct use of suitable materials. The proof of mechanical dependability is experience. Any given machine should be rated up to 25 percent on mechanical dependability out of a total possible score of 100.

2. A mechanically dependable machine may still prove unsuitable for snow surveys because it is not designed to deliver required performance. Performance proven to meet customary travel conditions in snow is the next most important qualification.

   There are many components of performance. A critical test of performance is ability of the machine to travel steadily and consistently in loose deep snow or on soft sticky snow. A mechanically able machine which cannot carry the necessary two-man party load at safe and consistent speed through deep soft unbroken snow is of limited use for snow surveys because such snow conditions prevail more often than not in snow survey schedules. As shown in the rating table, performance in soft snow is rated as nearly one-sixth of the performance total of 58 points.

3. The ability to sidehill seems only slightly less important than ability to travel on soft or sticky snow. Snow survey machines almost always

travel on forest roads. Such forest roads usually run along sidehills, at least for short stretches. Sidehill roads frequently fill with snow so as to present a snow surface conforming to the sidehill slope. This is nearly always the case in open rolling country. If the machine cannot find a route above or below the sidehill slopes, it must follow the road route. If the machine cannot travel successfully on the sidehill the remainder of the journey will have to be completed by foot, and such machine will have to be rated down as a performer in this respect even though its performance in other respects be good.

4. Ability to operate on ground bare of snow is extremely important for over-snow machines. Bare ground cannot always be avoided. The mother truck transporting a machine to snowline may be unable to negotiate a deep long snowdrift in a narrow road right of way, but beyond the drift there may be 100 yards or perhaps miles of bare ground to be traveled before the over-snow machine comes to unbroken snow cover. Especially in the springtime there may be dozens of patches of bare ground that will have to be negotiated by the over-snow machine. The ability to negotiate bare ground or alternating patches of snow and bare ground must be rated at least as high as ability to sidehill. It seems nearly as important as any other single performance characteristic. An over-snow machine that cannot safely and at fair speed travel on bare ground will have to be limited in snow survey use to special areas or special times and therefore is not the ideal machine.

5. Of lesser importance than ability to travel in soft deep snow, to sidehill, and to travel over bare ground, is hill-climbing ability. A machine that can ascend dizzy grades on snow is spectacular and doubtless very useful for some purposes such as in winter sports. Yet, in snow survey work, where machines usually follow forest roads, which seldom exceed grade of 18 percent, spectacular hill-climbing ability normally is not required. There are frequent instances, however, when good hill-climbing ability is necessary in detouring bad obstacles. Therefore, hill-climbing ability is not to be discounted, but is to be counted on the asset side. If an over-snow machine cannot ascend grades up to 25 percent in soft snow then the value of that machine is decreased to the point where its use might have to be restricted to certain routes and areas. Such a machine cannot rate up as an all-purpose snow survey machine.

6. Maneuverability of a machine in snow (or on bare ground) is very important in the performance scale. Unless the machine is so light in weight that it can easily and safely be man-handled, it is imperative that controlled mechanical power provide the means of maneuvering, turning sharply, reversing, etc. This is of great importance in timbered country and on narrow rights of way - the customary snow survey routes. Any machine lacking ready maneuverability automatically discounts its safety factor since the operator has less choice as to speed selection or route to follow.

7. Fairly high in the performance scale is ability to quickly surmount obstacles such as fallen trees, collapsed bridges, steep banks, gullies,

etc. If an obstacle of this sort is encountered at the beginning of a snow vehicle journey, the machine with ample power, showing versatile and limber performance, which can pass by or over the obstacle with a good degree of safety and with mechanical freedom will please the men who operate it, for they will probably complete their surveys on schedule.

8. Economy of operation may properly be classed as a component of performance. Of two machines which perform satisfactorily in all respects, and equally dependable mechanically, the better rating would be to the machine which costs the least per mile of operation for gas, oil, depreciation, repairs, amortization and perhaps, driver cost. Over-snow machines are now being used more extensively in snow survey work than formerly because it has been found that in most cases, although not in all, they reduce costs and provide snow survey results of high accuracy.

In this connection the following statistics* seem significant:

	Snow Surveyors Employed	Snow courses Measured	Foot Travel (Miles)	Machine Travel (Miles)
1947-48 Snow Survey Season	890	927	25,994	3,650
1948-49 Snow Survey Season	885	1,007	26,175	4,735
Percentage Change	-1.0	+ 8.6	+ 0.7	+29.7

In one year's time, without appreciable increase in financing, one percent fewer men measured 8.6 percent more snow courses by increasing foot travel less than one percent but through over-snow machine travel increased nearly 30 percent.

This is to be the future trend; fewer and better trained men traveling faster and farther in dependable machines, either aircraft or over-snow.

9. Of lesser importance in the performance scale is speed. This is not to mean that speed is not desirable, for of any two machines of equal performance in all other respects and of equal mechanical dependability, the race of course would be to the swifter of the two.

