Project Number: 41-PJ-2003

Technology and Mount Everest

An Interactive Qualifying Project Report

Submitted to the Faculty
Of the

WORCESTER POLYTECHNIC INSTITUTE

In Partial Fulfillment of the requirements for the

Degree of Bachelor of Science

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Date: April 15, 2004

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1.Technology
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3.Mt. Everest
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Authorship Page

We have all contributed equally to this project while each concentrating in certain areas. Matthew Kwiatkowski focused on communications technology and infrastructure. John Richardson focused on climbing equipment and human physiology. Ryan Seney focused on the local culture and human physiology. We found that in our research these areas often overlapped. Finally, we all were responsible for producing the final document.

Abstract

This project examines the technology western mountaineers brought to the Mt Everest region since the 1920's, the impact on the native's society and the benefits to the climbers. We have scrutinized the transformation of communications, mountaineering equipment, and pharmaceutical technologies and their associated consequences by conducting interviews and researching scholarly literature. Through our analysis, guidelines were proposed to protect society in Nepal and foster the safety of mountaineers ascending Mt. Everest.

Executive Summary

Since the 1920's western mountaineers have brought technology to the Mt. Everest region. The people living in the area surrounding the tallest peak in the world were fairly isolated until the British mountaineers started trying to summit the daunting peak. The mountaineers developed a friendly relationship with a particular ethnic group known as the Sherpas who reside in this region. The Sherpas have traditionally led simple lives, primarily as traders and subsistence farmers. Many of the Sherpas continued these long-established roles of the past, however many have expanded and have entered the trekking industry. They have been hired as porters since the beginning of mountaineering in this region, and now they own hotels and guide services. The early mountaineers brought with them warm clothing, radios, oxygen equipment and other climbing equipment. Since then, other western mountaineers have brought in several technologies including communications, medicine, and climbing equipment.

The purpose of this project was to study the effects of several technology groups in the Solu-Khumbu region of Nepal, which is located near Mt. Everest. This project focused on the impact on the local population as well as the effects on mountaineers who climb in the area. Research into the interactions between these groups was also performed.

After establishing a basic understanding of the region, and the technologies that were of interest, people were interviewed that would be capable of providing specific information in the areas of interest. These included local people who have been to the region, mountaineers who have climbed Everest, communications and climbing equipment manufacturers and designers, and an Internet Service Provider in the Solu-Khumbu region.

The technology climbing equipment has gone through several changes since the start of mountaineering on Mt. Everest. These increases in technology have aided climbers in reaching their goal of conquering the summit. Advances in materials science, design engineering, and medical research have helped produce items that make climbing easier and safer. Since the 1920's climbing ropes have transformed from relatively weak

natural fibers to very strong and supple nylon weaves. A rope in an undamaged condition has very little chance of failing during a fall. Reductions in weight and increases in sharpness in ice axes and crampons have made it easier for climbers to secure themselves to the mountain. Clothing, boots, tents and sleeping bags have had the most dramatic changes in the past 10 years. These items have greatly benefited from weatherproofing provided by GoreTex treated fabrics. The added trust in one's equipment also provides a valuable psychological crutch.

The early climbers brought radios in the 1930s to the region. These were the first means a climber had to communicate with anyone in the outside world. However, the radio's range did not extend further than base camp. In recent times, climbers have begun to bring satellite phones which can contact anyone in the world. The local people have benefited from these communications technologies as they have catered to the growing tourism business, adding local phones in most of the villages and even Internet access through cyber-cafes all the way up to base camp.

With the introduction of new technology as well as an expanding tourism industry, the local culture has changed over the years. Many of the locals are quick to adopt the new technology that is brought into the area such as solar panels, water heaters, and radios. In the cities, where most of the tourists visit, Sherpas have begun entrepreneurial ventures such as hotels, guides services for trekking and mountaineering, and cyber-cafés. The villages along the way to base camp and popular trails partake in welcoming western tourists and mountaineers as they travel through the region.

In our analysis of the impact by the technology in the area, we found that there is a high cost to transport the equipment to the region, install the technology, and utilize it. Currently, as much technology as the tourists pay for is put in, this method works well in tourist "hot spots." Another issue with the technology is that there is not enough of an infrastructure in Nepal to reliably support it. Finally, in locations where technology is being implemented, the newest version of the technology is installed. However, since they only have the newest equipment, this leaves the country vulnerable if a large system failure occurs, as they have no older system to fall back on. Many of the local cultures in

the region readily accept the new technology as it comes into the region. Even so, the majority of the technology is employed by businesses, affluent residents, and tourists. It will take longer for the average person in the region to adapt to the presence of these new technologies, and significantly longer before they become reliant upon them.

Other forms of technology, aside from communications equipment, could also benefit the region. Infrastructure, such as roads and electricity, needs to be improved in the region, as well as the country, in order to support the increasing amount of communications technology brought by the westerners. At the same time, the economy of the country could be improved in order to allow for the local people to purchase the technology on their own and at a pace they feel comfortable with. Projects to promote entrepreneurship could help to increase the average amount of money that is earned in the country.

Through our analysis of the mountaineering equipment and its history, we found that the improvements to the gear noticeably improved climber performance and safety. However, these benefits are meaningless unless proper training and education are sought by the climber. Superior physical fitness is also essential to summiting Mt. Everest. Obtaining the proper mountaineering skills will only cost a fraction of that of an expedition. These assets may be necessary to stay alive or save the life of another climber.

High altitude has many physiological effects on the human body. These effects can occur as low as 8,000 feet and may range from headache to death. Care must be taken to allow one's body to properly acclimatize to the environment. Several over-the-counter and prescription drugs may help supplement the acclimatization process or treat the symptoms of sickness. The most effective treatment is a descent of at least a couple thousand feet. In emergency cases a device known as the Gamow bag is available to simulate this descent. Failure to notice the symptoms early may lead to more serious problems. Certain sicknesses may alter a climber's decision making process further endangering himself and others around him.

Although treatments do exist, it is important that care is taken as the side effects of the drugs may be rather detrimental to one's long term health. Careful planning and education is still the key to surviving an assault on the summit of the highest peak in the world.

This project lays the groundwork for establishing a WPI Project Center in Kathmandu or in nearby areas of Nepal. Students can continue to research the topics of high altitude physiology, infrastructure development, and climbing equipment safety, using this project as a starting point. The Nepalese government and other organizations looking to continue the development of the country will also find the information gathered within useful.

Acknowledgements

Prof. Paramasivam Jayachandran
Our advisor, for providing us with the idea for this project, and for his background knowledge of Nepal and India.

Prof. Peter Hansen
Our co-advisor, for providing us with his mountaineering history expertise.

Rick Wilcox, Conrad Anker, Paul Giorgio
For sharing their mountaineering experiences with us.

Prof. Thomas Keil, Prof. Karen Lemone
For sharing their experiences in Nepal with us.

Subodh Manandhar at Square Networks
For actually responding to his E-mail, when no one else in the country replied.

Prof. Rustem Igor Gamow
For providing extremely informative anecdotes about his research.

Tommy Chandler, Russ Clune, and Bill Belcourt at Black Diamond,
Robert Beck at SCI composites
For providing information, views, and contacts.

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Chapter 1: Introduction

Western Mountaineers have long aimed to conquer the highest peaks, the tallest in the world being Mount Everest. During the attempts to summit this massive and destructive peak, the mountaineers have interacted with many people along the way, most predominately the Sherpas. The Sherpas are a friendly people residing in the region near the base of Mount Everest. Living at an altitude high above sea level for many generations has allowed them to be very capable climbers and porters. Their physiology may be such that their lungs can function at higher altitudes.

The summit of Mount Everest is at the limits of human existence. All climbers must rely on some form of technology to keep themselves alive. The amount of this technology depends on the climbers' personal preferences and goals. Most mountaineers must utilize bottled oxygen since most people cannot pull enough oxygen out of the air at extreme altitudes to survive. Communication technologies are also very important. Relaying vital information to climbers on their ascent is vital to their success as well as their survival. Western climbers are often away from home for months at a time and need to stay connected to loved ones.

However, with the rapid advancement of technology many more people are able to gain access to be able to climb Mount Everest, but this may not necessarily be a positive development. Heavy traffic on the mountain may cause accidents and cause unnecessary wear and pollution on the mountain. On the other hand, some of this technology has "trickled down" to the local people, perhaps aiding them in their daily life or allowing them to expand their businesses which aid mountain climbers and tourists.

This project accomplished several different objectives. These objectives involve the use of technology by the local population, the use of technology by the mountaineers who come to the area, the physiological effects on humans at high altitudes, and the changes in the local culture due to tourists and technology. Most of the information was gathered from interviews with mountaineers, internet service providers, travelers and other people

who have been to the region. Other questions were answered by performing statistical analysis on data that are currently present.

While technology makes it easier and more accessible to attempt to conquer Everest, it does not necessarily make it risk-free. In general, as technology improves, risk decreases, this technology has made expeditions to the mountain more attainable for the general public, or at least those with enough money to finance such an expedition. Does the increasing amount of technology make Everest a safer environment for everyone climbing it?

Just because the area's society is adapting to these changes does not necessarily mean that the changes are for the better. While traditional ethics are often valued as being superior to modern ethics; that does not mean that more modern values are not good for people. What is the point where all this new technology starts to do more harm than good to the people affected by it? Is this a point that has already been reached near Mount Everest?

By investigating these issues this project may serve as a guide to those wishing to do further research in the area. Manufacturers of equipment may be able to develop new products based on a need for a new product. Wired or wireless communication companies may be able to fine-tune existing products or create new ones that will allow more efficient devices that are used in remote locations such as the small villages around Kathmandu or at Base Camp itself. Perhaps one day portable devices would be rugged and efficient enough to justify making the whole mountain wireless.

Results from this project's research were presented in the spring of 2004. We determined what changes and forces affected the region, we then explored the question of what is right for the region. While it is not possible to come up with a clear definition of what is "good" and "bad" for a region, we can determine what changes have helped the region and which have been less beneficial. These results may rejuvenate interest in the topics, perhaps setting the ground for a project center to be established in the Nepal area or India. Future projects by students in this area of study, which benefit the local populations, will be enhanced by the analysis of the impacts of technology discovered in

this project. By looking at the past we can find new ideas to consider before adding even more new technology.

Chapter 2: Review of Literature

There are several areas in which background knowledge will be helpful during this project. In order to notice and understand the effects that technology has had on the region, we will first have to know about the history and culture of both the mountain itself and of the local people. The two main types of technology that we are studying are climbing technology and communications technology. In order to understand how climbing technology has evolved, we need to investigate the tools necessary for climbing and how they are used. In order to examine communications technology, we must first understand common devices that are available and then find out which of these are being implemented on Everest. The final area for investigation will be the hardships that are encountered on Mount Everest, in particular the effects of high altitude.

2.1 Mount Everest

Mount Everest is about 29,035 feet tall and grows about 4 millimeters annually[1]. It was formed about 60 million years ago.[2] Originally known only as "Peak 15", it was named after Sir George Everest, the Surveyor-General of British India, in 1865. Mount Everest is made up of three major geological layers, most of which are permanently covered with ice and snow.[3] The bottom layer is made up of gneiss covered with snow and ice most of the time. The middle band is a mix of easily eroded rocks, which makes it a layer with many cliffs and pinnacles. The top layer

Figure 2 – Geographic Location of Mt. Everest

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[1] "Re: Exactly, how high is Mount Everest?"; <http://www.madsci.org/posts/archives/apr99/925321325.Es.r.html> 11-5-2003

[2] "Mt Everest History and facts"; <http://www.mnteverest.net/history.html> 9-23-2003

[3] <http://www.k2news.com/lesson2.htm> 9-23-2003

begins with a layer of yellow limestone known as the "Yellow Band" and the remainder is made up of a gray limestone.

Mount Everest is in the Himalayan mountain chain forming the border between Tibet and Nepal, as can be seen in the map in Figure 1.[4] Over its history it has been known by different names in different regions. In Nepal, Everest is known as Sagarmatha, which means "goddess of the sky", and in Tibet it is known as Chomolungma, which means "mother goddess of the universe".

2.2 Climate

Nepal's climate varies from cool summers and severe winters in north to subtropical summers and mild winters in south.[5] The climate can be best summarized as shown in Table 1.

Elevation	**Description of Climate**
3300 – 5000 ft	Distinctly tropical
5000 – 8200 ft	Warm temperate climate, with lower temperatures, but only rare occurrences of snow and ice
8200 – 11500 ft	Decidedly cold
11500 – 16000 ft	Alpine
16500+ ft	Snow, glaciers fed by summertime precipitation

Table 1 - The differences in climate for ranges of elevation in Nepal

As shown, the climate of the country varies from the southern area, where the elevation is generally lower and located in the tropical latitudes, to the northern regions, such as Solu-Khumbu, which are at a much higher elevation.[6] In terms of the amount of precipitation

[4] <http://www.chinapage.com/map/map-everest.jpg> (4-6-2004)
[5] "CIA – The World Factbook – Nepal", <http://www.cia.gov/cia/publications/factbook/geos/np.html> (3-10-2003)
[6] World Geographical Encyclopedia: Asia (pp.121 – 122)

in the region we are studying, the average rainfall in Kathmandu is 56 inches.[7] Everest's unique climate is best described as an "unusual monsoon-alpine-desert setting."[8]

2.3 History

Mount Everest was first climbed successfully by New Zealander Sir Edmund Hillary and local Sherpa Tenzing Norgay in May 1953[9] using the route shown in Figure 2[10], although attempts were started in the 1920s using porters from Tibeta, Bhotia and Sherpa workers living in Darjeeling, India.[11] The Sherpas were originally trained to climb by British mountaineers, but later became known as excellent mountaineers in their own right.[12]

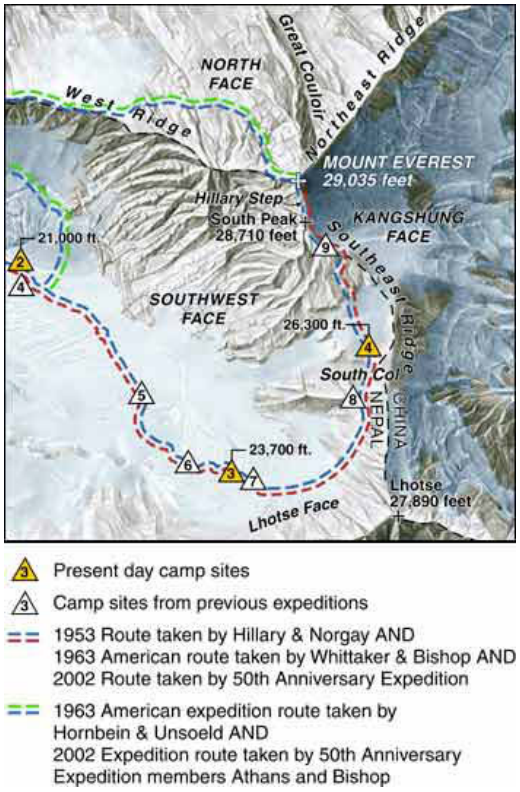

Figure 3 - Map Showing the Most Common routes

Since then, Everest has become the goal of many mountaineers. New technology has made it easier and safer to climb Mount Everest, which in turn attracts many more people to the idea of climbing. People now pay guides to take them to the summit of Everest, even if they have very limited climbing experience. While climbing was before limited to adventurous athletes looking for a new exotic challenge, currently anyone can pay $65,000 to travel to the region, hire a guide, and share in the experience of climbing the mountain peak. Much of the region around Mount Everest now thrives

[7] Encyclopedia Americana p.97
[8] Cobourn, Broughton; Everest: Mountain Without Mercy (p. 230)
[9] The Sherpas", National Geographic May 2003 (p.60)
[10] <http://news.nationalgeographic.com/news/2002/05/0513_020514_ADValtitude.html> (4-6-2004)
[11] Hansen, Peter H.; "Partners" (pp. 210 - 231)
[12] Ortner, Sherry; Life and Death on Mt. Everest

on the funds brought in by these new thrill-seeking tourists, which has converted the local economy into one which prospers on tourism.

2.4 The Sherpas[13] [14]

The Sherpas are an ethnic group that originally descended from Tibetans who migrated to the Solu-Khumbu region. Despite living in the shadow of Mount Everest, there has not been the life-long fascination with the mountain that the western mountaineers have. The main reason for this is that they revered the mountain as a sacred area.

There are few roads in the Kathmandu region which forces most of the Sherpas to walk everywhere they need to go. When most climbers come to the area, they stop in Namche Bazaar, which can be seen in Figure 3[15], and then walk for 6 days to the Everest Base Camp. In addition, the Sherpas are also hired to carry the equipment for the western mountaineers and other tourists.

Figure 4 - Sherpa village of Namche Bazaar

2.4.1 Culture of the Sherpas

The Sherpa lifestyle is an interesting mix of tradition and modern conveniences. Homes are often made of floorboards and a corrugated aluminum roof, which have been hauled up on trails from the south, where most of the trading occurs, by hired porters or on beasts of burden such as yaks. Some Sherpas have a toilet and sink brought up from the

[13] The Sherpas", National Geographic May 2003 (pp. 42 – 71)
[14] Cobourn, Broughton; Everest: Mountain Without Mercy (p. 85)
[15] <http://magma.nationalgeographic.com/ngm/0305/feature2/zoom1.html> (6-4-2004)

south as well, while wealthier Sherpas are now purchasing solar heating tanks for their homes.

Traditionally, the Sherpas have been semi-nomadic herders and subsistence farmers. The farmers raise yaks for milk, butter, hides, and as pack or draft animals for use. They also began to raise potatoes after they were introduced by the British in the 1800s. Potatoes are a staple crop in the region as they grow very well in the region's climate. During the monsoon of the summer months the farmers move their farming to higher elevations taking their herds of yaks and yak-crossbreeds with them to graze. In addition, these moves are often coordinated by the elected village guardians. The pastures that are used at this time of year are known as "yearsa's" and are found at altitudes as high as Mount Everest Base Camp.

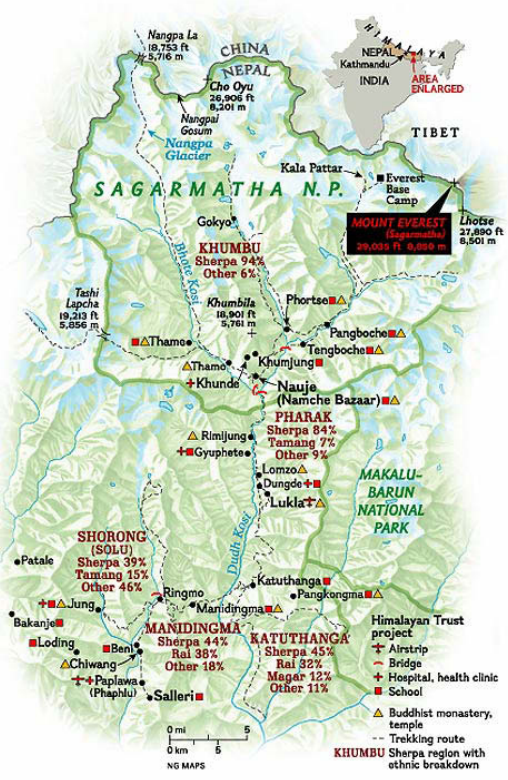

Figure 5 - Distribution of Sherpas

Sherpas are not native to the area surrounding Mount Everest. According to Tibetan texts, it is believed that they originally migrated to the region in the 16th century by traveling from the eastern Tibetan region of Khum. After crossing the Nangpa La pass, they settled in the valleys and canyons around the Bhote Kosi and Dudh Kosi rivers.[16]

The majority of the 70,000+ Sherpas in Nepal live in the Solu-Khumbu region, as can be seen from the map in Figure 4[17]. The two largest Sherpa areas are Khumbu and Pharak, each with a population consisting of 94% and 84% Sherpa respectively.[18] A minority of Sherpas now

16 "The Sherpas", National Geographic May 2003 (p. 57)
17 <http://magma.nationalgeographic.com/ngm/0305/feature2/index.html> (4-6-2004)
18 "The Sherpas", National Geographic May 2003 (p. 56)

live in the southern regions of Shorong (Solu), Manidingma, and Katuthanga, having expanded into these areas over time. These regions are more conducive to farming due to cooler temperatures.

The language of the Sherpas is deeply rooted in their Tibetan origins, as well as their religion, the Nyingma sect of Mahayanna Buddhism, which pervades most of their society.

2.4.2 Religion

Religion is an important part of Sherpa life, with most people following Buddhist teachings. Monasteries are important enough for people to support them and religious festivals are celebrated by every village.

The dominant religion of the Sherpas is the Nyingma sect of Mahayana Buddhism. This particular sect of Buddhism promotes a basic idea of compassion for all human beings, which is believed to be the reason why a strong caste system is not in place, unlike neighboring Hindu groups in Nepal. Also, this form of Buddhism was introduced to Tibet in the 9th century by Guru Rimpoche, and then later to the Khumbu region.

As the legend goes, when Rimpoche, the great "lotus born" Indian saint, came to Tibet he battled the wrathful Srungma mountain gods of the Bön religion. Upon subduing them he made them into defenders of the Buddhist faith. He then appointed the Everest goddess Miyolangsangma and another four of the benevolent "five long wife sisters" to look after the Khumbu region. These are the mountain gods who are believed to live in the surrounding mountains in the area.

Rimpoche also predicted that Tibet would be plagued by wars, and the devout would have to flee to sacred valleys in the Himalayas known as Bé-yül. These valleys are areas where there is a strong concentration of mystical powers and where spirits abound. According to the Sherpas, these valleys are to remain pristine and should not be spoiled by excessive human activity. Khumbu is considered one of these valleys. According to

tradition, the Sherpas believe that the surrounding mountains were the homes of gods, which is the primary reason why they never entertained the idea of mountaineering until the arrival of western climbers.

In addition, there are many sacred sites in the Khumbu region, however, visitors rarely see them, as they consist mainly of "meditation caves, 'self-emanated' impressions on rocks (such as footprints of legendary figures at Tengboche and Pangboche), and curious serpentine intrusions that are considered evidence for metamorphism – or of the *lu* serpent spirits)."[19]

Figure 6 - Tengboche Monastery

The patron saint of Khumbu, Lama Sangua Dorje was born roughly 350 years ago. Dorje once said that important gompas would be built at some of the sacred sites in the region, which was first realized when the first gompa was built in Pangboche. In 1923, the reincarnation of Lama Sangua Dorje's father, Lama Gulu, built the Tengboche monastery. However, Lama Gulu died shortly after the monastery was destroyed as a result of an earthquake in 1934. The monastery as it is today can be seen in Figure 5[20]. Lama Gulu's reincarnation is the present high Lama of Tengboche, Nguawang Tenzig Zangbu. Presently, gompas are now centers of learning and culture, thus creating the center of a Sherpa's spiritual life.[21]

2.4.3 Economy

Prior to the interest in Mount Everest and the international expeditions by foreigners, the Sherpas were mainly traders. During the 19th century, many Sherpas began migrating to Darjiling, India (over 100 miles east of Khumbu) in order to work in construction jobs for

[19] Cobourn, Broughton; Everest: Mountain Without Mercy (p. 85)
[20] <http://tengboche.com/> (4-6-2004)
[21] Cobourn, Broughton; Everest: Mountain Without Mercy (p. 85)

the British Raj at the time. When the British mountaineers started traveling from northeast India through Tibet, they began to hire porters from Darjiling to carry their equipment. At the time, the route through Nepal was inaccessible as Nepal was closed to outsiders until 1949. Following this and the introduction of western climbers to the region, the Sherpas' economy is dominated by local tourism.

The Kathmandu region hosts more than 20,000 visitors a year due to the tourist trade. These tourists are primarily from western cultures. In addition to acting as porters and guides for the climbing clients, the Sherpas also act as guides for trekking clients, for those who wish to explore the region at altitudes under 18,000 feet without any additional equipment. Such trekking expeditions include week-long hikes from Lukla to Kala Partat or Gokyo. The Sherpas also own most of the lodges, hotels and expedition organizing companies in the region, a total numbering over 300.

Historically, Sherpas have been divided between "big" and "little" people, with the big people being those with resources and power.[22] These big people had traditionally been afforded certain privileges, such as being able to have servants and not having to carry heavy loads. Today, the per capita income in Nepal is roughly $1,800 a year, as Nepal's economy is still about 80% farming. On average Sherpas in the climbing business often make five times this, reversing the traditional class divisions. Despite the economic incentives, most Sherpas are not involved with the climbing or trekking industries.

In addition, Sherpas are now less responsible for acting as porters than they have in the past. Today, many of the more experienced Sherpas are hiring other Sherpas or members of other ethnic groups in the area to act as porters while they plan and manage the expedition.

During the construction of a hospital in Khunde, Edmund Hillary had an airstrip built in Lukla, so that supplies could be brought to the construction area faster. However, the presence of the airstrip has made the region much more accessible to visitors as they can now fly most of the way to Mount Everest, where before there was much more hiking

[22] Ortner, Sherry; Life and Death on Mount Everest

involved. Consequently, this airstrip has helped to fuel much of the tourist trade in the area, due to the accessibility and the lower travel time for tourists who fly into the region.[23]

Recently, the tourist dominated trade has been in a downturn due to the combination of the international terrorist attacks of September 11th, 2001, and the domestic terrorism of the Maoist rebels in the region[24], the worldwide SARS epidemic has also deterred tourists from traveling. The combination of these incidences has dampened the usual flow of tourists to the region, stifling the tourism industry around Kathmandu.

2.5 Wireless Communication Technologies

There are two basic types of wireless communication for different uses, one to send digital data and another to send voice communications.

The most commonly used protocol for sending computer data is known as 802.11b, although there are variations such as 802.11a which uses a different frequency and 802.11g, which has a higher data rate.[25] There are several ways that this can be set up. There can be several non-directional transmitters covering an area within which any computer with a wireless card can access the network. A longer range wireless link can also be set up between two points using directional antennas to connect wired networks together.[26]

Satellite links use the same type of directional links, usually using a large satellite disk that must be aimed precisely at the satellite being communicated with. At the Everest base camp, this presents a problem because even very small moves of the satellite dish can cause the aim to be off, so the dish needs a steady place to be mounted. To solve this problem, the satellite dish at Everest base camp is mounted up the mountain above base camp on solid rock, instead of in base camp which is on a glacier and continually

[23] Cobourn, Broughton; Everest: Mountain Without Mercy (p. 85)
[24] "Nepal Maoist Rebels Move Their Attacks Into Cities", New York Times 10-12-2003
[25] "IEEE P802.11", <http://grouper.ieee.org/groups/802/11/main.html> 9-27-2003
[26] "TelecomWeb: Wireless Data", <http://www.telecomweb.com/wirelessdata/> 9-30-2003

moving. A directional wireless link is then used to connect the satellite dish to base camp, the short distance of this link making the movement of base camp insignificant. [27]

For voice communications, a satellite phone is most commonly used in areas where cellular service is not practical.[28] For most Everest expeditions, it is not practical to carry a satellite phone up the mountain, as they are fairly large. Instead, radio is used to communicate with the base camp, where the radio can be patched through the satellite phone.[29] For more recent expeditions, another way to get voice communication is to send voice data over the same network used for computer data, a technique known as Voice Over IP(VOIP). With this, special IP phones are plugged into the Ethernet connection, and they connect to a PBX server which provides traditional phone service. It is also possible to use an EtherPhone adapter to plug a normal telephone into an Ethernet connector. For wireless phones, it is possible to route voice data over the same 802.11b area network that is used for wireless computer communications and get the same results.

2.5.1 Wireless in Everest

The Everest region was first introduced to wireless communications gear through the radios brought by British climbers. While these radios were too big to be brought up the mountain, news of a successful expedition was brought by runner to Namche Bazaar, where it could be radioed to Kathmandu, and then back to England.[30] Later these radios became smaller and were brought along on the summit attempt so that those at base camp could tell where everyone was on the mountain. These also increased safety, allowing a rescue attempt to be sent out as soon as an emergency occurred, rather then leaving the climbers on the mountain to deal with the emergency themselves. Today there are radios that are small enough for every climber to carry one easily. While modern radios still require a line of sight location to be used, they have longer range and better audio quality than older radios. Modern radios are also more efficient in their battery usage, allowing

[27] Sherpa, Tsering, "Linking Everest", <http://www.linkingeverest.com> 10-13-2003
[28] "GlobalStar Corporate – Home", <http://www.globalstar.com> 9-30-2003
[29] "WirelessWeek.com", <http://www.wirelessweek.com/> 9-29-2003
[30] Conquering Everest film

climbers to stay in contact longer and more frequently, helping to prevent misunderstandings while up on the mountain.

As Everest started to become more of a tourist location, local telephone lines were added, which benefited both the local Sherpas and the tourists coming to climb Everest. These phone lines depended on a number of repeaters to allow the signal to reach the foot of Everest from larger cities in the area. When the repeater linking Namche with the rest of the world was blown up in 2001 by Maoist rebels, Tsering Gyaltsen Sherpa started looking into other ways of staying connected. He started out with 3 satellite phones and a small EAPBX telephone switch, which is normally used in office buildings to route local calls[31]. He connected this switch to local businesses and lodges with land lines, allowing anyone to have local service as well as being able to dial out over the satellite phones.

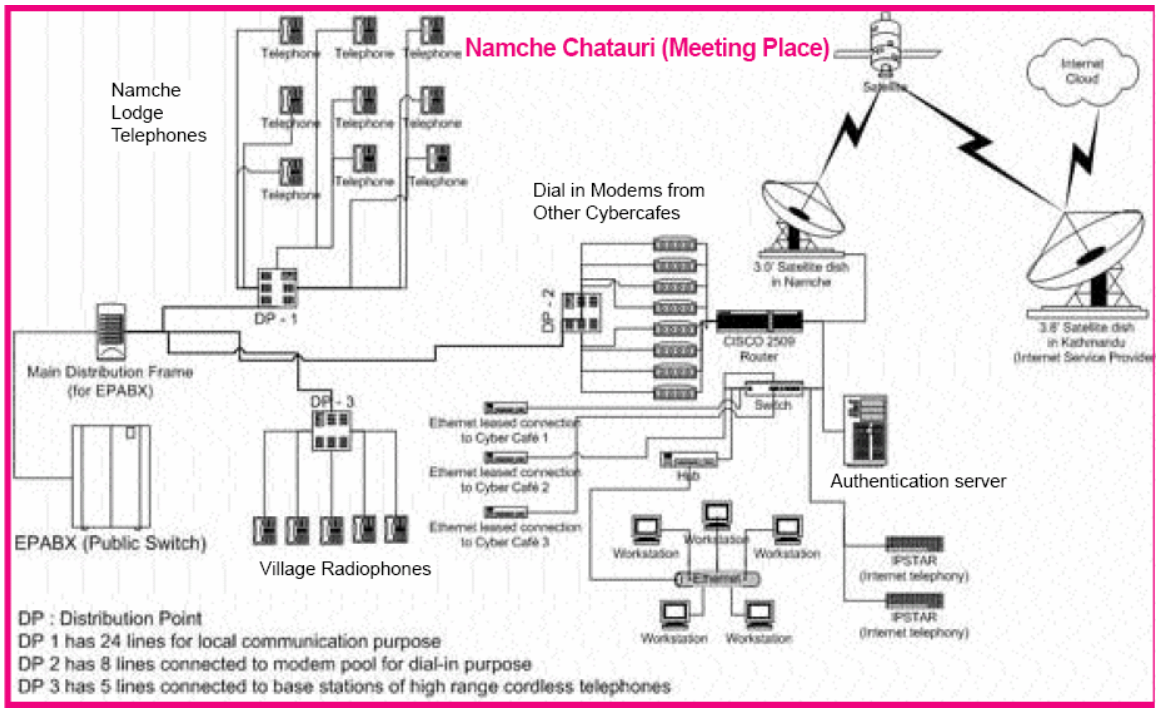

Figure 7 - Network Setup in Namche Bazaar[32]

A year later, Tsering has replaced the satellite phones with a VSAT satellite dish used to communicate with an ISP in Kathmandu. Over this he provides the same telephone

[31] <http://www.pbxinfo.com/> (11-9-2003)
[32] Appendix K-1: The COOK Report on Internet (p. 75)

service as before, as well as offering internet access to a number of cyber cafés in the area. He has also started using VOIP servers and phones in addition to the PBX switch to increase the capacity of the phone network without overloading the amount of bandwidth available. With the help of the Sagarmatha Pollution Control Committee(SPCC), Tsering also maintains a local directional wireless link with the Everest base camp, where there is another cyber café. The money raised from tourists using this link is used by the SPCC to promote the mountain and keep it clean. Tsering has also looked into setting up links with other local villages using Redline 5.2GHz radios. The entire network that Tsering has set up in that region can be seen in Figure 6.

While there are several different wireless links in use in the area, it is not power effective to provide a non-directional wireless link in the area. Because most of the wireless base stations are solar or battery powered they use directional links that consume less power and have a longer range, but anyone who wants to use the network must plug into a network jack at either end of the wireless links.

2.6 Climbing Techniques and Equipment[33]

There are a number of different routes and techniques that climbers use while attempting to summit Mount Everest. There are also many different types of equipment that mountaineers will use in various situations.

