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THE CHANGING CONCEPT OF ANTARCTIC SCIENCE

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Before assessing the new logistic tools available for work in Antarctica, it might be appropriate to look into the future, as much as may be possible at present, and estimate the major trends that may be expected in the scientific development of the continent.

In the five years since the beginning of the IGY period, immense gains have been made in our knowledge of the southernmost continent. The size, shape, elevations, ice thickness, ice volume and annual snow accumulation are now much better known, and the numerous oversnow traverses furnishing most of this information are perhaps two-thirds completed in the detail that is now considered appropriate. The annual patterns of surface and upper atmosphere, temperatures and wind systems, have been well established. The locations of all major ice-free areas are now known and mapping is proceeding at a rapid rate. The geological parties will soon have visited most of the new ranges. All but a few of the birds have been banded, and the biology of the land and the waters; the microbiology and bacteria are under close scrutiny. Truly, Antarctica is moving out of the darkness into the light. The IGY conception was a very successful one for Antarctica, and yielded enormous amounts of information. Much of this data is still to be analyzed and digested, but this is being done as rapidly as can be expected and scientists are busy in the preparation of scientific atlases and monographs. With the completion of the individual areas of study, there will be more synoptic studies of the overall continent. At the end of this first five-year period then the descriptive phases of the work is continuing in all aspects, with some parts nearing completion; and meanwhile the analysis period is now in full swing. What, then, can be predicted for the next five years?

The future of science is built on new knowledge. As more is known of a specific subject, methods are altered, sometimes even objectives. No true science is static but is continually following new and promising leads, and abandoning others. No attempt will be made to detail here the many changing and dynamical objectives of science in Antarctica, but a few of the main goals may be mentioned, mainly to portray the direction that Antarctic science appears to be headed.

What has been learned about the continent itself? Though little progress has been made in the main goals of the history of the continent and the paleoclimates in the past, at least science has in a sense stripped off the ice and revealed the geography of the continent itself, and this is the logical beginning. More and more is being known of the rocks, their types and most important their ages and the orogenies of the past. The ever penetrating search for fossils will continue at all fronts. Though scientists have progressed far in their details of the ice thickness, only a beginning has been made in the study of the ice movement in the interior areas, and on this movement will depend many of the answers to the questions of present growth, and past history of the ice. The inland ice must be drilled and aged, like the rocks, and the paleotemperatures determined. Many of the clues and past history of Antarctica lies in the deep sediments off shore and these must be gathered and studied.

The concept of the IGY was developed, as of the previous polar years, by studies of the upper atmosphere. The Antarctic continent with the geomagnetic poles and southern aurora zone is most important in this field and the knowledge gained has already led to new concepts and new recording instrumentation. The concept of the IQSY, the year of the quiet sun, was conceived to give a reference plane from which solar effects can be better evaluated. It is expected that great advances will be made here in the full exploitation of rockets and satellites, and particularly as viewed by synoptic studies at conjugate points, the ends of magnetic lines of force, north and south.

Much of the analysis of the meteorological data was required in the operational use, the weather maps being more urgently required than such maps as would portray the aurora or ionosphere. The unknowns for the aerology scientist now are outward and upward, outward into the vast ocean belt surrounding the continent and upward beyond the reach of the balloons. In the future there will be new tools needed to exploit these deficiencies, such as rockets and transosondes balloons. The oceans of the southern hemisphere are vast and many areas untapped or little exploited for their knowledge. The magnitude of the oceanographic problem is not alone for Antarctic science but these waters outward of Antarctica form the bottom waters over much of the globe, and if it were not for the vast problems of distance from the populated areas of the world, these seas would perhaps be logically the first to study. Both the studies of the oceans and the atmosphere above the oceans will be greatly enhanced by the satellites, and indeed the polar satellites is the greatest single potential logistics tool for the exploration of the weather of the vast area of seas north of the continent and the delineation of the Antarctic ice pack. No future foreseeable tool will have a greater direct application to the needs of meteorology and oceanography in the Antarctic.

For the biological sciences, much remains to be accomplished in purely descriptive work through taxonomy and centers of collections. Though the ecology of Antarctic species and the peculiar adaptation processes that distinguish Antarctic forms, require increased study, the need both in land and marine forms is for continued sampling. The biologist must by necessity be mobile but also he must have well equipped laboratories at hand to study his subjects in the field. In this aspect his requirements are more stringent than the geologist who is assured that his specimens can be brought back to the home laboratories much as he has collected them.

This bird's-eye view of scientific pursuits of the next five years is by no means thorough but it may help in its vague assessment to point the way for the logistic tools of the future. Obviously the great need is for mobility. While the upper atmosphere physicists and the meteorologists will be content for the most part at a permanent camp, the majority of scientists; the biologists, geologists, glaciologists and oceanographers need mobility, some with little equipment, others with elaborate equipment. Their stays at specific locations will never be permanent but will vary from a few hours to a few years. They will not be concerned with the dark winter months but will want to take full advantage of the daylight periods. Full concern should be given to the potentials of the satellite so that Antarctic science will be ready to accumulate, digest and utilize the enormous amounts of data that will be made available by this medium.

SYMBIOSIS OF ANTARCTIC SCIENTIFIC AND LOGISTIC OPERATIONS

Paul A. Siple

I. Introduction

Among broad technological advances of the past two or three decades those which provided improved sea, land and air transportation, communications, and power and laborsaving devices have been most responsible for the freeing of scientific investigators from the former arduous labors involved in exploring Antarctica. Living and travel conditions are only slightly substandard to average facilities available in other areas of the world. Except for occasions of misadventure men have been isolated from the lethal potential of the climate and freed from the time-consuming and strenuous essentials of survival. An Antarctic scientific observer can anticipate about 90 percent more time to devote to his investigations than was possible a quarter century ago even though he may still suffer by a 50 percent loss of the time he anticipates.

