ARCTIC SURVIVAL:

HUMAN FACTORS NOTES

Ben Barkow, Ph.D.
1991

Introduction

1. Background

Transport Canada (Canadian Coast Guard and the Transportation Development Centre) retained Melville Shipping to conduct a trial at Resolute, N.W.T. to further investigate systems to enhance the survival chances of seafarers who have abandoned their ships in the Arctic. Melville Shipping conducted a field test of equipment on Resolute Bay for a week, beginning February 26, 1991.

2. Purpose

Behavioural Team was retained to provide an ergonomist and Applied Psychologist as a trial participant and to observe conditions of equipment usage. Following the trial, the participant, Dr. Ben Barkow was to recollect his impressions formed while part of the trial and to supply these notes in written form to the project.

3. Notes limitations

These are the notes of an Applied Psychologist and Human Factors specialist. Observations were limited to those which:

(a) could be noted *without* direct questioning other participants,

(b) did not require tools such as rulers or thermometers for their assessment,

(c) could be kept in memory until an opportunity to record these impressions on paper occurred, and

(d) were prepared independently of other measurements, records, or reports arising from the trial.

Given these atypical conditions, readers of these notes should be cautious in placing undue confidence on their substance.

4. Observations

Observations of Arctic conditions took place over approximately three days. Of this time, the nights were spent with one night each in a Resolute hotel, in a heated portable hut, and in the insulated liferaft under test. No records of ambient temperatures were made but it is believed that temperatures were around -30° to -40°.

Other features of the trial conditions are described in context in sections below.

5. Trial and design assumptions

Any design exercise, including any Human Factors analysis, requires assumptions about boundary conditions of the "product" under design. Therefore, a field trial must relate in some manner to the conditions held as goals of the design exercise.

It is important to understand the conditions of the test in order to understand how they, implicitly and explicitly, relate to the ultimate design. A trial may not adhere perfectly to the conditions which it is created to address. But it must be designed to provide information to the researchers under *all* conditions. Moreover, discrepancies between the trial and the "real thing," need to be clarified.

Often in the rush of events organizing a field trial, decisions are taken and/or inadvertent circumstances arise which subtly subvert the trial from the boundaries intended.

It is necessary to identify the implicit assumptions of the trial in order to reveal their influences on the observations, such as recorded in these notes. Within the psychology of the situation, such departures are often subtle and easy to overlook.

The implicit and explicit "model" of survival reflected in the trial was as follows. Some of these assumptions are trivial or obvious but are recorded for completeness.

1. The gear as depicted below would be landed intact with the party. This is an ideal condition, but it is rarely possible to conduct trials under any other assumption.

2. Personnel are likewise intact, reasonably rested, and of high morale at the start of the experience.

3. A large but unspecified amount of knowledge of survival would be held by all members of the party. (In the trial, this was handled by providing two survival specialists as advisors who provided basic information and training on Arctic survival.) In practice, extensive training would need to be provided, as managed through CCG and private sector responsibilities.

4. Personnel would be unconcerned about threats to personal safety arising from any cause surmountable by the presence of survival specialists in near proximity and through proximity to a town. Likewise, personnel would perceive a subjective probability of death close to zero.

5. Toilet activities were outside of the testing scenario in as much as a tent outhouse and minor comforts were provided by agencies outside the survival party.

6. Likewise, cooking activities were partly mediated by outside agencies in that food would be provided, a sheet of cardboard was provided to prevent the cookstove from melting into the cooking shelf, and several food related objects necessary for Arctic survival were not available at the trial. These included, cookstove, pot, waterproof and insulated work gloves, mechanism for re-fueling the cookstove, lighter for the cookstove (or liferaft candle), and eating utensils. Further, the food used while quite suitable for experimental learning purposes, was not specifically intended for survival use.

7. Lines of authority, or more aptly, leadership roles, are defined. In the case of field trials and the employees taking part, individuals have expectations for leadership *in the trial setting* which may be quite different from how they would behave under survival circumstances. Thus their behaviour in the trial may or may not be predictive of the future.