The first observations of Mount Everest identifying it as the tallest peak were in the 1850's. Since then it has been the goal of many climbers to conquer its peak. The first attempt was in 1921. Fund raising for this trip was difficult at first and they had to seek sponsorship from a soap company. The projected expenses were to be between £3,000 and £4,000 which required outside sponsorship. Today Mt Everest seems to be open to

[33] Information in this section is a compilation of sources primarily consiting of the 6 years climbing experience of author John Richardson, "Mountaineering, Freedom of the Hills", and "Climbing Anchors" by John Long

[36] "Mount Everest news", <http://www.mounteverest.net/story/MaleclimbershaveabnormallyshapedspermOct302003.shtml>

anyone who has the money to spend. The typical cost is about $65,000 and can fluctuate greatly depending on services required. For example, a helicopter rescue will add close to another $10,000.

2.6.1 Ropes

Ropes are used in expeditions for many reasons; the underlying principle of all of them is safety. The lead climbers use ropes as their direct link to safety while climbing steep rock or ice. This rope is held by another climber known as a follower. This follower performs what is known as belaying, a combination of braking and providing slack in the rope. As the leader climbs higher he secures the rope to the rock, ice or snow, providing a safety point, or anchor for himself. The worst case scenario is considered to be falling twice as far as the distance between the leader and the anchor. Another way to use the rope is to link everyone together on a single rope. This is used for glacier travel where steep climbing is not encountered. In this case if one climber falls the others are usually able to arrest his fall as a group. If all the climbers are pulled down they can use their ice axes to slow and eventually stop their fall much more effectively than one climber falling alone. Fixed ropes are set up to provide assistance to the porters or guided climbers. Ropes are also used for hauling gear and in rescue situations.

2.6.2 Ascenders

Ascenders are devices that are used to climb the rope directly. These are hand held devices that are used in a pair with an etrier or daisy chain. Etriers or daisy chains act like a ladder for the feet of the climber. This allows climbers to bypass very steep or impossible sections.

2.6.3 Harnesses

Harnesses allow a climber to tie directly into the rope while improving their comfort and increasing their safety. A harness provides the climber with a waist loop as well as a pair

of leg loops. These loops distribute the forces generated in a fall to a larger area of the body placing less pressure on the climber's lower back and spine. Harnesses also can provide gear loops for storing gear conveniently at his sides so it can be found easily while climbing. This configuration allows the climber to be better balanced rather than using a gear sling which raises the climber's center of gravity and places bulk between the climber and the mountain.

2.6.4 Belay Devices

Belay devices have aided climbers in a technique that is used to catch a falling climber. This is done by the lead climber tying into one end of the rope and another climber controlling the free end. There are several devices that assist in belaying by adding significantly more friction and requiring less strength to hold a much greater force. This allows a climber to stop a fall with very little or even no slipping of the rope. Some such devices are auto-locking or have an auto-locking feature. Belay devices can also be used to rappel, or descend rope.

2.6.5 Rock and Ice Protection

Rock and ice protection can be provided in many ways. Often the best and most reliable is using what it known as "natural protection", or simply tying of a sling around a tree rock or ice chandelier. Artificial means are used when these options are not available which happens to be most of the time. There are several devices ranging from thin slivers of steel that are pounded into a rock with a hammer to complex spring-loaded camming devices to titanium screws that are screwed into ice or snow.

2.6.6 Carabiners

The carabiner has to be one of the oldest and most versatile devices. They can be used to secure the rope to a piece of protection, set up as a belay device, or just for holding gear.

It is very rare for these pieces to fail, usually only under abuse or misuse. This makes it one of the most reliable pieces.

2.6.7 Ice Axes and Crampons

Ice Axes or Ice tools and crampons are the main source of traction of the climbers for their hands and feet respectively. Ice axes are swung and the tips buried in snow or ice, providing a place to pull oneself up from. They can also be used to cut steps for others to climb. Ice screws are placed by creating a small hole with the ice axe and then twisted into this hole. Crampons are used much the same way but on the feet. The front points are kicked into steep ice or the bottom points used for traction on glacier ice or snow.

2.6.8 Oxygen Equipment

Mt Everest is one of the only mountains that requires most climbers to use supplemental oxygen. The air at this elevation is under reduced pressure and therefore does not allow the normal amount of oxygen into the lungs. There is the need for the gear that is used to be light as well as strong and reliable. If a climber that has been using oxygen suddenly is without at altitude the effects can be catastrophic.

2.6.9 Clothing

In the extreme environment that is encountered while climbing Mount Everest, clothing is one of the most important items that a mountaineer has to stay alive and frostbite free. The object is to block wind, maintain a water proof state, and keep body heat near the climber. Since the terrain and thus the environment changes very often so must the amount of clothing. The clothing is meant to be layered, providing increasing amounts of insulating air between the climber's skin and the outside environment. The base layer is meant to keep the skin free of perspiration and to place a layer of warm air next to the skin. The intermediate layers are to provide insulation and to reinforce wind and waterproofing. The outer layer is meant to provide a barrier against wind, rain, and

snow. This layer may also be filled with insulation depending on what the altitude dictates.

2.6.10 Boots

Boots have to take the most abuse and therefore are very important. They are in direct contact with the snow and ice so they very easily transfer the cold temperatures to the already susceptible to cold feet. They must be stiff enough to allow positive footing and secure crampons to them. They must be tough enough to stand up to sharp rocks, ice, and the occasional poke from a crampon. They must also be waterproof and come up high enough to prevent snow from getting to the foot.

2.6.11 Tents and Sleeping Bags

Sleeping warm helps climbers adjust and feel refreshed when they awake. Sleep is essential to maintaining alertness and making good decisions. A good tent and sleeping bag is essential to obtaining this valuable sleep. The premises behind tents and sleeping bags are much the same as of clothing. Since these items have to be carried it is very important to be very light as well as waterproof and windproof. Tents come in various sizes and are catered to the situation in which they are used. This ranges from the emergency single person bivouac to the large tents that are used in base camp.

2.6.12 Cooking

Nutrition is very important to maintain the strength and morale of climbers. At these altitudes it is very important to have efficient and light devices to cook. Cookware must be very light and transfer heat well. Stoves must heat quickly and burn without an excess of oxygen. Therefore, cooking gases must be tailored to suit this environment. Kerosene, for example, will not burn at altitudes above 20,000 feet. Although most of the cooking is done at either Base Camp or Camp II, stoves are used to reheat the food

and to provide drinking water by melting snow. Proper hydration is essential to the success of such an expedition.

2.7 The effects of High Altitude on the Human Body

The effects of climbing Mt Everest on the human body are numerous. The vast majority of these effects are due to the lack of air pressure. The lack of pressure reduces the partial pressure of oxygen. This means that even though the percentage of oxygen in the air is the same, there isn't as much oxygen in a breath of air due to the fact that the lower pressure lowers the density of the air. The pressure on top of Mt. Everest is about one third that of sea level. With this small amount of oxygen the human body must work extremely hard to gain enough oxygen to survive. With this added effort, normally simple tasks such as eating, walking, or even crawling into bed can be exhausting. Without proper acclimatizing techniques serious illnesses and even death can occur.

2.7.1 Illnesses

Acute Mountain Sickness (AMS) is the first illness and the least serious that climbers have to contend with. Unfortunately the symptoms are quite common to everyday illnesses. These symptoms include headache, dizziness, fatigue, dry cough, loss of appetite, nausea, vomiting, insomnia or disturbed sleep. It can begin as low as 8,000 feet, not even as half as high as Base Camp.

High Altitude Cerebral Edema (or HACE) is a more serious condition. This affliction is due to a build up of fluid in the brain which can lead to permanent brain damage and/or death. Signs of this ailment include unsteady gait, inability to perform simple daily tasks, confusion, loss of memory, hallucinations, psychotic behavior, and coma. These symptoms tend to mimic those of hypothermia which is not impossible in the extreme environment found on Mt Everest. Temperature of the sick should be taken to determine between the two.

The most dangerous is High Altitude Pulmonary Edema (HAPE). This condition fills the lungs with fluid further inhibiting the little oxygen there is from getting to the red blood cells. Climbers who have obtained this condition are known to turn blue or purple in the skin, nail beds, and lips. HAPE victims will tend to cough up sputum that is occasionally mixed with blood. It is further marked by undue shortness of breath, tightness in the chest, feeling of suffocation, weakness, fatigue, cough, foaming at the mouth, and bubbling and crackling sounds from the chest. The onset of confusion and delirium are also common in advanced cases of HAPE.

The causes of these illnesses are linked to a condition known as hypoxia, or the inability to supply the proper amounts of oxygen to the tissues of the human body. The body has many responses to the change to an oxygen reduced environment.

2.7.2 Physiological response

There is an increased breathing rate which increases ventilation but is only effective to about 3,000m (well below base camp). This hyperventilation causes an excess amount of carbon dioxide to be expelled from the body. This may disturb the pH of the body and contribute to AMS. Much moisture is exhaled from the body during breathing and this increased rate leads to a one being easily dehydrated. The arteries leading from the lungs to the heart and from the heart to the body dilate and constrict respectively perhaps aiding in restoring the balance of oxygen in the blood. Despite this, the driving pressure from the atmosphere is lowered so much it is difficult for the O^2 to reach the blood.

The heart responds very well to increased altitude. There is increased output initially but that normalizes to sea level output levels with in a couple of weeks. The heart may initially beat up to 140 beats per minute at rest. This may increase the likelihood of clotting, strokes or cardiac arrest to those who are predisposed.

The brain may suffer permanent damage to being exposed to this oxygen-deprived environment. There may be a slowing of the functions of the cerebrum due to hypoxia. This may cause poor judgment leading to many of the accidents that occur at extreme

altitude. Most tests show that the brain recovers most of its functions within a year of return to normal altitudes.

The blood undergoes significant changes in chemistry. First there is a reduction in plasma due to dehydration. Later (within a few days) Hemoglobin is created to help bring more oxygen to cells. Within a couple of weeks more red blood cells are produced. These changes allow the heart to regain normal operation since there is more blood volume. It also provides a larger volume of fluid for sweating.

2.7.3 Other effects

There has been some evidence that high altitude affects the reproductive system in males. The sperm count and amount of testosterone serum has been reduced in climbers to 7,821 m. Sperm are also deformed. These effects were reversed by the end of 2 years (only 3 months for shape). This is a newly found effect and will need more research.[36]

The exceedingly cold and dry environment on Mt Everest compounds the effects of the other ailments. The stress and the lack of relative humidity will dehydrate the body rapidly. One pint of fluid will replenish the fluid lost from 1 pound of body fluid lost. Alcohol and other diuretics should be stayed away from.

The effects of UV radiation are very prominent at such altitudes. Ultraviolet radiation increases about 5% for every 1,000 feet of elevation. Therefore, around the summit of Mt Everest there is about a 145% increase in radiation from sea level values. The snow also reflects the UV rays. Proper care needs to be taken to prevent sunburn, and eye damage. Snow blindness is a reversible but extremely painful result of not wearing proper eye protection in these types of environments. It is marked by blindness and inflammation of the eyes.

Chapter 3: Methodology

The aim of this project was to determine the effects on mountaineers and the local population due to the changes in technologies that are being employed on and around Mount Everest. The particular technologies that we focused on are the equipment used by the mountaineers in order to climb Mount Everest, as well as the communications equipment that they and the local residents employ. The project's focus was on Mount Everest, as well as Kathmandu, Namche Bazaar and the smaller villages in Nepal surrounding the mountain.

There were several major objectives we accomplished in our project.

1. Analyze the impact of better communications technology on the local population
2. Determine how better technology has influenced climbers
3. Assess the effects and beliefs on the use of medicine in treating the physiological reactions due to high altitude

Our first goal was concerned with the impact of communications technology on the local population. In order to determine different views on this subject, our group conducted several interviews to get a personal and professional view on several key issues in this area. We interviewed several Westerners who have been to Everest both before and after it became a tourist hotspot, which gave us an outsiders impression of what changed due to technology. This included faculty on the WPI campus who have visited the region, in particular Professor Karen Lemone and Professor Thomas Keil. Some of the questions we asked these people were, "What forms of technology did you observe being used locally?", "How widespread was the use of these technologies?", and "Did you observe any cyber cafes during your travel, and how busy did they appear to be?"

Our group is also interested in the communications technology that is being used on Mount Everest, in particular the existence of an experimental mobile "cyber café" that has been tested at Base Camp. Our group hoped to interview the people responsible for

the maintenance of the facility in order to find out information about the design of the technology, the purpose and use of it, how it was adapted to the area, the impact so far, etc. We did manage to interview Subodh Manandhar, the director of business development at Square Networks in Kathmandu through E-mail. We asked a number of questions designed to determine how much and what kinds of technology are used in the region and how modern that technology is. We also tried to find out whether the technology is used mainly by the local people or by tourists.

We also spoke to several of the equipment manufacturers, who made the equipment used by Square Networks. These companies included, Agilis Communication Technologies, Cisco, and Space-Star. Through these contacts, we learned how their equipment is designed to work.

We had hoped to interview both porters in the area as well as Sherpas to gain an understanding of the local viewpoint about technology. We intended to ask questions about people's opinions on technology as well as questions about each person's background, as that will influence their answers. Since they live in the area, these people could have been able to provide us with personal insight into the changes of the region and how they may have changed the lives of local people. We sought to have these interviews be conducted via phone or through E-mail and other Internet based technologies; however, we were unable to find a person in position to be interviewed.

Another major question pertains to the use of technology while actually climbing Everest, and whether better technology has made it safer overall or whether the better technology is offset by a lack of experience in the people climbing. One group that we focused on was the climbing community, specifically the Western mountaineers. To gain some insight into the Western mountaineering community our group interviewed several climbers in the New England area. We asked questions relating to the experience of climbing, as well as areas relating to climbing culture, equipment, training, technique, etc. To supplement the perspective of the Western-hiker community, our team would liked to have interviewed an experienced Sherpa climber to find out about their views on

the modern technology being used, however were unable to find such a contact in the time available.

Our team interviewed several mountaineers who live in the New England area. Rick Wilcox owns a retail store and guiding service located in North Conway, New Hampshire. He has summited Mount Everest and leads many trekking excursions to base camp. He has been involved with the climbing community for at least 20 years. Also in the area was Paul Giorgio, who has summited several times. We interviewed these people in person.

Some of the interviews regarding the climbing equipment had to be performed over the phone. We interviewed mountaineer Conrad Anker over the phone, as he currently resides in Montana. He summited Mount Everest in 1999, as part of the Mallory/Irvine Research Expedition. Some of the questions asked were, "Do you feel safer or more secure because of the improvements to the equipment?", "Where do you think the biggest changes have been in the technical climbing gear?", and "Do you feel that the gear has allowed more people to get into the sport?" These interviews provide us with insight as to how the technology is used and give us an understanding of how mountaineers feel about it.

In addition, we inquired some of the manufacturers of the equipment that is used by the climbers during an expedition. Oxygen equipment used particularly on Mt. Everest is one of the items that we intended to learn more about. Some of the equipment manufacturers we obtained information about are Black Diamond, The North Face, Marmot, Trango, and Petzl. Some of the information has been obtained through data sheets, and limited knowledge of technical specifications has been gained through interviews. We also gained important first hand knowledge of the effectiveness and use of the equipment.

Through these interviews we determined how the new textiles (clothing, sleeping bags, tents, etc.) have decreased the risk of frostbite, hypothermia and even death. We also asked about equipment changes that have changed the face of climbing such as the

spring-loaded camming device. Other areas of interest include how the equipment has helped training or has gotten relatively inexperienced people to the top of Mt Everest.

We also acquired statistical evidence concerning how the equipment has improved by comparing mechanical and other properties of the materials that are being used today compared to those that were used in the 1920's. In addition, we also researched the increases in safety due to the introduction of new equipment such as belay devices, harnesses, and rock and ice protection.

Another objective of the project was to examine the physiological effects of high altitude on the human body. To do this, we interviewed Professor Rustem Igor Gamow over the phone, as he teaches at the University of Colorado at Boulder. Professor Gamow is responsible for the invention of the Gamow Bag which is a medical device that is used by the climbers on Mount Everest and other remote areas to help combat altitude related sickness. We also examined the drugs that are used to help combat high altitude sickness. We contacted drug companies to find out what they are, how they work, and how they should be used.

Phone interviews were conducted using a cellular phone attached to a recording control device from Radio Shack. This device allowed the usage of a hands free kit to speak into and listen through while being connected to a recording device. In this case the recorder was the hard disk of a laptop running a .wav editor. The created .wav files were modified for clarity and noise reduction and then compressed to .MP3 format for portability over a network. Interviews conducted in person were recorded using an omni directional dynamic microphone connected to a laptop computer. The .wav files were treated in a similar manner as above. The interview with Subodh Manandhar was conducted over E-mail, a list of questions was sent to Subodh as part of the E-mail. He then replied with his answers to the questions in a return E-mail.

Chapter 4: Results of This Study

During the study, large amounts of data were collected. This information was compiled from interviews, scholarly research, and other sources. The results are presented and organized in several sub-sections that follow, correlating with the areas researched in this project.

4.1 Communications Technologies

4.1.1 Local Communications

As tourists have visited the Everest region, they have brought a lot of technology with them that was previously not available to the native people. One of the goals of the project was to determine how this influx of technology has affected the local population.

One area in particular which we examined involves changes in communications, both on a local and a global scale. There are several different types of technology used for different classes of communication. These different classes include local phone service, global phone service, and internet connectivity.

Almost all Internet connectivity in Nepal is satellite-based, sometimes even local connections in the country. Internet providers in remote locations can buy a satellite or wireless link to an ISP in Kathmandu, with data, in turn sent over another satellite link to the rest of the world. Using this satellite technology it is possible to get an internet connection almost anywhere that there is electricity, but it is still not heavily used due to the cost of setting up and maintaining a connection. According to Subodh Manandhar, the director of business development at Square Networks in Kathmandu, the bandwidth usage for the entire country of Nepal is only about 15 to 20 Mb/s.

A satellite link requires several pieces of equipment to function properly. Satellites are usually launched by large telecommunications companies which then sell bandwidth on them to other companies. A typical satellite ISP would purchase a large portion of

satellite bandwidth and then resell it to individual customers. In Namche Bazaar, the other end of the satellite link is at Square, an ISP in Kathmandu, from where it goes through another satellite link owned by Sinosat to connect to Websatmedia Teleport in Singapore. From there, they can connect into one of the major high bandwidth OC-3 backbones that make up the internet.

In order to connect to a satellite link from the ground, one needs both an antenna and a transceiver. One company which makes satellite communications equipment is Agilis Communications Technologies. What would be recommended for a satellite uplink sold to the end users of a link would be something similar to the AHT Series Hybrid VSAT RF Transceiver made by Agilis. This equipment includes both an outdoor dish and a transceiver to receive the signal. A satellite dish, such as the one shown in Figure 7[37], will be used to upload and download data. This type of dish must be carefully aligned with the satellite it is communicating with, and must be in a steady location where it will not move out of alignment with the satellite. In the areas around base camp at the base of Mount Everest, this can cause a problem because base camp itself is on a glacier which is always moving. Although it is only a small movement, it is still enough to move a satellite dish out of alignment. Because of this, satellite dishes must be placed away from base camp where they can be anchored on solid rock. The other piece of equipment is a transceiver, shown in Figure 8[38], which is connected to the satellite dish and filters the proper signal out of all the data that is received by the satellite dish. Depending on the transceiver, it can then be connected to a computer or directly to a network of computers.

Figure 8 - 21dBi Parabolic Antenna

The amount of bandwidth that it is possible to get through a satellite depends mainly on how much you spend on the link. A typical communications satellite, which could be used for television broadcasts and phone conversations as

Figure 8 – VSAT Outdoor Transceiver

[37] Appendix K-2: Cisco Aironet Antennas (p. 34)
[38] Appendix K-3: Agilis AAV 680 Series Full C-Band VSAT Outdoor Transciever (p. 1)

well as internet access, can handle a total bandwidth of about 6 GB/s. While this may seem like a lot, it is split up between all the people using the satellite. Things like television broadcasts take more bandwidth, and are more sensitive to timing issues, than a typical internet connection.

For shorter distances within Nepal, 802.11a/b/g wireless links are used fairly frequently to provide internet connectivity. Using equipment from companies like Cisco, these links can be used reliably at distances of up to 25 miles. To maintain long distance links requires a high-gain antenna which looks similar to a satellite dish, such as the Cisco antenna shown in Figure 3-2, and like a satellite dish must be carefully aligned with the dish that it is sending and receiving data from. These dishes must also be mounted high enough off the ground to clear all obstacles in the way. For a 15 mile link on flat ground, Cisco recommends mounting the antennas at least 100 feet off the ground. This much clearance is required due to the curvature of the earth for links longer than 6 miles and the width of the actual signal path, which spreads out through a Fresnel zone, as can be seen in Figure 9. Table 2 shows Cisco's minimum mounting height for links of various distances with no obstructions. If there are terrain obstructions they recommend mounting the antennas this many feet above the highest obstruction as well as an extra factor. The terrain in Nepal provides some difficulty in this area, but usually links are not at that long a range and repeaters in high areas can be used if necessary to extend the range.

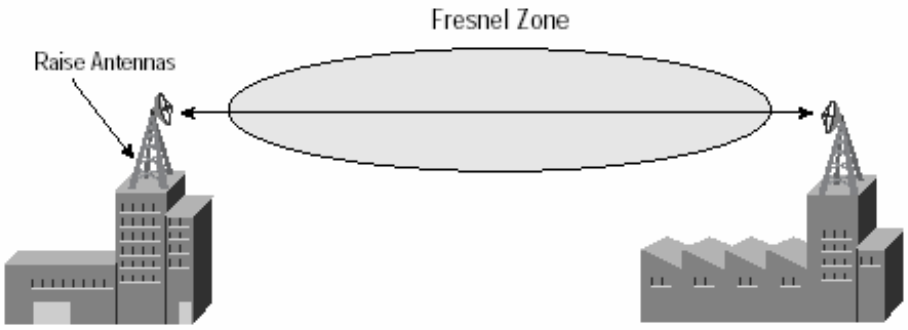

Figure 10 - Fresnel Zone for long distance wireless links[39]

[39] Appendix K-2: Cisco Aironet Antennas (p. 12)

Wireless Link Distance (miles)	Approx. Value "F" (60% Fresnel Zone) ft. at 2.4 GHz	Approx. Value "C" (Earth Curvature)	Value "H" (mounting Ht.) ft. with no obstructions
1	10	3	13
5	30	5	35
10	44	13	57
15	55	28	83
20	65	50	115
25	72	78	150

Table 2 - Minimum height requirements for 2.4GHz antennas at various distances[40]

A larger obstacle to the use of wireless links is the amount of power that they require to work properly. A long range wireless link can take about 200 watts of power to maintain, depending on the distance the link is to be used over, which is about as much as the computer at the end requires and much more than the equivalent wired network would require. The poor electrical grid in Nepal does not help with this problem, and often generators or solar panels are used in remote locations to generate all of the power used.

Another growing phenomenon which uses the internet is the growth of cyber-cafes, which allow anyone to use a public computer to access the internet. While these are mainly popular in the larger cities, they are also found in smaller villages, often as the only internet connection available. While these cyber cafés are often found in tourist-friendly areas and are used by tourists, the local people are also starting to become accustomed to using the internet. Cyber cafés can be found regularly from large cities like Kathmandu all the way to Namche Bazaar. There has also been a cyber café set up at times right at base camp.

[40] Appendix K-2: Cisco Aironet Antennas (p. 12)

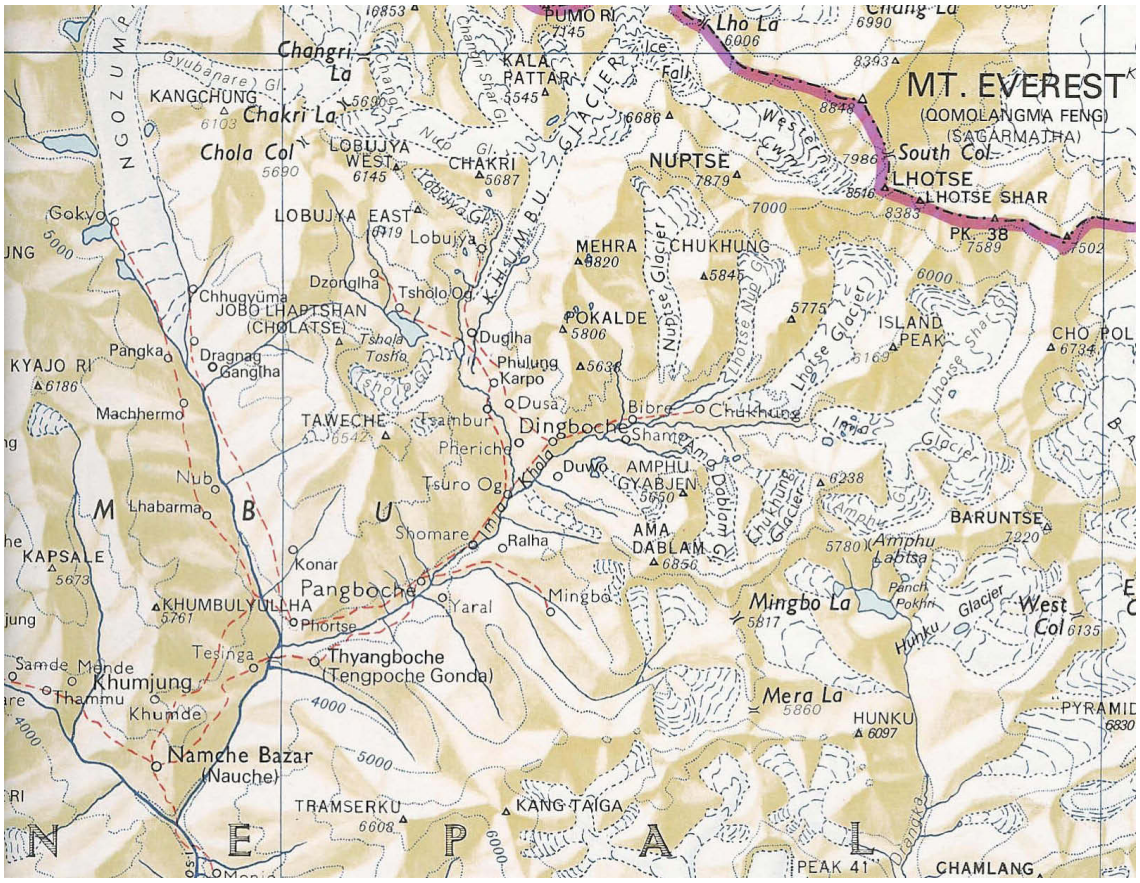

Figure 11 – A map of Namche Bazaar and Mt. Everest[41]

Local phone service in Nepal usually uses traditional phone lines. Larger cities are all wired with traditional analog phone lines. These are owned by fairly large telephone companies which charge subscribers for telephone service. In the cities, almost all houses are wired for telephone service, and most people have a telephone in the house. Computers that have a modem and are connected to a dial-up service are less common, but there are a number of dial-up ISPs in Kathmandu which provide this service. Most businesses are also found in the larger cities and make use of the phone system to do business.

Smaller villages that are not near to a larger city, such as the ones seen in the map in Figure 10, often use a PBX system to handle local calling within the village itself. While there are not many phones within the typical small village, this allows a lodge, for example, to have telephone access to call the local police if necessary. For villages too

[41] The Times Atlas of The World Ninth Comprehensive Edition (Plate 30)

small for a telephone network, there is usually a radiophone in a central location which is used to talk to other local villages or to connect with a larger city and from there to the outside world.

One company which manufactures PBX systems is Nortel Networks with its Meridian Systems line of PBX solutions. These can provide from 60 to 80,000 separate telephone lines that can be connected internally, while also sharing a smaller number of external lines. These systems are usually used in large businesses, hospitals, or college campuses to provide phone service internally that does not incur phone charges while still allowing outside calls from any phone. In Nepal it allows unlimited local calling without using limited outside bandwidth.

For phone calls outside of these wired networks, often VOIP technologies are used because they are less expensive than satellite phones and are easy to set up due to the infra-structure already being in place. VOIP products are often made by the same companies that make PBX hardware and can interface with the PBX directly through an Ethernet connection. There are also products into which a normal phone can be plugged which allow the voice data to be sent out as IP packets. These packets can then be sent out over the internet link using less bandwidth than a normal phone conversation would. Once they reach their destination, they are decoded and the call reaches its intended recipient over their usual phone line. It is also possible for two callers using VOIP technology to talk directly without the data being decoded into an analog signal and re-encoded.

The point at which analog telephone signals are translated into IP packets depends on where the caller is located. In larger cities, phone service exists much as it does in the United States, with analog phones being used until a signal has to go outside of the local area, when it is translated into packets transparently to the user. Phone companies in the United States also use VOIP transparently for long distance calls to save money. Some of the local villages, instead of using analog phones and a translator, use IP phones, which translate the voice data directly into packets without needing an analog phone line. These phones can be plugged directly into an Ethernet connection with no additional

hardware. In the United States, this method is usually only used with companies that have their own PBX and use VOIP internally anyway.

Overall, the group which benefits the most from this improved communication is businesses. ISPs and cyber-cafes are both growing forms of business, providing other established businesses the ability to communicate easily with the outside world. There are also a number of large businesses in Kathmandu which are only local parts of larger companies which operate worldwide and which need to communicate with other parts of the company. In these ways, the communications technology is constantly being pushed forward because of the needs of the business community.

Another group which uses these communication technologies frequently is tourists. Outside of the major cities, communications technology is being added much faster in the areas which have large numbers of tourists visiting. These tourists are generally Westerners who are used to being able to communicate with anyone easily and often go looking for the same types of technology when they are visiting. While the technology is used by the locals as well as the tourists, in many cases it would not have been introduced without the incentive of and money from the tourism business.

4.1.2 Infrastructure

Communications is not the only area in Nepal that has been improved by the use of imported technology. Electricity is readily available in cities, although blackouts and brownouts are still common. Even remote areas now have at least some electricity due to the use of generators and solar panels. Solar panels are often seen as a sign of affluence, with those people who are better off having more solar panels and being able to power more different things. There is also a lot of moving water in the area, and submersible hydro-power generators are used where possible, although this can mean that there is a lack of electricity during the fall months when the water levels are lower. While the lack of a dependable electric grid is still a problem, it does not prevent electricity from being produced in small amounts where it is needed.

Figure 12 - Transporting a Satellite Reciever to Base Camp

Roads are another area that is being improved with modern technology. Currently there are not very many roads in the region due to the steep rocky terrain, but more are being built to make transportation easier. Transportation is also helped by having airports in the area so tourists can fly in directly rather than having to travel most of the distance overland. In order to transport goods and materials, it is often easiest to have things carried by people. Sometimes animals are used, as seen in the photo in Figure 11[42], but usually people just hire a large group of Sherpas to carry their items.

4.1.3 Mountaineer Communications

While much of the gear used by those who come to climb Mount Everest is equipment physically needed for climbing, these climbers also use advanced electronic technology to help aid them in their goal. One piece of electronic equipment that has improved dramatically is the radios carried by climbers. Unlike older radios, modern radios are small and light enough that every member of the climbing team can carry their own radio, which improves communication between team members and improves safety, as anyone in trouble can call nearby team members or base camp for help. Modern radios usually send out digital signals which, while still line-of-sight, offer better range and audio quality than their older counterparts.

Another piece of electronic equipment typically carried by climbers is a tracking device or avalanche beacon which allows each climber to be tracked down by a radio signal in case of an emergency. These avalanche beacons generally have a range of 20 to 80 meters and allow even someone completely buried to be quickly located. Modern avalanche beacons generally have a graphical readout which makes it easy for someone

[42] <http://www.linkingeverest.com> (6-4-2004)

to use even with very little training. Older avalanche beacons required several hours of training to learn to use them properly because you had to listen to a tone to tell where someone was while using them. GPS receivers are also used by rescue searchers to coordinate exactly where they have searched when looking for a missing climber. GPS is generally not used by the climbers themselves because it is not always accurate enough. A difference of just a foot or two could put someone over the edge of a cliff if they were relying only on GPS for positioning.

Battery technology for these portable devices has also improved with most important modern devices using rechargeable lithium-ion batteries or high-capacity disposable lithium batteries. These allow devices to operate for longer periods of time at the cold temperatures found on the mountain. Solar panels can also be carried to recharge the battery packs. While a solar panel cannot supply enough power to run electronic equipment directly, it can recharge batteries.

4.2 Culture of the Sherpas

There are many different cultures in the Solu-Khumbu region of Nepal. Some of these cultures are curious about the western tourists and the technology that they bring to the region, while other groups are not. Typically in the region, when a village or group has seen the benefits of any change that is brought to them, they are willing to embrace it.[43]

With the influx of tourists, many of these groups have put themselves on display for the tourists who come through. While they benefit from this with additional income from performing for the tourists, many of the songs and dances that they perform are not actually part of their original culture. It may be a virtual culture, developed and displayed primarily to entertain the western tourists, often for a fee.[44]

One of the major problems facing the area is a large gap in the quality of living. People working in the tourism industry, such as porters, earn a lot more money than the people who do subsistence farming, which is common outside of the cities. In the region, and

[43] Appendix C: Paul Giorgio Interview
[44] Appendix G: Thomas Keil Interview

probably the rest of Nepal, technology has become a sign of affluence. For example, in areas that house residents who are wealthier, either through trading or the tourism industry, their houses are typically outfitted with solar collectors to provide electricity. While western technology is available in Nepal, the price remains the same as it would be in countries like the United States. Due to the low per capita income in the country, only the wealthier citizens are able to obtain the technology that would provide comforts such as electricity, hot water, and telecommunications. In the cities, televisions and personal computers are available for purchase.