The technology of polar logistics, * formerly a highly specialized art has now become virtually a minor engineering adjustment to standard operating procedures. This does not imply that logistics operations themselves do not require a high degree of specialization with the ever increasing complexity of devices; rather, it means that the failure to make sound environmental adjustments are less apt to result in serious human hazards. Therefore, adequate logisticians without previous polar experience can meet requirements peculiar to Antarctica with low risk of endangering human life, albeit the depreciation of facilities and equipment as a result of poor adjustment to environment may reduce the available transportation, supply and economic backing. Wherever these latter factors are seriously limited, the need for greater polar experience in assuring the increased effectiveness of logistics support becomes more important so that economic supporters of the total effort do not discontinue the effort prior to meeting the over-all objectives of continuing missions. In the long run, for missions with no anticipated terminal dates, the increasing of logistics effectiveness and efficiency is desirable, if not mandatory. To achieve this requires an equal effectiveness and cooperation among the participants of the missions being logistically supported. Achievement of the latter in cases of scientific programs appears to be largely a matter of qualitative and quantitative selection of projects and personnel, and above all to adopt scheduled planning compatible with logical and reasonable logistics support requirements. *That is, scientific support requirement should not, as is its normal nature, increase* radially on all fronts simultaneously; but rather, adopt linear and segmental steps in a systematic manner to achieve equivalent goals in a similar period of time.

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*Logistics as used in this paper connotes all material aspects of Antarctic living and operating requirements necessary for an individual or a group of individuals to carry on its specific mission. Thus, logistics support for a mission of "logistics support" may dwarf the logistics support of a mission such as a "scientific program."

By the linear and segmental approach the logistics support system can be oriented about a main axis of communications and transportation rather than disperse its efforts in many different directions. The point often overlooked by the users of the logistics support is that effective radial logistics support decreases in service potential by the typical fourth power of other radiation laws, as compared to deflecting, focusing and concentrating the energy along a narrower path.

I have participated in expeditions with wide variations in the approach to logistics support of scientific programs. These have included: planning for both science and logistics by a common authority; divided authority; science added on to existing logistics; logistics tailored to specific science missions; priority missions transcending over lesser projects; radial and linear support. Contrary to opinions I've often heard expressed relative to which factor should take prime leadership between logistics and science operations, I believe either system will work equally effectively, if the personnel involved cooperate in planning and operations with a spirit of mutual respect and oneness of purpose.

II. Essential Partners of a Union

For Antarctic activity, as with all other types of scientific field work, success depends upon the combined effectiveness of the scientific program and its supporting logistics. The purpose of this paper is to outline the inter-responsibilities and respect for one another when research and logistics are handled, as is frequently the case, by separate specialists. Only in exceptional cases can we assume that the scientist is a capable logistician or vice versa. A logistic technician is not necessarily a polar technologist simply by assignment. He needs experience to become master of his trade; and although he need not be a scientist, if his task is to support scientific missions, he at least must be sympathetic to the aims and methodology of science. Despite the extensive formal training scientists receive they may prove clumsy or downright helpless as logisticians, if they have not studied this art as diligently as they pursued their own scientific discipline.

For the purposes of this discussion we will assume that we are dealing with both capable scientists and capable polar logistic technologists, and that together they form a team with a common purpose. This attitude alone is the most important assurance for success. We will assume also that neither group nor individual is more important than the other; but rather that each is vital to the other, if the mission is to be successful. Expert logistics tailored to polar requirements will not alone assure the success of a scientific mission; if the scientist fails to perform good research, the effort is a waste of time for all. Similarly, if a superior scientist or team of scientists are furnished poor or inadequate logistic support for their mission they may never have a chance to achieve their goals. Simple as this logic sounds, the degree of success and esprit de corps hinges on the wholehearted, mutual understanding and cooperation which historically has made certain polar operations differ from others.

To begin with, let us examine the general nature of the problem and the responsibilities of the two elements. In extreme cases the scientific element may be expected to receive such full support that they are at liberty to spend full time on their scientific mission. Often this is not practical, for the size of the party may not permit five or ten men necessary to look after the personal needs of a single individual. In small parties the scientist may be expected to share in some housekeeping duties. It is not unreasonable that he may be at least expected to make his bed, keep his quarters and working space clean, wash his own clothing, and even help to some extent on community chores such as K. P., snow melter details, or cooperate with all hands in emergencies, etc. From the human standpoint it is not best for morale that any man be served "hand and foot," unless the mission creates unreasonable working hours for an individual. That is, if everyone works basically on an 8-hour day, each can reasonably put up with his own lot; but when one's assignment or devotion to duty continually consumes the entire waking hours, whether he is a scientist or a logistic technologist, he merits special consideration.

Unbalanced work loads whether assigned or self-imposed can engender a basis for criticism and hurt feelings. Some men can't remain idle if they feel responsible for a never ending load of work ahead. It is natural that they should feel resentment for extra assignments to share in community chores so that the rank and file of men can end up with a 6 or 8 hour work day. Scientific or logistics personnel who continually cut into their leisure hours to continue their work are sufficiently dedicated to merit relief from community tasks whereas others may have duties which require only occasional attention during the work day except during emergencies or breakdowns. These "idle men" can rightly irk the "overworked man" when the latter is taking his turn on K. P. or snow shoveling extra duty. Such problems as these are basically the task of balancing time among a team; and, fundamentally is the joint problem of the station scientific and support leaders unless, of course, they themselves have become victims of the disease of idleness.

