COLD REGION LOGISTICS PLANNING AND MANAGEMENT

by

J. L. Hulsey
P. A. Koushki
F. L. Bennett
John J. Kelley

in

Journal of Cold Regions Engineering

1992

PICO
Polar Ice Coring Office

Polar Ice Coring Office
University of Alaska Fairbanks
Fairbanks, Alaska 99775-1710

PICO
TJC-108

September 1992

PICO is operated by the University of Alaska Fairbanks under contract to the National Science Foundation, Division of Polar Programs.

COLD REGION LOGISTICS PLANNING AND MANAGEMENT

J.L. Hulsey, M. ASCE; P.A. Koushki, M. ASCE; F.L. Bennett, F. ASCE; and J. Kelley

School of Engineering/Polar Ice Coring Office
University of Alaska Fairbanks
263 Duckering
Fairbanks, AK 99775 USA

Tel: (907) 474-7816
FAX: (907) 474-6087

List of Key Words

- Management of Remote Operations
- Cold Regions
- Extreme Environment
- Logistics of Operations
- Logistics Planning
- PERT Scheduling
- Logistics Components
- Polar Operations

ABSTRACT

A successful cost-effective exploratory operation in a remote, harsh (cold) climate is largely dependent upon the attention given to logistics management and planning.

Since the discovery of oil and other mineral resources in the Arctic, significant interest has been generated in exploring this and other extreme environments in the interest of seeking knowledge and potential resources. Although numerous experiences of long-duration remote sites in the Arctic is documented, a comprehensive dynamic logistics system for short-duration explorations is lacking.

In this paper, logistics components for short-duration research and development operations at remote sites with extreme climatic exposures are identified. The framework of a dynamic management and planning system for logistics is presented.

A preliminary nationwide survey of experts, active in planning short-duration explorations in remote extreme environments, estimated the time required for each logistic component of a hypothetical research operation in the Arctic. The results of the survey, showing optimistic, most likely, and pessimistic logistic activity times (procurement/lease/contract/delivery), were used to develop a PERT scheduling network.

COLD REGION LOGISTICS PLANNING AND MANAGEMENT

J.L. Hulsey[1], M. ASCE, P.A. Koushki[1], M. ASCE,
F.L. Bennett[2], F. ASCE, and J. Kelley[3]

INTRODUCTION

The global population has doubled and redoubled in the last seven to eight decades. This growth rate continues to, dramatically impact socioeconomic, political and environmental aspects of the world. One such impact area is the tremendous rise in the rate of resource consumption and its consequential rapid drain of nonrenewable resources (Seager, 1990). The polar regions, the ocean floor, and space may soon become the only option in the search for nonrenewable resources. The race is inevitable and the challenge is vast. The discovery and exploration of oil and other valuable resources in the Arctic and other remote areas has already earmarked the beginning of the race.

The increased level of resource development operations and research activities in the Arctic and Antarctic has, in general, created a staggering demand for information and, in particular, a need for logistics planning of these activities. This type of knowledge will serve the immediate practical needs of agencies operating in extreme environments.

While considerable experience has been gained and documented in support of long-term operations in remote cold regions (McFadden and Bennett 1991), less attention has been devoted to the support of short-term exploration, research, and development

---

[1] Associate Professor of Civil Engineering, Univ. of Alaska Fairbanks

[2] Prof. of Engineering Science Management, Univ. of Alaska Fairbanks

[3] Assoc. Professor of Marine Science, Univ. of Alaska Fairbanks and Director of PICO

activities. It is the planning and management of logistics for these latter kinds of projects that are the focus of this paper.

An attempt is made in this paper to propose a framework for a comprehensive logistics information and planning model for remote short-term operations. Knowledge shared through monitoring and updating an information system with data from previous operations for the purpose of improving the cost effectiveness of future polar operations is discussed.

The need for the development of a comprehensive and dynamic logistics information and planning system is important to the success and cost effectiveness of operations in remote regions (Kelley, 1989). It was in recognition of this vital need that the Arctic Research and Policy Act of 1984 and the Arctic Research Commission was established (Roederer, 1989).