Another issue facing the region is a problem of malnourishment. Since western conveniences like refrigeration are not commonly available, most of the residents have to buy fresh food daily. Some of the more popular foods such as meat and eggs are bought by trekkers who visit the area. While this is good for the local merchants, they raise the prices of the food to make a larger profit from the mountaineers, which in turn raises the price of food for everyone else in the region. Since the average resident does not make a lot of money, they cannot buy the food as the price was increased due to the willingness of mountaineers to pay a higher price.[45] These inflated prices force local people to eat primarily vegetarian and dairy products.

4.3 Climbing Equipment & Gear

4.3.1 Ropes

Ropes have basically remained the same since the change to nylon. A lot of fine-tuning has been done to improve the maximum impact and the number of high factor (long) falls that the rope can withstand.

At the start of mountaineering, the ropes that were available were made from natural fibers such as manila and sisal, and looked similar to the one shown in Figure 12[46]. Nylon ropes were developed

Figure 13 – 1920s Rope

[45] Appendix G: Thomas Keil Interview
[46] <http://www.grivel.com> (4-8-2004)

during World War II. These ropes were very strong capable of holding more than 4,000 pounds. While being so strong they also displayed a great deal of elasticity allowing the energy produced during a fall to be dissipated dynamically through the rope, saving the climber from an abrupt and possibly life threatening jolt.

The first nylon ropes were made of a twisted construction much like the rope that you can find in a home improvement type store, however they were very stiff and difficult to handle. They produced a considerable amount of friction when pulled up from the lead position on rock or ice. This phenomenon is known as rope drag. Rope drag can be quite difficult to overcome, especially on a long, sustained, difficult route, even possibly throwing the climber off balance.

Kernmantle ropes such as the one in Figure 13[47] were the next step in the development of the climber's lifeline. These ropes are composed of a braided or parallel nylon filament core, which is then wrapped in a nylon sheath. These ropes are excellent in reducing the disadvantages of twisted nylon rope. The stiffness can be controlled to suit a particular climber's preferences. Friction is greatly reduced allowing for less chance of pulling oneself off the rock while trying to manage the rope. The elasticity can also be controlled, which solved the problem of the early nylon ropes as they were too stretchy to be used to ascend the rope efficiently.

Figure 14 – Nylon Rope

Another deficit of rope is the effects of water. Ropes have been shown to retain only 70% of their strength and hold significantly fewer falls when wet. Water may enter the rope when dragged across snow or ice and then re-crystallize when freezing temperatures are encountered. This water expands and can make many tiny cuts in the core of the rope. This has also been combated lately by manufacturers adding a silicone or Teflon based coating to the rope making it at least partially water resistant. This also gives the

[47] <http://www.rei.com> (4-6-2004)

added benefit of improved abrasion resistance and lower rope drag when it is run through gear. When this treatment has been applied to a rope it is then known as a dry rope. Although they are considerably more expensive, they are far more versatile to own because they will allow you to use the same rope for both rock and ice climbing. An additional benefit is that a frozen rope is very difficult to handle and even impossible to use when trying to climb it or to rappel down.

Static ropes are still used. They have little to no stretch and therefore are not meant to be used for free climbing. Static ropes are used for fixed lines on expedition climbs such as on Mt Everest. Their other uses are for hauling equipment, rescue, setting anchors, and any time when the rope is to be climbed. Thousands of feet of this rope are used on each expedition.

Dynamic ropes come in several sizes and are chosen depending on climber's preferences and performance and weight needs. A climber who expects to fall often on shorter routes will choose a thicker and therefore heavier rope. A climber not expecting to fall uses the rope for pure protection purposes and therefore will choose a lighter rope that is more manageable, but will hold a fewer number of high factor falls. Some climbers choose to use two very thin ropes (8-9mm) as opposed to one thicker one, which allows them to have more freedom in protection placement and allows the leader to belay two followers at once. All but the thickest types of ropes are used on Everest, since the terrain is wildly varied. The thicker (11 and 12 mm) ropes are simply too heavy to be worth carrying. Impact forces that are required to break a rope depend on something known as a fall factor. This is the height of the climber above his last piece of protection multiplied by 2, divided by the total amount of rope that is let out from the belayer. For instance a climber climbs 50 feet and places a gear along the way; he then climbs 15 feet above his last piece and takes a fall. His fall is then 30 feet. The total length of rope that is out is 65 feet. Therefore the fall factor is 30/65 = about 0.46. This is not a bad fall by today's standards but may very easily have broken a manila (hemp) or sisal rope. The impact force (IF) is found by taking the maximum force and dividing by the sum of the mass of the climber and his gear and acceleration due to gravity. The impact force is defined as:

$$P_{\max} = mg\left[1 + \sqrt{1 + \frac{2k}{mg} \cdot \frac{H}{L}}\right]$$

$$IF = \frac{P_{\max}}{mg} = 1 + \sqrt{1 + \frac{2k}{mg} \cdot \frac{H}{L}}$$

Equation 1 – Impact Force[48]

Where m is the mass of the climber, g is acceleration due to gravity, H is height of the fall, L is the length of rope let out, and k is to the elasticity of the rope.

Failure for a kernmantle rope is about 25 kN, as is shown in Figure 14, where a hemp rope is about 11kN. It has been determined that the maximum that a human body can endure is 12kN without injury. Today's nylon kernmantle ropes will allow a max of about 7.5 kN due to its high elasticity. The nylon kernmantle rope will only allow about 7.5kN of force to be transmitted to the climber. This yields about 15 kN at the belay point. The breaking point is still about 10 kN more than that.

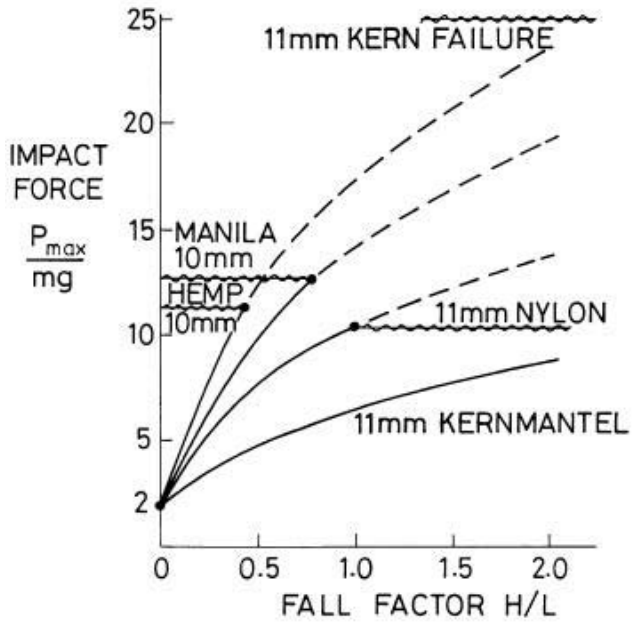

Figure 15 – Impact Force vs. Fall Factor[49]

[48] Appendix K-4: Sports Engineering

4.3.2 Harnesses

Harnesses simply did not exist originally. Instead of using a harness, a climber would tie directly into the rope, a practice that was not only uncomfortable but also quite dangerous. A climber would simply wrap the rope around his waist several times, concentrating force on his lower back. This combined with a virtually static rope made what would be considered a small fall today a fall that could have paralyzed or killed a climber before WWII.

During the 1960's this problem was addressed with waist belts that often knocked out climbers after hanging in them for as little as 10 minutes. This was then solved in the '70's by Don Whillans and his sit harness, which introduced the incorporation of leg loops.[50]

Figure 16 – Black Diamond Alpine Bod Harness

Today there are several types of harnesses to accommodate every type of climber and body style, including children. The primary type is a seat harness, shown in Figure 15[51]. This type of harness incorporates a waist belt as well as a pair of leg loops. This helps distribute the load of a fall across a larger area of the body greatly reducing injury in a fall. Seat harnesses can become quite specialized. Climbers on Mt Everest prefer what is known as an alpine harness. These are quite simple harnesses that offer little to no padding and are extremely easy to get in and out of, even while wearing crampons. The other attraction is light weight. Such a harness is the Black Diamond Alpine Bod (375g) or the Petzl Pandion (290g). These traits are acceptable since the

[49] Appendix K-4: Sports Engineering
[50] Ibid
[51] <http://www.bdel.com> (6-4-2004)

harnesses are mainly for safety and are not designed for a climber to be hanging in one for an extended period of time.

Harnesses should conform to the UIAA[52] standard EN 12277 Type C. (for sit harnesses) This requires that it can withstand an impact force of 15 kN, while ideally distributing 7.5 kN to each leg.[53]

4.3.3 Belay devices

Figure 17 – Modern Belay Device

Originally a loop of rope was simply looped around the waist or some natural object and was pulled tight and subsequently slack was given to the climber as necessary. This would protect the leader if he happened to fall. Within the past 15 years, devices such as the one shown in Figure 16[54] have been created that have helped to aid the belayer (the person who guides the rope for the leader, and then would follow behind the leader) to be able to control the rope much easier. These devices work by creating a large amount of friction on the rope since they wrap the rope in a very tight angle. Typically to hold a large fall all the belayer has to do is apply a force of about 25 pounds. A table comparing popular belay devices can be found in Figure 17. This should be very easy to someone who is able bodied. Simple belay devices maybe brought to Everest. More complex devices, such as the auto-locking Petzl Gri Gri, offer a huge improvement in the sport climbing world has no place on a route like Everest. Some climbers resort to older methods such as using a special slipknot known as a muenter hitch. Other climbers don't use them at all since they free climb. Ropes that are used on fixed sections are simply

[52] Appendix K-5: UIAA Standard for Harnesses
[53] Appendix K-6: Petzl Pandion Instruction Sheet
[54] <http://www.rei.com> (4-6-2003)

clipped into with a carabiner and don't require such a device. Routes other than the "normal" routes may benefit greatly from these devices.

Stopping Power

Rope	Pyramid		Jaws		B-52				
Diameter	WEI	WEO	V-side	Smooth	Correct	Wrong	ATC	BRD	Reverso
10.7mm	25.9	24.7	6.0	21.1	19.2	24.7	22.3	4.8	25.9
9.8mm	34.3	35.7	15.6	35.5	28.0	39.3	31.9	9.6	45.3
8.4mm	34.5	36.9	20.4	40.5	23.2	41.7	36.7	10.8	46.5

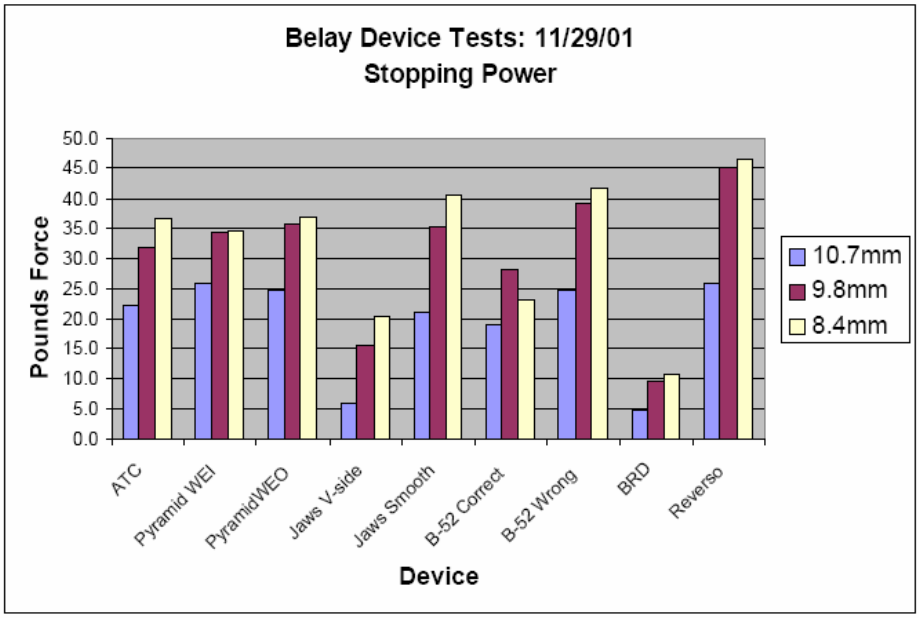

Figure 18 – Stopping Power of Belay Devices (11/29/01)[55]

4.3.4 Rock and Ice Protection

Protection for the rock climber is achieved through placing simple anchors to attach the rope to. This was done primarily using pitons, thin wedges of metal that are beaten into a crack using a hammer, which leave scars when removed. One of these pitons can be seen in Figure 18[56]. Another method is to utilize natural protection, such as placing a sling around a rock horn, ice pillar, or other natural

Figure 19 –Piton

[55] Appendix K-7: Belay Device Tests
[56] <http://www.rei.com> (6-4-2004)

Figure 20 - Modern Chockstones ("Nuts")

object. The first cleanly removable protection was in its infancy in the late 60's and early 70's. These were known as chockstones or nuts. They were said to have limited utility and unless placement was extremely secure they did not protect as well as a piton.[58] These devices were sometimes as simple as a screw nut with a sling or loop of aircraft cable running through them. John Stannard wrote an article stating how the incessant pounding of pitons was destroying the climbs. Black Diamond (at the time Chouinard Equipment) began mass-producing a wide range of chockstones such as those in Figure 19[59]. By 1973 placing pitons has been all but abandoned. A large breakthrough occurred in 1978 when "friends" became available on the retail market. These were adapted from a simple camming device created by Mike and Greg Lowe some 11 years prior. These "friends" were the first spring loaded camming device. These are simply known today as cams. These developments changed the world of climbing forever. More skillful climbers rather than burly strongmen began to dominate the sport.[60]

Figure 21 – Modern Ice Screw

Protection while on Ice or snow was done by pounding hollow wooden stakes into the snow. Today's ice screws, like the one shown in Figure 20[61], are much easier to use. Simply make a small pilot hole using the pick of an ice axe and thread the screw in. They are made from very strong stainless steel or even titanium. The teeth on the ends often are heat treated for hardness so they stay sharper longer. This helps the climber place the protection easily. Swivel

[58] Long, John; Climbing Anchors
[59] <http://www.rei.com> (6-4-2004)
[60] Graydon and Hanson; Mountaineering: The freedom of the hills
[61] <http://www.grivel.com/Products/img_chiodi_ice/img_dettaglio/3b.jpg> (6-4-2004)

handles aid in turning the screw by placing a longer lever arm on the screw. These handles fold out of the way when not in use also helps placement. A hanger is provided for a carabiner to attach to. Petzl has developed the next step in ice screws by combining the hanger and the handle.

Figure 22 - Snow Picket

Pickets are still used but they are composed of lightweight aircraft grade aluminum instead of hollow wooden stakes and look similar to the one in Figure 21[62]. They are "T" shaped for increased holding power. An expedition may use hundreds of these devices especially in the Khumbu Ice Fall portion of the ascent.

4.3.5 **Carabiners and Slings**

Most of the progress in this piece of equipment has been in adapting the shape for different needs. Advances in Materials Science and Computer Aided Design has allowed for very light carabiners to hold as much, if not more force than heavier counter parts. For example, a Black Diamond Neutrino like the one shown in Figure 22[63] weighs only 31grams but will hold 24 kN of force across the long axis. This carabiner also has no moving parts making it extremely reliable, especially in cold conditions.

Figure 23 -Black Diamond Neutrino Carabiner

[62] <http://www.rei.com> (6-4-2004)
[63] <http://www.bdel.com> (6-4-2004)

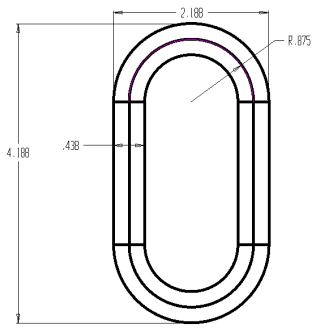

Figure 24 – Dimensions of oval carabiner

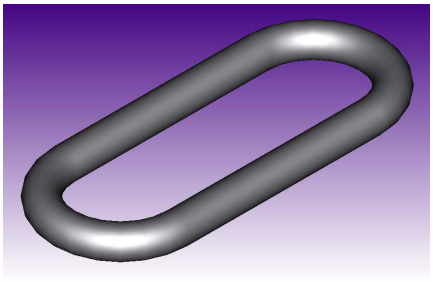

Figure 25 – 3D rendering of oval carabiner

Properties of Carabiner Materials		
	AISI 1030 Steel, water quenched from 870°C (1600°F), 540°C (1000°F) temper	Aluminum 7075-T6
Ultimate Tensile Strength (psi)	92100	83000
density (lb/in^3)	0.284	0.102
weight of carabiner (lb)	0.4	0.143

Table 3 - Properties of Carabiner Materials

To determine the change in technology, a carbiner was modeled in CADkey (see Figures 23 and 24) to obtain approximate volumes of a typical carabiner so that the weight may be obtained using the density of the material. A common mid-carbon steel was used as a benchmark material. Today's carabiners are produced from 7075-T6 aluminum. As one can see in Table 3, the ultimate tensile strengths of the materials are not too different, whereas the density and therefore the weight differ by a factor of about 3. This shows the tremendous weight saving in these carabiners. Further weight reduction occur when the material is removed from the areas that do not experience as much stress.

Slings that are used to span between the carabiner attached to the protection and a carabiner attached to the rope are made of a material known as spectra. This is the strongest fiber known to man. A thin 5/8" wide sling can easily withstand 27 kN of force. This allows many of them to be carried at a very low weight and they don't take up much space. Nylon tape slings have been used since shortly after World War II but are heavier and not as strong.

4.3.6 Ice Axes

Figure 25 -Modern ice axe with leash

The biggest advancement in the mountaineering ice axe is the shift to light weight materials in the handle. Aircraft quality aluminum (ASTM 6061 or 7075) is the most common material used. Some handles are fiberglass or carbon fiber, this again is to get a very high strength to weight ratio. Handle lengths are selected by the climber such that when it is placed by the side of the body the climber can hold the top of the pick and barely reach the top of his foot with the spike at the bottom of the handle. This is typically 60-90 cm in length. A modern ice axe can be seen in Figure 25[64].

During the infancy of Himalayan mountaineering the picks were fairly straight. This has been changed to a curved pick, which is more efficient and provides a more positive attachment to ice. Much improvement in steel has occurred throughout the years. Using harder steel allows the pick to be sharper and more resistant to wear, consequently making it easier to place into snow and ice. Using stiffer steels will lessen deflection when hitting the snow or ice reducing the number of swings that a climber must make to secure himself.

[64] <http://www.camp.it/ukprodotto.asp?MF=02&F=14&C=1289> (6-4-2004)

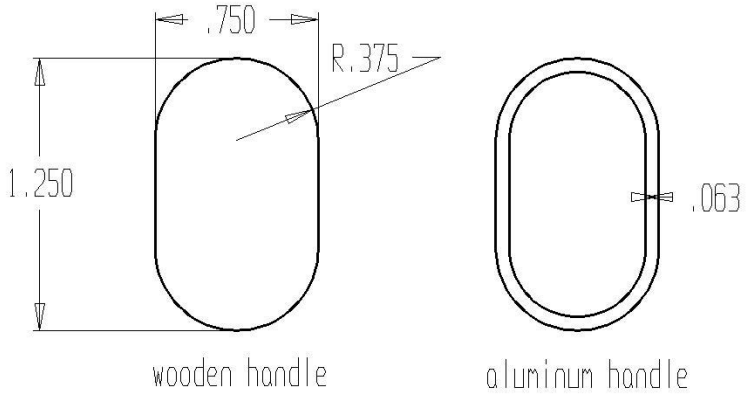

Figure 26 – Dimensions of Wooden and Aluminum Handles

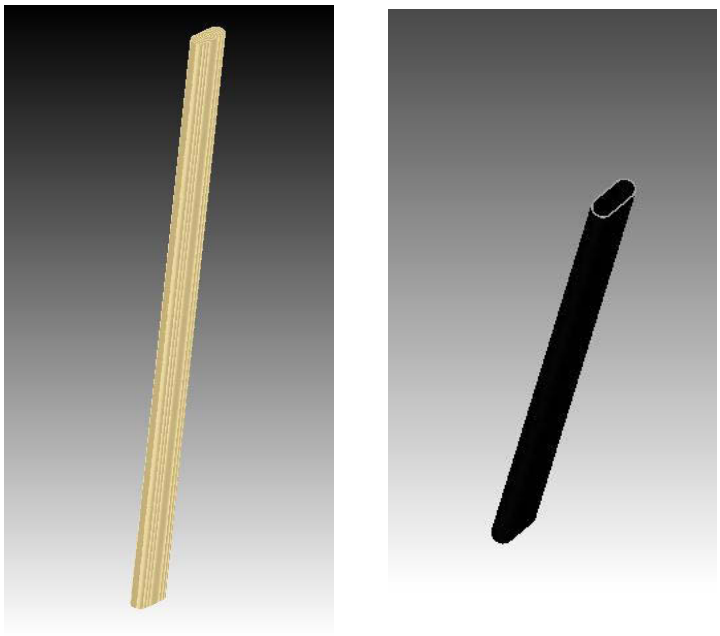

Figure 26 – 3D Renderings of Wooden and Aluminum Handles

To better understand the improvement in the ice axe handles, a wooden handle and an aluminum handle were modeled in CADkey (Figures 26 and 27). This was to aid in obtaining volumes and areas. The cross sectional area was determined using the equations found in Appendix J. Using the ultimate tensile strength for the materials, the maximum load that these handles could support was found. To simplify the setup it was assumed that these were loaded only in a tensile manner. The findings show that for an aluminum handle that is about 2 ounces lighter it can withstand about 2000 lbf (pounds

force) more. This is clearly a large advantage to the climber. The results are shown in Table 4.

Comparison of Handle Materials		
	Wood (hardwood, hickory)	Aluminum (ASTM 7075-T6)
Ultimate Tensile Strength (psi)	17500	83000
Cross Sectional Area (in^2)	0.817	0.1975
Max Force (lbf)	14297	16392
Volume for 28 in Handle (in^3)	22.8	10.4
Density (lb/in^3)	0.03	0.102
Weight	0.684	0.564

Table 4 - Comparison of Handle Materials

Some climbers prefer to use a Black Diamond Whippet (Figure 29[65]) which is a trekking pole with a self arrest attachment. This allows for added balance while traversing extreme pitches. This is held in the downhill hand while a straight handled technical ice axe (50-60cm) with a hammer, as seen in Figure 28[66] (instead of an adze) is held in the uphill hand. According to Conrad Anker this method, "is quite cat like, [provides] good attachment to the slope." The hammer is good for fixing pitons for the fixed routes. Technical ice axes are smaller lighter and more accurate. They are designed more for climbing vertical ice than mountaineering and are normally used in a pair.

Figure 27 - Short Technical Ice Hammer

Figure 28 - Black Diamond Whippet

[65] <http://www.rei.com>(4-6-2004)
[66] <http://www.backcountrystore.com>(4-6-2004)

4.3.7 Crampons

While the points are still made of steel the hardware that attaches the crampon to the boot is made of lighter weight materials such as aluminum or plastic. The biggest advancement here has been the step-in binding system which provides a more secure attachment to the boot while improving feel. This binding system is also a lot easier to put on and remove. Before nylon or leather straps were wrapped around the users boot. This was a nuisance. This is still the method for boots that are not crampon compatible.

Figure 29 – Black Diamond Bionic Crampons

The steels that are used on the points are much harder and may even be treated or coated to further improve hardness. Black Diamond has begun laser cutting the points on their Bionic crampons, shown in Figure 30[67], for "providing superior edge finish and point sharpness for the AISI 4130 steel spikes."[68] This is done using the Cincinnati, Inc. "CL-7A laser cutting system delivers 3300 watts, and its diffusion-cooled resonator concentrates beam power into a tight focus spot."[69]

4.3.8 Oxygen Equipment

In 1920 the oxygen equipment was very crude weighing in at about 32 pounds while the four O_2 tanks were full. There were two types of masks that were used. The standard mask was regulated by biting on a hose within the mask. The other mask was known as the economizer. This was setup with two valves in such a way that the exhaled breath was stored so that it could be breathed again since it still had an appreciable amount of oxygen present within it. Another method of supplying oxygen was the use of an oxylithe bag containing sodium peroxide which produced O_2 via a chemical reaction. This contraption, nonetheless, was only beneficial when the climber was at rest and

[67] ASM, Advanced Materials and Processes, December 2003, page 17
[68] Ibid
[69] Ibid.

therefore was not brought on this expedition. Upon arrival of the O_2 tank and mask systems at Mt Everest it was found that only 3 of the 10 systems that were brought functioned as they should. The remainder had to be fixed or used as spare parts, proving the unreliability at this point in time of the oxygen gear.

The use of oxygen was regulated such that it should feel as the climber was at about 15,000 feet above sea level no matter what altitude he was above that. This is a height that would be quite comfortable for the climbers of the caliber that were making the attempt on the Earth's highest peak. Since a heavy load for these climbers was considered to be 60 pounds and the higher they went the lower that number was. It appears as if the load that was to be carried near the top was around 20 to 30 pounds. This means that very little but the O_2 gear was carried.

Figure 30 - Intial Oxygen Systems

The 1922 expedition reached 27,300 feet and proved the worth of oxygen both in revitalizing the climbers after climbing and allowing them to climb faster while carrying more than those not using oxygen. They had to retreat when the oxygen equipment failed. This equipment was crude at best using football (sic) bladders as re-breathers.

For the 1924 expedition the oxygen equipment was improved. First it was redesigned by German engineers. However this brought the weight up and the center of gravity was moved backward. This made climbing and particularly descending quite awkward to the point where wearers of the gear would have to turn around and face up the mountain while walking backwards. Irvine, a bright 21-year-old climber, modified the equipment yet again when it arrived at Base Camp. He managed to improve the functionality while losing about 5 pounds of weight from the apparatus. Such a device is shown in Figure 31[70].

[70] < http://www.pbs.org/wgbh/nova/everest/exposure/gear.html> (4-6-2004)

Figure 31 – Poisk O_2 System

Today's bottles are much lighter and are able to hold more gas due to being able to withstand higher pressures. They are designed to be placed in a climbers pack and therefore need only the hoses and mask attached to the tank. There are two main suppliers of these types of tanks the Russian Poisk system and the SCI composites system, based out of California, USA. The American system was used by two out of three of the mountaineers that were interviewed. There is a problem with getting counterfeit Poisk systems. As a result, many of the American teams spend the extra money to have the SCI system shipped over to Nepal. A Poisk system like the one in Figure 32[71] can be purchased in Kathmandu. Typical flow rates are around 1.5 – 2 liters/min. This will grant the user about 11-13 hours of oxygen from a single tank of compressed oxygen on the SCI system. The Poisk bottles are smaller and are designed to have two or three of them in a pack (12-18 hr climb time). This allows you to drop strategically placed bottles along your route.[72]

Figure 32 – SCI O_2 Bottle

Two out of three of the mountaineers that were interviewed used the SCI oxygen bottles and system. Robert Beck, Technical Director at SCI, was kind enough to provide further information on these bottles, an example of which is shown in Figure 33[73]. Typical fill pressures are around 3,000 psi, however 4,500 psi is possible (Rick Wilcox opted for 4,500 psi). This yields an engineering factor of safety equal to about 3.4. This means that the burst rating for one of these bottles is 3.4 times higher than what they are filled to. This is a relatively large ratio. Much larger pressures could be obtained, however valves and regulators are

[71] <http://classic.mountainzone.com/everest/98/climb5-21oxygen.html> (4-6-2004)
[72] <http://www.windhorse-trek.com/poisk_oxygen.htm> (4-6-2004)
[73] Picture Courtesy of Robert Beck, Technical Director at SCI

only reliable below 5,000 psi. The materials used and the design of the bottles are the same as those used in firefighting breathing apparatus. However there is a demand for these to be lighter. SCI oxygen bottles are manufactured from drawn 6061- T6 Aluminum alloy wrapped in high tensile strength carbon fiber (750,000 psi) with epoxy / resin. This is then wrapped in fiberglass and gel coated for protection. These bottles are many times stronger than steel and a fraction of the weight. This system is a very significant advantage to the modern mountain climber.

4.3.9 Clothing

Figure 33 - 1920's Climbing Attire

Clothing at the infancy of Himalayan mountaineering was seemingly crude. Edward Felix Norton provides a record of what he wore on his 1922 and 1924 expeditions. This setup cost about £50 (allowance provided by the Everest Committee.), at the time this was $217.39.[74] Today adjusted for inflation, this would cost about $2,155.85.[75] Comparatively, this is about the same amount of money that you would pay for contemporary mountaineering apparel. Norton wore a thick woolen vest and drawers (base layer), a thick flannel shirt accompanied by two sweaters as an intermediate layers. This was followed by a "lightish" knickerbockers suit of wind proof gaberdine and knickers lined with light flannel. A pair of soft elastic putties was worn. His boots were felt bound and leather soled. He had them nailed lightly with standard alpine nails. This was all under what was referred to as a very light pyjama suit known as Messrs Burberry's "Shackleton" windproof gaberdine. This was the only addition to the outfits used in the Alps for decades. For gloves Norton used long fingerless woolen mits (sic) and a gaberdine

[74] < http://eh.net/hmit/exchangerates/>
[75] "CPI Inflation Calculator", <http://www.jsc.nasa.gov/bu2/inflateCPI.html> (4-6-2004)

overmit. When cutting steps with an ice axe, he substituted the woolen mits for silk. This was for increased sensitivity. [76] Clothing similar to this can be seen in Figure 34[77].

4.3.9.1 Base Layers

Figure 34 - Base Layer Clothing

Base layers or those that are next to the skin such as underwear are made out of specialized polypropylene, and look similar to those shown in Figure 35[78]. These are surprisingly warm. One of the authors of this paper has had experiences where a base layer and a light jacket (unlined nylon with waterproof/ wind proof membrane laminates) have been sufficient in 20-degree weather during moderate exercise. These materials wick perspiration away from the skin allowing the wearer to stay dry, which is the key to staying warm as materials are about 20 times less insulating once they are wet.

4.3.9.2 Intermediate Layers

Intermediate layers are worn are to provide a dead air space in which to trap body heat. This layer should also be able to block any wind or precipitation that may find its way through the outer layer. This is typically a heavy weight fleece, like the one in Figure 36[79]. Fleece is a product that is made from polyester fibers that traps air within the fabric. It also allows water

Figure 35 - Heavy Weight Fleece

[76] Unsworth, Walt; Everest: The Mountaineering History (p. 106)
[77] < http://www.pbs.org/wgbh/nova/everest/exposure/gear.html> (4-6-2004)
[78] <http://www.backcountrystore.com> (4-6-2004)
[79] <http://www.marmot.com> (4-6-2004)

vapor to transfer through although it is usually tight enough to block liquid water droplets.

A light wind jacket, or wind pants may be worn to keep cold out and warm in. These are meant to back up the outer layer's wind and water proofing.

4.3.9.3 Outer Layer

Figure 36- Typical Down Suit, aka 8000m Suit

Here the down suit rules supreme. Most climbers prefer a one piece like the one in Figure 37[80], although a few opt for separate pants and jacket. The key here is GoreTex, an expanded Teflon film that is hydrophobic (water-repellant) in nature. The pores that are created in this film are small enough so that a water droplet cannot come through however water vapor can easily pass through. W.L Gore has created a line of fabrics that are specifically designed for insulated outwear and sleeping bags. This fabric treatment is known as DryLoft, it is designed to allow down or synthetic insulation materials to loft better. This is important to allow a dead air space to be created by the garment, which is the mode by which this type of outerwear insulates against the environment. It also allows the insulating materials to remain drier inside the fabric. Steps have also been taken to reduce condensation between layers of fabric. Materials are about 20x less effective in insulating when they are wet. DryLoft is also designed to reduce convective heat loss from the outside. While these materials aren't quite as impervious to water (will leak at lower pressure) as some of the other types of GoreTex, they are considerably more breathable which is important in an instance of sustained aerobic activity. They are 100% windproof, very light (1.4oz/sq yd) and pliable.

[80] <http://www.mountainhardware.com> (4-7-2004)

4.3.10 Boots

Four types of boots were brought along for the 1922 expedition. Climbers brought ski boots, which at this time were made of stiff leather. A pair of felt boots with Lambskin uppers that went to the knee. High Moccasins that were made in Canada and finneshoes from Norway were transported to Everest. Crampons from Dural were also used.[81].

Currently a rugged hiking boot is sufficient up to and around base camp. After that a plastic mountaineering boot is in order. These boots although heavy are very warm and waterproof. They are sometimes known as a double boot because there is a soft insulating liner that is enclosed in the hard plastic shell. Some climbers may prefer the comfort and flexibility of a leather boot as there are many good ones on the market now. These however don't stand up to water for as long a time. Near the summit an over-boot is used regardless of the boot. Gaiters are used when the snow is deep. These prevent snow from entering the gap between the pant and the top of the boot.