III. Cleavage Tendencies

Smooth, effective cooperation between scientific and logistic technicians forming an Antarctic team depends upon minimizing avoidable causes of physical and psychological friction. In this paper physical friction is intended to connote physical activities and situations which destroy, hinder or disturb the operations of either the scientific or logistic activities. A few simple symbolic examples serve to recall typical examples.

A science team member in an enthusiastic urge to try a new experiment laboriously strings out a long surface wire antenna oriented carefully. A few hours later a cold, tired tractor operator drives along an accustomed path, and may or may not see the new antenna. His tractor treads not only cut the wire, but the wire tangles in the tracks and he spends an hour cutting it free. The science experiment is terminated at a critical moment. Both men involved grow angry and their colleagues join sides.

Another example: An irate cook gets downright fed up with two meteorologists who always arrive late for meal time which adds to his galley duty hours. One day he decides to teach these gentlemen a lesson in punctuality, when they are even later than usual. He throws out the food and closes the galley. The two men arrive already frustrated because of instrument difficulties during observation periods which conflict with the scheduled meal hour. Tempers flare with righteous indignation and bystanders join sides to create a real station-wide emotional upset.

Still another example: The station logistics leader orders a team of his men to clean out the passageways that have become unsightly and hazardous. The men with these limited instructions clear the passages including a few unidentifiable objects and personal effects. An hour later troubles begin. A scientist is fuming when he discovers his box of spare parts he'd pulled into the passage earlier that day is gone—yes, gone for good—"We thought it was just an empty box of excelsior and burned it." Angry also are two pi-ball observers who lost their balloon run because of local smoke. A light breeze was not only drifting pall of smoke from the trash fire, but soot in large chunks are falling promiscuously into the snow area for the camp's water supply. The anger and beefing doesn't die down quickly, for a radio operator coming off watch discovered his spare clothing duffel bag he set outside the barracks while cleaning his room was buried under a pile of heavy boxes and barrels by the diligent work team. —Just when the radio operator needed an item in the bag before bathing and turning in.

There is no point of continuing examples of these familiar expedition "rough spots." Obviously in retrospect one could easily recognize the solutions: pre-planning, thoughtfulness and consideration could solve most of such problems. — The antenna should have been placed in a zone inviolate to tractor movement. Meal hours should more flexibly adjust to observation hours and emergencies. And, if a leader has authority to command, he must assume responsibility for clarity of instructions and think of ramifying problems, if his subordinate who may take minimal instructions too literally does not bother to think.

We will discuss the physical pre-planning in greater detail a little later on. However, let us return to the subject of psychological friction for a further look at the problem.

IV. Differing Opinions

Psychological friction between the logistic and scientific elements of a team may for our purposes be divided into four classes.

1. Personality idiosyncrasies.
2. Higher command influences.
3. Uncoordinated regulations.
4. Uncoordinated planning.

1. Personality idiosyncrasies is a random element present in varying amounts in each member of any social community. It is not restricted to either logistics or scientific personnel. "Odd balls" will crop up, especially where neophytes are selected for a task by nominators who are inexperienced in spotting personality weaknesses. The types of traits most commonly irritating to others on an expedition include: technical incompetence of assigned duty; habitual carelessness, discourtesy or clumsiness; "goof-offs" and job shirkers; slovenly and unsanitary habits; inconsiderate noise makers; uncouth and loud talk; excessive practical jokers; moody or quick tempered grouches; stingy lenders; unauthorized

borrowers; losers of tools; extravagent users of limited supplies; and finally, those who develop real or imagined physical disabilities or unmanly traits, including disloyalty and tale carrying.

In only a slight way does one dare to generalize the differences common among the two classes of expedition citizens-scientists and logisticians. Where the latter are selected from a military source, their prior enforced training or vestige of discipline tends to maintain better cleanliness habits but worse language habits than the civilian group as a whole. The usually higher degree of formal education of the scientists is generally respected by the less well educated, unless the former flaunts his knowledge with an air of superiority which quickly engenders disgust toward his apparent asset.

2. Higher commands who issue orders from afar to affect the endemic social order of a station can have excessive effects in morale and esprit de corps, both good or bad. Unfortunately, there seems to be a principle at stake which governs such matters. In a field operation, distrust, misinterpretation, and accredited stupidity square with the distance between forward and rear echelons, both of whom are well meaning and rational. Clearly, this is mostly due to faulty communications; each minimizes words or holds back as unnecessary, the rationale behind its respective demands. Patience, restraint and sympathetic understanding are required at both ends. Rear echelons should far exceed their share of give and take with a distant field group, the latter of whom feels penalized, whether actually or not, by isolation and minimal comforts. They resent being left out of planning, news, or decisions affecting them. Because logistics controls the major lines of communications, they may more easily abuse it. Higher commands, exercising unnecessary precautions or simply yielding to expansiveness of their feeling of authority, can unwittingly tantalize the morale of a field party or advanced station already overtaxed by local problems. It is well to bear in mind that this same sort of misunderstanding, bred by distance between loved ones, has broken up many a marriage or engagement of expedition men. Broken morale can destroy a man's ability to fulfill an assignment.