Survival support systems

1. Liferaft and structures

1. Introduction

The conditions of the trial were sensible enough. A reasonably weatherproofed liferaft was used. However, practical considerations obliged the experimenters to arrange conditions such that cooking and toilet activities were conducted outside the liferaft.

This required supplementation by means of several structures. Windbreaks made from snow blocks were also required to supplement the protection provided by the liferaft; windbreaks were also deemed essential for cooking and toilet areas.

2. Living area

1. Liferaft

A self-inflating liferaft similar to those currently carried abroad ships was used. This liferaft was modified to include felt and air space insulation. It also had a vestibule compartment and vent.

Liferaft inflation is by no means a simple issue. If the automatic inflation systems fails, a manual back up must be available. Thus an easy to use pump should be included. Ease of use is important because a lot of air is needed to inflate the liferaft. But ease of use depends on whether the user can use hands or feet, and whether the person is standing, crouched in a partly inflated liferaft, or recumbent.

The location of air valves is of the greatest importance and they should be sited and marked clearly.

Naturally, the air compartments must be separated so that a leak in one does not deflate all. On the other hand, it is desirable to have as few compartments as possible for ease of inflation. And as few leaks as possible! A serial organization of compartments connected by successive check valves and sequenced according to likelihood of puncture (most likely to fail to be designed at the end of the chain) is required.

In the Arctic environment, even simple mechanisms like air valves can be impaired through the rigours of cold and condensation. In a survival setting, repairs are done creatively using available tools and

available information. Thus it can be beneficial to improve "available information" by simply putting a picture of the air valve internal mechanism alongside some of the valves. Thus if repairs are needed, the repair person will have a better appreciation of permissible and not permissible means of repair.

Some assembly is needed to attach the vestibule and insulation felts. Assembly is not intuitive, various means of facilitating proper assembly should be used. For example, no part should be able to be attached in any way which appears initially to be sensible (as a first impression to the builder) but which turns out later to be incorrect. Or there should be a requirement that mating parts have dovetailing or matching visual patterns.

As discussed later, it is important to help seafarers remain oriented. Thus personal storage pouches and straps for hanging articles should be provided.

How many people can the liferaft accommodate? The trial included five individuals covering a range of body sizes. The five seemed to fit comfortably enough for purposes of survival.

2. Related structures

Other structures used during the trial (in addition to the liferaft with attached vestibule) were:

- a wind protected cooking area with places to stow gear so that they could be easily retrieved following snow storms and winds,
- a tent with extensive windbreak for an outhouse,
- a yellow rope for guidance from the liferaft to the outhouse,
- a windbreak about 1.5 m high surrounding the liferaft, and
- an ice container (as a source of ice for making potable water) formed from one of the liferaft storage capsule halves.

3. **Cooking area**

A separate cooking area was created because cooking could not be performed in the interior or vestibule of the liferaft used in the trial. This cooking area:

- was protected from the wind by natural features, digging out a floor, and through the building of a windbreak comprised of about 30 snow blocks mounted to a height of about 2 meters,

- had a cooking shelf covered with a sheet of cardboard which was required to prevent the cookstove from melting into the shelf,

- served as a stowage area; the "kitchen" was also designated the general storage area for tools such as the block cutting knife and saw because it permitted some protection from falling and blowing snow, and

- was also used as a general escape from the open area out of doors and for team conviviality away from the wind.

4. Toilet area

As previously discussed, the toilet area was not deemed part of the experimental trial. An analysis of the psychology of toilet activity and issues of personal hygiene, must be conducted.

5. Out of doors and exercise area

Arctic conditions, assuming as is done here a steady-state or long-delay rescue strategy, requires that the liferaft be vacated as much as possible in order to limit the formation and the freezing of condensation. Thus the party, under the conditions and assumptions tested here, must be prepared to spend almost all their awake time out of the liferaft. In practice, this means either engaging in building or in what would be called recreational activities.