Figure 37 – Millet Everest Boot

The preferred boots for summiting Everest are the Millet Everest boot, shown in Figure 38[82], and the LaSportiva Olympus Mons, shown in Figure 39[83]. The Olympus Mons shares several features with the Everest boots. They both offer tough nylon gaiters, with Aramide or polyamide reinforcement, respectively. These are in the same family as Kevlar, which is what bulletproof vests are made from. This provides protection from ripping the gaiters with crampons or sharp rocks. Both boots provide plenty of insulating foams. The foam has been aluminized in the Everest Boot while the Olympus Mons has a "Thermo-Reflective Aluminia" lining. These treatments reflect thermal energy radiating from the foot back towards it. These boots feature Vibram (a brand that has revolutionized climbing and mountaineering footwear) soles. These provide excellent traction due to

[81] Unsworth, Walt; Everest: The Mountaineering History
[82] <http://www.millet.fr> (4-6-2004)
[83] <http://www.sportiva.com/products/mountaineering/olymons.html> (4-7-2004)

design as well as the stickiest rubber available for boot/shoe soles. It also wears quite evenly further aiding the durability of the boot. Both boots have very stiff insoles. The Mons features a carbon fiber honeycomb insole adding great stiffness to weight ratio. The Mons has a molded sole that accepts crampons much better than the Everest boot. They are approximately the same weight at about 6 and a half pounds per pair. The performance characteristics of the Mons (accepts crampons better, better feel, better fit) is quickly pushing this boot above the tried and true Millet Everest boot.

Figure 38 - LaSportiva Olympus Mons

4.3.11 Tents and Sleeping Bags

The weather during the 1924 expedition was particularly nasty. This made for a good test on the tents. The largest weighed around 16 pounds, which was not bad for the size of the tents used (6-8 person). These were strong, but leaked when it snowed.

Today's tents are only slightly lighter but are considerably stronger and more weatherproof. A six person tent will weigh slightly over 14 pounds. Geodesic domes as used in base camp for communication equipment, gear storage, etc., are rather large and most men could stand upright within it. These tents are extremely strong and weatherproof; consequently, they weigh about 50 pounds. One of these tents can be seen in Figure 41[84]. Smaller tents (2-3 people) like the one in Figure 40[85] are used in the higher camps and weigh 6 to slightly over 10 pounds. They are aerodynamically designed to be stable in

Figure 39 – Smaller Tent (2-3 people)

[84] <http://www.mountainhardware.com> (4-7-2004)
[85] Ibid

high winds. Double wall tents are used which breathe better than a single wall tent. Single wall tents also tend to have problems with condensation. Conrad Anker stated that Everest is, "One of those climates where breathing and tent comfort are of importance." Sleeping and recovering is critical to getting up the mountain. Sleeping in a warmer environment allows the body to save energy while it is sleeping because it doesn't have to spend as many calories staying warm. This allows the body to spend the hard-to-choke-down calories actually climbing the mountain rather than wasting them sleeping. Tents that have sewn sleeves and aircraft aluminum poles are favored on Everest because of their strength. Tents need to stand up to very strong winds, often as high as 120 miles per hour. Aerodynamic designs are becoming popular because the tent doesn't get blown around as much, or even worse blown off the mountain. The first layer is of nylon while the outer layer or fly is nylon but with an added (poly)urethane coating. Often the same anchors used for climbing are used to secure the tent.

Figure 40 - Expedition Type Tent, suitable for base camp (pictured without fly)

Sleeping bags that are used during the Mt Everest expeditions are rated to a comfort level of -20 degrees to -40 degrees Fahrenheit such as a North Face Solar Flare Endurance, shown in Figure 42[86]. This rating means that a normal person will be comfortable wearing moderate clothing in a -

Figure 41 - North Face Solar Flare Endurance

[86] <http://www.thenorthface.com> (4-7-2004)

20 degree environment. Testing is conducted by using a copper dummy in a laboratory environment. Some bags on the market are rated to -40 degrees. The mountaineers we have spoken with have been comfortable in the -30 degree bags. These bags are down filled (typically 800 fill down) so they need to be in waterproof materials in order to maintain the insulating properties of down, since once down gets wet it is almost entirely ineffective. The same GoreTex DryLoft that is used in the 8000m suits are used in these bags.

4.4 Combating Physiological Effects

4.4.1 Reduction of the Effects of High Altitude

The old climber's adage of "climb high, sleep low" plays a key role in proper acclimatization. It has been recommended that at altitudes above 3000m that one should not climb more than 300 meters in a day. Descending may be all that is needed to cure a climber who has been suffering from any of the high altitude ailments. One can always return once they have recovered.

Proper hydration and food intake are also important to combating the effects of the altitude. This, however, is true with any athletic activity. There is a tendency for the body to burn more fat than carbohydrates at these altitudes due to the pH already being off due to low oxygen intake, and the lactic acid that is produced when carbohydrates are burned will further tilt the body toward an acidic chemistry. This may be taken into consideration when choosing a diet. For many years climbers would eat Sherpa food which, due to what is readily available in the area consists mainly of potatoes, rice, and lentils. This is not very high in fat or protein. In any activity protein is important to repair muscle that has been worked.

Climbing a mountain such as Everest poses a challenge that is as much mental as it is physical. Therefore, a climber's morale must be kept high, eating the foods that he or she is accustomed to may aid in this. Carrying freeze-dried or dehydrated food allows climbers to eat prepared meals that are very easy to warm up at high altitudes using lightweight propane stoves. Water is obtained by melting snow with these stoves. Paul

Giorgio states, “The higher you get, most people can't eat. Personally, I can eat at any altitude but these helped me immensely. If I had to eat Sherpa food I would probably shrivel up and die, but since I can eat Western food, high in proteins and stuff, it keeps me as close as I can to being at home.”

The problem with not being able to eat is a physiological effect of being at high altitude. This is an area that needs more study by scientists. Another problem associated with high altitude is dehydration. Since the air is very dry and the body is in a state of constant stress and in increased breathing rate, the body dehydrates very rapidly. It is difficult for a person to force themselves to drink enough. Proper hydration is key to maintaining good circulation which delivers crucial oxygen to the brain and body. The effects of dehydration are very similar to that of AMS and therefore may compound the problem.

4.4.2 Acute Mountain Sickness

There are many drugs available that can help the ailments. Acetazolamide is effective in preventing Acute Mountain Sickness. One of the commercial names of this drug is Diamox, which is produced by Lederle Pharmaceutical. The chemical name for Diamox is *N*-(5-Sulfamoyl-1,3,4-thiadiazol-2-yl)acetamide and it has the chemical structure shown in Figure 43[87].

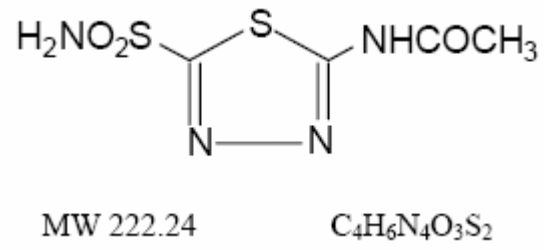

Figure 42- Diamox Chemical Structure

Diamox blocks carbonic anhydrase, which helps to control the secretion of fluids as part of treatment for abnormal fluid retention, such as cardiac edema, by acting as a diuretic. Diamox works by preventing carbon dioxide from entering into the cells of the patient. By inhibiting carbonic anhydrase in the central nervous system, Diamox appears to reduce the amount of abnormal, paroxysmal, and excessive discharge from the neurons. The action in the kidney helps to neutralize the body’s chemistry, by carrying out sodium, water, potassium, and HCO_3 ion from the body.

[87] Appendix K-8: Diamox Prescription Sheet (p. 1)

Diamox is also recommended for preventing the symptoms of Acute Mountain Sickness (AMS). Diamox is used as part of the acclimatization process, particularly for those involved in a rapid ascent, and for those more susceptible to the symptoms even in a moderate ascent.

Diamox can be purchased in oral tablet form, each tablet containing 125 mg or 250 mg of acetazolamide and the following inactive ingredients: Corn Starch, Dibasic Calcium Phosphate, Magnesium Stearate, Povidone, and Sodium Starch Glycolate.

For prevention of AMS, the recommended daily dosage is 500 mg to 1000 mg through divided doses using tablets or sustained-release capsules as appropriate. In the need of a rapid ascent, for instance a rescue attempt, the higher dosage of 1000 mg is preferred. It is desirable to initiate dosing 24 to 48 hours before ascent and to continue for 48 hours while at high altitude. If symptoms persist, it is recommended to continue usage for as long as necessary. In addition to using Diamox, Tylenol (chemical name paracetamol) can be used to treat some of the symptoms of AMS such as headache, dizziness, pain, etc.

4.4.3 High Altitude Pulmonary Edema

Calcium antagonists and vasodilators can help prevent and treat HAPE. High Altitude Pulmonary Edema can be treated with nifedipine. Nifedipine is a vasodilator, a chemical which prevents contraction of veins and arteries. This is accomplished by reducing the flow of calcium ions over the cell membrane of cardiac and vascular smooth muscles. At the same time, nifedipine does not alter the concentration of calcium ion in the blood serum, allowing proper metabolism and preventing the negative effects of taking calcium from bone. Nifedipine is a 3,5-pyridinedi-carboxylic acid, 1,4-dihydro-2,6-dimethy-4-(2-nitrophenyl)-dimethyl ester. Figure 44 shows the chemical structure of the drug.[88]

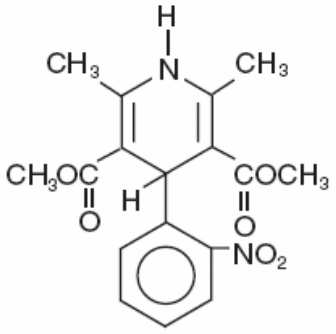

Figure 43 – Nifedipine Chemical Structure

[88] Appendix K-9: Adalat CC Prescription Sheet (p. 1)

Nifedipine operates by increasing nearby arterial diameter, therefore reducing vascular pressure. This reduced pressure on the heart translates into a reduction of pressure on the lungs' vascular structure. This consequently, allows oxygen to flow normally due to lack of moisture being forced into the alveoli of the lungs. This buildup of fluid in the lungs is the primary condition of pulmonary edema. Nifedipine is selective due to its bonding to voltage-dependent receptors in vascular smooth muscle. This bonding does not interfere with other processes in the body.

One source of nifedipine is ADALAT CC, which is produced by Bayer Pharmaceutical Corporation. ADALAT CC is designed to be taken daily through oral consumption while on an empty stomach, adjusting to need. The recommended treatment regimen for HAPE is 20 mg every 8 hours. However, ADALAT CC is not normally intended to be used in cases of HAPE; rather it is an arthritis and hypertension treatment.

MEAN REDUCTIONS IN TROUGH SUPINE BLOOD PRESSURE (mmHg)
SYSTOLIC/DIASTOLIC

STUDY 1		
ADALAT CC DOSE	N	MEAN TROUGH REDUCTION*
30 MG	60	5.3/2.9
60 MG	57	8.0/4.1
90 MG	55	12.5/8.1
STUDY 2		
ADALAT CC DOSE	N	MEAN TROUGH REDUCTION*
30 MG	58	7.6/3.8
60 MG	63	10.1/5.3
90 MG	62	10.2/5.8

*Placebo response subtracted.

Figure 44 – Results of Blood Pressure Study of ADALAT CC[89]

In studies, the use of ADALAT CC was observed as decreasing both systolic and diastolic blood pressures in test subjects. The diastolic pressure is the reading that is taken between heart beats, and the systolic pressure is the reading for each heart beat. This study was done in two double-blind, randomized, and placebo-controlled tests with 350 participants who used ADALAT CC in 30, 60 or 90 mg daily doses over the course

[89] Appendix K-9: Adalat CC Prescription Sheet (p. 2)

of 6 weeks. Figure 45 shows the results of the two tests. On average in both tests, ADALAT CC reduced the systolic blood pressure in a range of 5 – 10 mm of mercury (mmHg), and reduced the diastolic on a range of 3 – 5 mmHg. These readings were taken 24 hours after each dose. It should be noted that the second trial added a beta-blocker to patients not controlled on a beta-blocker alone. In addition, the ratio for the average reading and the peak readings ranged from 41% - 78% for the diastolic blood pressure and 46% - 91% for systolic.[90]

4.4.4 High Altitude Cerebral Edema

Treatment of High Altitude Cerebral Edema utilizes a regimen of dexamethasone. Dexamethasone is a synthetic adrenocortical steroid that comes in a crystalline powder form. The powder is of a white to practically white color, is odorless, stable in air, and is insoluble in water. Chemically, dexamethasone is a 9-flurou-11β, 17,21-trihydroxy-16(-methylpregna-1,4-diene-3,20-dione). The chemical structure is shown in Figure 46.[91]

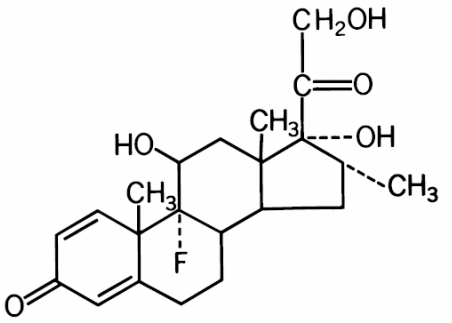

Figure 45 – Dexamethasone Chemical Structure

A common form of dexamethasone is Decadron, a drug that is developed by Merck & Co., Inc. Decadron tablets are produced in 3 dosages: 0.5, 0.75 and 4 mg. In addition to dexamethasone, the tablets contain calcium phosphate, lactose, magnesium stearate, and starch as inactive ingredients. Other inactive ingredients are the chemicals used to color code the various dosages.

Adrenocorticoids occur in nature, such as hydrocortisone and cortisone, which exhibit salt-retaining properties. These are often used to treat deficiencies in the adrenal cortex. Synthetic versions, such as dexamethasone demonstrate effective anti-inflammatory

[90] Appendix K-9: Adalat CC Prescription Sheet (p. 2)
[91] Appendix K-10: Dexamethasone Prescription Sheet (p. 1)

properties when used to treat issues in many of the body's systems. Glucocorticoids cause changes in carbohydrate, fat, and protein metabolism. They also suppress the body's immune responses. When dexamethasone is used as an anti-inflammatory in an amount equivalent to hydrocortisone, dexamethasone has no salt-retaining property unlike hydrocortisone and other derivatives.

In cases of cerebral edema, Decadron Phosphate is used through an initial 10 mg intravenous injection. This is then followed every 6 hours with a 4 mg intramuscular injection until the symptoms disappear. Typically, a change in the patient's condition is noticed within 12 to 24 hours of the start of the treatment.[92] Evacuation of the patient from the mountain is critical in cases of High Altitude Cerebral Edema.

There have been some reports of bloodletting and the use of prophylactic aspirin to thin the blood and reduce the risk of clots, strokes and heart attack.

4.4.5 Gamow Bag

A Gamow bag (Figure 47), a portable hyperbaric chamber (a.k.a. "the iron lung"), can be used to help stabilize the affected. However, the subject may worsen once they are taken out.

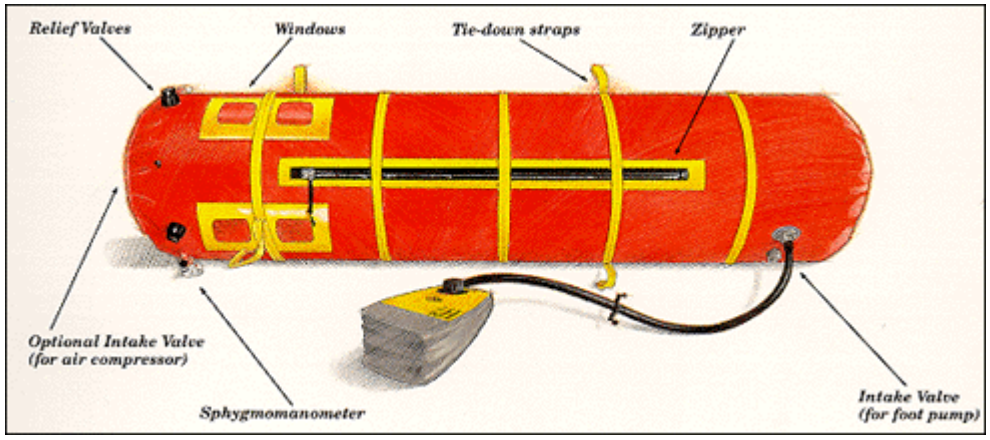

Figure 46 - Gamow Bag[93]

[92] Appendix K-11: Decadron Prescription Sheet (p. 7)
[93] <http://spot.colorado.edu/~gamow/images/gamovbag.gif> (4-7-2004)

While trying to create a device that allows an athlete to train under optimal conditions, Dr. Gamow stumbled across the idea to simulate descent. He originally produced a device known as the "bubble" that allowed an athlete to train at sea level while physically being at moderate altitude. The idea to use a portable version of this "bubble" came to him and one of his students when one of his students' best friends died on Makalu. Professor Gamow explains, "Now if there is a helicopter there or plane there that's probably the easiest way to go down. But often, particularly Tibet or the Tibetan Plateau, there's no where to go down, or if your hurt, you can't walk, the weather is bad. But the bag will take you down within a couple thousand feet, 6,000 feet, in a few minutes. 'Cause all you do is pump air in with a foot pump, and if you put an altimeter in there you can be at 20,000 and two minutes later you can be at 4,000. So it simulates descent, but it is exactly the same air that you have when you descend."[94]

The bag can quickly be inflated in roughly 2 minutes to a pressure of 2.5 psi gauge. On the summit of Mount Everest, this would be a decent of approximately 9,000 feet. Putting more than 2 or 3 psi into this polypropylene bag, would turn this device into a bomb. The benefits of a higher pressure would not be all that beneficial.

The climber would begin to feel changes within 10 minutes, while more severe cases would take a matter of hours. After proper treatment with the device, the climber should be in a state such that they may begin descending in order to evacuate for further medical treatment.

This life-saving device weighs a mere twelve pounds, which does not burden the climbing team, while providing a vital resource to them. It's most useful in remote areas that would take a few days to receive help. Areas such as ski resorts, although high in altitude, are usually not that far from medical assistance. These bags typically cost around $2500, which is only a small portion of the cost of an expedition to Mount Everest.

[94] Appendix F: Rustem Gamow Interview

Use of oxygen equipment is very effective in preventing these conditions from occurring. Conversely, if there is faulty equipment the results are catastrophic. Everest is unique in the general use of oxygen.

One of the techniques we received from Conrad Anker was to use a small amount of oxygen intermittently while climbing. He used a very low flow rate from the bottle, and says that he would "use it a little and turn it of and then use it a little and then off, so it wasn't like it was a high flow of gas at low elevation"[95]. By doing this he only used about one or two bottles for the whole expedition. He also states that with oxygen he "would feel warmer, because your body it oxygen starved, it is shunting blood from your extremities and into the core. You feel cold more on say your hand than your back or something"[96] Mr. Anker also mentioned the use of the capillary fill test, which is a quick and simple test that is performed on the nailbed of a person's finger to check blood flow rates as well as for dehydration. To perform the test, the person applies pressure to one of their nailbed, causing it to turn white and thus forcing the blood from the bed. Once the bed is white, the pressure is removed allowing the blood to flow back into the nailbed. The person then measures the amount of time it takes for the nailbed to return to the pink color, with the normal reading being a refill time of 2 seconds. A result longer than that may be an indicator of conditions such as dehydration, shock, or hypothermia.[97].

Mr. Giorgio provided us with the following insight on the use of oxygen. He says, "For 99% of the other people, they could never make it if they didn't have it, they get lethargic, tired, they make bad decisions, their thought processes are erratic."[98]

One of the major points to surviving on Mount Everest is by using oxygen apparatus to provide oxygen to the brain and the rest of the body. The use of the apparatus offers greatly enhanced chances of summiting due to the dampening of effects caused by oxygen deprived environments.

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[95] Appendix B: Conrad Anker Interview
[96] Appendix B: Conrad Anker Interview
[97] "AllRefer Health – Capillary Nail Refill Test", <http://health.allrefer.com/health/capillary-nail-refill-test-info.html> 2-18-2004
[98] Appendix C: Paul Giorgio Interview

Chapter 5: Analysis of Results

This section explains the observations found in the areas of research that were studied by this project. These observations are organized into the three main objectives explored in this study. While three discrete objectives were researched, there are a large number of interactions in the results and observations among these three objectives.

5.1 Impact of Technology on Local Population

One objective of our project was to analyze the effects that communication technologies have had on the local population. We have found several themes regarding the introduction of technology in Nepal. One issue is the difference between what is possible and what is practical. It is technically feasible to bring equipment for a high-speed internet connection to anywhere in Nepal, but it takes lots of money to set up and maintain. Satellite phones can be used all the way up Mount Everest, but it will cost several dollars a minute to keep in touch with anyone using them. The amount of satellite bandwidth available is limited, and to get internet connections to remote locations in Nepal you must compete with television broadcasters and large telecommunications companies for bandwidth, which costs money. Tourists are willing to pay extra to have the types of connectivity that they are accustomed to having at home. As a result, the advanced communications technology in Nepal is more for the tourists than for the local people, because the local people cannot afford to pay for that level of communications on their own.

In order to set something up permanently, there must be an infrastructure to support it. You can set up an internet connection anywhere, but there still needs to be a steady supply of power to be able to make use of it. Simple wireless repeaters could be put on every hilltop in Nepal, but they won't work without a consistent supply of electricity. In Nepal the power grid is not entirely stable, as brownouts and blackouts are fairly common in locations that have electricity. This is another problem which takes a large initial investment in equipment to solve. Because it is so expensive to build, infrastructure such as roads, electricity generation and plumbing are being added slowly,

mostly in the tourist areas where there is a steady income from outside to support these improvements. It also does not make sense to deliver a wireless internet connection to an area where no one has a computer to be able to use it. It is also not easy to work in remote areas because it is difficult to even get there and you must bring everything you may need with you since you can't rely on a pre-existing infrastructure. The tourist areas also have an advantage in this respect because they already have the roads and transportation methods necessary to move supplies and equipment into these areas. It is easier to add on to this limited infrastructure than it would be to start building from scratch somewhere else.

When implementing advanced technology in places that did not have anything before, often a whole generation of technology is skipped. Wireless internet links are being used over long distances in Nepal while completely skipping over the stage of having wired links. While the wireless links are easier to install and maintain, they are not as reliable or as fast as a properly designed wired system. The newest technology is not always the best for a certain purpose. Many people think that if Irvine's camera is found on the mountain the film would still be able to be developed, but if a camera lost today was found years in the future the pictures on it would likely be lost for good. "The reason for this is that the black and white film in the 1920s was less sensitive and would not be as affected by the ultraviolet rays [of the sun]".[99] A digital camera could fare equally well on the summit, and pictures could still be read from the camera as long as the storage media remains intact. It is impossible to get technology that is both cutting-edge and time-proven. In countries that have had such technologies for a longer time, there are often layers of technology, so if the latest version fails there are older technologies to fall back on. When implementing things for the first time, people usually use the newest technologies which have all the capabilities that anyone else has, but they then have nothing to fall back on when something goes wrong. For example, if the Internet connection or electricity were to be lost in Namche Bazaar, they will also be without a phone connection as their phone system runs on VoIP which requires the use of the Internet to make phone calls. This is a situation unlike most systems in the United States,

[99] "Mallory and Irvine The Final Chapter", http://www.everestnews.com/malloryandirvine2004/intros2004qa.htm

as a traditional phone grid is still in place and does not rely on the Internet for phone access.

The local culture must also be considered when implementing new technology in the area. While the Sherpas have been quite curious about the technology and have embraced it readily, groups in other areas might not do this. Even so, it takes time for ideas about certain things to change. Just because modern communications technology is available in Nepal, it does not follow that Nepalese will start to think of communications in the same way that we do in the United States for example. Just because they have this communications gear does not necessarily mean that it is easy to communicate with them. As an example of this, we sent out several E-mails to businesses and organizations trying to gather information, but most went either unanswered or bounced back due to a server not being in service. In the more modern parts of the world there would often be a response E-mail or some sort of contact even if it was just an automated form letter. Many companies will try to provide as much help as they can when dealing with customers or people that are in the position to recommend their products. With today's spamming issues there is the possibility that certain spam blocking software may block legitimate E-mails from ever reaching the intended audience. In Nepal, it is mainly businesses and tourists are mainly driving and funding the adoption of these new technologies, and it will take longer for the average people to get used to it, and even longer before they come to rely on it. Our search for opinions of the technology from people living in the Solu-Khumbu region proved this.

In addition, newer "technology" in Nepal does not mean only new electronic equipment. New methods of farming or irrigation are just as much considered technology as new electronic gadgets, and may take just as much adapting to by the local people. Projects like those by Heifer International will probably have more of an effect on the local people in the short run than new communications. Heifer has several ongoing projects in Nepal, which range from providing livestock for sustaining farming and income generation to raising Angora rabbits for wool trading.[100] Projects such as these provide the local communities with basic ways to earn a better living through entrepreneurship, which will

[100] Heifer International <http://www.heifer.org/Our_Work/Our_Projects/Index.shtml>

over time improve the economic landscape of the region. Hopefully, as more and more people become entrepreneurial, the western technology can be used by more people.

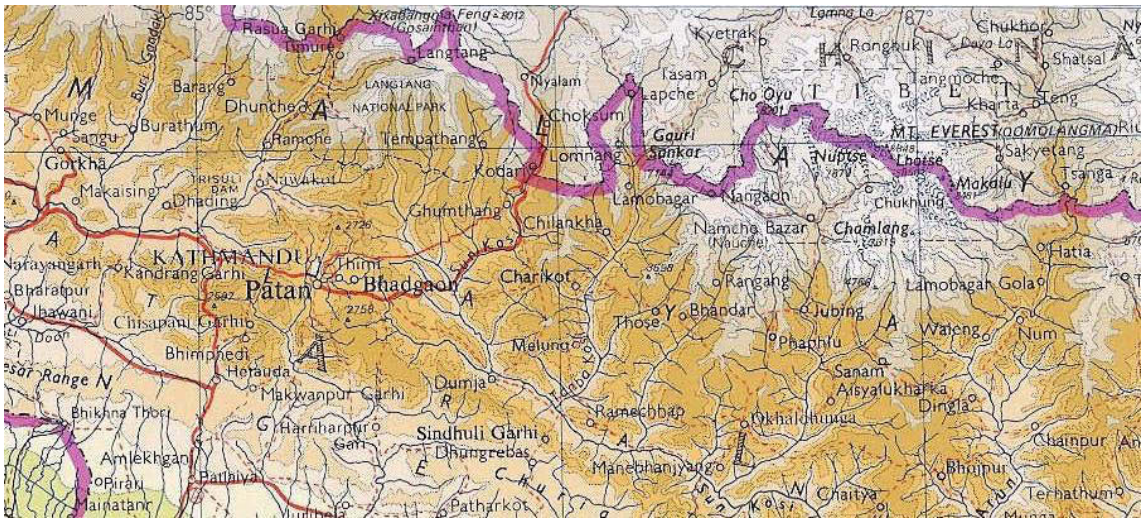

Figure 47 – Map of Kathmandu and Mount Everest. Solu-Khumbu region, Nepal.[101]

In the Solu-Khumbu region, seen in the map in Figure 48, a change in the culture has occurred over time. The presence of tourists, in addition to technology has been the cause of this change. For instance, the villages have learned to perform certain acts, such as dancing, to entertain the trekkers and mountaineers as they come through their village. These dances and other rituals are different from those that are normally part of the Sherpa culture, but are performed to please the Western tourists.

5.2 Impact of Technology on Mountaineers

A second objective of our project was to determine the impact of new technology on climbing itself. First, better equipment improves safety. Several new devices have been created such as the belay device, ice screws, and harnesses, which have fulfilled certain needs that climbers have to climb safely. Other devices have been improved such as crampons, ropes, and most importantly boots. The improved devices offer large advantages in strength and durability over the previous versions. If the devices are properly cared for and used properly they are nearly failsafe.

[101] The Times Atlas of The World: Ninth Comprehensive Edition (Plate 30)

While new gear does help to improve safety while climbing, the technology is only as good as the person using it. Even the best technology sometimes fails and climbers should rely on their own ingenuity, talent, education, and experience more than they rely on their gear to save them if something goes wrong. This is not to say that gear is unimportant; a modern rope will stop a fall much better then an older one, but the protection still needs to be placed properly for it to work. Having better equipment also gives a psychological advantage, as climbers don't have to spend time worrying about their equipment holding up and can concentrate on technique and making proper judgments. The devices available today are much more efficient and easier to use allowing the climber to ascend more quickly. This is important if the proper turn-around times are to be followed. On Mt. Everest, the rule of thumb for a time to retreat back to camp is between 11 am and 1 pm.

While the use of technology for climbing helps experienced mountaineers, it also allows more inexperienced tourists to attempt to climb the mountain. From our conversations with mountaineers, most people say that the inexperience of the tourists is not what makes them a safety concern, but rather the sheer number of them on the mountain; this tends to be when poor decisions are made. There are only a limited number of routes up the mountain and only a limited amount of time to try to make it to the summit. There are several changes which could be made to improve the safety in this area. Groups would need to obey a limit on the number of people climbing on each route at a time, although such a limit does not currently exist. Groups should also turn around from their summit attempts at a specified turnaround time, about 11am, which does currently exist but is currently ignored or treated as a flexible suggestion by most groups. The safety of the group should be more important than getting to the summit, something that many people forget when they are actually out on the mountain heading for the summit. These poor decisions can be from several reasons. The first is that man is naturally greedy. The financial incentives can encourage the guides to take unnecessary risks when trying to reach the summit, which may lead to accidents. The second is that the physiological effects do cloud judgment. Regardless of the cause, poor judgments that put others in danger on the mountain have been made in the past, and could be made in the future.

The people climbing the mountain should also have some knowledge of mountaineering skills. Climbing should be learned through a natural progression, with climbers establishing skills on less dangerous mountains and working their way up to the more difficult peaks. Climbers shouldn't have to rely on the guide to be able to survive. The guides are responsible for leading people up the mountain, setting up ropes, camps, food, etc., not taking care of the lesser experienced climbers along the way. Groups should establish that their members have the proper mountaineering skills before starting off, and that if something happens to the guide each group member is capable of surviving on their own, if not being able to rescue the leader him or herself. The individual climbers should also be both physically and mentally fit; they should not need help for just basic tasks while on the mountain.

Along the same line, while the gear may be lighter and easier to use, the environment hasn't changed and is still a huge drain on a person's mental and physical strength. Conrad Anker commented, "Yeah, I can go out with gear from 30 years ago and climb waterfall ice five (WI 5) pillar out here in Highlight Canyon, because I know how to climb it. I could make do. It would be easier with a lighter weight one but it is still possible. It's the same thing. Humans want faster cars and all that stuff, and that's their plan."[102] The physical challenge will always exist; the only way to make the mountain itself easier would be to modify the terrain itself which is virtually impossible. The equipment's improvement is asymptotic; it can only get so good before it reaches beyond its usefulness. You can't overcome certain physical phenomenon such as gravity or lower partial pressure of oxygen due to altitude. A person's physical fitness and climbing skill outweighs the benefits of a technologically superior equipment setup. People in the past 50 years have been able to successfully summit Mt. Everest without the equipment that is available to the public today. Currently, the probability improves with the number of attempts to reach the summit.

We have noticed that in general, mountaineers as a group tend to desire to climb in the most "natural" way possible. Climbing "naturally" suggests using the bare minimum of equipment that one would need to survive. These climbers hold in the highest regard

[102] Appendix B: Conrad Anker Interview

climbing without any aid, be it technical or medicinal. For instance, the majority of mountaineers would rather climb Mt. Everest in the manner in which Reinhold Messner has climbed it. Messner summited in 1980 without the use of oxygen, Sherpas, or even a climbing partner. All of the mountaineers that we have spoken to have never used Diamox or any other drug on themselves while climbing. The two climbers that used oxygen would like to try it without, if given the opportunity, and the remaining mountaineer that was interviewed climbed without oxygen assistance. Sherpa support is often minimized on personal climbs as both a measure to reduce cost and to keep the climber doing as much of the work as possible.

While many mountaineers seek to climb without artificial aids, the environment on Mt. Everest tends to be incompatible with this desire. The combination of harsh weather and the low amount of oxygen in the environment makes it an extreme environment to climb in. The choice to climb Mt. Everest with as little assistance as possible comes at a major sacrifice for survival. For example, a study on the use of supplemental oxygen showed that climbers have a better chance of survival post-summiting when using oxygen as part of their descent.[103] If a climber is to sacrifice this and other pieces of vital equipment, in addition to human support in the form of Sherpas and members of a climbing team, this may affect their chances of survival. On the other hand, a single climber with support or a small party may be better off than one of the larger expeditions, such as the groups that were involved in the bottleneck accidents of 1996.

Mountain climbers on Everest have to cope with many challenges during their excursion to the summit. One such trial is adapting to the new environment that they have placed themselves in. Another ordeal is properly utilizing the tools that they have brought with them. Generally, it seems that climbers readily conquer these obstacles.