3. Discussion of uncoordinated regulations will here be confined to a station or field party, even though it be founded upon command of higher absentee officials. The nature of this source of friction arises commonly by the logistics controllers of a station establishing rules and regulations affecting the scientists or scientific operations without consultation. Meal or recreation hours, communications regulations, use of facilities and equipment, off-limits, safety precautions, etc. These are clearly prerogatives of the station logistics officer-in-charge; however, if the times or the restrictions hinder the science programs directly or indirectly, the station logistics OIC is abusing his authority, for he is hindering the very program he is placed there to support. It has been my own experience among responsible adults of a close knit expedition community, that the fewer the administrative regulations the better. Furthermore, the reason for those that are necessary should be amply made clear by prior open discussions.

4. Uncoordinated planning is a sin which can be induced by either the logistic or scientific elements of the station. Furthermore, it can be aggravated by vagaries in the weather that suddenly makes the time ripe for action of several events requiring the use of the same equipment, facilities or manpower simultaneously.

Conflicts in priorities for use of transport, communications and physical assistance are most common. Well coordinated plans and generous compromises become essential. Health and safety in emergencies take precedence over scientific accomplishments; however, in times of opportunity, low priority logistics activity should not cause postponement of scientific efforts well planned in advance.

Scientific planners seldom anticipate their needs, changes and delays to the extent of the desires of their logistics supporters. If the logistician knows the exact requirements of his support mission well enough in advance, weather and providence be willing, he can reasonably meet his goal. Science as carried on in the Antarctic is of two types: (a) routine observations which can usually be planned well in advance, and (b) scientific problems germinated on the spot. A geologist, for example, may not know which of several peaks he wishes to visit until he sees the strike of the formation; an oceanographer needs to linger for a longer look when he discovers a new rise or a deep; an ionospheric physicist wishes to shut off all local interfering electronic equipment when a solar flare suddenly occurs; or a biologist insists on reaching a treacherous pinnacle for his senses suggest that it's the nesting place of a rare bird.

In short, science in the field needs to change its plans according to the opportunities that arise. It is here that the logistics personnel must exercise patience with the scientists' apparent changeableness of plans.

As mentioned earlier, the natural trend of science is to spread out radially like an expanding amoeba. If, however, the over-all planning is more linearly channeled, the random spread of science will be held in more reasonable bounds for providing logistic support.

Let us finally turn to the more concrete physical problems which arise between scientific and logistic elements especially at a station site.

V. Site Selection and Installation Development

We will start at this point with the assumption that teamwork is balanced so there is proper morale and respect among the scientific and logistic personnel. Normally the scientific mission can be well defined. However, its peculiar characteristics may be highly demanding on the physical arrangements in order not to destroy or introduce hindering interference. We will examine some of these cases a bit later. The responsibilities of the logistic staff are more embracing. They include not only physical assistance to erect or arrange scientific setups; but, they incorporate the entire element one could loosely refer to as housekeeping, including communication, transportation, food, water, heat and power service, safety and health. With such broad responsibilities it is easy to see why the logistic staff may at times feel that the very existence of the facility and its operation exceeds the piecemeal scientific missions of individuals; although the mere existence of an Antarctic station implies a purpose. Some stations exist for logistic reasons alone to support field parties or satellite stations, others for political or even economic reasons. However, we are concerned here only with those whose primary mission is dedicated to scientific research of one sort or another.

Interference most common to scientific programs include those which introduce vibrations, visual obscuration (smoke and vapors), power failures or variable electric voltage, electronic disturbances, drifting snow, inadequate working spaces, improper heating or shelter, noise, etc. Logistics operations by their very nature can produce these interferences unwittingly. The layout and operations of a camp can do much toward self-eliminating many of these problems, if the design is well planned ahead of time. This, however, is not always easy to do, for the scientific requirements introduced one or two years later may demand new considerations not laid down at the time the station was first planned. Therefore, we should seek principles of design which will minimize interference in general.

In laying out a camp or polar scientific station it is desirable to first determine the prevailing wind direction. In some areas the variability may make it difficult to establish this within the limits of one right angle quadrangle. This quadrant should be layed off at the start running indefinitely away from the camp as an inviolate sanctum for the exclusive use of the scientific program. The wind blowing from the prevailing direction will make this area least contaminated. If it is not walked over or driven over, it will remain essentially virgin snow suitable for glacial studies close at hand. Barricades should be set up along the borders of this quadrant to prevent tractors or logistic operations even accidentally entering this zone. During construction of facilities bordering the apex of this windward quadrant, minimum working paths close to the buildings may be necessary for a temporary period only. No storage of supplies or wide swings by vehicles should be permitted.

The down-wind quadrant opposite the science up-wind sanctum should, in turn, be given over entirely to logistics operations and the scientist should not expect to utilize space in this zone without receiving or causing logistic interference. Outdoor storage, transportation movement, etc., should be confined to this quadrant as much as possible. The two intermediate "cross-wind" quadrants should be layed out in compromise form to accommodate the requirements of both science and logistics, as necessary. In general, one of these quadrants may be assigned mostly to science and the other to logistics; however, various logistic operations may interfere with one another as do various scientific operations, especially if there is not ample planned space. One conflict which must be resolved next within these two intermediate cross-wind zones is camp water supply, under the province of logistics command. The station must have a continuously clean supply of snow for melting unless the specific locale is such that a lake or artificial water well is available. The snow collecting area for water supply should be in the logistics "cross-wind" quadrant bordering on the edge of the up-wind (exclusive science) quadrant. Snow coming from this direction will be least contaminated by the station itself, and the snow collecting area can form a barrier to help protect the science up-wind quadrant. The water supply system should never be on the down-wind side of camp for sooner or later it will be seriously contaminated unless subterranean snow is mined.