It is necessary to keep the large muscles active in order to generate body heat. While the frozen Arctic provides as it were a very large exercise playpen, some consideration for the proper psychology of exercise is needed. This includes various conflicting requirements:

- having enough exercise, mostly accomplished by walking and building; building as an exercise is paradoxical in that it means risk of injury and wear to gloves and suits. It may not engage all of the body muscles, excessively taxes some muscles, can risk back injury, and does

not lend itself as well as walking to close attention to one's own ventilation and other interior environment control factors. On the other hand, building is productive, it leads to improving the site and enhancing survival odds.

Requirement for exercise or recreation include the following:

- not getting lost while exercising,
- maintaining motivation for the exercise, and
- ensuring proper social aspects such as de-emphasis on *competitive* sports aspects.

It is not trivial to suggest that what, in other contexts, would be called "recreation" be carefully planned for a survival situation. Considerations of boredom, stress, "the devil finding time for idle hands," sense of psychological effectiveness, and so on, can be enhanced by designing "leisure" time. By "design," is meant attention to training, equipment complement, instructions, reading or thinking materials, games, etc.

2. Clothing

1. Insulated Survival Suit

1. Protection

The major piece of gear is the survival suit. These suits have zippers on the lower leg and a long front zipper. Men have a zippered fly; the women's model had a zipper which continued under the crotch and is covered with a heavy flap, in the manner of flys.

Over all, the suits worked quite well given the demands for warmth, flexibility, durability, vapour venting, and comfort, to which they were put.

Some special considerations may be in order for working with snow blocks. This is the most arduous activity performed in any amount during survival procedures. The suit possibly could be more helpful by taking into account:

- proper lifting means great flexibility for knees and protection when resting on knees on the frozen ground,

- further protection on forearms for lifting and carrying blocks, and

- more protection from snow coming off blocks and into pockets on the suit front when carrying blocks.

The survival suit has to be designed with regard to the typical activities to be undertaken. Thus both the suit and the tasks can be configured toward mutual suitability.

In general, with shorter survival time horizons, the survival suit can be an all-in-one affair. It can include foot protection to remove the need for boots, built in mitts, and something to substitute for the scarf and balaclava.

Protection of the head and face by the survival suit are discussed below. Functionality for toilet activities under realistic conditions remains to be reviewed.

2. Ventilation

Some further refinement of vapour control might be useful besides the zippered openings used in the trial. People sweat in different bodily and time patterns and differently in response to various forms of exertion.

3. Storage and access

The tags on the zippers were too small for ease of grasping when mitts were worn. Personal whistles, for use when separated from companions in a snow storm, could be attached to the main front zipper tag in order to provide a better grip.

Some snow got into pockets during handling of blocks. Better fastening is needed also; Velcro-type closures, a mainstay of fastening technology in the south, have the potential for being clogged with ice in the Arctic.

More and more purpose-built pockets might be helpful too. For example, pockets designed for eyeglasses, gloves, mitts, food, snacks, and so on.

2. Sleeping bag

The sleeping bags, of conventional design for "-60°" worked acceptably well. However,the bags were not easy to use and would possibly add to the stress and frustration of seafarers. A simpler bag would be desirable.

With a shorter rescue horizon, it is possible that no sleeping bag would be needed, just a more adaptable survival suit.

3. Feet

In the trial, two kinds of foot wear were provided. For each, woolen socks were used.

- Mukluk style boots reaching to just below the knee were used. These were all snow white in colour, molded rubber around the foot, and canvas above. They had full liners and thick soles.

These functioned well. Naturally, it is undesirable to have so many loose bits: boot, sole, liner, two sets of laces, and socks.

- Soft "booties" with Hollotherm insulation which came to just above the ankles were also used. These were soft, light weight, in a colour which contrasted with snow (and thus were beneficial to those who, elsewhere than in the Arctic, would be wearing eyeglasses), but slippery for walking. Even when used with rubber overshoes, these were considered of questionable advantage due to the insecurity of their footing, the softness of the soles (which felt, realistically enough, like walking on mushy goose down pads) and lack of ankle support while walking and working.