The number of people involved in the sport of mountaineering has definitely grown steadily throughout the past decade or so. This is not because more people are becoming serious mountaineers or due to the improvements in gear, but they have fallen into the hype provided by the media. Several books and movies have sparked the interest of

[103] Huey, Raymond and Eguskitza, Xavier; JAMA, vol. 284, p. 181

people looking to try something new. The guiding industry, competent mountaineers leading paying customers up a mountain, has grown tremendously due to this. This is fueling the problem of too many people on the mountain. Conversely, it also enables those mountaineers to partake in what they love.

5.3 Physiological Response to High Altitude

One common theme that we have found in our studies is that humans are very adaptable. After spending just a few weeks at high altitude, the human body starts to adjust to make up for the lack of oxygen. After generations of living at higher than normal altitudes, numerous changes, as exhibited by the Sherpas, are present and make it easier to function at high altitude.

Humans may make adaptations to their environment through adding technological devices such as supplementary breathing systems or the creation of drugs that yield a physiological change within the body to allow a person to exceed his natural limits. While the human body has its finite limits the abilities of the human mind or collection of minds is not as defined. Science has allowed the development of techniques that will allow a person to survive in environments that are normally lethal. For example, if there was a way to drop a person at the summit of Mt. Everest, chances are that he would be dead within 10-20 minutes due to the lack of oxygen.

Over time, many changes occur to help the climber survive in a low oxygen setting. Such transformations may occur almost immediately while others may take generations. Increases in breathing rate and red blood cell production occur quickly. There is some argument that Sherpas that have lived at high altitude for many generations may have enlarged lung volumes and different structures than those that live at lower altitudes, showing that over time, the body can adapt to the climate and high altitude.

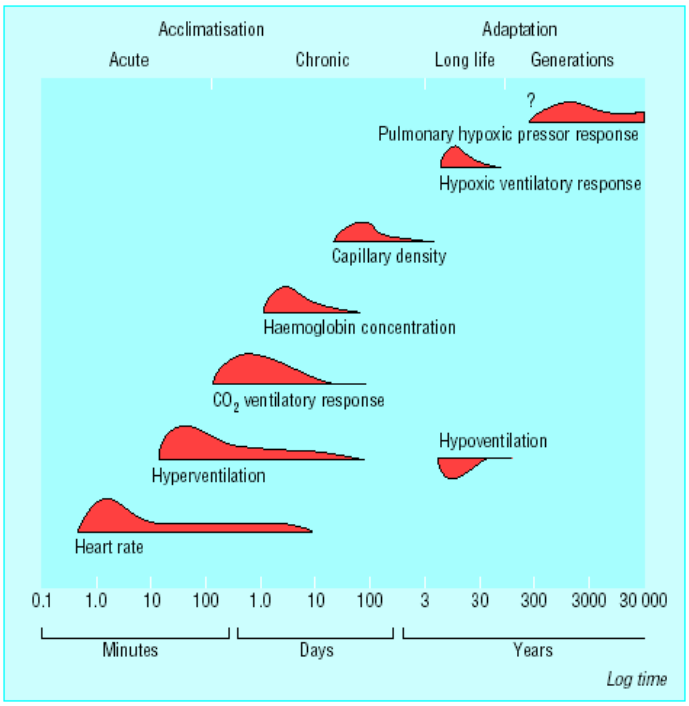

Figure 48 - Time course of acclimatization and adaptive changes plotted on log time. Curve of response shows rate of change[104]

People have many different opinions on the use of technology to improve or speed up this acclimatization process. Some people find it easier to adapt to high altitude naturally than others. As Giorgio pointed out, he and some other climbers were able to climb without oxygen, but for most people having supplemental oxygen makes a large difference in their climbing ability. Some feel that the use of oxygen is not ethical and gives the climber an unfair advantage. There are also differing opinions on whether to use drugs to help deal with high altitude. Drugs such as Diamox or even Viagra may be used to speed up the process. Any drug that improves circulation and blood flow will be an aid to a high altitude climber. Some people believe that these drugs should only be used as needed, while others believe that they should be taken ahead of time to prevent any problems from happening in the first place. Many drugs are available to treat the several high altitude sicknesses, namely, Nifedipine and Dexamethasone are designed to be used only when needed. Still, other mountaineers believe that drugs should not be utilized at all. The side effects of the drugs that are used are very severe and they may possibly be addicting. Either way caution is advised. Most of these drugs were not

[104] Appendix K-12: "ABC's of Oxygen"

created to be used in this way, they are intended to treat serious illnesses that are chronic in nature and are not related to high altitude.

The Gamow bag is a device that has saved many lives since its creation in the late 1980's. It is simple, light weight and very easy to operate, making it an extremely valuable tool in high altitude expeditions. The bag works similarly to the iron lung being that it is a hyperbaric chamber. An affected climber may experience a descent of many thousand feet in a time span of about two minutes. This is critical to the survival of a climber who has contracted High Altitude Cerebral Edema or High Altitude Pulmonary Edema, where a quick descent is essential. This buys the climber time until the other party members can get him or her down to more permanent medical attention. The invention of the Gamow bag has significantly improved the safety of climbers on Mt. Everest.

Since it is impossible to predict whether or not a climber will become ill, planning ahead and having these countermeasures handy plays a key role in ensuring that everyone in a climbing party will return home safely. These technological creations have significantly increased a person's chances of survival on Mt. Everest.

5.4 Uniqueness of Mount Everest

A final theme that we have observed throughout this project is what makes Mount Everest different from other mountains. Physically, Mount Everest is unique because it is the tallest mountain in the world. Everest is also isolated from any major population center, and its very geography makes it difficult to get to. It takes time to get climbing equipment and supplies to the base of the mountain, and even if you take a helicopter from base camp, it takes several days to get back to the outside world. For instance, Giorgio pointed out, "It takes two months to climb Everest, it takes two weeks to climb McKinley, and it's also in the US so if you want something…you can pick up the phone and get something with a credit card or whatever, you can do it. Over there you can't, you've got to be very resourceful and plan way ahead"[105]

[105] Appendix C: Paul Giorgio Interview

Mount Everest also has a psychological effect on people. Because Everest is the tallest, it is like a trophy, something people can brag about having climbed. Most people wouldn't be interested in climbing a smaller mountain when they can climb the biggest. Often only professional mountaineers climb just for the sake of climbing. Oxygen is used on other mountains for medicinal purposes, but Everest is the only place where it is really needed as a performance enhancer. About 95% of the people who climb Everest would never summit the mountain without the use of oxygen equipment. Everest has a sense of being hard to get to. Just getting to the base of the mountain is part of the experience in addition to actually summiting. If it seemed easy to get to the top of Everest, it wouldn't have the same effect on people. George Mallory was quoted as saying he climbed it, "Because it was there."

In addition, the location of Base Camp is situated at an altitude that is at least 3,000 ft higher than the tallest peaks of the Rocky Mountains. In this sense alone, Everest is already a formidable challenge to a mountaineer, as the starting point is higher than the summits of many other peaks. Base camp is also more remote than any area found in the United States, and requires several days of trekking to get to because there are no roads that lead there. Also due to the absence of roads, supplies need to be carried to base camp by porters.

Mt. Everest offers many challenges in its location, terrain and environment. Humans have adapted to conquer these challenges in different ways. Sherpas have their physiological adaptations while western mountaineers have utilized technology to summit the peak of Everest. The Sherpas and westerners have interacted in a positive manner as the mountaineers and tourists have brought technology to the area. This has not been limited to the climbing gear. Communication technology has also been brought to the area to improve the lives of the Sherpas and the safety of the climbers on the mountain. Much effort has been made to help improve the lives of the people living in the area around Everest and Kathmandu, such as creating schools and hospitals. Therefore, this partnership has benefited everyone involved.

Chapter 6: Conclusions and Recommendations

There are many suggestions that can be made for further improvements in technology, infrastructure, and protecting climbers and the society of Nepal. There are several conclusions about the information that was gathered which are presented below.

One conclusion from our analysis is that for technology to be distributed further throughout the region, the per capita income of the area needs to be improved. One method would be the continued effort of Heifer International, and other organizations that aim to provide a more basic form of technology, and to provide the opportunity for local people to improve their own standard of living. In addition, this could allow for the local population to independently bring in new forms of technology, rather than it being brought in only by the Western tourists and mountaineers.

The continued presence of technology in the region will continue to change the culture of the Sherpas and other people living in the Solu-Khumbu region. Already, the technology is beginning to speed up some activities in the area. As one example, the system for obtaining a permit to climb Mt. Everest used to only involve paper taking about a year to be processed. Only recently the government begun to speed up the processing through the use of a computerized system, now the process takes a couple months.[106] Only time will tell what future impacts technology will have on this culture that measures distances between locations in days.

Before a major increase in the amount of technology is to be brought into the region, there is going to be a real need for the necessary forms of infrastructure to support it. For the use of the communications technology, such as satellite television, computers and the Internet, there needs to be a real push to improve the underlying facets of the region. Electricity will need to be readily available, and reliable. People also need to be able to afford this technology, along with their basic daily needs, which means that people are going to need to earn more money in order to raise their standard of living in order to afford the technology. Additional roads will need to be built and existing ones need to be

[106] Appendix C: Paul Giorgio Interview

upgraded in order to make it easier to bring in additional technology. This lowers the cost of transporting it from the southern regions to the northern regions of Nepal.
While it seems that all encounters with technology in the area by the local people are positive, there may still be a point that may push them too far, too fast up the technology ladder. The Sherpas are a friendly, clever, curious people who have survived for many generations using fairly primitive devices to create elaborate irrigation systems to feed their crops. The use of large machinery in the high farming areas would probably be more of a hindrance to them due to the steep, rugged terrain. Their ingenuity has allowed them to grasp and embrace the technology that the mountaineers and other tourists have brought with them. While it has been so readily accepted here, this doesn't mean that another isolated culture may take to a large flux of technology so quickly.

More care must be taken when appropriating permits for climbing Mt. Everest. Currently there may be as many as 1,000 people on the mountain in a given time. However, in areas such as the Hillary step on the southern route of Everest, it may take 20 minutes in order to climb it. Only one person may pass at a time. There is only a small window of time in which it should be climbed in order to follow the accepted turn around time. In a scenario where the step is reached at 8 a.m., that only leaves about 4 hours to get people through if they are to adhere to a proper turn around time. This means about a dozen people can get through. Consequently, about one small party can make it through. Therefore only 12 permits should be given out (including those given to the climbing Sherpas) to begin a climb on the southern route on any given day. It may be necessary to spread this out over 2 days to allow for climbing speed differences among groups. Perhaps a committee should be set up at a permanent base camp or nearby village that will be in communication with climbing expeditions on the mountain and can coordinate who makes summit attempts on each day. This will prevent too many people from trying to squeeze through these dangerous areas.

Continued research in Materials Science and Design Engineering will allow devices to be tweaked further to strengthen and lighten them. This will allow them to be more reliable and easier to carry. In technical climbing, devices such as the spring loaded camming device have revolutionized the sport. Perhaps in alpine or expedition climbing a device

can also revolutionize this activity. Likewise, another revolution in technical climbing may allow more difficult routes to be climbed, opening other areas of the mountain. This will also allow more people to climb the mountain at once. Summiting the mountain using the usual routes is considered the pinnacle of mountaineering. Making more routes available would provide another goal for people who have already fulfilled their aspiration. In addition, other routes may open up naturally, which will need to be explored when that occurs.

While the mountaineering equipment does make it safer to climb, due to its increased strength, education about its use and practice with the gear is the only way to ensure that it is utilized correctly. Several good books are available on how to correctly place gear into rock and ice. These should be read and the techniques should be practiced in a safe setting well before climbing any mountain, never mind Mt. Everest. Several climbing schools exist and make a great way to learn how to use the gear and develop climbing techniques as well. Classes are available in many locations around the country and many outdoor sporting goods retail locations have a school or offer classes. Recreational Equipment Incorporated (REI), Eastern Mountain Sports (EMS), or any of the independently owned and operated stores offer these or can direct you to them.

Perhaps there should be some sort of licensing for climbers or a "test of skills" section should be included in the permit process in which a climber must provide proof of mountaineering skills or have climbed a "qualifier" mountain. Possibly, this system could be created or managed by a professional mountaineering organization as "qualifier" mountains below 8,000 meters, such as Mt. McKinley, are located outside of the Himalayas. In addition, such a licensing system could be used to regulate the climbing of other hazardous mountains such as K2. This would be similar to how the Boston Marathon controls its participants. A runner must provide proof that he or she is capable of completing a marathon in an acceptable amount of time due to the large numbers that the race draws. This would limit the number and control the quality of climbers by only allowing experienced climbers and eliminating those whose inexperience may cause problems on the mountain. All climbers should have a certain skill set. They should be well versed in avalanche survival and rescue, crevasse rescue, basic first aid (possibly

only allow wilderness first responders), search and rescue techniques, in addition to survival and climbing techniques. In addition to the above training, the climber should be physically fit. This will allow the guide to do just that, guide. He or she should be responsible only for choosing and setting up the route and possibly taking care of permits and other organizational dilemmas. Each person who is making an attempt on the summit should be relatively self-sufficient, with the exception of Sherpa and Base Camp support. He should not teach a person how to climb as they are ascending the tallest peak in the world. Obtaining these skills is an easy task if one is dedicated and ambitious enough. Also, acquiring these skills takes only a couple months of training on the weekends and a couple thousand dollars. This is not a lot of time when one looks at the amount of time and money necessary to scale Mt. Everest. In addition, while the time and monetary commitment seem large, the training provides vital skills for use in mountaineering.

Rick Wilcox pointed out that it is important to test the gear that you are using before you head to Everest. All gear and clothing must fit properly in order to function properly. Also manufacturing techniques are not necessarily flawless and this is why companies offer warrantees that protect against manufacturing defects. Finding out that your $700+ boots leak as you are climbing up Everest will destroy your chances of summiting safely. However, if you test them out at Mt. McKinley, for example, you can get a new set of boots within a couple of days. This is impractical if not impossible at Everest, as it takes at a minimum of 4 days to get from the U.S. to Base Camp, and this is only in the case that the equipment is flown in from the U.S. and then brought to camp via helicopter from Kathmandu.

Future research would be better suited for work at a project center in the area, or in northern India, in cities such as Darjeeling, Manali, or Uttarkashi that already have mountaineering centers. One of the major problems inherent in this project was learning about the culture and the impact of technology on it. All of the research for this part of the project could not be accomplished first hand, but was gained through interviews, books, web pages, and other sources. The use of a project center in the Solu-Khumbu region, Kathmandu or another location in Nepal, would allow for continued research on

the impact of technology on the local culture. In addition, this would allow for an easier survey of the actual technology being used in the region, both in cities like Kathmandu and Namche-Bazaar and the villages. In addition, this could allow for a study on the effects of the tourist industry on the region, a topic that is not within the scope of this project. Topics of interest that could be studied in more depth at such a project center could be a first hand look at the interaction among the tourists, mountaineers and local communities. Biology, Chemistry, Bio-Chemistry and Bio-Technology MQPs studying the effects of high altitude or drug treatment of the associated ailments could take place at a project center in this location, as there is a wealth of knowledge still to be uncovered in this topic. At this time there is no drug that has been specifically designed to treat the effects of high altitude sickness, one that has been solely designed for this purpose may allow for safer drug use on expeditions. Many other IQP and MQP topics exist, such as further studying the communications technology and the reliability of mountaineering equipment on site. In addition to these projects, others would include feasibility studies of installing hydroelectric generators in villages, building roads, or improving the irrigation systems in Nepal. Civil Engineering MQP opportunities could include implementation of aforementioned projects that were found feasible. Mechanical and Electrical Engineering MQPs could be established to improve the climbing and communications technology that is present now. Another area for further IQPs is the ever changing amount of technology in the area, and the changes in culture that are being created there. This was one of the original goals of this project, but was difficult without experiencing Nepal first hand. Other projects could include the establishment of basic utilities and services such as irrigation, electricity, or transportation to one of the villages in the region, similar to projects done at other centers maintained by WPI.

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John Long; Climbing Anchors, (Falcon Publishing, 1993)

Brief look at history of gear. Rock anchor placement and building theory

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Large book with in depth history of the mountain itself and various expeditions.

Waldman, Amy, "Nepal Maoist Rebels Move Their Attacks Into Cities", *New York Times on the web,* 12 October 2003, <http://www.nytimes.com/2003/10/12/international/asia/12NEPA.html> (12 October 2003).

Talks about the impact of the Maoist rebellion on Nepal. Mentions the impact on the tourism industry, as well as background on the conflict.

Appendix B: Conrad Anker Interview Transcript

Phone interview on January 22, 2004, 2:00 pm. This interview was used to determine the experience of climbing Mt. Everest.

John Richardson: Conrad, How long have you been involved with the sport of mountaineering?

Conrad Anker: Oh I'd say since I was 16, Climbing, but being in the mountains a fair bit younger probably since I was 12.

JR: Where did you grow up?

CA: Central California, Tuolumne County and its about one hour outside of Yosemite National Park. We would go into the mountains as a family and it's kinda a logical progression from being in the mountains to getting into climbing.

JR: Great. When was your first expedition to Mt. Everest?

CA: First and only full climbing expedition on which I was a member, was in 1999 and that was the Mallory / Irvine Research Expedition.

JR: Oh, Awesome. What type of gear do you prefer to use?

CA: Depending on the applications, what would you say?

JR: For Mt Everest.

CA: For Everest. There's primarily high altitude climbing equipment that you need for it. It's very specialized. You need to have double boots, down suits, and oxygen systems. Those three items are unique to the 8000m peaks. You don't need that kind of gear for most mountaineering. So, those work out well. I am an employee of The North Face, and I have worked with North Face for twenty years. So I endorse their product. I used it for Everest and it is very good for those purposes. They have a really good down suit that works out very well.

JR: Did you use their tents as well?

CA: Yes, I have used their tents on Mt Everest as well, certainly.

JR: You've only been to the summit once. Is that correct?

CA: Yes.

JR: Other than the gear, how do you see Mt Everest as being different from say…Is Mt Everest different from the other 8000m peaks?

CA: Yeah, there's the obvious quantifiable difference which is the elevation. But the fact that it is such a trophy mountain, if you want to use that word. It's created two unique routes, being the north and south side the south side being a little more popular from the north side. The south side you access it through Nepal the North side is through Tibet. And those two routes are extensively fixed, they are supported by Sherpas in all phases of it, in working through the ice fall, getting into position. So there is a lot of support there. And there's the whole business of it for people going up climbing Mt. Everest.

JR: How do you feel the gear has changed throughout the years?

CA: The big improvements are in fabrics and if you look back to what Mallory and Irvine were using in '22, '23, '24, all their clothing, all their fibers were organic. They were mostly silks and wools and cotton and combination weaves of that. And they would have impregnated cotton as a wind proof. The Second World War brought nylon around. Then there were nylons and plastics and they came into the climbing world in the 60's. The climbing ropes were earlier. They were right after the war. They were using climbing ropes made of nylon, offering more strength.

JR: How about more of the more technical gear, rather than clothing. Where do you see the big changes there?

CA: the ice axes are pretty much the same. For waterfall climbing obviously the climbing gear has changed. For mountaineering where you are on something like Everest which is a moderate angle for a very great amount of time, there really hasn't been much of a change here. The big improvements again are in the materials. In this case, you have the fabrics in clothing; in this case the materials have become lighter and stronger. That is the goal in equipment design.

JR: So with that you are talking about the movement from a wooden handle, which I am guessing was probably ash, to aircraft aluminum.

CA: Yeah aluminum and fiberglass. It's continually improving.

JR: Do climbers on Mt Everest ever carry technical ice axes with them.

CA: Yeah they would. When I went to the summit my combination was a Northwall hammer, a 58 cm Northwall Hammer in my uphill hand and in my down hill hand I had a Whippet which is a ski pole with a self arrest grip, its made by black diamond, and that was my combination. I had my hammer along so, in case I had to re-fix a piton or pound on something I had a tool but it is also short enough so that on the uphill side it was of use. That combination of tools is quite cat like, good attachment to the slope.

JR: Interesting. Do you feel safer or more secure, because of these improvements, or is still pretty much you against nature.

CA: You feel it, any time you have something that can make it easier, then it's certainly an advantage. It doesn't make it easy it is still a really challenging mountain. For instance the oxygen, as those systems continue to get lighter and be able to carry more gas. I think the next thing is going to be putting the oxygen into the system. Instead of being a mask. In these areas of inefficiency you will have oxygen on demand, you will have oxygen that is calibrated to your O2 saturation level. It's kind of being electronically tested as you go up. So there is efficiency to be gained in that. Again it's a small margin. If you only have a few thousand people a year at the most, it's probably 1000 at the most for Everest, the market is tiny, tiny, tiny compared to the billions of people on our planet.

JR: Certainly. Do you feel that the improvements in gear have allowed to get into not just mountaineering on Everest, but in mountaineering sports like technical rock or ice climbing?

CA: Your question again? Has it let more people in?

JR: Yes

CA: Ok, well certainly, there's gonna be more people that want to go check it out. The real change is that it's accessible and people are aware of it. It's an option as something to do.

JR: Do you feel that this is more media related than saying ok these ropes are safe; if I take a fall I'm not going to die.

CA: Yeah, there is more awareness of it. I would say you need to stress in your work here that climbing is very dangerous. To say that it is safer just because of technological improvements is misleading in a way. It's still a very dangerous sport, maybe if people do feel more comfortable they'll come try the sport.

JR: So you do feel that it does have some part in it.

CA: Yeah

JR: Do you feel that these improvements can make up for a lack of skill and athleticism?

CA: It will give people a sense of self confidence. And it's a really good way for them to be more confident about what they are doing.

JR: So it's more psychological than physical.

CA: Yeah, I can go out with gear from 30 years ago and climb waterfall ice five (WI 5) pillar out here in Highlight Canyon, because I know how to climb it. I could make do. It would be easier with a lighter weight one but it is still possible. It's the same thing, Humans want faster cars and all that stuff, and that's there plan.

JR: You were speaking about oxygen before. Since Mt Everest is one of the only mountains that almost requires the use of it. Can you describe your experience with it? Which system did you use? What did you have for flow rates? And How much do you feel that it actually helped?

CA: I used it the night before summit day, slept on it. Kind of on a very low flow, and then on summit day I had one jug of it. I used about a third of it on the route. Use it a little and turn it of and then use it a little and then off, so it wasn't like it was a high flow of gas at low elevation. I probably used maybe one or two bottles. The system that Eric Simonson uses they are refillable jugs. I forget the exact name of it, but it's not the Poisk system, it's the other one.

JR: There's basically two systems, the American and the Russian, right?

CA: Yeah it was the American system, and certainly when you are up there it makes it easy. You can be climbing that much quicker. I noticed that the Hillary [capillary] refill on my nailbeds was quicker when I had oxygen going on. I would feel warmer, because your body it oxygen starved, it is shunting blood from your extremities and into the core. You feel cold more on say your hand than your back or something. As you well know.

JR: What made you decide to not use oxygen until you got up to a rather high altitude?

CA: I felt fine without it, I would still like to go back and give it a go without oxygen. I felt that in '99, timing wise I could have done it without oxygen I feel. But what's hindsight 5 years ago almost. The reason we were there was for a, I was making a TV movie, we summitted on the 17th and the 15th we had performed a rescue, we had a bunch of, there were three Ukranian climbers, one had fallen off the mountain, one had severe frostbite. The other guy survived a night out above the yellow band. It was pretty grim for them. And I saw this, having to do this rescue, getting those guys down, was like god what a bunch of work that is. So in the interest of doing the film which we were doing for Nova/PBS we felt that we should give this an honest a shot as possible, so that meant that using oxygen made the success a little bit more easy.

JR: So better safe than sorry type deal.

CA: Yeah, you're over there and your on somebody else's nickel, I wasn't getting paid by them, I made some money on that expedition afterwards. You gotta keep in mind that an Everest trip is pretty expensive.

JR: That's what I have heard. The permit rates have gone way up from what I understand.

CA: Yeah, but why not? I think it's a bummer that climbers have to deal with the price increases. But America's the greediest body on the planet, we can give a little back by that way. It would be great to see corporate America back that up but anyways.

JR: OK, How much warmer, lighter, drier would you say these boots, coats, gloves, sleeping bags, tents are? Could you give me some incite as to how the rating system for sleeping bags works? What type of bags would you use while your up there.

CA: Yeah. They rate the bags by putting a copper dummy that is hooked up to a computer sensor in a laboratory setting. And that's how it is decided. They measure it and say this bag is this warm, that's how they decide in a laboratory setting. It's relative to one bag to the next. Everyone sleeps at a different temperature. Some can stand a bag that is not as warm as another. But for something like Everest which is dry and high altitude, down certainly is a useful, I mean it's the preferred insulating matter. Then it just depends on the fill weight. Where you want to be warmer. Personally, I felt that is was worth it to take a heavier bag, It cost you a little extra weight, but you would sleep warmer at night. Sleeping warmer there is an energy savings because of that.

JR: So are you talking about a negative 40 degree bag?

CA: Probably a minus 30, I don't think I took a minus 40 up there.

JR: And today's tent's, can you tell me a little more about that?

CA: There continue to be improvements. They have nice strong aluminum poles that create the strength in the tent. But they're the most important component there. I like to have, for something like Everest where you are exposed to very high winds, a sewn sleeve rather than a clipped sleeve it makes stronger. And then a fly on it, it creates a dead air space, It's heavier than a single walled tent but it is stronger and warmer. But a lot of things on Everest, because of how they are changing, because there is so many people there it changes.

JR: The fabrics that go into that is that GoreTex or some other sort of treated, or membrane material. .

CA: There are single wall tents and that is good for single applications. But what you have a series of camps and people climb between them and leave them there. It's a different type of climbing style. On to a single wall, which is a laminated, or a membrane type tent. There are problems with condensation in there it doesn't breathe as well as a double wall tent. It's one of those climates where breathing and tent comfort are of importance

JR: I guess what I am trying to get at is where does the fly get the weatherproofing from. What's the preferred method of doing that?

CA: Probably a Urethane coated Nylon. That's the preferred method in the business.

JR: Ok, In boots, What do you prefer in boots, The Everest One Sport or is there something else?

CA: When I summitted I had the One Sport. And I have been using the other ones the Olympus Mons from Sportiva.

JR: I've heard that those are a decent improvement, especially with the sole, it excepts crampons a little better.

CA: Yeah, Yeah it accepts crampons well, and if you build it with a shell that's going, you know insulates. It's going to work out really well.

JR: Where do you think that the biggest changes in technical climbing gear have come in?

CA: The camming device, that's the first thing, designed by Ray Jardine. The thing is the gear is getting lighter, it doesn't weigh as much. You can depend on it more readily. But yeah the camming device, it kind of went of the idea of nuts and that sort of thing, it's just an application of it. And the belaying device. The GriGri, which came out in about 1990, that's a very good device. It belays and it has a self lock it has many ways that it works out.

JR: Now is it correct to assume that when you are climbing on Everest you are not belaying out a pitch. Or do you do some belaying on Everest.

CA: On the second step. There are a few areas that you have to do these large step.

JR: Would you bring a GriGri for that, or are there problems with freezing?

CA: No I wouldn't bring a GriGri on Everest.

JR: Probably an ATC or something like that?

CA: I just use a muenter hitch it doesn't weigh anything. And it does the job. Your not doing all that much, if your going up and down fixed ropes you probably want, which is better than an ATC is the figure 8, it doesn't kink the ropes as much. But most of the time people just clip a 'biner into the rope and wrap the rope around their arms and slide down that way. So it's kind of that unique side of mountaineering on both sides of Mt. Everest.

JR: So no big improvements in ropes since nylon ropes.

CA: They are continually getting stronger. It's a braided nylon with a core (sheath?) on it and that makes a huge difference.

JR: And you said the mountaineering ice axes haven't really changed in god knows how long right?

CA: Yeah. Well the design with the curved pick. You know slight modifications, never more than 5%.

JR: How do you feel that technology helps out with rescue attempts.

CA: Well you have stronger gear. The biggest advent is probably the use of radios and other communication.

JR: I was talking to another person and they had said that the avalanche beacons were a lot easier to use. They are a lot simpler.

CA: That's more recreational. I don't see a lot of them in use out there on Everest. Once your on the fixed route your kinda following a path.

JR: So people pretty much know where you are going to be if there is a problem.

CA: Yeah.

JR: Can you describe your experiences in dealing with the permits, or any other infrastructure type problem.

CA: Again the communication ahead of time, pay the fees that they are requesting, and everything goes from there. I don't have anything worth while. It's no different than getting a license plate I guess, at the DMV. You have to what you want to climb that's the big thing, know what your objective is.

JR: So, It's my understanding that you never guided someone to the top, you were on your own expedition.

CA: Yeah we were a commercial trip, but we were making a film. It wasn't something like a guided expedition; I don't want to do that.

JR: It's just not your style or you don't believe that they should happen.

CA: Oh I don't, you can do what ever you want up there as long as you keep the place clean and you don't harm people and other animals on the way up there. Go have a blast climbing the mountain. Go pay someone; I think it would be better for the mountain. I support it. I think it's a good healthy thing. I'm not oh it's bad that they are guiding Everest. I mean we do a lot worse things that we should be worried about. Taking people up Everest? Personally no, it's not where I want to be.

JR: How has the food changed? I know before they used to use the dehydrated meals kinda like the military rations. What is being done now?

CA: It's still pretty much the same technique where they are using dried foods and things like that. So the challenge is just getting down the calories. You're in a inhospitable environment, your appetite weans so you need to make sure that you have all of your calories.

JR: Is that part of the Acute Mountain Sickness or is that sort of a psychological effect.

CA: It's not psychological, it's physiological it's a result of something or the other. That's an area of interest, you could probably figure out the case and what's causing that.

JR: Have you ever run into someone who has had the High Altitude either Pulmonary or Cerebral Edema?

CA: Oh yeah and I have carried them down mountains. They're hurting and they need help.

JR: Was that the incident you spoke about on Everest or is a different incident?

CA: Yeah, it was a different time. Well and Everest, and McKinley in Alaska a couple of times.

JR: Did you ever use a Gamow bag in either of those situations?

CA: Yup, they are available at base camp. People do use them.

JR: Is it as revolutionary as it sounds?

CA: Yeah, It definitely is good, it does the right job. It enables you to stay healthy.

JR: Have you ever used any medications to help with acclimatization?

CA: You can take aspirin and you can take Diamox. And hydration and good diet those are very important too.

JR: Was Diamox used basically as needed or did this become a regimen?

CA: The medication is taken in advance, in anticipation of illness. Its called prophylactic, your taking a drug prophylactically, that's the current thought on Diamox. Its small amounts of Diamox taken to help with the acclimatization. There are other ones. I have no experience with them. I only have a limited experience with Diamox, don't take my word as endorsement; go check with your doctor.

JR: What have you used in the way of electronic devices on your expedition?

CA: I used an avalanche beacon as you mentioned. Those are always good and helpful. At Base Camp I might have a little Minidisk player or something to listen to some music. A laptop, if it's a commercial expedition we are reporting about it. We'll have a laptop and a satellite phone and all that stuff. So quite a bit.

JR: How reliable are those devices in the harsh conditions that you encounter?

CA: As long as you know how to warm them up and prepare them, they work pretty much without flaw.

JR: How do you warm these devices up?

CA: Put them next to your body.

JR: OK, so there's no separate heaters for them.

CA: You could use hot packs, but I don't carry those things up for them.

JR: Not worth the weight in other words, right?

CA: Right.

JR: How do you get these recharged, how do you power them? Is it solar chargers?

CA: Yes solar systems.

JR: Would you carry older equipment, something that is more tried and true, to fall back on.

CA: No if I'm taking it it's been tested. I can count on i. I don't have the weight allowance to carry two of them.

JR: The cyber café that was built at base camp you weren't around during that time were you?

CA: Yeah

JR: Kinda switch gears again. How much technology was around in the area near Everest? For example, Namche Bazaar or Katmandu, or any of the villages you may have encountered on your trek in.

CA: What do you mean by technology.

JR: Electricity, phones.

CA: In Katmandu, yeah it's a city like we have here. You can find an internet café with DSL. When you are in the field you have to have all that linked up via satellite phone.

JR: What about in the smaller villages. Do they have any of these modern conveniences?

CA: The smaller villages probably won't they would when westerners come. They bring that in.

JR: Okay then we wrapped that up a little quicker than I had expected.

CA: Yeah well you had some really good questions there. So is this coming out in the paper or how are you… What's your plan with it?

JR: Well this is for what we call an IQP, which depending on who you ask is either an Interactive Qualifying Project or an interactive Qualifying project. Basically it's a school thing, it's like a thesis, a junior thesis.

CA: Oh good.

JR: This isn't going to be out in a newspaper this is more of a thesis type thing. I doubt this is going to be published or anything. Basically we used to have a project center over in that area and with the problem with the Maoists and what ever, we've decided to close the center, and we are trying to get it open. So this is part of trying to get more interest drummed up for reestablishing it. (CA: oh good) WPI has project centers in London, Puerto Rico, I think we are starting one in Dublin, Ireland, we have a couple places in Italy, I believe there is one in Germany. We have one in Bangkok. We have them all over the world. Basically their will be areas that have a problem and they'll say we don't have a lot of money to fix this, so we have these student groups go over and solve these problems. So, there was one on micro hydroelectric plants I think somewhere around Taiwan or Bangkok, or something along those lines. They go in a do a full evaluation of the problem and make recommendations, depending, and after that's done they may send another group to actually go and implement it. So the implementation will be their project. All these projects tend to build off each other. So it's nice to get in on kind of a ground level one, where as you're doing your own work versus working on somebody else's. So, that and the 50th anniversary and the Internet Café that all helped spark this. It's been interesting. We are probably close to two thirds of the way done, we've done all our background so that we can ask intelligent questions, then we will be doing the analysis of it within the next couple weeks and then, we have to really break our backs to get this all written up by the… I think it's the middle of March we have to have everything done by. Otherwise we have to run into an overload situation next term where we have to register for more class time than we're allowed so we have to spend more money and what not. And that's not a good thing when you are a student. You have enough of a time trying to put food on your plate, than to pay for more classes.