Speed, however, is relatively less important than other performance characteristics. A machine that can travel dependably and steadily at 10 mph over widely varying types of terrain and through snow of wide range in supporting power will probably deliver the survey results more rapidly than a machine which travels very swiftly on hard snow over flat open terrain but travels haltingly or with temerity up or down narrow, tortuous, steep sidehill roads. There is a relation between weight and safe speed of machines. It is doubtful if heavy machines should safely exceed 20 mph in snow. Lighter machines may safely go faster in open terrain than heavy machines.

*Includes 12 western states but does not include British Columbia.

Figure 1.-- Two Pontoon Tucker Sno-Cat. This machine and earlier models have been used for several years in the west.

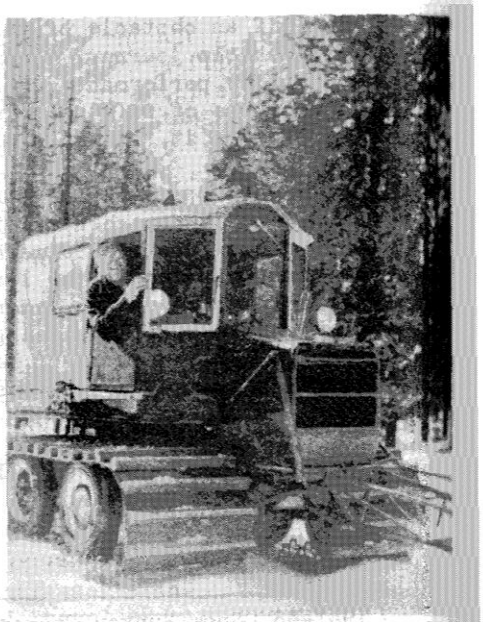

Figure 2.-- Recent Experimental Model over-snow machine developed by Utah Experiment Station and Soil Conservation Service.

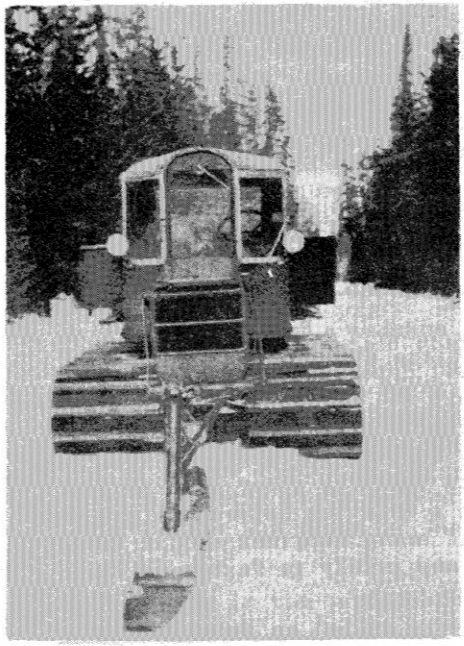

Figure 3.-- Same machine as Figure 2 showing retractable skis used to assist with steering under difficult conditions.

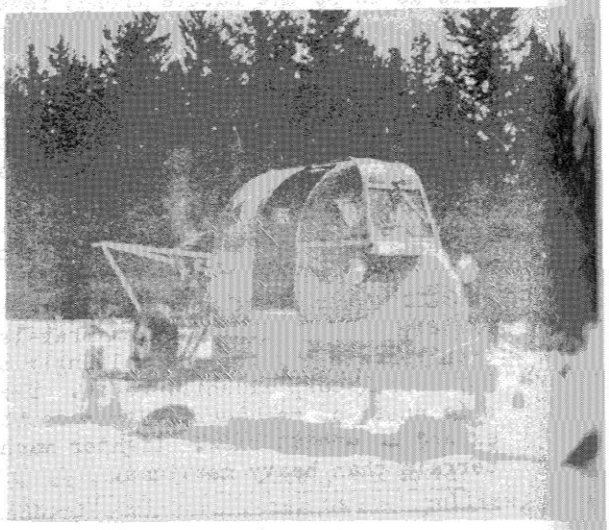

Figure 4.-- Propellor driven snow plane with retractable wheels.

Traveling on snow surveys differs from traveling a regular and well known route over snow, as might be the case with a mail contractor. The snow surveyor travels his route as seldom as once a year and rarely more than four times in a winter at monthly intervals. Fallen trees or boulders, hard-to-see telephone lines, thin and eroded snow bridges over cold, swift streams or washouts, snow laden branches, snow buried stumps, and other natural hazards all frequently conspire to reduce a safe speed to 8 mph or less.

All of you with much experience in driving over-snow vehicles have found it frequently necessary to drive in flat light. Due to lack of shadows your eyes failed in perception of depth. Probably some of you have actually either run directly into a heavy vertical snow drift or may even have driven your machine over a cornice under such conditions. These lighting conditions are common in snow survey travel. Conditions may even be so difficult for safe driving that it may be necessary to send a man on foot ahead of the machine in uncertain terrain in order to gain depth perception. Speed under such circumstances is of course unsafe, to put it mildly.