These booties were high enough to be covered over by the survival suit legs and so not much snow entered them. They were considered at least as warm as the mukluks.

4. Hands

1. Ordinary protection

Frostbite starts to set in within seconds in the high Arctic in February. Thus it is essential to have hand protection which is both functional for performing survival and work tasks and provides enough

insulation. These goals conflict in as much as the human hand, and the sort of work done with our hands, is often fine grained, requires feedback for control, and is precise. An approach is for the provision of two types of hand protection, for

(a) coarse work and non-work settings and another for

(b) fine work.

For general protection, the trial used a conventional Arctic mitt. These had nose-wiper pads and a removable liner. They appeared to work well enough but might prove marginal for seafarers with poor circulation in their hands and for more challenging or longer exposures than found at the trial.

2. Protection during fine work and manipulation

For fine work, heavy cotton gloves were provided. These proved to be barely warm enough for protection longer than a few minutes of use, too thick for the demands of some of the work settings (such as some tasks with the cookstove), readily got wet and quickly became frozen, were a chore to keep track of and they were the same colour for both hands and for all persons.

It might be suggested that further attention is needed to find the right mix of design features to accomplish the purposes needed. The use of *at least* two types of hand protection (and with some spare sets) seems inevitable but the mix of features might be done differently.

In addition, the *tasks* for which hands are used can be re-examined. For example, a cooking and eating set up or a cookstove or re-fueling system which can be performed using heavy soak resistant gloves might be a sensible direction for further Human Factors development.

At the other end of the spectrum, the snow tools *were* designed for effective use wearing heavy mitts. Could they work with thumb-less mitts (for greater warmth)?

5. **Face**

The face needs a lot of protection since it includes delicate, sensitive, exposed, and/or psychologically significant parts. Some parts need

outside exposure (i.e. mouths, noses, eyes, and ears) but still must be protected from cold, sun burn, snow blinding, drying, and strong winds.

The technology associated with the protection is at a very rudimentary stage of development. Ears *can* be kept warm enough under hoods but this must be done without losses to hearing.

In the trial, a cotton scarf about 2 meters long was provided. This was used to cover as much of the face as possible without obscuring vision.

The scarf collects moisture from the breath and this freezes. When the segment in front of the mouth and nose becomes packed with condensation ice, the scarf is moved around the head to expose a dry section. While very simple as a concept, it works well enough. There may be some other low-tech approach that would work better than a general purpose cotton or woolen scarf.

The survival suit had an excellent hood with fur trim and a stiffening wire at the outer edge. By virtue of its shape and the sewn in stiffening wire, it can be shaped into a tunnel in front of the face to control wind intrusion.

3. Food and drink

1. Introduction and preparation of food

In this trial, food and its preparation did not simulate very closely any practical survival design. Thus the experience did not provide solid lessons applicable for future design. Therefore, the comments in the following sections are hypothetical.

As a guiding principle, the target goal for food is *no preparation or extraneous handling at all.* This can be accomplished for short time design targets. Thus in a two day horizon, a thermos containing 10 cups of water suitable for keeping inside the survival suit could be provided. Nothing more to eat or drink is needed.

For longer time horizons, training in the recognition of potable ice, the gathering of ice, and the preparation of drinking water in bulk would be more appropriate.

Likewise with food. The ideal would be unit portions of single-dish meals which required no external heat for preparation. Of course, to have any moisture content means to become frozen and thus externally-supplied cooking heat for preparation is needed. In turn, heat provided

directly within the package and/or the eating surface (the two should be the same) is better than heating food in hot water using melted ice.

2. **Foods**

As mentioned under the assumptions above, the food was of limited usefulness for purposes of learning from the trial. But some lessons arising from the food experience include:

- the importance of easy access through proper Applied Psychology of packaging. This means ease of identifying contents, ease of opening parcels under Arctic clothing constraints, minimizing the number of separate containers and items, respect for the hazards of spilling liquids on oneself, biologic and thermal heating value, fuel consumption, and, of course, questions of nutritional value to survival,

- cooking needs to designed for effectiveness and in light of the psychological needs surrounding preparation and eating,

- eating arrangements need to be considered, and

- food, the pleasures of eating, the emotional correlates of sustenance, and the social component of meals, has an important psychological function which should be explored by professionals before settling the design.