Serious interference often arises between logistics and science use of electronic equipment. Each requires its own antenna systems. The antenna systems can in due time create a gross hazard to the logistics transportation service. Logistics support communications should be located in the logistics "cross-wind" quadrant with the antennas as far removed as practical and still permit proper orientation and servicing. The farther the antenna can be removed from the station site the less interference will be induced into the electronic recording devices used by the scientists. Ionospheric antennas and other electronic recording devices should, if possible, be located in the science "cross-wind" quadrant opposite from the logistics communications quadrant; and, in turn, signal emitting antenna should be placed as far away from the camp as practical and efficient. If a magnetic tunnel is to be established, this may have to be oriented along a magnetic meridian. It should be placed parallel to the appropriate border of the science up-wind exclusive reserve quadrant; and, if necessary, oriented to enter the adjacent science "cross-wind" quadrant. Tunnels or paths leading to seismic stations and other observatories should, where possible, be placed on the bordering edges of the up-wind science quadrant. Meteorological equipment should be placed in the up-wind exclusive science quadrant; however, it should not be so scattered or create damage by snow drift or compaction to any more of the science quadrant than necessary. In general, they might well border along the logistic snow collection zone in order to provide part of the barrier to further inhibit unauthorized entry into the science up-wind quadrant.

The building layout itself should, in general follow these same principles and orientation; i.e., the science and logistic buildings, in accordance with their functions, should occupy the apexes of their respective quadrants as outlined above. Of course, in small stations there may be but one or two buildings, whereas in larger stations there may be many. The most favorable windward facing corner of the science buildings where the least station-originated interference by vapor, smoke or thermal refractions will be encountered should be reserved for scientific work dependent upon good atmospheric visibility. This would include the aurora, meteorological and astronomic observatories, etc. Heating plants, electrical generators and any devices which could create vapors or vibrations should be located in the down-wind building section facing toward the logistic quadrant. Obviously, the vehicle maintenance shop will belong in this area as well. This is not necessarily a desirable location for a garage entrance for it is also the snow accumulation zone on the lee side of the buildings. If a compromise is to be made, the garage entrance might be placed facing more toward the communications quadrant where cross winds will keep the entrance free of drift. Outdoor storage (temporary or for longer periods) should be placed along the borders of the logistic quadrant, which will tend to restrict vehicle traffic close to the camp into this one zone. Occasionally, vehicles will be required to enter the other quadrants for work purposes; but, this should be done under close supervision to prevent damage to lead-in wires, tunnels and other facilities. It will help to lay out a narrow vehicle path encircling but close to the buildings where all lead-in wires can be specially protected from traffic injury.

For stations that are intended to remain in existence over a period of years, each annual group of inhabitants should learn to respect the problems that they create in regard to the future. The worst offense of all is the broad scattering of debris, discarded vehicles, barrels, and shipping crates which induce drifting around them, and finally burial. The life of many stations has been shortened by the unwitting "jacking-up" of the surface. This is commonly due to poor management of outdoor storage caches. For example, full drums of fuel may be cached in an orderly fashion during the summer months; however, before they are to be used they may be drifted to their tops. In order to get at them or to prevent loss of the entire cache, it is standard procedure to dig the barrels out and set them on the surface again. In some cases this is done two or three times in a year. As a result, the entire surface will build up by drift snow to the height of these barrels each time they are elevated; and, in the course of two or three years the overburden dome will be "jacked-up" 20 or 30 feet. The weight of this snow encroaching over the buildings and tunnels can cause them to collapse. Carelessly discarding debris or leaving piles of shoveled snow on the surface does the same thing and each generation of needless surface discontinuities builds the surface higher and higher. If no science quadrant has been layed out into the prevailing up-wind quadrant, and this becomes a dumping ground as well, the piled-up section will proceed at a more disastrous rate for the station lies in the drift path. It should be the responsibility of the logistics officer to continually police the area for the removal of all unnecessary objects standing above the level of the snow. In the future expansion of a facility empty barrels and crates, trash and debris will make excavation most difficult and at times virtually impossible. One station recently replaced had to be moved five miles from its original site in order to get clear of debris which had been permitted to accumulate in all quadrants. If the station is supported by aerial drop or aircraft, the air strip should be placed at a convenient distance away from the buildings in the logistics down-wind quadrant.

An inevitable problem arises in the disposal of unwanted or discarded material of both the scientists and the logisticians. Burnable material could be periodically disposed of by having it burned at some suitable point in the logistic quadrant down-wind. Smoke can interfere with visual observations; and, even the flames could interfere during the night time period with visual observations such as those of the aurora observers. Trash that cannot be burned should be disposed of in an orderly manner such as a cache or a trench bulldozed out and marked on the station map for future reference. They should be also placed in the logistic quadrant or closely adjacent thereto. The modern cut and cover subsurface construction provides a hopeful solution to accessible storage caches as well as waste disposal.