CA: Well great, I look forward to seeing it. Keep me posted on it.

JR: Will do. I will send you our results or even a full copy of our report. I can email you a file or something, for your own entertainment.

CA: well good deal, it was nice meeting you, maybe if we are at a trade show or something we will have to touch bases and if you are interested in trekking in Nepal.

JR: Excellent. And if you're ever in New England we can climb together.

CA: Yeah that would be great. I don't have any plans for it off the bat but if I have a date for it, we'll see if we can hook up.

JR: I've climbed waterfall 4.

CA: Uh huh so you're getting after it.

JR: We have a little ice bowl maybe 20 minutes away from Worcester, in Auburn, Massachusetts. It's the closest place next to going to Rumney or something up in the whites. So it's nice to have something 20 minutes away to kind of bone up on your skills and it's good you don't have to spend 3 hours on one route, it's only a 60 foot waterfall but you get the skills down,

CA: Yeah that's what we want, to improve the skills.

JR: We've got a couple nice cliffs in the area to do some rock climbing on. I got up to about a 5.10, a couple of my project routes were 5.11. I've gotten a little out of shape lately 'cause of the amount of school work that I have had. But the mountains will always be there

CA: Well sounds good.

JR: Ok

CA: Well, I'll talk to you soon then

JR: Thank you very much Conrad.

CA: Yup, bye.

Appendix C: Paul Giorgio Interview Transcript

In person interview January 29, 2004, 11 am. This interview was used to determined the experience of climbing Mt. Everest.

Ryan Seney(RS): When did you go to the region, what years or how recently?

Paul Giorgio(PG): 98, 2000, 2001, 2003

RS: Where did you travel in the region?

PG: Strictly Everest, in that region.

RS: What was you purpose in going, just sightseeing or was it just to climb?

PG: Trekking for the first time, and the other three for climbing.

RS: Where exactly did you stay while you were traveling?

PG: In Kathmandu and in the valleys. In Kathmandu I stayed in a motel and in the valleys I stayed either in a tent or in teahouses.

RS: Did many of the locals speak English?

PG: No but, since I've been going there each year it's grown immensely. Anybody that's working with a guide or climbing group is being taught English heavily.

RS: Did you encounter any other languages when you were traveling, any other ones that were widely spoken at all?

PG: No, just other climbing groups that you'd see like Chinese, Japanese, you know their languages.

RS: How receptive were the locals to people visiting from the West?

PG: Yeah. Thats their livlihood, the more people they see from the West, the more money they make so they welcome it all the way. If they don't see anybody they start to get nervous and scared.

RS: Did it vary for any trips, or for anywhere you went in the country?

PG: In general their whole country is based on tourism.

RS: Were there a lot of Westerners in the area while you were visiting?

PG: Yes

RS: Did you spend any time aside from climbing and trekking just traveling around and seeing little villages and stuff like that?

PG: Very little

RS: If I could ask a couple technology related questions, like stuff that you may have seen, did you see any forms of technology such as electricity, phones, cable or satellite TV, or computers being used locally while you were around?

PG: Yeah. Electricity is run through the valley, phones are run through the valley, satellite was brought in strictly by us. Fax machines are in a couple towns, that are just used by westerners, and computers the same thing.

RS: How widespread was the use of these technologies, were they very widespread or was it just one or two spots where you saw it?

PG: It's grown. It's only a couple isolated areas once you go up into the valley, but it's grown. You can tell it's taken off really quickly.

RS: Were you able to communicate back home? What methods did you use such as E-mail, local phone, satellite phone, cell phone?

PG: Satellite phone and E-mail.

RS: Did you see a lot of cyber cafe's in the Kathmandu area? Did you see a lot of them at all?

PG: Plenty of them in Kathmandu. There's some in the villages going up and we now have a cyber cafe at base camp.

RS: How big did these cyber cafe's appear to be?

PG: Very

RS: Were you able to use any of them?

PG: Yes, all the way up.

RS: What kind of clientele did they seem to have? Was it mostly Westerners or was it local people?

PG: All Westerners.

RS: What do you think the general attitude of the people in the region is to using technology? Are they generally acceptive of having new stuff brought in or are like "We just don't want to use it"?

PG: As soon as they see what the benefits are. They've gotten nothing but benefits from the Westerners. They've been so primitively laid back on many aspects, when we bring the new technology they're very eager to see what the gains are.

RS: Does it seem like the region would benefit from a flow of technology into it?

PG: Yes, very much so.

John Richardson(JR): Just one more thing to add to this: What was the nature of these cyber cafe's. Was it one computer in a set home or was it like an array of computers, how were they set up?

PG: Kathmandu was like an array of computers set up. Once you get up in the villages, Namche is the last cyber cafe you can find and it's at 11,000 feet, they have a couple up there probably with about five or six computers.

JR: How long have you been involved with mountaineering?

PG: Probably 15-20 years

JR: When was your first expedition to the summit of Mount Everest?

PG: 2000

JR: What type of gear are you using?

PG: Outerwear?

JR: Outerwear, technical, climbing equipment, what type of ropes, how much, if you remember. Did you use protection?

PG: I have an array of gear. I don't have responses like some people you interviewed. Whatever sponsor they have, I just have a bunch of mumbo-jumbo: Marmot coat, North Face fleece. I've got just an array of stuff. Whatever I can get on sale. I don't have any gear sponsors so if it rips I just buy myself something else, something that's comparable. My boots are Everest One Sports, now Millet owns them. Grivel crampons.

JR: Is that like a G12 or a Rambo

PG: G12's. Black diamond belt, harness. I've just got an array of different kinds of companies.

JR: Ice axes, do you carry a technical ice ax or just a mountaineering style?

PG: Mountaineering style.

JR: When was the last time you've been to Mount Everest? 2003?

PG: Yes

JR: Do you see any change in the past three years in the gear itself?

PG: The gear hasn't really changed much. Change of weight with Goretex and stuff, but the gear hasn't changed much at all. Boots maybe a little bit, they've gotten a little more lightweight, but really nothing complex has changed.

JR: Okay, so just a little tweaking?

PG: A few improvements here and there, it's not as bulky as it used to be, but the last years I've been there it really hasn't changed much at all.

JR: How do you feel that Mount Everest is different from any of the other 8,000 peaks or any other formidable mountains like McKinley?

PG: What's different?

JR: Yeah, what makes it stick out?

PG: Obviously it's the pinnacle that everybody uses because it's the top. What makes it stick out is that basically that and where it is, it's remote location. Compared to McKinley, McKinley is ... it takes two month to climb Everest, it takes two weeks to climb McKinley, and it's also in the US so if you want something, we're used to you can pick up the phone and get something with a credit card or whatever, you can do it. Over there you can't, you've got to be very resourceful and plan way ahead. You really can't do that like in McKinley or somewhere else.

JR: What about anything particular to the climbing challenges, anything particularly difficult about Everest, other than extreme altitude?

PG: It's the weather, some parts are steeper. Some people say it's an easy mountain, some people say it's a hard mountain. It doesn't kill people because it's a walk in the park.

JR: Do you feel safer and more secure because of the improvements in gear and infrastructure-type things as well?

PG: Yeah, you get better communications with other people and stuff like that, communications with the outside world, you know when there are storms coming. If you don't, you're just rolling the dice.

JR: Do you feel that this makes it easier as well as safer? Because you have lighter gear.

PG: Yeah, yeah. I would say it's easier because you're not expending energy towards a wasteful effort. When you got the technology and you know what you're walking into, you don't waste your time

JR: Do you feel that the gear has allowed more people to get involved with mountaineering and its associated sports like technical rock climbing and ice climbing?

PG: No, they just do it because they want to.

JR: Do you feel that these improvements are made up for a lack of skill or athleticism?

PG: Some of them, yes. Technologically. Some people will think they get a lot of skill and be caught up in compensation by modern conveniences.

JR: Mount Everest is one of the only mountains that almost requires the use of oxygen. Did you use an oxygen system when you climbed there?

PG: Both with and without

JR: Can you describe your experience with the oxygen system? What kind did you use? What type of flow rates did you use? How much do you feel it really helps?

PG: It doesn't help me at all really. I used the Poisk system,on one and a half liters. I've gone with and without it and it really doesn't change me, nothing for me at all. For 99% of the other people, they could never make it if they didn't have it, they get lethargic, tired, they make bad decisions, their thought processes are erratic.

JR: Can you describe how much warmer, drier, lighter the clothing is than your average run of the mill for instance down suit. How much warmer is that than say, the jacket you're wearing today?

PG: Yeah, it'll handle like minus 30, 50, 60 degrees, depends on what the layers are and stuff. What I have on today is good to maybe minus 5, 10.

JR: Can you describe the tents that you've used? The sleeping bags stuff like that. Why is it more waterproof, more stable?

PG: Gortex is the number one thing for everything. It's made mountaineering change a lot in that aspect, but there really hasn't been major improvements in the tents. Some of them make them more aerodynamic so they don't get blown off the mountain. They flex and bend with the winds and stuff like that. But that's just tweaking.

JR: What do you think of the changes in technical climbing gear?

PG: The biggest thing is the Goretex. Nothing really has changed that much.

JR: Ice axes, camming devices, rock pitons, ropes, stuff like that? Does the harness you use add a certain benefit?

PG: No, I don't think so. That hasn't changed much at all. ... Nothing, really.

JR: How do you feel that technology helps with any rescue attempts, or did you even run into that situation?

PG: Technology, having outside communications, satellite phones, walkie talkies, stuff like that. You can get people outside of the group ... it's enormous. It means life and death. Just absolutely, all the time.

JR: Can you describe your experiences with dealing with obtaining permits, or any other infra-structure like problems?

PG: Permits are a pain in the butt over there, they push paper, we push computer buttons. That's the difference in technologies, they're still pushing a tremendous amount of paper so it's a slow, drawn out, long process. You need the locals to get the ball rolling. Once you get the ball rolling, it's a tedious, repetitious process where they are used to it, we're not.

JR: Is this process months long, years long?

PG: It used to be years long, now it's months. You get done quickly now, they're getting so modernized they know Westerners won't deal with their pokiness so they are moving they get the ball rolling.

JR: I know a few years ago they were limiting the number of permits given. I was talking to Rick Wilcox and he said there was only I think 7 for 1991 that were given out. Now there's a lot more than that, whoever wants to climb it, if you have the money, your going?

PG: That's true.

JR: Have you guided anybody to the top?

PG: Yeah, I guided in 2001 and 2003.

JR: What's your opinion on these commercial expeditions? Do you feel that they should be limited for safety reasons?

PG: Most people don't like them, most true mountaineers do not like commercial expeditions. I don't care either way, personally. I've been on a commercial expedition. Should they limit it? Yeah they probably should. If you just keep throwing more and more people at the mountain eventually there's going to me a monster amount of people getting killed. I've been up there in 2 huge situations and if they turned anywhere if they stayed that way… In 2001 they walked into a beesnest and if it stayed that way it would have been 10 times worse than in '96. Last year we came so close to getting a hundred people killed that we couldn't get any closer so it would make '96 look like a walk in the park. There's just too many people. They need to throw a limit on there. The commercial expeditions, they should only allow x amount. Do I know a number, no I don't. Have I ever thought about putting a number on it? No, but it's not my business. It should be regulated somewhere.

JR: Where do you see the biggest dangers occuring with too many people? Is it bottleneck type areas allow a certain number but have safe type areas in the mountains to stay. What's causing it?

PG: Bottleneck areas. Once you get beyond the south summit there are a lot of bottleneck areas, a lot of people are going to get stuck, you're just going to have to wait to get them out.

JR: Do you think that there should be an almost mandated turn-around time? I know that the weather gets pretty nasty on a regular basis, almost on a daily basis.

PG: Most teams use a 12:00 noon time for turn-around, but nobody adheres to that. They just run it.

JR: Do you feel that the food has changed, or do you think it helps with dealing with high altitude? Are you doing anything different lately?

PG: Foods changed immensely. When I first went it was all Sherpa food and their diet consists of potatoes, a lot of rice. We have been westernizing many of their dishes all the way up the mountain. It used to be freeze-dried food. Now it's shifted a little to boil in a bag stuff, basically, made in the US, pre-made meals sealed up in a plastic bag. You boil the water, put it in, it heats up and eat it. It's actually very, very good. It's changed immensely in that aspect.

JR: So these foods have a lot more protein and what not than potatoes and rice. I think that helps the climbing, helps with recovery times and whatnot?

PG: Yeah. The higher you get, most people can't eat. Personally, I can eat at any altitude but these helped me immensely. If I had to eat Sherpa food I would probably shrivel up and croak, but since I can eat Western food, high in proteins and stuff, it keeps me as close as I can to being at home.

JR: Have you ever experienced or had to deal with anybody who's suffering from high altitude cerebral edema or pulmonary edema?

PG: Both

JR: Have you had any personal experience with it yourself?

PG: No

JR: How did you help those people deal with that situation?

PG: One of them I got the person down. One of them I got a helicopter. One of them was a foreigner from another team. I tried to inject him with dexamethasone and he refused and he died. Another got carried out.

JR: Do you have any experience with the Gamow bag?

PG: We've had one, never used one.

JR: What types of medicine have you used to help with acclimitization?

PG: Me?

JR: Yes, you yourself.

PG: <*shakes head no*>

JR: You never used diamox or anything?

PG: No.

JR: What have you used in terms of electronic devices on your expeditions to the summit?

PG: CD players, satellite phone. That's about it. We had computers down below, actually I used a palm pilot for some testing.

JR: What were you using for power in those devices?

PG: Solar, Batteries. We had generators at base camp.

JR: The batteries, were they rechargable or were you carrying just regular old

PG: The rechargables don't work really well for some reason so we just used disposables.

JR: We've been having a little argument about this. If you were carrying say a video camera, are you using rechargable batteries then or is that when you used the solar collector.

PG: Rechargables on those. I personally don't have a solar collector to power a video camera.

JR: When you're using you CD player or something like that you're using disposable batteries?

PG: Yes

JR: What did you use for communication with base camp?

PG: Walkie talkies

JR: And those are powered with rechargables again?

PG: Disposables

JR: How many sets of batteries did you have to carry?

PG: We probably would have 2 or 300 AAs and we take what we need going up.

JR: What did you have as means of communication with the rest of the world?

PG: Sat phone

JR: Did you actually use it or just have it with you?

PG: Used it

JR: Did you pay the $2,000

PG: No

JR: That's what I have been finding. How would you rate the reliability of bringing electronics at these high altitudes and coldweather and whatnot?

PG: Good

JR: Did you have to do anything specific to them?

PG: Keep them warm. Usually I would keep the batteries warm next to my body. Basically if you want anything to work you need to keep it warm.

JR: Do you have anything else that you think would help aid this project?

PG: Not that I know of

JR: Okay, I guess we're all set then. Thank you very much for your time, you've been a great help.

PG: Great

Appendix D: Rick Wilcox Interview Transcript

In Person Interview December 30, 2003. This interview was used to determine the experience of climbing Mt. Everest

John Richardson: This is an interview with Rick Wilcox on December 30th, 2003. Rick how long have you been involved with mountaineering?

Rick Wilcox: With mountaineering, since college, I went to the University of Massachusetts and met some people there who were into mountaineering. I had already learned some rock climbing and Ice climbing through the AMC (Appalachian Mountain Club) in high school and early in college. So my junior year, I got invited to go to Mt. Bono, which is the ninth highest peak in North America. One of the guys was trying to climb the ten highest peaks in North America. So we went up to Mt Bono with some of the college loan from my senior year. And climbed it so that was my first big climb.

JR: On your website in mentioned that you worked over at EMS (Eastern Mountain Sports) for a while and then you started your store here back in the 70's can you tell me a little more about that?

RW: When I was in college at the University of Massachusetts in Amherst in my junior year Eastern Mountain sports opened their third store in Amherst. I got selling gear mostly in the evening doing my homework and holding the fort for the store. And after I graduated I went to work for them full time which was 1970. Actually I went to the artic Institute for six months and worked in the Yukon, and then when I came back from them in the fall of '70 I went to work for eastern mountain sports in Boston. And they were opening stores like crazy. So in the spring of 1971 they opened the store here in North Conway. Actually it was this building right here. So I came up and was the store manager, till 1979, when they went public and got some new management. SO I went down the street and bought International Mountain Equipment which was in the movie theatre, actually the building next to the movie theatre, you know now a couple blocks down. And then in 1988 this building went up for sale. So I bought it and moved the company in, and we have been here ever since.

JR: Nice

RW: Yeah

JR: So when was your first expedition to the summit of Mt Everest?

RW: Well, I have only been to the summit of Everest once, and, my dream of course was like a lot of people, to climb Mt Everest and as I got into my thirties I realized it was time I got going over to the Himalayas. In 1985 I had the opportunity to go to Cho Oyu which is the sixth highest peak in the world, with the Polish and we did pretty well, we didn't summit but we came close, but we climbed the peak next to it

which was the 18th highest in the world. And after we did Ngojumba Kang 1 which is 26,100 feet tall. I went back the next year and attempted Makalu and got real high on that. Didn't quite get to the summit. Went back a couple more times. But during those late eighties I realized it was time to get going with an Everest permit if I was going to do that. I got together with my friend Mark Ritchie from Boston, We applied for the spring of 1991 and eventually through endorsement from the American Alpine Club, and fundraising and team organization and all that type of stuff we did get the permit. And that was my big Everest deal was to lead eight climbers in the spring of '91 to the summit of Everest. We did the Hillary Route the normal route on the South Side. We went over in March and actually in February I guess got up to base camp and in mid march got the route ready with a minimum of Sherpa Power, because we didn't have any money basically we only had four climbing Sherpas and they never slept above Camp II.

JR: Wow

RW: Yeah that is pretty unusual for any Everest Expedition.

JR: Yeah it is.

RW: Early May got up to the south col. Established Camp IV, Got blown off by the wing came down. Rested 10 days went back up and summited on May 15th. 4 out of the eight made the summit it was Mark Ritchie, Barry Rugo, Steve lafarier and Myself.

JR: Very Good. What type of gear were you using then?

RW: Well, we were using quote state of the art equipment for the time. Fortunately we had Everest One sport Boots. I think are fantastic, we all had those and they worked fantastic, they are very light weight, built in gaiter, lots of foam, lots of insulation.

JR: Is that the Boot that is known as the Millet Everest boot now?

RW: Yes that is the modern day version of it. They went from a company called One sport to millet and might have been tossed around a couple of times in the last 10, 15 years. We had Wildthings one piece insulated climbing suits, and pretty much normal stuff. Dachsteins with shells over them.

JR: OK

RW: We did but some bottled Oxygen which was one of our most expensive items. I think we bought about 20 bottles. And between shipping them over and getting them to Everest I think we had about 20 grand invested in that. We wound up using a few bottles at the south col. For sleeping, which was good. We were also able to find quite a few and use what was already up there. Cause there is tons of stuff up there. And we each had one bottle for summit day. We left at midnight, we climbed to the summit. Pretty decent time. Mark and Steve made it by 8 30 in the

morning and I was there with Barry at 9 30 quarter of ten. The bottles at 2 l/min would last 13 hours so we were on the top at say 10 and turned the oxygen off for say an hour and started down around 11 and were back at camp at one. So we basically ran the bottles dry but we got we were going and got down ok.

JR: What oxygen system was that that you were using? Was it the Poisk system out of Russia or did you use something else?

RW: No we were using the American made system which is not as popular as it used to be because the Russian stuff is readily available in Katmandu and it's cheap, relatively speaking and you don't have to ship over, its already there you can pick it up right in Katmandu. My experience with the Russian system, I lead an expedition to Cho Oyu in the year 2000 and 50% of the bottles leaked so we had a bad experience with it, I think they have improved it over the past few years. But I am not as excited about that, and if I ever went back to Everest which I won't probably unless I'm delirious, but if I went back I would definitely invest in the American equipment.

JR: What was the name of the American equipment?

RW: I'd have to look that up, they were made in California, they were Kevlar wrapped aluminum bottles and we pressurized them to around 4500 psi I think. And shipped them over on a commercial airliner. You can't ship them on a regular airliner. So I couldn't tell you right off hand who that was but I guess I find out.

JR: Yeah if you could shoot me an Email or something that would be great. So the Ice axes or whatever you were using, were they still wooden handled cause I saw some of those on display or were they aluminum?

RW: We had aluminum lightweight ices axes and in fact mine broke cause they were made a little too light weight. They have tweaked them a little bit since. If you go and look at the dummy over there you can see it has a broken adze on it. But just light weight, light weight crampons, they were step in which work great on the boot. Today things have changed for sure, but basically we had good light weight gear.

JR: As far as protection was concerned what were you using?

RW: We did Everest kinda the traditional way. We put in 5000 feet of fixed rope. We put in 8000 feet in the Ice Fall (khumbu) and then we put in 14, 00 up the Lhotse face basically from camp II to Camp IV was fixed pretty much all the way. So the terrain which is about 10 miles from Base Camp to the Summit and about 50% of that was fixed. We didn't fix anything Above Camp IV, we did that solo, that is the entire Summit day we just soloed up and down. We didn't use rope or harnesses or anything. We didn't protect the Hillary Step or Anything like that. We just did it. But you figure we were going along just un roped…I don't like to use the word solo because we were always with someone but solo in the fact that we weren't tied to anybody but we were in a group. We weren't alone by any means if you weren't

attached to someone you were attached to a fixed rope. We never belayed a pitch. Nothing like pitching it out like on an alpine climb or if you were out climbing with a buddy or something. So either fixed rope or not one of the other.

JR: So when you were fixing these rope what were you using? I mean stakes, dead man anchors, screws?

RW: Um yeah, through the Ice falls mostly Pickets, we used a hundred ladders. Over crevasses and doubled up ropes over the ladders so if the ladder broke you would have something or if you fell off the ladder you would be hanging on at least one rope. Then after we got through the Ice Fall which is kind of a manufacturing project.

JR: Sounds it.

RW: Pretty much pickets and a few Ice Screws up to camp II and then a lot of Ice screws actually between 2 and 3. And then some rock pitons between 3 and 4 up where you know they call the yellow band up onto the Geneva spur and then some more pickets. So it was fixed pretty much the whole way.

JR: So nothing like any camming device or nuts or anything?

RW: Nope all rock pins, probably 2 or 300 pickets at least… A lot of hardware. We were able to find a lot of old stuff that we were able to reuse. But most of the fixed ropes every year get buried in the ice. So there are layers of them down there.

JR: Interesting to know. So how much technology was in the area as far as what the sherpas that were living there were using at home. Did they have electricity, television, telephone anything like that yet?

RW: In 1991 I believe that the town of Namche Bazaar had electricity, I think they only ran it at night, it was off of a small hydroelectric plant in the town of Thome which is right near there. And there was no telephone service no fax no internet service of any kind at that time in 1991. we didn't use anything on our climb except inter-camp walkie talkies. We didn't have any communication with the outside world at all.

JR: How do you see Mt Everest being different from any other formidable mountain as far as the climb is concerned? Like what is specific to Everest that sticks out in your mind.

RW: The thing that sticks out in my mind is that it attracts the traditional high altitude mountaineer, which I would classify myself as, somebody who through the teens and 20's climbed in the alps went to Yosemite and did big walls. Eventually got up to Alaska climbed Denali went to Peru went to Ecuador went to Mexico and became lets say a really well rounded mountaineer. Where do you go when your done with all that? You go to the Himalayas, I did 4 expeditions to the Himalayas before I summited Mt Everest. And I felt that when I went, obviously in a non

guided situation, I went just with my climbing buddies that we were well prepared for the climb we were proficient and Mark Ritchie you know he's world class, a good solid team, we worked hard for it. it wasn't easy by any means. We summited 50% of the team which is unusual 4 out of 8 the other 4 people made it to the last camp.

JR: Unsual meaning that's high or that's low?

RW: That's a high percentage. If you look at it for example history prior, you go back to sir Edmund Hillary they had 35 climbers and 90 climbing sherpas to get 2 guys to the top. The Americans in '63 about the same ratio, 35, 40 climbers getting Jim Whitaker and ghumbu to the top. And then the west ridge guys getting 4 Americans to the top but then again 6 out of potentially 50 or 60 guys. So 10% whereas we were 50% on our team, which we thought was terrific.

JR: What do you think has changed to make that possible

RW: Well let me finish my thought, you had asked what does Everest attract, now that's one category of climber you know Reinhold Messner has been there, you look at every top climber in the world they have been there. Its sorta like doing a big wall in Yosemite, you go out and you do El Cap (El Capitan), you gotta do it its one of those prerequisites that if your going to be a climber it's just one of those things you just go do. So if you going to be a high altitude climber you're going to go and climb Everest. And all the boys have been there, but then there is another group of people that don't go any where else in the Himalayas, but I don't necessarily, I mean to be respectful here, but I don't think they have earned their spurs, as we would say in mountaineering. If going to Everest is your first Himalayan experience, if going to Everest is the top of the first mountain for you, maybe base camp is a high altitude record for you, and of course there is the whole guided scene. With people paying lots of money to go up with guides, guides who are very proficient mountaineers by the way. It's a little bit strange for the climbing people to look at the over achievers, the people who have been very successful in the business world and other facets of their life but not necessarily in mountaineering. To go straight to Everest and try to climb it. It's amazing, but Everest gets guided the most of any of the Himalayan Mountains, of any of the big mountains for that matter. People aren't interested in Mt Eslu or gashuba 2 or something like that. They want to go to Everest, they want to do the same as the big mountaineers do. They want to do the big one. I like to look at it as flying an airplane, you're either up front flying it or you're in the back along for the ride. When we went to Everest we flew the airplane, we going to fly from Logan airport to over to maybe London, we were going to fly we made the decisions. We put in the ropes, we carried the loads, we put in the work to climb the mountain. If you go on a guided trip, does all the work for you, hires a gazillion sherpas to do all the load carrying between all the camps, do all the cooking, and you just kinda go up between the camps, I think the achievement is still amazing still just making it up even using that technique, but I think that in reality you have to look at the reward for the effort, I could compare it to our ascent was not as pure as say Reinhold Messner who did it without bottled oxygen. We used the bottle on the summit day, so you could say that the ethical,

the style it wasn't quite as pure as his. He's the ultimate; you know a oxygen-less ascent of the north ridge with nobody helping him you know that's the ultimate. We weren't quite there, but we were along way from getting all our loads carried and cooked for. And carry the ropes and all that stuff. So you have to look at the achievement with respect to how you did get to the top of Mt Everest. So we felt good about our climb.

JR: It's Impressive, Do you feel that those people that are being guided should be there?

RW: I understand why it happens…a guide working for me in North Conway area can make $20,000 working maybe 150 days in a year, a guide working on Mt Everest in three months he can make $50,000. So it's big business, it's the bucks. There is a certain guide who, like myself. Has a craving for the Himalayas, and though I don't guide Everest I guide other big peaks over there Cho Oyu, we just came back from Annapurna 4. I think there is kind of a dual sym going on your making a living doing something you absolutely love. You get a fix out of it and the clients provide the means. So I would never knock the clients.

JR: I understand that there are some very dangerous areas, bottle neck areas like the Hillary Step. What's the best way to handle that?

RW: I think there are a couple problems with that, when we summited Everest in '91 we were the only people on the south col period. We had the whole place to ourselves all day. We didn't have to worry about anybody else, we were alone, no bottlenecks, it was terrific. No fixed ropes no problems, spectacular day. No need to worry about the weather nothing. Today with 30-40 people starting out at the summit at the same time, guided or unguided yes you have a lot of problems. And I think it can be safe within reason if the guides and the climbers follow the rules of high altitude climbing, and one of the rules is the turn around time. The turn around time on Everest should be about 11 in the morning. That gives you eleven hours to get to the top. We did it in 8.5 or 9.5, I mean if you can't do it in 11 then you are just not going fast enough. What happens is short roping, fixed roping slows you down. Fixing the Hillary Step and the bottle necking all prevent people from doing it in 9 or 10 hours. You see some of it they are going too slow there not up to it and some of it is they just have too many obstacles to get over and fixing the ropes and all this kind of stuff take time. So I see the problem that, all you have to do is go back and read Krakhauer's book on 1996, I mean they broke every rule in the book and they paid the price, 14 deaths 8 in one day. You want to play with a big mountain like Everest and break the rules you got a good chance, I mean it doesn't always happen, people get away with it. They talk about a rogue storm, I don't buy that at all. Every afternoon they get a storm the wind comes in and the clouds come in. Some days are worse than others some days the wind is only 30 mph and it's only a little bit cloudy and yeah you can manage to get down or get to the top and then get down, but this particular day yeah 80 mph winds and blowing snow storms and the whole bit but that happens every day. If you remember in the book by midnight there was no wind and it was clear again. That's how Bailman who was with the lost climbers navigated back to the camp at the south col. It's a daily meteorological process, the mountain goes through, you need to get off the summit

by noon it's that simple there has never been a guided party that has summited before 11 o'clock in the morning ever, so the odds of guided parties making it to the top and playing by the rules are low. So you have a choice you can turn people around at the south summit 200 feet or 2, 3 hours below the main summit at 11 o'clock and be safe and bring them all home alive or break the rules and take a chance and sometimes you make it sometimes you don't make it , and in the case of the Krakhauer book, wipeout. That's the price you pay by screwing with the rules.

JR: It's nice to get some first hand input on that. Do you feel that the improvement in climbing gear has aided the safety factor?

RW: Absolutely, The gear is fantastic and if you go back to Hillary never mind go back to Mallory and them I mean single leather boots with nails, not even crampons bent over on the inside. I mean, you know, the gear is a huge improvement. What I look back to is the Krakhauer book one of his guys he lost both hands to frost bite because his mittens blew away and basically his nose and ears and his face were destroyed. But his feet were ok because they were in the Everest One Sport boots and it blows me away that if that were Mallory or Irving or Hillary that they would have lost, or well they wouldn't have lived, they'd be dead, so the gear saved him.

JR: How do you feel about the ropes and what not, do they play that big of a role or have they not changed enough?

RW: I think the rope does but I haven't seen a major change in ropes since I have started climbing in the 70's. A rope is still a rope, yeah they have better impact forces.

JR: Same with the 'biners and the pitons and the like.

RW: Yeah they have done some tweaking, there is some lighter weight gear and some warmer clothing, but I think that one of the advantages we have over our predecessors is that we know every inch of the mountain before we ever even go there. I read every book, I've watched videos, and I've talked to people who have done it. So as I came around each corner and got to the Hillary step I knew what was coming. There was very little surprises, I mean it was I very well planned, well executed expedition, we had a lot of information based on the people that had been there. I mean why not. That's the difference between going to Everest and going to Ngojumba Kang 1, I mean who you going to talk to about Ngojumba Kang 1. No body, there isn't anyone who could tell you.

JR: Do you feel that it has made it easier.

RW: Oh absolutely, it's the lack of information that causes stress and fear. I mean you don't know. Think of Hillary going up for the first time. Think of Mallory and Irving, they were told there was a monster at the summit that was going to eat them. You can say in your mind "yeah right that's a bunch of bullshit" but you know there is that one little thing there that says is there something up there waiting for me. As you pull up over the top there is a dragon going to eat me.

JR: Yeah or a Yeti or something

RW: Yeah or a Yeti, who knows until you do it. So we had a tremendous advantage 'cause we had access to the information. If you want to have an adventure you really have to go to somewhere no one has been before. The adventures on Everest were in the 20's and 50's and the west ridge in the 60's.

JR: Do you feel that it is the gear that is allowing more people to get into the sport or is it other things, just people wanting get out and do something outside, do more adventuresome things, sick and tired of being stuck in the cities or what.

RW: I think the media plays a big part in that. I think there are 3 or 4 different things going on there's the real climbers that read the books and make it a personal goal, then you get the people who make millions of dollars and you know Sandy Pittman she's married to the guy from MTV, money doesn't matter, no object and time lets go do something exciting. She signed up to go on one of the shuttles. Then you have the person who goes sky diving gets out of the parachute and says ok now I'm going to go try ice climbing, I'm going to the moon, I'm going to go do this. It isn't that they are skilled in those activities they just want to experience it. I think that's what guiding Everest is all about, experiencing Everest without having to go to school for 20 years to learn how to do it.

JR: Have you seen more people trying to become true mountaineers grow in the last say 10 years.

RW: I'd say that the true mountaineering community, whether your goal be Mt Ranier, or Denali, McKinley, is steady, I don't see huge growth. I see some growth in guiding. And I think that there are certain mountains that are getting guided more and more and more, to the point where the guiding community has to take a look at it. Like Denali and Ranier and Everest. And say what are the route capacities on these mountains and say should we be limiting the number of people on the mountain. On these routes. When I went to Ranier I chose a route that isn't guided much. So if you have the skills you can work around the guided parties. But I don't think it works for the guy with out the skills.