10. Considered of least importance in the rating of performance is ability to cross open flowing streams. There are times and places of course when an over-snow vehicle simply must cross an open stream if its mission is to be accomplished. Therefore, the ideal over-snow machine for snow surveys must have this ability. There is more to this than simply plunging through the water. Usually air temperatures are below freezing and the free water entering various track parts or covering submerged skis will, more often than not, almost instantly coat such parts with ice. The machine, therefore, must be able to operate with ice in these vital parts if it is to be considered a successful open stream crosser.

    Open water crossings may be estimated at not more often than once each 800 miles of geographically dispersed over-snow travel. Therefore, inability of any machine to cross open water is not a critical drawback, although it does rate a machine down by about 3 points out of total possible 100.

11. Leaving performance as such in the rating scale, the rater must consider safety of the machine. Is the braking system adequate to hold the machine quickly and securely? Will the lighting system provide safe vision in the stormy dark? Is the cab sufficient to protect the machine's occupants from destructive forces such as falling limbs or freezing winds at minus 40 degrees? Would the cab protect the occupants if caught in an avalanche? Are there dangerous projecting moving mechanisms such as exposed drive shaft, etc? What is the stability of the machine on steep sidehills? Can it be readily overturned?

    These are the sort of questions that should be answered in assessing the safety factor of a machine. Safety should rate equally high with any component of performance although not as high as mechanical reliability. Mechanical dependability of itself increases the safety rating of any machine.

12. Unless an over-snow machine can be transported easily, quickly and cheaply from its home base to the snow fields, that machine becomes less of an asset for snow surveys over large areas. This characteristic is described in the rating table as "Portability." In general, the lighter the machine the more portable it is likely to be inasmuch as a mother truck of lighter weight might be used. The bed length of truck or trailer required to haul the over-snow machine should be considered. The ability of the over-snow machine to load and unload itself from the mother truck is important.

13. The final item in the rating table is "Comfort." To dyed-in-the-wool snow surveyors this might seem unimportant. Nevertheless, it is the factor which may decide whether or not a certain trip can be made on schedule. When air temperature hovers below minus 20 degrees F, and particularly if a chilling wind blows, it is a severe and possibly dangerous physical hardship to travel swiftly for any length of time in an exposed position without physical activity to maintain body temperature. Men do better work and return more promptly with more accurate results if provided with adequate protection from the elements. Therefore, a cab of some description on over-snow machines is imperative.

The writer's proposed rating table for use in applying a numerical rating to any over-snow vehicle follows:

1.	Mechanical dependability		25 points
	Performance		
2.	Ability to travel on soft or sticky snow	9	
3.	Ability to traverse steep side slopes	8	
4.	Ability to operate on ground bare of snow	8	
5.	Ability to ascend steep grades	7	
6.	Maneuverability	7	
7.	Ability to quickly surmount obstacles such as fallen trees, gullies, steep banks, etc.	6	
8.	Economy of operation	5	
9.	Speed	5	
10.	Ability to ford open flowing streams	3	58
	Other Qualifications		
11.	Safety	9	
12.	Portability	5	
13.	Comfort	3	17
	Total		100 points

Any machine with numerical total rating of 80 or more may be considered good for snow surveys; 65 to 79 fair, and below 65 poor.

DISCUSSION

by

George J. Klein
Canadian Research Council
Ottawa, Canada

Mr. Work has discussed the requirements of an over-snow vehicle in a broad general way and has done it so well that it is difficult to add anything of real significance.

This paper's real value lies in that it clearly sets down these requirements from the point of view of one who has had considerable experience with various vehicles.

The rating table proposed by Mr. Work clearly reflects his experiences with the use of vehicles in snow surveys; and it is interesting to note the emphasis placed on mechanical dependability.

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THE CANADIAN SNOW-COVER SURVEY

by

George J. Klein
Division of Mechanical Engineering
National Research Council of Canada
Ottawa, Canada

Every winter, for several months, almost the whole of Canada is covered with snow. This fact has made snow such a common-place material to Canadians that the need for its scientific study is not generally appreciated. Even the simplest study of the effects of snow on the Canadian economy will serve to show that, although long neglected, snow is a material which merits a great deal of scientific attention in Canada.

The National Research Council of Canada has appreciated the importance of snow and ice for some time and has been carrying out investigations in this unusual field of research since 1935. For the benefit of those who may not be familiar with the National Research Council of Canada, the Council is the Dominion Government's main research organization. It has eight Scientific Divisions covering practically all branches of science. Its laboratories are quite extensive, modern and well equipped and employ a staff of 3,000.

The initial problem undertaken in this field by the Council was the investigation of the performance of different types of aircraft skis on snow.