Food preparation and eating time provide an opportunity for relaxation but, with poor design these can greatly heighten anxieties. Jokes should be printed on the food packages.

Here's an arctic food joke.

Two men are stranded in a desert. The come on a dead snake. "You eat it Jack," says Tom, "it is too disgusting for me." So Jack eats it. They walk on.

They come on some decaying wood. "You eat it Jack," says Tom, "it is too disgusting for me even to think about." Jack eats the decaying wood.

They walk on and Jack vomits on the ground. "Oh great," says Tom, "at last, a nice hot meal."

3. **Eating utensils**

A set of eating utensils were issued to members of the party. These could not be used with mitts on and functionality of work gloves, as described elsewhere, was not satisfactory. There should be no practical obstacle to the provision of food in such a manner as not to require utensils for eating.

However, the critical need for water in sufficient quantity would make it impractical to prepackage more than about two days' worth. Thus utensils such as water cups or durable straws are needed.

General observations

1. Alternate assumptions

1. Liferaft and structures

The balance between

(a) a superior liferaft and

(b) a practical liferaft supplemented by other structures

is a basic design issue.

Option *a* is an ideal which may not be practical. Option *b* supposes some expertise in snow construction, tools, able manpower, and the presence of personnel with appropriate mental resources.

The time horizon of recovery influences this design decision. If the horizon is short, then the optimal mix may be:

- small training expenditure,
- large equipment expenditure, and,
- improved ability to recover shipwrecked seafarers quickly.

2. **Survival clothing**

If a short time horizon for recovery were assumed, then it is possible to imagine that all survival clothing could be configured within the "envelope" of a survival suit. This would be like a small child's snowsuit. All the pieces of clothing would be attached: hand protection, foot protection, walking soles, face protection, etc.

A more omnibus type suit would be simpler to stow and use. In the furor of abandoning a ship, there would be no problem keeping track of bits and pieces of clothing (such as multi-layered boots) or the threat to harmony arising from confusions about who owns what items.

2. **Building with snow**

Snow block construction is a practical option if all on site conditions noted above were met and if one or more of the party have, say, three hours of training and practice. It would be better if some alternative to ordinary snow block construction with saws and knives were developed.

Solely for illustration and not seriously put forward is the following concept. Perhaps a construction using air gaps formed by bags with snow shoveled over the air bags is possible. Shoveling snow requires no training, little skill, minimum vigour, and a minimum number of psychologically and physically healthy personnel can do it working individually, if necessary.

3. **Identification and colours**

It serves an important psychological function to identify one's own things and to maintain responsibility for their care. Likewise, it can materially reduce the opportunities for disagreements among party members.

The Arctic seems a featureless environment to those raised in the south. Since all the suits were orange there were very few clues to the identify individual, the disorientation of survivors is heightened. If suits were individualized by some means, even if random or arbitrary, it would help people be better oriented.

Having left and right pairs of boots, liners, gloves, etc., which are the same colour is an esthetic nicety which is wrong in the Arctic.

It is recommended that a person's personal kit be a distinctive colour (as well as otherwise marked with a visual pattern which could compensate for

the common male disability of colour vision weakness) and left and right pairs be consistently distinctive. Thus the kit for seaman number one should have left items with red large dots on green for all left items, blue large dots on green for right items, and red and blue large dots for non-handed items.

4. Miscellany

The positive value of windproof pants was not established by this observer during the trial.

Major issues concerning training remain to be explored. Training should include some very subtle matters relating to social etiquette under extreme survival challenges, or leadership styles and the conflict between formal leadership and functional leadership.

The question of eyeglasses — a veritable jungle of all sorts of psychological issues — deserves the most careful analysis. As far as functional acuity is concerned, the situation is better in bright periods of the year when the pupil is stopped down. But this compensation is only one consideration of many.