JR: What types of equipment do you prefer to use, what are your preferences, brand names, different types of harness.

RW: Well I being in the business, have a pretty good feel for new gear. I think there is something that is always interesting to me…A lot of people come to me and say I am going Everest I would like to test out some new gear on our trip to Mt. Everest. You wouldn't take untested gear to Mt. Everest, you want to make sure that it works before you go to Mt. Everest. So we do we experiment with a lot of different types of gear so when we find something new we jump all over it. The newest thing in boots, since boots is one of the most important things on Mt Everest, is these La Sportiva Olympus Mods, I actually have a pair right here that just came back from Annapurna IV. And they were fantastic and I would use them over the Everest one sports right now (really?) oh absolutely, I think it's the next step in

boots they aren't 10 times better but I would say they are maybe 5 or 10 percent better, but they are better. But now I have another piece of gear that I would recommend that people use in the Himalayas or even or something like Denali. That wasn't available a few years ago, thoroughly tested, great, go for it.

JR: What makes those different?

RW: They have a molded sole that accepts crampons better, that's about the big difference. Because of the molded sole when climbing with crampons this boot feels more like a technical boot whereas the Everest One Sports are a bit squishy feeling so you have a little more sensitivity (the one sports are a bit sloppy?) right. It adds more sensitivity on the slopes and things like that. That's the one thing that I didn't like about the Everest One Sport they were beautifully warm, great, just a bit squishy. I don't know how else to describe it.

JR: I understand. How warmer, lighter, drier, are the boots, the gloves, tents, the sleeping bags.

RW: I don't think there has been any major breakthroughs since the early 90's when we went. But we would use the same GoreTex/Down sleeping bags. Marmot, Western Mountaineering, we'd use similar one-piece suits, the boots a slight improvement with the La Sportiva, the Ice Axes a slight improvement, slightly stronger for the same weight. The gear has really come around to where it has kinds leveled off. They are constantly tweaking it, but I haven't seen a break through.

JR: How would you compare the technology now to when you just got into it in the 70's?

RW: I was in mountaineering early enough so that I was in double leather boots, with felt liners. The main thing was the weight, and then they would get wet and they would freeze solid as a rock. So we had some wonderful improvements over the years in that type of gear. The rope hasn't changed too much. Sleeping bags, down with GoreTex, super. Lighter weight backpacks, stronger fabrics. We used wool underwear. Now we are using all polypropylene. So yeah there have been some neat changes but if I had to use that gear I could. I climbed Mt Logan in 1970, which was my second big peak, it is equivalent to McKinley, it's 19,850 the highest peak in Canada. I spent about 3 months on the peak working with the Artic Institute, The gear I had was wool pants with nylon wind pants with wool mittens, with a wool jacket, with a 60/40 mountain parka, there was no GoreTex there was nothing like polypro underwear. Yeah we had good stuff for the time. We though we did alright, we thought we were fine, we didn't know any different. The funny thing is with technology is that if you don't know that there is any better then you think you are fine. Then you are happy with it. As the clothing and the boots evolved then they are lighter and warmer you think its great. I don't think there has been anything earth-shattering, if you want to go back to 1920 then every year, the works. I mean those poor guys. There wasn't enough people to pay attention to. I mean the market is based on need. If there is a push, a demand for the gear to get better then yeah they will make it better, then they'll sell it. They can't go out and

make gear better if there is no market for it. That's the economics of the whole thing.

JR: I don't know if you can answer this or not, I don't know if you have any experience with this, but does technology help with any rescue attempts?

RW: I think the technology in rescue is electronics. It's not so much the clothing they wore cause that's all the same in the last 10-15 years. But we are using very fancy rescue radios we can talk to base camp a rescue team and the hospital, we can talk to all those people all at once. We have GPSes. That's the latest in figuring out where you are and where you've been. You take a GPS and you download it at the end of the day. They can plot your course on a computer so they know where the mountain has been searched *exactly*. Not "gee I went up through the woods here and went over there and they make a mark on the map. They go to exactly where you were. The other thing that is interesting is the transceivers that we use, they have been around about 20 years they are a device that you wear if you have been in an avalanche danger area.

JR: An avalanche beacon?

RW: Right, a beacon. And in the last 10 years they have gone digital. And they have become user friendly in the sense that you don't have to train with them for several hours you can just use them. For example, this F1 which is actually quite sophisticated. It would take 10- 20 hours to learn how to use properly the new ones would take probably 10 minutes. I mean you could give them to someone who has no idea how to use it and it will take them right to the person, as long as you got it turned on right. The ones prior to the F1 might take a lot of training. And it's got a lot to do with the signals. Before we used to follow a sound with an earpiece now we just look at a little screen. It'll tell you that your 20 meters from the guy go this way. So that's the stuff we use in rescue work. It's pretty high tech.

JR: What is your experience with obtaining the permits? Was it painstaking, or fairly easy?

RW: The Everest permit in 1991, was extremely difficult to get, there were limiting them only 7 and 3 were for the Hillary route the others were for the southwest ridge and the western face, which we wouldn't have a chance at. (why not?) We just weren't a big muscle expedition to attempt a route like that. You had to get the endorsement from the American Alpine Club you had to prove that your could raise $500,000, you had to compete with all the other people out west who wanted the permit for that year. We got it, we were the National American Mt Everest Expedition for that year in 1991. So there is a lot of competition, a lot of politics, you know I did have the strongest team at the time. So it's fair. The permit only cost $5000.

JR: Only?

RW: Yeah, now if we went with the same 8 guys it would cost $80,000 for the permit. It's $10,000 per person, and all you have to do is write the check to the guy in Nepal and you get the permit. You don't need to get the endorsement from the American Alpine Club, you don't need to go through any of that process. You got the money you got the permit. Last spring there were 27 expeditions on the south side of severest. Most of them on the Hillary Route and on the north side another 20 expeditions for the north ridge. So they let 47 expeditions go on just those routes. So you've got an average of 30 or 40 sherpas and 10 or 20 climbers. Even if you have just 10 climbers you've got thousands of people on the mountain at once. So if even 50 people got to the top on one day its still a relatively small percentage of the people on the mountain.

JR: Do you Feel that that has exceeded Everest's route capacity.

RW: Well I think that this is where the money thing has got in the way, yes, yes I do. I feel that 50 people on the South Ridge is a problem. It take someone about 20 minutes to climb the Hillary Step. And if you got 50 people trying to climb it the math doesn't add up. So some people are not going to make it up. Some people are going to have to turn around or take a chance with their life. They still die up there, there is nothing new about that. Yeah I think that this is a problem. I would be pretty bummed if I spent all my money and some money I didn't even have and work hard for 3 and a half months to get to the Hillary Step and have 10 people in front of me. And then have to turn around because somebody was too slow. Watch the clock hit noon and then one o'clock and have to turn around 15 20 minutes from the top of the world. But that's the right thing to do. The real right thing to do is to avoid the crowd somehow. That was all an accident by the way we were trying to climb it in the eighties, in the eighties Everest wasn't hyped up the way it is now. It seems to be every other day that somebody is talking to me about Mt. Everest, or there is a movie coming out or a video or I got something going on or the 50th anniversary of Hillary or this and that and it seems like its' getting a lot of press.

JR: Like this project. We used to have a project center in Nepal but something happened with the Maoists and it was deemed to dangerous so they shut down the center. We are now trying to reestablish it, and this project is part of trying to get a new project center started.

RW: I going to have to write the book "How to Avoid the Maoists While Trekking in Nepal" Which I have successfully done in my last 5 expeditions over there.

JR: How has the food changed?

RW: Well actually I think we got smart about food. Back in the 70's we used to use freeze dried food and we nearly died eating. Now we bring real food. We have what I like to call airline food. They are all hydrated, prepared food that you just have to heat up. And that's what we use now. So it's a lot better.

JR: What type of gas do you use to cook with?

RW: Well anything over 20,000 feet which is nearly everything you do in the Himalayas you have to use the screw on canisters with the stove set up. They have to be heated because the cold affects the cylinders, the pressurized propane. But if you know how to deal with that they work fine. That's exactly what they used 100% above Base Camp. Where the sherpas establish a base camp at say 17-5 typical height for a Everest Base Camp. They use kerosene stoves. But we don't take the kerosene stoves above base camp because they are messy and heavy and hard to run, awkward and huge. They are great big stove for doing all the cooking.

JR: Have you ever had any experience with the High Altitude Pulmonary or Cerebral Edema?

RW: Not personally.

JR: Not personally, but have you seen anyone with it.

RW: Yes I have seen the effects, we watched, actually didn't see him but saw the effects the next day, of a fellow who was dead on Makalu from it. It's a pretty avoidable situation, if you understand the rules again. And one of the neat things about climbing on the south side of the Himalayas is that your approaches generally start from below 10,000 feet, and you hike up through ten thousand which is at the altitude where potential problems can occur. So if you follow the rule of a sleeping altitude a thousand feet per day over ten thousand then if you do a 10 or 14 day hike up to Everest Base Camp then you should be fine. We've run 25 or 30 treks and never had a single person have anything more than mild altitude sickness which everybody gets.

JR: Headaches, Nausea?

RW: Headaches, lack of appetite may be a little bit of the whirlies. And like I said nothing that ever became life threatening. We have met people in bad shape and help rescue them and get them down. But never anybody in our groups because we are very conservative in our itineraries at altitude.

JR: Great. Did that person end up using a Gamow bag, the one that got sick.

RW: No the guy that died on Makalu was prior to the invention of the Gamow bag. In 1986. we carry Gamow bags with us now, I think they are terrific devices. And we even carry bottled oxygen on our lower altitude climbs and treks.

JR: You mean for medicinal use?

RW: Yeah, and like I said we haven't had too much trouble. And we have helped a lot of people but the real cure is just to get people down to lower altitude. If people get the whirlies and their not doing good, get them out of there, don't sit around and say let's see how he is in a couple of days, he'll be dead in a couple of days, get him out of there.

JR: The mountain will still be there.

RW: That's right. You can go down, recover, and come back up, there's no rule against that. But if you go into a severe situation you need to get out or you'll be dead.

JR: You can't really do to much then. Have you used any medications to help with the acclimatization?

RW: We have dispensed diamox occasionally. It's not handed out like candy like some people do. I hate doctors who say you gotta have it. I have never taken one myself, have been on 38 expeditions over 18,000 feet and never needed it, but I have had them around. I fell that it can become addictive. If you run out you can freak out, you can ruin your trip. I feel that it has a minor benefit that if someone is doing well during the day but not sleeping well at night then it can help, I might give him some to help him sleep better. But I don't hand it out on route and say ok now everyone is going to be on diamox for the rest of the trip. I think that is a huge mistake. That is the only drug I have ever dispensed. There are other drugs that can be given out, which we carry like methadex, or what ever it is that is for the swelling of the brain. It can be injected or pills it comes as both. These drugs I have never used. And the drug that they used on that movie on K2…

JR: Vertical Limit?

RW: Yes, Vertical Limit they were running around shooting something into themselves…I have no idea what that would be.

JR: That's Hollywood I think.

RW: Yes, yes it is. So the bottom line is if you are having trouble with altitude go down. Once you're properly acclimated it is amazing what you can do. And I suppose that there is the person that may just get it after they are acclimated, but I haven't seen much of that.

JR: I have heard about the use of Viagra for use on Mt Everest to help with the acclimatization, have you heard much of that?

RW: Yeah I have heard a little about it. We had a couple of doctors on the last expedition who were joking about it. And I guess anything that stimulates you is going to improve you performance a little bit. I haven't any experience with it or met anyone who has had personal experience with it. The main thing is to figure out how to get oxygen into the blood and if it helps do that then it's going to be good. I have always felt that letting your body acclimate rather than trying to enhance your body some how is the way to go. It's the safest way to go for sure.

JR: What have you used in the line of communication gear. I know you mention the 2-way walkie talkies. Has there been anything else?

RW: That's the only thing that we ever used on any of the trips. And if it's a real climb, you know on a bigger mountain then we will bring radios for every camp, so

everyone knows what's going on. They have improved over the years. They do have satellite phones but the permit for the use of a SAT phone in Nepal is $2000. So you can either sneak one in and take your chances or pay the $2000. Nobody that I have come across decided to pay the $2000 to make a few calls home to mom. The other thing is the Base Station Satellite dish which became popular in the early 90's. Again permits are necessary, you can call home, E-mail, fax and all that kind of stuff. I think one of the things I kinda like about Himalayan Climbing is that you can get detached from the outside world. You can go into the mountains and come out 2 months later to find out that yeah there was a war, or an earthquake. Even if a family member had died you couldn't do anything about it, the only thing that it would do is ruin your trip. I know that one of my grandmothers died while… actually 2 days after I summitted, May 17, 1991, my mom's mom died. And I didn't hear about it until I got home. Not that that would have been traumatic but she was 96 and I would have been like "oh well granny went up to heaven". But if one of your parents died or something, because it take so long to get out of there and get home, your talking from base camp, even if you put balls to the wall, your still talking three or four days. If you got on a helicopter and then a flight to Bangkok, then you flew to LA. Then flew to wherever, your going to miss the funeral. The point is that by being detached, you take away the stress of everyday life, running the business, the school, you know 4 teenagers a wife, you know all the things in life can be really stressful, particularly, money these days. We tend to abuse it so much. I don't experience that stress in the mountains, I get a better nights sleep, I eat better, I get good exercise everyday, I feel great. I'm happy and then when I come home I deal with everything that is going on. Part of the Himalayan experience for me is just getting away getting in good shape and feeling good. Get you batteries recharged. I've been to the Himalayas 18 times. I hope I can keep going I'm 55 now, so we'll see. I used to tell everybody I'd retire at 50 so we'll see.

JR: So you're doing another trek this spring.

RW: Yeah, another trek this spring, I have 14 clients to do a Everest/Cho Oyu trek. For about a month I have a private to the Khunde area we are going to do a trekking peak. Probably (?) with a client that we have guided before. For Spring 2005 look like Cho Oyu from the north, with a guy I guided before, that's a big climb that's a really hard climb. Very profitable climb .

JR: Hard in what manner?

RW: It's very time consuming to climb an 8,000 meter peak you are looking at 6 or 7 weeks instead of 3 or 4. And the clients are paying $15,000 to $20,000 a piece instead of 4 grand, you can make a lot more money, it infinitely more dangerous than trekking. You have to go up to high altitude so you have all the problems that go with that. I will have some assistant guides, so I have to deal with that. Young bucks that are strong and some climbing sherpas that can run circles around all of us. And then after that it looks like back to (merv?) peak in the fall of 2005, so I have the next 2 years pretty well booked. Back to the Himalayas at least 4 more times, and I don't have to get out of this chair and market it. And seemed for a long

time like " how the hell are we ever going to go over there" for the first trip. It seemed like forever to get there and now it's like "what do you want to do?" Let's go do this, let's go do that.

JR: Awesome, good for you. Have you ever run into using any given technology and it failed.

RW: Not really, it took us a while to get cameras working with lithium batteries, and video, but now we have all them working at minus 40. But in the old days that certainly wasn't true.

JR: What did you have to do to get them to work?

RW: Well the main problem with the batteries was when in got cold they stopped working. Until the technology of lithium came along we weren't able to power our video cameras or anything. But now we do we just pop them in and go. I have lithium on my video camera, and it works great. It lasts for 10 hours, its rechargeable and tells you how much time is left on the battery. It's just fantastic. Those are some of the big changes. And then there's the digital technology, if you want we can look at the pictures out there and I can show you the difference there. You can see the difference between digital and slides, slides are obsolete, and I'm still a slide guy. But now I'm taking video. We had a guy on this last trip to annapurna IV that just crankin pictures. He was hauling around the heap of batteries and what not, solar chargers, and computers. But I think that that will all get downsized over the next 10 years and it's the way of the future. Just carry around a small little camera and it will take panoramas and what ever you want to do. It's amazing what that can do.

JR: Is there anything that you haven't said that you feel is important to this project.

RW: I think the most important thing is people understand the risks involved, there is a darkside to all this mountaineering, people get killed and when you're dead your dead forever, it's that simple, you blew it. I think that anybody who aspires to climb in the Himalayas never mind Mt. Everest needs to acquire the proper mountaineering skills, Even if they are guided, I don't want to take people to Everest if they haven't been up Denali, haven't been to school and learned crevasse rescue, haven't learned winter camping skills and avalanche and all that. Have all their gear totally dialed in. When I hear a box of boots opening for the first time at Everest Base Camp and putting them on it blows my mind. What are the odds that they are going to fit let alone if they even work. Guided or unguided they need to get the schooling that is appropriate for the goal that they have and that's where I see the weak link. People just going up with very little schooling into a potentially very dangerous situation and get stuck or separated from your guide, your screwed if you don't have the skills.

Appendix E: Robert Beck E-mail Response

Received March 11,2004. To determine the benefits of modern oxygen systems.

What type, size, weight of the bottles that are appropriate for a Mt Everest Expedition?
Re: 6 to 9 liter water volume

How many is the average/person taken on a climb?
Re: I do not know.

What pressure is typical to fill these bottles to? How much more pressure could these hold (theoretically). What is the degree of safety on these bottles?
Re: Typical pressure 3000 psi for oxygen, however 4500 psi would also work. Safety factor – burst minimum 3.4 X operating pressure. Could hold whatever pressure you required – valve & regulator technology lagging for pressures above 5000 psi.

How would this type of bottle compare to the breathing apparatus used by firefighters?
Re: Same design and materials of construction.

What materials are used?
Re: Aluminum liner (6061-T6) carbon fiber max. tensile strength of 750,000 psi, epoxy resin and hardener and fiberglass protection layer.

What is(are) the manufacturing process(es) that is (are) used to create the bottles?
Re: Deep drawn liner, spun closed, heat treated, ported, liner coating, wet wind carbon with resin, wet wind fiberglass, add label, gel, cure, autofrettage, hydrotest, FlowCoat, seal seat, inspect and ship.

What makes the SCI system better than the Poisk system?
Re: Do not know anything about the Poisk system.

What else do you need to use the system?
Re: Procedures, controls, qualified operators, advanced Engineers, material specifications and testing equipment.

Can you provide me with any details on masks, regulators, etc?
Re: No.

Do you have any Mt. Everest Experience? If so, I have another questionnaire that I could send you if you have the time.
Re: No.

Could you share any information that you have gathered detailing the effects of Oxygen use on a Mt. Everest climber?
Re: Do not have any.

Appendix F: Rustem Gamow Interview Transcript

Phone interview January 27, 2004 1:00 pm. This interview was used to determine the usage, effects and creation of the Gamow bag.

John Richardson: The first question that I have for you is: What was your inspiration for designing the Gamow bag?

Rustem Gamow: Oh, actually, one of my early early students, my first year on the faculty in 1967, and at that time he was a rock climber. And I was an assistant, in the lab I was the boss, and he was the student. On the rock, he was the boss and I was climbing behind, at that time cleaning the rock of pitons etc. Many many years later I had another student, and we were working on where to train, where would an elite athlete train, the best place in the world to train. Many people had said, and this was in the eighties, at altitude. People went to train at altitude with the sort of thinking, I guess, is that if there was less oxygen the body would adapt and become more efficient and therefore there would be benefits for you at sea level. My student was a high school athlete and said "no", he didn't really believe that that was true. We looked at some papers and it did turn out that performance increased as you went down in altitude and even below altitude. There was an experiment down in, I think it was a gold mine in South Africa, 5000 feet below sea level. If you measured aerobic capacity it increased. Now, that's pretty obvious but it wasn't obvious to us 15 years ago. So performance just decreases as you go to altitude. And we concluded that if performance decreases as you go up, training would decrease. Because we coupled the two, just lying in bed, your having no performance and therefore no training. But if that's true, you should really perform, of if you train where you perform where you do maximum, at sea level or below sea level. So that simple project we put together probably in 1985, maybe 1984 or something like that. At about that time *Sports Illustrated* got a hold of the article and wrote quite what I thought was the complimentary article, except I guess, it was not too complimentary, they said there is this eclectic, eccentric professor at university of Colorado, who thinks you should train not at altitude but at sea level, or below sea level. They had a cartoon of somebody running in a gold mine. So we had built a device, we had called it the "bubble," it was 8 feet in diameter and you could blow it up with a vacuum cleaner and pressurize it. You would put a trainer inside it, and actually train in Boulder, Colorado, but it would be at sea level. If you put two and a half psi. in you would be back down at sea level. So you could live high, which is an advantage because you have more red blood cells. But train low a couple of hours a day, you'd be in the bubble. Then one night, one late night at 11:30, 12 my first student who had read about it in *Sport Illustrated* and he had been climbing in Makalu the year before hand, and his best friend died of altitude sickness. He is the one who suggested, why don't you take the bubble, which is this great big thing, and make it small. Not to improve training but to treat mountain sickness. And so within a week we went from a bubble to a soft sausage. The American Alpine Club heard about it and invited me to Las Vegas. Then as they say everything else is history, because that is the invention that got everybody's attention. So we went out not to design a device for mountain sickness it wasn't a

medical device, it was a device to train athletes. So when I teach my classes you often find new device, so you need to keep your eyes open for everything. I think Post-it Notes, allegedly, somebody was trying to get the best glue in the world, and he got something that was sort of reversibly sticky, and they got Post-it Notes. And they made billions of dollars. And Teflon is another story like that. So sort of the accidental.

JR: A lot of times that happens, you just need to know what to look for if you do notice it. Not be like aw it's a mistake and throw it out the window.

RG: Right, absolutely. And being a professor is the nicest of all possible worlds 'cause you have all these young people, with tremendous energy, and a bunch of ideas. Like most peoples ideas, most of them don't lead anywhere, but you just have to work through them. That's kind of a long winded answer to you question.

JR: That's fine that's why I am recording not trying to get this all by hand. It's better to just have you talk than feel rushed. Take your time, I'm obviously not going to complain about the amount of information that you are giving me. You've also actually answered my second question with your answer to the first. So I am going to move on to the next question. What other areas can these bags be used? What other applications do they have? Rather than just treating altitude sickness.

RG: There's a company called Oxy Health and they have been using the patent that we had for the mountain bag, they have a medical device in which they use mild hyperbaria, meaning 3 or 4 psi gauge, to treat a variety of medical symptoms. I'm not too familiar with that. I have seen some of the data. Groups of people in every field are always suspicious of each other. There's something called HBO, which is Hyperbaric Oxygenation, which would treat black lung disease, decompression disease, and wound healing and carbon monoxide poisoning. But you used a tremendously high amount of pressure and you use pure oxygen. 1 or 2 atm of pressure or more.

JR: 2 Atmospheres??

RG: Right, and that's what the medical device is. And there's some controversy about mild hyperbaria, which is which is only a fraction of an atmosphere, would have medical benefits. But apparently, a lot of people believe they do, and as far as my only involvement in that case is that I get a royalty fro m people who use my patent. They tried to use the bag for various different, they tried to make it into a slightly higher pressure and make into a decompression bag for SCUBA divers, for the divers who have gotten the bends.

JR: So, something they can keep on a diving vessel rather than having to transport the diver to the hospital.

RG: Right, well before you transport him to a hospital. My feeling is that none of this has really taken off. Partly because the bag itself, the real great benefit is that it is so simple, air tight zipper and a pressure release valve on an air tight bag and you

can backpack it any where in the outback. Once you try to get higher pressures with oxygen, like the bag they make for dive boats, then you have to have SCUBA tank to blow the bag up and if you are using pure oxygen then you have to have a special face mask, which brings in the oxygen and then dumps it to the outside, because you can't have oxygen in fabric, and so its much much more expensive and much more cumbersome. But what the bag was designed for finally was for the outback for the high altitude; from my point of view it has saved thousands, well you can't really tell how may lives it saved because the people didn't die. You can't necessarily tell for sure they would have died.

JR: What exactly is the premise behind the bag? How does it work? In other words describe its operation.

RG: All it does, well all mountain climbers for the last 100 years or so have high altitude climbers have known that the cure for mountain sickness, all types of mountain sickness is to descend. Just go down. Peter Hackett who is probably the best known High altitude physiologist, has said if a man is drowning in a swimming pool what's the first thing that you do. And nobody almost comes up with the right answer. What would you say, if a person was drowning in a swimming pool how would you treat him?

JR: Get him out.

RG: Yeah get him out of the swimming pool, well congratulations, most people don't say that. Most people say mouth to mouth resuscitation or what ever. But get him out of the swimming pool. So if your dying from high altitude…

JR: Get him down.

RG: Right get him down. Now if there is a helicopter there or plane there that's probably the easiest way to go down. But often, particularly Tibet or the Tibetan Plateau, there's no where to go down, or if your hurt, you can't walk, the weather is bad. But the bag will take you down within a couple thousand feet, 6000 feet, in a few minutes. 'Cause all you do is pump air in with a foot pump, and if you put an altimeter in there you can be at 20,000 and two minutes later you can be at 4000. So it's simulates descent, but it is exactly the same air that you have when you descend.

JR: Because it's the partial pressure, not the actual amount of oxygen, that's doing the damage, right?

RG: Well, because the partial pressure goes up the percentage of oxygen remains always the same. It's the partial pressure that is important. If you go down half an atm. Then of course you increase the concentration by a factor of 2. So that's the simplest explanation, you simulate descent.

JR: How quickly can you inflate this bag? 2 minutes you said?

RG: 2 minutes or less.

JR: Wow. What is the pressure that the bag is inflated to?

RG: Well I'll say 2 psi gauge, meaning that if you are at sea level and its 14.7 psi on the outside it's 16.7 on the inside.

JR: So say you are on the summit of Mt Everest, you've got approximately 7.3 give or take psi.

RG: I don't think so, it's a third of an atm. So It would be about 4 or 5 psi.

JR: So then 2 psi above that, so your talking about 7 psi.

RG: Well it's a little more complicated; now I haven't talked and thought about this in a couple of years. What we normally say when I talk about it is when you go into it and put 2 psi in it you go down I kept telling you 6000 feet, the higher you are you always have 2 psi gauge, but the higher you are the bigger difference you get. So if you are at the top of Everest at 29,035 feet or something you probably go down 9000 feet. So its kinda good news, You'll never go down to sea level, but it turns out that going down several thousand feet has always been a great benefit.

JR: What's the limiting factor here, why can't you put three or five psi in? Because it's a fabric bag and it just won't hold that much or…?

RG: Well more or less,. It turns out that before we get the patent for it, there were many chambers and they were all made of steel and with concrete and were really heavy. Because if you want to put in 35 psi, a couple of atms if you wish then it's like a bomb. The type of pressure we put in is more like putting it into an air mattress, or a sleeping pad. So we tried comically, we tried some polypropylene and some macramane, and turned around. I have a tennis court at home and a couple of students and I put in oh 1 atm, about 15 psi, and we had it on one side of the tennis net net and we were hiding on the other side of the tennis net, using binoculars to read the gauge because if it were to explode it would be a big explosion, whereas if it were two psi then its really not that dangerous. So physically, it's not very destructive but physiologically there is a tremendous benefit.

JR: How long would you say that it takes a patient to show signs of recovery?

RG: You know nobodies ever done tremendously quantitative experiments. The one that I was involved with was in 1988 and there was a young woman who was a physician from Australia if I remember correctly. And she had a high altitude headache and a raspy cough and the doctors up there at the clinic, which is about 16000 feet, said you are going to have to go down or just stay here until you feel better, and the headache goes away. This was sort of a standard treatment. She was eating and walking, she wasn't catastrophe bad. But this is one of the first times that we thought of using the bag. So she said she would try it, I forget exactly what the numbers were, but here were about five of us standing around, and you could

talk to them inside the bag. And I said to her how bad is your headache on a scale of 1 to 10. And it was a 4 or something like that, and after 10 minutes it was a 3, after another 10 minutes it disappeared and the amazing thing was on that one experiment it never reappeared. And so two days later she went climbing. So it depends on how bad you are but if you have a chamber you certainly want to go into to it before you start spitting blood and going into a coma.

JR: Obviously, but you start seeing physiological changes within a few minutes. Great.

RG: I would say probably 10 minutes. We've had people both in '88 and they were unconscience in the bag and they were in the bag for 2 hours and they were feeling much better. We would open up the bag and give them some hot soups and Tibetan tea and would go back in again. In one case the helicopter came the next day and flew him out, it bought him a lot of time. But he walked to the helicopter whereas he had to be carried on a yak when he came to the clinic.

JR: Where was this, did you say?

RG: that was in a place called the Himalayan Rescue Association Clinic in Nepal. It's a about a 1 day or 2 day trek depending on how srong you are from base camp of Everest. Its called Tharache I thinks its T-H-A-R-A-C-H-E.

JR: Ok, so this isn't the Khunde hospital.

RG: No this is on the way to Everest. Well so is Khunde but this is again about 2 days depending on how strong you are from Khunde.

JR: How heavy are these devices? Just so I can get an idea of portable they are.

RG: The bag is eight pounds. And the backpack and the pump is another 4 pounds. So its about 12 pounds.

JR: Wow, not bad at all.

RG: Yeah compares to a couple hundred pounds.

JR: Right, when did this start becoming an excepted device, when was it's use really starting to become widespread?

RG: Well I would say thatg in the beginning in '88. I sold the technology to DuPont in 89 if I remember correctly and the donated a few bags to the Khunde hospital up there and Sir Hillary, and it was a standard device up there and they were wearing out pumps, cause you know we built it for occasional use but in the hospital it's 24 hours a day. It was a very simple device and I felt very lucky just to have stumbled upon it . And I tell everybody its fame and fortune, lots of fame and not so much fortune.

JR: It's an amazing discovery and its helped a lot of people. You've already answered what they are made from. Have you run into any similar devices, like is there another device that can help with this?

RG: the are a bunch of copycats, and the funny thing is when you make a copy cat there all called Gamow's bags. It's like a trademark. I still call IBM copiers, Xerox machine because Xerox is just what we called in the old days.

JR: Right, nobody says cola they all say Coke or Pepsi.

RG: Right, right and inline skates is rollerblades and Rollerblade of course is a company name. So there is an Australian group making the bag and I've never seen one, I've seen pictures, it has a rear entrance. It's called PAC, P-A-C I think it's called pressurized air chamber. And the French copied the bag, and I was there when they copied it actually, on Everest. And it called Cirtec and it's made out of Leon France then I understand that the Pakastanians have made a device like that. At one point there were lots of legal conflicts and lawyers back and forth which is all a little humorous it's a very small market still. And the army now uses it they have it in Afghanistan I haven't seen it but I understand that it is in camouflage. When I sold it, I sold it in '89 to DuPont, I sold everything, I sold the patent and all the know how and this and that. My whole goal in life of inventions is to have someone else market it and develop it and four times a year send me a check. Which they have been doing religiously so far.

JR: Yes, I saw on your web site that you would much rather do research than marketing.

RG: Right, Right.

JR: Which I don't blame you. What altitude do you feel that these device start to become useful. For instance at 10,000 feet or are there instances where it becomes useful even under that?

RG: There's a little bit of controversy, I think most people…You can always find any number you can look for. There are some reports that people have died at 8000 feet and even 5000 feet in Denver. Most people don't believe it, most say you need to be above 8000 feet. Ski areas, for instance here in boulder, Colorado, I know people get in trouble when they come down and they come from sea level and fly into Denver they are up all night drinking alcohol and eating greasy hamburgers. They get on a ski lift and boom they are at 11,000 feet. 10 people a year die in Summit County from high altitude. DuPont at one point tried to have bags in all of the ski areas, that turned out to be sort of a failure. Because, if you are really sick then they put you in an ambulance and they drive you to Denver. And you feel just fine but not because the ambulance did anything, but because you went down. That's probably still being done, or they just put you on oxygen. You got 5 people coming in an sucking oxygen. So if you have a medical facility, and you have oxygen and warm rooms and ambulances, then the Gamow Bag is a little silly to use. But if you happen to be at 20,000 feet and 5 days away from anything. The bag really showed its colors for what it was designed for…the outback.

JR: So it's more useful in remote areas than it would be a t a ski resort. Have you seen any improvements or have you made any improvements to it since you invented it, or did you wash your hands of it after a while?

RG: I think the mountain bag is basically the same bag that I sold back in '89 I think it almost Identical. The corporation OxyHealth I saw their bags just recently and that's made for medical devices. And that's much much heavier, whith double zippers and you got a frame on the inside, you've got an electric motor and big windows. But they cost I think $10-20,000. I don't know you might want to look, I didn't look at their website, but its called OxyHealth.

JR: How much is the Mountain Bag?

RG: Oh I think it's the same price, $2495 or something like that. I'm not really sure. I remember when, before I had sold it, or just when DuPont had it. It didn't act very price sensitive. Now I can act like a business man, I'm working on another invention, and hopefully I will start marketing it in March, and it's a coat for a dog, I will tell you that much. My feeling is that it should be $39.95, that's my feeling, so we have to figure out how to make them and advertise them and still make a profit at $39.95. If we did it at $69.95, I think that it would decrease; you know people wouldn't buy it. You increase the profit but you decrease the number of sales.

JR: Naturally, you said twenty four ninety five for the mountain bag, that's twenty four hundred ninety five dollars right?

RG: Two and a half thousand yes.

JR: I was going to say wow.