A new station is like an infant that is bound to grow in size. Each new generation of occupants provides the requirements and nourishment. If the potential of growth is not reckoned with in the initial site planning and layout, growth will proceed randomly into any nearby unoccupied space. Unplanned growth can become cancerous in nature and can "sicken" a station in time, and even hasten a period of abandonment for an entirely new site. If scientific and communication antennas and lead-in wires are not restricted to a specific quadrant, the station becomes so strangled with wires that the transport traffic cannot move effectively about the station. If new buildings are scattered about the periphery without well-defined access paths, resupply of the original center buildings becomes increasingly difficult. Random new piles of excavated snow, higher new buildings and more caches and debris jack-up the snow level at an ever-increasing rate with new drift patterns to complicate operations. Perhaps the best solution to this growth dilemma is to plan the growth along the cross-wind axis of the station. If this is prepared for from the start, then it would appear necessary to develop a high overhead or undersurface conduit system for lead-in wires and a generous removal of antenna "farms" well away from the buildings which in turn favors the reduction of interference between scientific and logistics electronic equipment.

Scientific programs tend to develop their own more intimate logistics self-support; i.e., related to the science operations, instruments, and specialized gear. Each discipline may have a little of its own and because these personnel may be unschooled in the arts and engineering of logistics may create their own interference patterns. The interferences may develop concurrently between disciplines or linearly between succeeding generations. Furthermore, the carelessness with placement of new facilities, excavation or abandonment of materials and equipment may contribute to the lessened suitability of the station site for future generations of research workers inheriting their chaos. The rudiments of Antarctic logistics is a worthy prerequisite course for all visitors to the continent so that they learn to respect the interferences their unwitting carelessness may cause to fellow workers and to following generations.

Because logistics must serve itself as well as the science community, it may tend to become so self-centered in improving its own comforts, working conditions and facilities, that it loses sight of equal improvements for working and living conditions of the scientists. It is obvious that everyone, scientists and logisticians alike, benefit from improved facilities such as a galley, workshops, sick bays, communications facilities, etc; however, there is a tendency to place lower on the priority list an increase in the quality and quantity of working and living space for the scientists' partners of the wintering and summer seasons.

The change-over season for stations coincides with the busy field season and resupply period. It is also a period of psychological nonconformities; i.e., the past wintering group is anxious to go home, the new wintering groups are bewildered by the strange new world they find themselves in, and the "summer visitors" are in everyone's way or impatient and demanding for assistance to get the most out of their brief stay. It is during this period of disconformity that there is the greatest need for stable, experienced intermediaries with authority to set things right. It is only human nature that a departing crew leaves unaccomplished maintenance for the next year's crew. However, due to lack of experience and understanding they let the needed maintenance go until winter makes the work nearly impossible. They let the work go until spring; but, by then, they have learned to live with the problem as one can in due time get used to a hole in one's trousers. It's easy again to avoid the responsibility even though they recognize the necessity by now. Thus can develop the spiraling deterioration of a station. To cope with such a problem affecting both the logistics and scientific potential of a station, it appears desirable to introduce a third partner to the station. This partner could be in the form of a summer maintenance and turnover team representing the highest joint authority of both the logistics and scientific operations. If the work party were to be composed of industrious and skilled workmen under an experienced leader, the required maintenance and mistake of the departing wintering crew could be rectified and the new wintering crew could receive on-the-job training. The weakness in this suggestion lies in compounding the personnel requirements and the task of finding the broad experienced leadership willing to accept so much responsibility for so mundane a task. The strength of the concept lies in the provision of a "paternal" strong leadership of the station when it is at its weakest ebb (at the height of the work season), and that it would undoubtedly pay for its costs by the improved longevity of the station.

In this paper I recognize that I have drawn instinctively upon the problems and solutions of stations built on deep snow surfaces. I've neglected those fortunate enough to be built on solid land. The neglect is for two reasons: first, that they are in my opinion less unique than those built entirely on snow (though they do have specific problems); and second, that my own experience of wintering over four times has never been at a land-based station.

VI. Summary

The harmonic symbiosis of scientific and logistic elements of an Antarctic mission can be strengthened by adhering to certain principles. A few of the more salient ones are repeated here in summary:

1. Establish a proper and respectful attitude toward the important responsibilities each has to the success of the joint mission.

2. To receive maximum quality and quantity of logistics support scientific field missions should, as much as possible, be oriented along linear segments directed annually toward a new area or goal.

3. Establish the camp in such a manner that the interfering operations are most widely separated and inviolate from one another.

4. Orient the camp to give the prevailing up-wind quadrant and adjacent segment to the scientific operation, whereas the down-wind quadrant and adjacent segment should be devoted entirely to logistics. Do not attempt to intermix them.

5. In rough layout the station buildings should be allocated to the services facing the appropriate quadrants. All sources of vapor and smoke, as well as vibrating machinery, should be concentrated as much as possible into the down-wind or adjacent logistic quadrant.

6. Storage caches and disposal areas should be located in down-wind zones and never permitted to unnecessarily jack up the surface level of the snow above its normal accumulation rate.

Of all the principles mentioned, by far the most important is the one which establishes proper attitudes and cements both the scientific and logistic teams into a single mission unit. There will always be problems and conflicts; however, if a spirit of cooperation and common sense are employed, the mission will be successful and the station will engender high morale.