RG: It's a little interesting. When I was making them I was making them for $1000. I was having them made in Chicago and was selling them for $2000. So a factor of two over the manufacturing cost. And I sold, I don't know a hundred, I don't know how many I sold. So a hundred times a thousand, probably not that much. But I made a thousand dollars off every bag I sold. But when I sold the technology to DuPont, I sold probably 100 and DuPont sold a thousand but instead of getting 50% I only got 5%, so it turned out that it was about the same number. You sell a lot for a small profit rather than a few for a big profit.

JR: What other projects are you working on the help lessen the physiological effects of high altitude? I understand if you can't really talk about any of these.

RG: Well I am working with another student, well ex-student who is in my lab for a few years. And his name is Aaron Shupp and we have been working on a high altitude mask and it humidifies the air, so if you are sleeping at 20,000 feet so you get warm air so you don't use body energy to warm up the air and it's humidified so you don't get dehydrated. It you also get a little bit of CO2 so you increase your rate of

breathing. We've got a letter in wilderness medicine coming out, I hope, soon. So what you should do, when is your paper due?

JR: We are trying to finish it up in five weeks from today so we are kinda on crunch time here. We spent, oh I don't know, we started this project at the beginning of September. You know we spent quite a few weeks. Just doing background research, then a few weeks doing a rather intensive project proposal, our project proposal is like 35 pages long. Because it incorporates a lot of things, one of my partners is concentrating solely on communications; one of my other partners is concentrating mainly on how the technology has affected the social aspects, like how it has affected the Sherpas, and the other Nepalese.

RG: That's very very interesting. Are you an Engineering student?

JR: Yes I am. I am a Mechanical Engineering student with a Materials concentration. So I, am a rock and Ice climber myself, so I am gravitating more towards the gear, so when someone says this is a carbide coated Ice axe, I know exactly what it means, whereas when someone starts talking about electronic jargon, I don't know it but my friend who is an electrical engineer does, so that is why he is concentrating on the communications aspect of it. So we are taking all of our strengths and combining this all into one project.

RG: That's wonderful, for many years, I haven't taught it in a few, but I taught a course called structures. Well Structures: why things don't fall down. And actually I ended up teaching the seniors in mechanical engineering who needed the course for graduation, and of course all of them knew more, and of course I'm a biologist, I'm a completely trained biologist. Although, I have been an Engineering professor for 37 years. It was a wonderful course, I wish I had a video tape of it because one group of students, a group of students three at a time was going through one at a time, would go through the design of snowboards and I was like holy smoke. And another, again a three man team, went through the design of a baseball. You know what it takes to make a baseball. Then some hockey equipment even shoulder pads. But all from structures all different aspects of it. But as you said they always cover it from a purely marketing point of view, from an electrical point of view, a mechanical point of view. It was a wonderful class, I enjoyed sitting back and letting the students do their thing.

JR: I had a class similar to that, now WPI is kinda unique where it has seven week terms, instead of a 14 week semester. So we move extremely, extremely fast here so we had to take a simple object, we chose a combination wrench and we had to take it from a conceptualization all the way through market research and everything all the way to the final product. We had to say if we are going to make this we would need to have this many of this type of machine and go through all the processes. Figure out how long it would take to make one, how much it would cost for materials, how much it would cost for labor, how much for janitorial staff, every thing. (RG: a widget) yeah pretty much and get this done in seven weeks, with three people, normally you have a company that does this and it takes them a year. So we are sitting here like, wow, so what we wanted to do was improve a wrench,

ok what's wrong with it. Ok it wears out and it causes the bolts to round off. Lets make it out of a harder steal so it lasts longer. Right now it's conductive what happens if you drop that across the terminals of your battery what if you your working on your car, you'd get a good jolt. Ok let's coat it with a an insulator, well we can't make it to soft, like if your working in a high heat applications, Polycarbonate has a melting temperature of 550 degrees Fahrenheit.

RG: You're saying wonderful stuff and that's what we started doing a few years ago. We have what we call ITL, Integrated Teaching Laboratories. What are you going to be doing after you graduate?

JR: I'm going to go on to grad school.

RG: In mechanical engineering?

JR: Yes, well Materials Science and Engineerig, I'm going to continue focusing down until I find something that I really want, so I've got the Mechanical degree with the concentration, them I'm going to turn that into a Master's degree, then someday down the road I want to get my PhD and concentrate in either polymers or ceramics.

RG: If you like these things, being a professor, it's almost a political situation, particularly modern days, but it's a wonderful life, always working with exciting people and if your not the kind of professor that says I have to use students as technicians then you can learn almost more from the students as they learn from you. Which is wonderful. Yeah it's always a joke from my day, that behind every successful man there is at least one exhausted woman a wife. Then behind every professor there are ten exhausted PhD students. The professor writes the grants and the students do the work. But there should be a compromise in between. Although the rules have changed a little now because they work in larger groups. My personal history was like I was adopted by an engineering college and I have been teaching students about space biology, because I was at the beginning of the space problem and there was a lot of money in that. But now you have engineers that know lots of biology, but I was the first one that was brought in from the other side of campus.

JR: I see you are listed in the Chemical Engineering Department.

RG: We have changed the name it's now the Chemical and Biological Engineering. After 100 years,. I guess the acronym is CHBE but it doesn't come rolling off the tongue. I would love to see this once you complete it, or have a good rough draft of it. You can send it to me, Email it to me, that would be wonderful.

JR: It'll probably be quite large so I'll warn you ahead of time so you can check to make sure there is enough room in your mailbox.

RG: I would prefer a hard copy, because I would just make a hard copy anyhow.

JR: I can certainly get your mailing information from the website, right?

RG: Oh I think so. Let me just give it to you it's just my name, Chemical and Biological Engineering Dept, campus box 424, University of Colorado, Boulder Colorado, 08309

JR: Ok, very good. I'll let you know when to expect that.

RG: If you ever come out on a red eye special, we can have dinner down here in boulder.

JR: Thank you but time and money is both short handed right now.

RG: It only gets worse

JR: Please don't tell me that.

RG: I know, I know. The best thing that I have told my students and I have told them over the years. When they are suffering, particularly engineering students, my courses aren't very hard, but they have difficult courses, and they are suffering before finals. Just think you'll look back 10 years from now or 20 years from now and you think these were the happiest days of my life. I remember one lady looked at me and said Professor Gamow that's really depressing.

JR: Seriously.

RG: Well it's a little bit true and a little bit not true.

JR: I can't see this being any tougher. I took a break for a while and went on co-op and I just excelled at my job without having to put much effort into it and I had all this free time. And could do what I wanted to do but this whole school thing is very difficult.

RG: Oh, I know I was running for many years, I don't run it any more but I ran the pre-medical program for many years. And the arts and science students saw that we had to suffer through the medical curricula, but if you have engineering training then you might lack some of the bedside manner but in terms of the work load, it's a piece of cake.

JR: One of my friends graduated from here then went on to do his master at a different college he says he hadn't had that much free time since kindergarten.

RG: Well listen good luck, let me know if you have any clarification questions you can send me an email and I will try to answer it.

JR: It's been a pleasure talking to you.

RG: Thank you very much.

Appendix G: Thomas Keil Interview Transcript

In person interview on January 27,2004, to examine the culture of Nepal around Mt. Everest.

Ryan Seney: We're just here to interview you for the IQP we're working on. Did you look at our project proposal at all?

Thomas Keil: No I didn't

RS: Ok. We're doing an IQP about the technology use on Mount Everest and the region around it, um, like how it's filtered down into the local communities and stuff like that. So we'd heard that you were going, had been to the area and were curious about that.

RS: When have you gone to the area?

RS: Ok. When have you gone to, uh, when have you traveled to the region? Like, any specific times?

TK: Well actually several different, different times. My daughter has lived there for 15 years.

RS: Ok

TK: So uh… I guess I've been there about six, seven, eight times.

RS: You've been there recently though?

TK: Two, a year and a half ago.

RS: Ok.

TK: But I should say that I've never really been very close within Mount Everest. I've been in the Sherpa country. But… but… yeah, the Mount Everest area is so crawling with tourists, its not a nice place to go.

RS: So you've been, like, to Kathmandu and places like that?

TK: Oh sure, Kathmandu. My daughter lives in Kathmandu.

RS: Ok. Alright, cool.

TK: I've been to a lot of other parts of Nepal, but never really to the Everest base camp or Namche-Bazaar, or any of the tourist destinations, I try to stay away from the tourist areas.

RS: So the main purpose of traveling there is to visit your daughter, or were you there just doing…

TK: Nah, I'd go visit my daughter for a while and do a trek.

RS: Where have you gone trekking, actually?

TK: Long-ton, national park, which is fairly west of Everest, east Nepal, jajowa Nepal, (inaudible)which is next to Makalu its the fifth largest, highest peak in the Everest region (trails off) Makalu base camp, which is in north sherpa country Monaslu, which is again west, its west of, well between Everest and the Anna Purna Range, the standard thing is to go down there to the Anna Purna range but again that is another area crawling with tourists.

RS: Where exactly, where did you stay like when you were visiting, like, were you staying in hotels, or just…

TK: Sometimes in a hotel in Kathmandu, sometimes with my daughter. Of course in a tent when I was trekking.

RS: Did many of the locals speak English that you encountered?

TK: Very few.

RS: Very few. So, so you were outside the tourist areas for most of that?

TK: Uh, yes. Yeah, the closest that anybody comes to speaking English are those guiding a trek, to the people living there it's not needed

RS: Um. Did you encounter any other languages on your traveling around?

TK: Pretty much anything you can think of. Well, Israeli is spoken a lot there.

RS: Were the local people receptive to visitors when you traveled? Did this vary during like, did this vary from place to place, or was it for the most part?

TK: Yeah, Nepal is several hundred different cultures, different ethnic identities, different traditions and all. So yeah, there's a big range. In some areas, everybody is extremely curious of the Westerners. In other places, some people have never seen Westerners, and they're not curious. I speak a little Nepali, so I can have a little conversation, a simple conversation. Not that Nepali is the first language of a lot of people from Nepal. In Sherpa country, you find Sherpa, Nepali is just the standard language of the country. But then they grow up with a different one.

RS: How many other westerners were in the areas when you went away? You said that you stayed away from most of the tourist areas, but in other areas where you went, where there still a small amount of Westerners?

TK: It depends. The first trek I went on was along Lon-ton Valley which is a popular trekking destination. I'd say, in ten days, we probably saw about a dozen Westerners. The last trek I was on, the only Westerners were the group who did the trek.

John Richardson: Basically, if you don't want to see anybody you don't have to.

TK: No, you don't actually, it's interesting one of the treks I went on, the Mount Sulan, but actually my guide didn't speak very good English. So we get to the middle of this trek which was 25, 26 days and ran into a friend who actually worked in the trekking industry and it was the first real time I had to speak English, in two weeks.

RS: So basically, you spent a lot of time walking around the country side, and stuff like that? Do you visit a lot of villages or towns, rather than cities?

TK: Yeah. There are very few cities, Kathmandu, well Aprensive Nabrahamar, which is to the south (inaudible) in the middle of the country. But it's hard to even call either of those places a city. Kathmandu is really the only one I would call a city.

RS: What forms of technology such as electricity, phones, cable/satellite tv, computers, etc. did you observe being used when you were traveling? Did you notice any of those?

TK: Sure. Yeah. Again, it depends on what little bit on the part of the country. The issue in Nepal is basically poverty. You know, it's a very sophisticated culture in a lot of ways but the per capita; the income is only two to three dollars. Most people only see two to three dollars in cash. So most Western technology costs the same in Nepal as it does here. Nepal is an unbelievably cheap place to live, you can get a good hotel for $15 a night. If you want a shared bathroom, you could for $5 a night. The food was cheap. But, buying a television set for your living room costs the same as it does here. But two of the places that I visited was close to the Everest region, which was the Sherpas, or the people who do the trekking industry. One of the few sources of Western currencies in the country. It's a fairly affluent region, a lot of houses have solar electric panels, those who have been on top of can run a radio and those are expensive $6000. One of the ways you can tell whether an area in Nepal is affluent is by looking for solar panels. And actually, the Delpo and Wistcont region is affluent for another reason. The people there are really good traders. They bring rugs from Tibet take them to Kathmandu and they raise goats and sell them. So they're well too see solar panels. There's not a whole lot of electricity in Nepal, away from the roads. And there aren't a lot of roads to speak of. But there are a few places. The ideal solution for electricity in Nepal, in my opinion, is a submersible turbine, which would be in a stream. Nepal's got a lot of water. In principle hydro-power is the way to go in Nepal. The problem is you can't build dams because anyplace that is even slightly flat, is there cultivated, they're growing rice or wheat. And to build dams means to flood it something very controversial in Nepal Most of their big hydro plants you'll have to displace 200,000 to 300,000 people, and there's no place for them to go. Because the country is very crowded. So you need to seek alternatives. 20 kilowatts provides

enough electricity for a village. You'll see that. Again, it's a question of affluence. People know about submersible turbines, (trails off) Places that have that, people have VCRS, so you can watch video tapes. But you risk changing the culture in a lot of ways. I don't think I've ever seen a computer, outside of Kathmandu. Well not true. Pokoro is a sort of resorty area, there's hotels there, it has some business there. But you go to a village; I've never seen a laptop.

JR: (Something about satellite phones)

TK: Occasionally, you see satellite phones. Cell phones don't basically even work, in Nepal due to the Mountains. So satellite phones are the way to go. Again they're expensive.

JR: The permit, to use them in Nepal is $2000, so most of the people that I have talked to just smuggle them in?

TK: The last time I was there we had a satellite phone. Yeah I never called anybody it's expensive.

RS: So pretty much the technology is mostly limited to places where they can find power such as cities and stuff like that?

TK: Right. And of course, power in Kathmandu, there's blackouts, brownouts, a lot of the system. Depending on the time of the year. Spring typically there's a lot of water. Fall it's dry. So that' s when you get brownouts.

RS: So kinda like California.

TK: There are other sorts of bits of technology around. You know there's a war going on? In the center of Nepal.

RS: Yes.

TK: But the army posts, what are left of them, they have solar panels, and they have radios there. that's what you usually do if you get in trouble, what you try to do to is get to an Army post. But I don't know if, you've never been to Nepal?

RS: No.

TK: You know, one of the ways to understand a little bit about Nepal is to meet a Nepali and ask them where they're from. They'll give you the name of the village, which region. So you say "Uh. Where's that?" They'll tell you "It's an eight day walk from Jeerie." Jeerie's where the road ends in the Sherpa region, so you can take a car up to Jeeire, and you walk, that's the standard mode of transportation. Now there's an airport, but that's money again. And it's actually kind of dangerous. Because the altitude is 4,000 feet. If you fly in there, you have to be very careful to the acclimatization period.

RS: So when you traveled, were you able to communicate back home then, primarily through the use of phones?

TK: In Kathmandu, yes. Of course I could've used a satellite phone but I thought it was [unneeded] to use a satellite phone. So you're not going to use it for routine conversations. I didn't use it at all. It's specifically for emergency use.

JR: What are the regular phone rates there?

TK: Well, they're high. It costs… it really depends on how you do it. There are all kinds of internet operators. We typically pay a dollar twenty per minute, for a long distance call to Nepal. Which is fairly high, when you can call Europe its 60 cents. It costs about twice that much. You'd be better to go there. There are these floating 1800 numbers that you can call, when they're working, you can call long distance for about 20 cents a minute, but they don't always work. We've tried a whole bunch of those over the years. Actually, E-mail is a good idea, especially in Kathmandu. She teaches (inaudible) in fact, if you look at their house it looks very Western in terms of technology. Refrigerator, all those kinds of things but they're very affluent. Still, my daughter's salary is $250 a month, which sounds pretty dismal here, but it's enough to live very well.

JR: More than the average person makes in a year there.

TK: Yes, more than the average person, your typical civil servant's salary in Kathmandu is $30 a month. Even in Kathmandu, that's not a lot of money. You've got the apartment, which is $50 a month, [something smaller] for $30 a month. You know, very spacious.

RS: When you've been to the area recently, were there a lot of cyber cafes in the cities at all? Did they usually appear to be busy at all?

TK: I don't know that I would call them cyber cafes. There are a whole bunch of E-mail, internet services in Kathmandu. But they aren't the way we think of cyber cafes, you know a whole bunch of computers. They tend to be little tiny holes in the wall with like one computer, you walk in and if there's nobody there, you pay to sit and do whatever it is, send a message or make a phone call. That's what a lot do. So if they're in a place that has electricity, they would go to the store, since that's a public [phone]. But Kathmandu, you can buy anything in Kathmandu. The country is poor, but Kathmandu has a street, I guess, for Rolexes, you can buy Rolexes there, anything in the world is available there, because it's a tourist destination.

RS: Did you ever use any of these cyber cafes that you saw around?

TK: Yeah. I've used E-mail.

RS: Was the main user clientele mostly westerners or local people?

TK: It's a little bit of both. There are a fair number of Nepalis who travel around the world. Particularly, people involved in the trekking industry. The Sherpas have done really well financially with the trekking industry. Very often, they get invited by somebody they guided to come back and visit them in the States. There's a music camp that I go to every summer, which has a Sherpa cook, who treks. He comes there every summer, which is off trekking season, and works as a cook. So there's a fair presence of Nepalis in this country. So these cyber cafes, that's a way of communication with friends and relatives.

JR: Do they use the internet for business purposes as well? Being there are a lot of Nepali sites per say.

TK: There are not a lot that are really in Nepal. There's one that I look at all the time: Nepalnews.com. But the website is actually here, to avoid the government taxes on things like that in Nepal is high. The stories that are on Nepalnews.com come from Nepali newspapers and from Nepali reporters and whatever, but that website is physically in this country.

JR: Do you think there's a lot of that going on? You see someone starting a trekking service over there, they'll team up with someone over here in the states and say "I need a website, I want people to come here, what can you do for me?"

TK: That's a very common way to do it. The bandwidth to Nepal is not great.

JR: Yeah, we've heard that.

TK: Anytime you try to use an actual Nepali site, there's no guarantee that it's going to function particularly well. That's true of telephones as well.

JR: We've heard what the entire country uses. Any one WPI student takes that up if not more.

TK: Something like that. I don't actually spend a lot of time looking at real Nepali sites. The ones that I look at are physically located in this country, because of functionality.

RS: What is the general attitude of the people in the region to using technology? How accustomed are they to seeing new forms of technology? Do they seem willing to use it?

TK: We're basically talking about communications technology and electricity and things like that. I think there's been a change in the 15 years that I've been going there. I already said that the amount of change up there is really substantiated over the period of time. Substantially relative to zero, still at a low level compared to this country. Fifteen years ago, E-mail wasn't all that ubiquitous in this country either, but it was basically non-existent in Kathmandu.. You couldn't use credit cards, but that's technology also. But that's changed now, credit cards are in Kathmandu at

least. In a village, there's nobody that knows how to use a credit card, but in Kathmandu, credit cards are known about.

RS: Does it seem like the region would benefit from the flow of technology into the area?

TK: That's always an interesting question, because you change cultures by introducing technology. That's part of the reason why I've never been to the Everest region or go on the Anna Purna Round. If you do the Anna Purna Round during high trekking season, in October-November or March and April, your gonna see more Westerners than you will see local people. There's like 50,000 people that do the Anna Purna Round every year, and there's only a few thousand Nepalis that live in the villages. The same thing's true going to Everest base camp, but it's not quite as many people. And it's really changed the culture, westerners like to have the native people dance and play music for them. So they dance and play music for them. It's not dancing and music that they do themselves, they're just making this up, entertaining the tourists. It's really those two areas where the culture has been distorted. The same thing would happen if large amounts of western technology come out, if they were available. It's the simple things like, most people in Nepal don't have refrigerators. If everybody had a refrigerator, it changes the way you buy food. It changes the economy, of the area, and trekkers already do that, malnutrition is a big issue in Nepal. Trekkers insist on buying eggs, and buying meat and vegetables from Nepalis, who raise their prices so Nepalis can't buy them, and this makes the malnutrition problem worse. All kinds of technology, I think, has an impact that is not always foreseeable. To me, in Nepal, one of the biggest technological needs is actually much lower-level than communications and electricity. Are you familiar with Heifer International?

RS: No, not really.

TK: It's a billion dollar foundation at this point. What Heifer has done in countries like Nepal, but it's world wide, is they buy animals for people who live there. You know, subsistence agriculture, except for Kathmandu, that's life for everybody in the countryside. The only way to get out of that sort of day to day grind of subsistence agriculture is find a way to become entrepreneurial. And one way of becoming entrepreneurial is to own an animal, like a water buffalo. I don't know if you've seen pictures of what agriculture in Nepal looks like, but the country's so steep, it's all terraced stuff. But tractors aren't much good to you it, but water buffalo are great in the rice patty. You know water buffalo, is used to plow the soil in the rice patty. If you own you can do that, if you own a goat you can sell milk, make cheese. Chickens, you can sell eggs. Well most people, in Nepal, can't afford to buy water buffalo. But Heifer International's motion is "ok, for $750" I bought water buffalo for Nepalis, we used to give them as Christmas gifts. We'd donate $750 to Heifer International to help buy water buffalo and to give it to them. You know, that's technology again, it's sort of entrepreneurship rather than communication and electricity. Those are things in the Nepali environment have a big impact on people's quality of living. It's not just Nepal, it's all over the world basically. And that kind of technology has a little impact. I'm not sure how you're

thinking of distributing the technology. If your idea is to look in and then give every household in a village, well first of all electricity and then a package of a computer, phone, VCR, all these things. I don't know what, it's really sort of unpredictable, the effect would be. In some ways, I think improving technology in Nepal is improving everybody's income. If people become more entrepreneurial, and they have more cash. I talked about the solar panels in the Solu-Khumbu, in the Sherpa region, and in Delpo. Well nobody came and gave these out, these people one way or another have became entrepreneurial enough to have money to buy them. There are places where every house has got a solar panel. I'm not suggesting that people are not resistant to technology, but they see their neighbor gets a solar panel, and "oh these people have lights", and they can listen to a radio, well you know that's a comfort, so they do it. But they did it themselves.

JR: You mention radios, how many radio stations would they have? I'm sure its not all that widespread, but you'd find one or two, right? At least not what we're accustomed to.

TK: Well there are more stations involved. Your reception is an issue, but, people listen to BBC surely. Something that we've forgotten about totally in this country is there's a whole short-wave spectrum, in every area, that has news on it, and whatever. FM stations are useless in Nepal because of the line of sight problem, and the line of the sight is not so good. But shortwave works real well. Of course, if people get affluent enough, they'll go get a satellite dish. I have not see any place outside of Kathmandu that has a satellite dish.

RS: We have seen pictures from when they were setting up a cyber café at base camp years back. They were hauling the satellite up through cities on the back of a water buffalo, its kind of surreal, never seen a satellite dish getting carried by a beast of burden pretty much.

TK: Yeah, it's an interesting transportation problem in the area. Specifically there's a luxury hotel in Namche-Bazaar, which you know has its own generators and I'm sure its got a satellite dish. But all that stuff had to be hauled up there. It's more typically on the back of a person, some areas the yaks are used for transportation and carrying. But, a lot of it is the people carrying.

JR: We were watching something, where they were carrying a Jeep. If they soup up the Jeep a little bit, it would've been able to go out there, but it was a regular Jeep, with poles all over the place. It was kinda weird to see a bunch of people carrying a vehicle.

TK: Well, you know, it's very steep. It's almost hard to imagine how steep the country is, when you think about walking on a trail, well it's up and down all the time.

JR: With those camera angles…

TK: You don't see how steep most things are. I don't know why anybody would want to take a Jeep to most places in Nepal. It's like years ago, there was some

international mountain bike society decided "well Nepal would be a great place to have everyone come and do the mountain biking among the highest mountains in the world." So, they go and those people they're out on the trails and they're carrying the mountain bike, the mountain bike is absolutely useless in almost all Nepal.

JR: I saw a program where there were a couple guys who had off-road unicycles. Well, they were cycling well unicycling, I guess, they had to cross the entire Himalayan Range. But they were a little crazy.

TK: They were a little wacky I think. That is another issue of technology, is transportation. You know in some respects, one might argue, the biggest effort to be taken in Nepal would be to simply put more roads in. It's doable, it's very steep, again money is an issue. The roads do grow every year, a few new roads here. You must have looked at a map of Nepal. (Gets map) These black spaces, there's no roads whatsoever. This gets you to Solu-Khumbu, there's Djery that's where the road ends, no roads whatsoever in that whole area. This is where I was in western Dalpo, and you'd notice there's no roads there. You go to Pokria and you fly from there to Jonston there's an airport there, but no roads go from there. So big blank spaces, with no roads, and most of the roads tend to be in Trie where its fly

RS: Looks like its just enough to get you over the boarder from India too.

TK: Uh right. And that's really bad. To go to Delhi, which is like, whatever, 300 miles from Kathmandu, is a 48 hour bus ride. The roads are very complicated, they have landslides all the time, roads are blocked. So Kathmandu is really isolated, the only decent road into Kathmandu is the Chatsulah-Chinese road which goes into Tibet. But then, once you get to Tibet, what do you do, because there aren't any roads in China that go to Tibet. Getting your technology into Solu-Khumbu is not easy, even if it's a laptop.

JR: More weight that you have to carry.

TK: Yeah

JR: Is there anything else that you feel that is relevant for us, that you haven't already spoken on.

TK: I can't think of anything off hand. It's just the two of you on this project?

JR: There's a third person.

TK: Who's the advisor?

JR: Professor Jay and Professor Hansen.

TK: Ok, very nice to see, a lot of similar problems, but without the steepness issue. Yeah, I mean its an interesting thing to talk about in a country like that. I guess my

major message is that you need to be kind of cautious with tinkering with cultures. You know this has happened, even in the famous US Peace Corps, which has a substantial presence in Nepal. You know, they really struggled with introducing technology, and they're typically talking about a lower level, they're talking about that of irrigation. Well you know, you're dealing with a country whose culture is really very sophisticated, and a whole hell of a lot older than ours is. There's centuries of trandtion, and they do use technology; it's not western technology in the sense of electricity and computers and communications and so on. But the irrigation systems in Nepal are unbelievably complicated, and they've grown over centuries too. And that's technology in a way, your definition of technology can become when "people get together and organize things in a way that makes life easier for them" that's technology in some kind of place. And that's familiar to the Nepalis, it's really very well organized, and it has to be because the country is incredibly crowded. Every square foot of arable land is cultivated, and even some places that aren't very arable. And something needs to be careful, maybe not introducing technology. And you can see that, if you go see Kathmandu. Kathmandu is probably the most polluted city I've ever seen in the world. It is really painful to walk out on the streets in Kathmandu. That is one of the little blessings that technologies have delivered to Kathmandu, these polluting taxis, buses, whatever. You can see the it in the valley its got erosion problems. The pollution all gets trapped in there. The place is almost becoming unlivable, the way the pollution is going. Not that anybody I think is going to give up their transportation technology in Kathmandu, but there are impacts that are not always anticipated. But that's what makes it unique.

JR: All right. I guess we thank you for your time. You've provided quite a bit of insight for us.

TK: Do you look at the NepalNews.com website?

JR: I think we have, a way back, when we first started this. But we have split our focuses different. He's focusing on one particular area, and I'm focusing more towards like what the mountaineers and stuff are using, and the other guy's focusing on all like "how do you make a satellite phone work at 8,000 meters". Seeing what they're doing, what they're using, why it works now, what took them so long to get the communications stuff into the area.

TK: Right, well satellite phones are a pretty recent development.

JR: Right, but like the difference in battery power in that extreme cold, anything but a lithium ion battery, which is fairly recent, really hasn't worked. You lose charge on them immediately in the cold.

TK: Yeah, I would take a solar collector up with you.

JR: Yeah. You can recharge it, but the cold just drains the life of it. But with the lithium ion battery you just keep them near your body, and you plug it in and it works.

TK: I would recommend, regularly looking at the NepalNews website. Not because it's going to give you really anything specific, but I think you'd get a really good sense of what Nepal is about just by looking at what the stories are. A lot of it is technologically related, and you can see what is happening.

JR: Ok, thank you very much.

Appendix H: Karen Lemone Interview Notes

Notes from an in-person interview held on December 12th, 2003. The purpose of the interview was to learn about the culture of Nepal around Mt. Everest.

Q: Where were you staying during your visit?
A: Stayed in Fullbright House, Kathmandu, which is an urban setting. Also stayed at Kathmandu University, in Dhulikhed, which is a more rural area.

Q: When did you go to the region?
A: August – December and June – July from 2002 – 2003.

Q: Was there any chance to travel locally?
A: Traveled a lot. Did lots of trekking to base camp and other lesser known places. Also did local hikes.

Q: What forms of technology did you observe being used locally?
A: Phones are a real problem there. There are very few of them. Cell phones can be found The "boonies" use radio phones (roughly one per village). Some areas have no electricity as well.

Q: Were the use of these technologies widespread?
A: Very little electricity in the country as a whole. Little use of phones so none of these technologies were really widespread.

Q: Were you able to communicate back home? What methods did you use? E-mail, local phone, cell phone?
A: All by E-mail. Other people in the group used other methods.

Q: Did you see a lot of cyber cafes in your travels? How busy did they appear to be?
A: Lot of cyber cafes in Kathmandu and in other major cities. Very busy. Mostly with foreigners. Some Nepalese, since they run them.

Q: How prevalent is the English language in the area?
A: In Kathmandu, and the tourist areas, people spoke English. Almost all tourist related areas and things were spoken with English.

Q: Are other languages prevalent in the region?
A: Lot of different languages in the villages. Tibetan was one of the more common ones. Lots of other languages are from the tourists.

Q: Did you visit the Everest café?
A: Namche-Bazaar had the closest cyber cafes to Mt. Everest. The Everest café wasn't there, since base camp didn't have it there. In general, Base Camp was very sparse.

Appendix I: Square Networks E-mail Response

E-Mail response received December 13, 2003. Includes answers to questions about the use of communications technology in Nepal.

How modern is your equipment and how often do you upgrade equipment on average?

Re: Very modern models. Usually satellite communications equipment basic models remain the same for 2-3 years. So we are uptodate. Upgrades usually happen interms of firmware upgrade which range between 1-2 years.

What companies manufacture the equipment you use?

Re: Agilis Communication Technologies, ComtechEFData, Cisco, Suman, Space-star, Prodelin

Do many of your large customers purchase a leased line or is more of your business selling wireless and VSAT connections?

Re: We are more into VSATs and Wireless connections for those who require dedicated 24x7 Internet access

How much of your buisness is with consumers versus reselling to companies or other ISPs?

Re: Our business model is such that we mostly do whole selling, that includes services to other ISPs and Corporates as well.

How large an area does your company service?

Re: If you mean geographically, then we currently cover 3 major cities in Nepal and 1 small site near Everest.

What challenges exist in providing internet access to remote regions?

Re: No. 1 challenge would be accessibility to those sites. Cause they have to be reached by foot, few days walk or on Mule backs. Then comes electricity. Not many remote areas have good stable electricity. So to keep the communications equipment performing well, we require ups systems with good battery backups. Or solar panels.

Are your services used more for personal uses or for business purposes?

Re: More for business purposes

How prevalent are cybercafes in your area of service?

Re: Well cyber hubs are good business in Nepal and in the near future we shall be catering to their need as well.

How large a market for service providers exists in the region?

Re: Not a large market I'm afraid. The total Internet bandwidth consumption in Nepal is currently approximately 15-20 Mbps and Internet backbones are only reached through Satellite

How is phone access wired in the area?

Re: City areas have good phone access. However many rural areas have satellite based telephony.

Are phones a staple household appliance?

Re: Yes in cities they are

How many houses have phone lines running to them? What percentage of these actually have phones in them?

Re: I don't have the exact data sorry.

How did you get involved in providing internet or telephone access in Nepal?

Re We only provide data commuications through Internet /satellite not IP telephony as there is no policies yet. We had a good team with knowledge and experience, so we decided to get started.

Where did you gain the knowledge and experience to work in this field?

Re: Long story.....

Do you think brining these technologies to this region has provided an overall benefit to the area?

Re: No doubt. it has opened new windows of opportunities to the locals of.the area.

Appendix J: Equations Used to Determine Mechanical Properties of Ice Axes

In order to find the Area of the handle it was decomposed into a circle and a rectangle.

The area A of a circle with radius r is equal to:
$A = \pi r^2$

The area A of a rectangle with base b and height h is equal to:
$A = b \cdot h$

Cross sectional area is equal to the sum of the two areas
The volume is the area times the length of the handle

To find the mass of an object multiply its density ρ by its Volume V

$mass = \rho \cdot V$

The maximum load that an object can endure before breaking is its Ultimate Tensile Stress UTS multiplied by the Area of the cross section A

$\max load = UTS \cdot A$

Appendix K: Contents of Supplemental CD-ROM

1. Appendix K-1: The COOK Report on the Internet
2. Appendix K-2: Cisco Antennas
3. Appendix K-3: Agilis Outdoor Trasciever
4. Appendix K-4: Sports Engineering
5. Appendix K-5: UIAA Standard for Harnesses
6. Appendix K-6: Petzl Pandion Instruction Sheet
7. Appendix K-7: Belay Device Tests
8. Appendix K-8: Diamox Prescription Sheet
9. Appendix K-9: Adalat CC Prescription Sheet
10. Appendix K-10: Dexamethasone Prescription Sheet
11. Appendix K-11: Decadron Prescription Sheet
12. Appendix K-12: ABCs of Oxygen