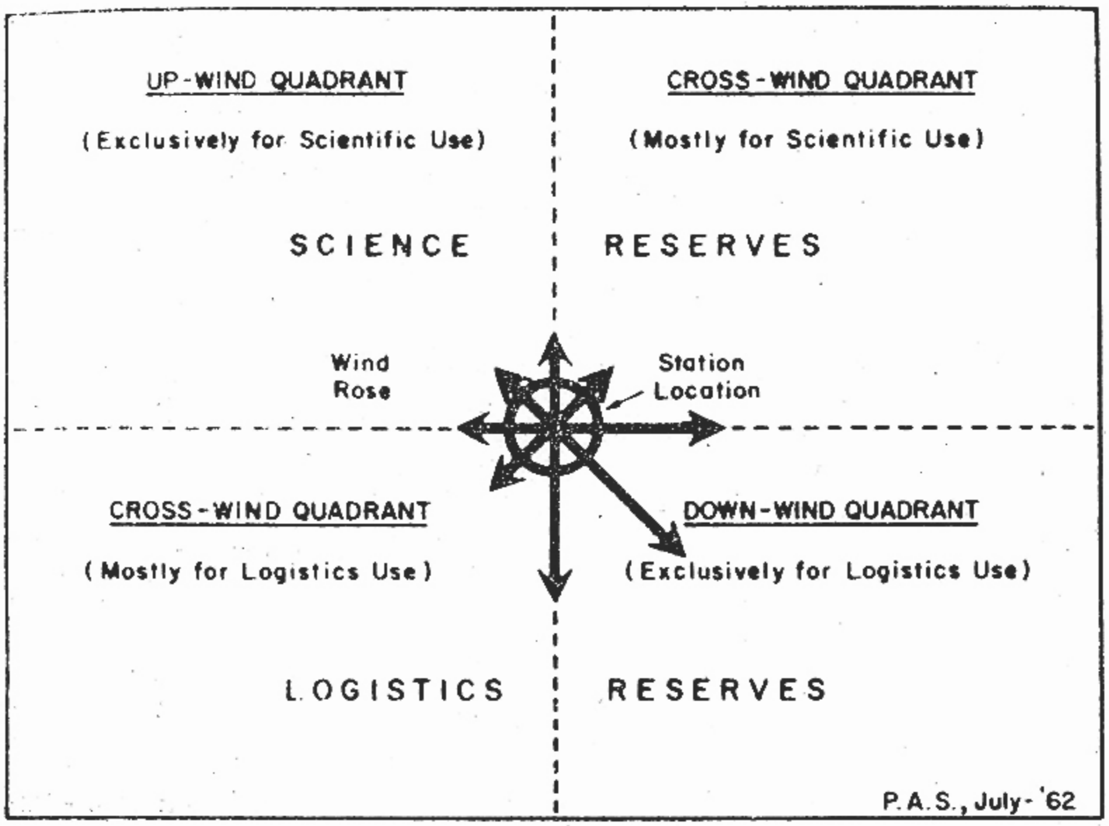

Figure 1. Idealized Antarctic Station layout with respect to primary prevailing winds.

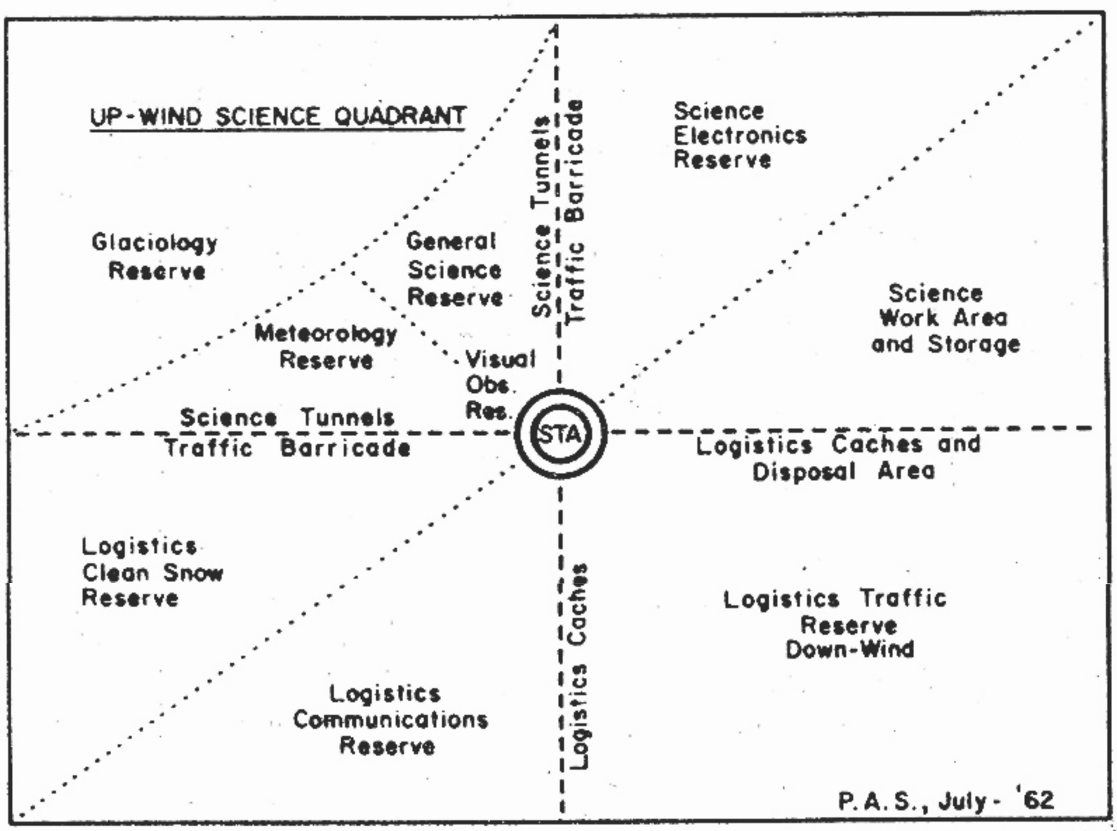

Figure 2. Functional distribution of reserved areas around an Antarctic Station.

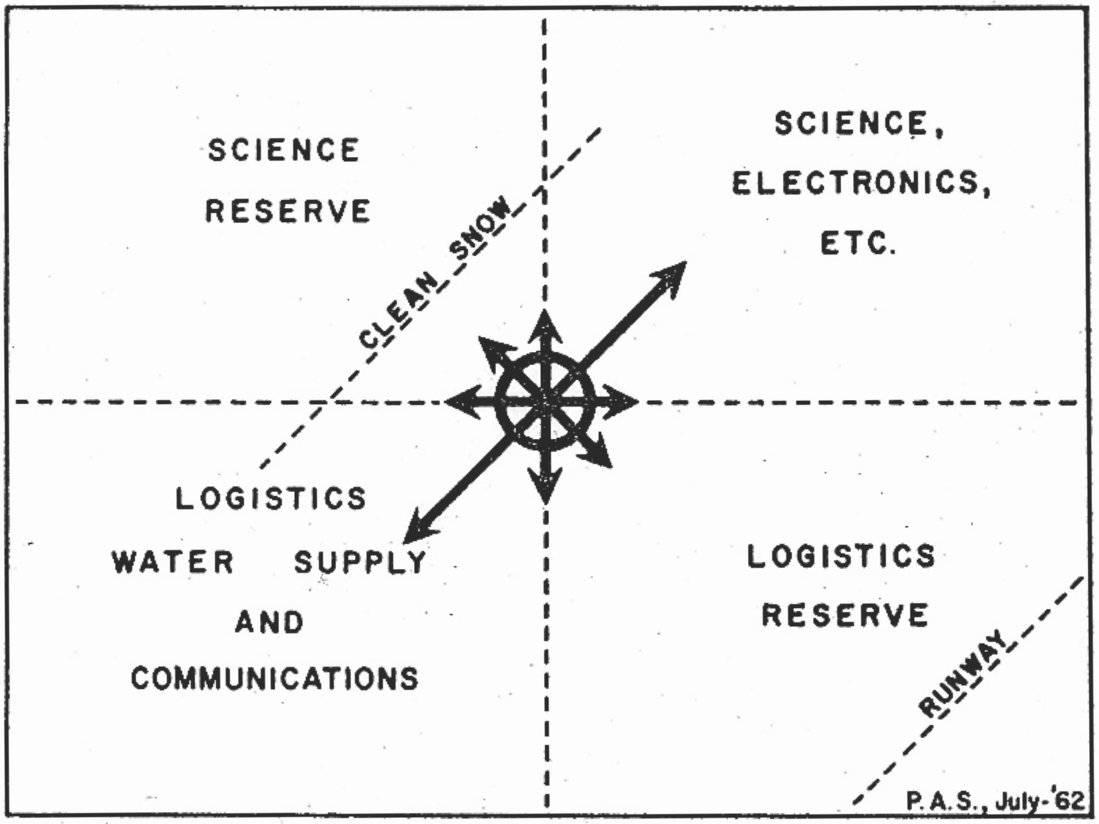

Figure 3. Alternating wind solution to Antarctic Station layout.

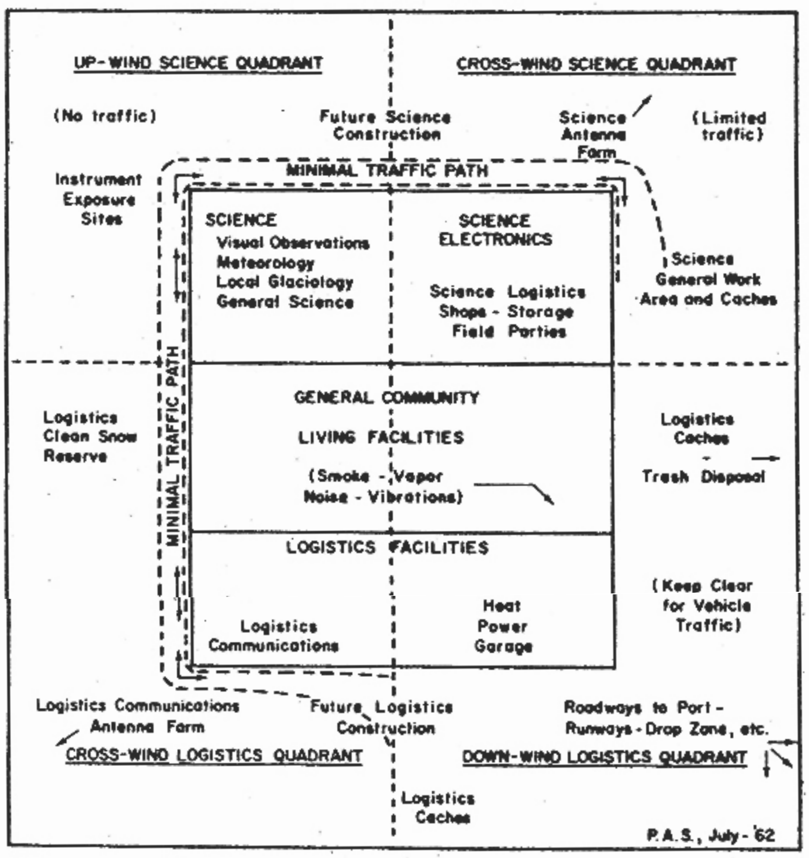

Figure 4. Idealized facilities layout for an Antarctic Science Station.