Extreme cold environments may be characterized by three attributes: extreme low temperatures, remoteness, and inaccessibility. It is because of these attributes that the cost of logistics for operations in these environments plays a critical role in an operations' cost effectiveness. For example, research indicates that the dollar cost of logistics for polar operations has constituted from 20 to 80 percent of the total program cost for operations conducted by the Department of Defense (Wang, 1971). The logistics cost of polar operations today has assumed an even more critical dimension due to rapidly rising costs and shrinking budgets (Porter, 1989).

An effective logistics system plan for remote operations must, at its outset, have an ultimate respect for the sensitive environment. The Arctic and Antarctic, especially, play a vital role in shaping global climate and are likely to respond significantly to future climatic change (Maxwell, 1989). Unfortunately, the problem of arctic haze is now a well documented case of air pollution in this remote and sensitive region (Heintzenberg, 1989). A comprehensive logistics information and planning system should have, as its ultimate goal, the promotion of maximum operational harmony with the polar and other remote ecosystems.

In spite of the significant socioeconomic, political and environmental impacts of the logistics of remote, short-term operations, available information on this subject is extremely limited at best (Benson, 1989; Moslehi, 1990; Cominco, 1991). It is to this critical gap that this paper is addressed.

The specific objectives of this paper are: a) to identify components of logistics systems and an approximate component time duration for a hypothetical remote operation, b) to determine the critical path and critical activities of such an operation, using PERT scheduling, c) to propose a framework for a comprehensive planning model for the operation, and d) to recommend a dynamic mechanism for the documentation, updating and dissemination of this information.

Logistics System Components

A prerequisite to the development of an effective logistics information and operation plan is to identify the components of these operations (Koushki et al., 1991). Figure 1 illustrates the logistics components for a remote, cold operation. These components include the geographic location, human, equipment, supplies, shelter, utilities, transportation, and external factors. It is important to recognize that while these basic components generally remain the same for all operations, a significant degree of variation may be expected in subcomponent configuration from operation to operation. These variations are a function of the operation's size, type, duration, availability of resources and technologies, and geographic location.

Geographic Location

This component affects, quantitatively and qualitatively, decisions for all other logistics system components. Factual knowledge concerning the climate (weather conditions, permafrost, temperature variations, wind characteristics, etc.) and the remoteness with respect to proximity to population and transportation centers can significantly impact the choice/cost of the other components of the operation.

Human

The human component includes the manpower resources required to carry out the entire operation, as well as those which address their physical, psychological, medical/dental, recreational, and spiritual needs. Remote regions are characterized by isolation, inaccessibility, and extreme environmental harshness. A significant degree of care and attention must be given to the selection of individuals who are able and willing to accept these rigorous conditions. These individuals will need to understand, be aware and be capable of handling the potential negative impact of working in remote and isolated environments.

Recognition and provision of recreational, spiritual, medical, and dental needs should also receive a high priority in the list of criteria to improve efficiency of these operations. Preoperational training of manpower for the performance of their assigned tasks should also be recognized as an important variable. Accidents are generally the cause of significant operational inefficiencies, especially in remote polar regions.

Equipment

Selection of appropriate equipment is of critical importance to the success of operations in remote environments. Included in this category are communication, scientific, and field support equipment such as those related to recreational activities. In the selection of equipment, a significant degree of attention should be given to its calibration, operational complexity, repairability, maintainability and durability.

Supplies

Due to isolation and remoteness inherent in these operations, the provision of adequate and appropriate types of supplies may critically affect operational efficiency and productivity. Subcomponents of this category include food stuff, materials, and most importantly, fuel supplies for heating, lighting and propulsion. Special attention should also be given to waste disposal for sensitive environments.

Shelter

In remote operations, three types of shelters are commonly used: field, semipermanent and mobile. The extreme temperatures prevailing for most of the year in these regions should be a prime factor in the selection of appropriate types of shelters. The energy efficiency of shelters, especially for long operations, their transportability, and assembly/disassembly requirements could result in a considerable savings in operational costs.

Utilities

The utilities component of a logistics system in extreme environments incorporates such important subcomponents as power needs (heating/cooling/lighting/operations, etc.) water supply, communication (telephone/television/radio), and waste/pollution management systems. Due to the sensitivity of environmental issues, especially in the Antarctic region, the likely impact of the operation's waste and pollution, and their efficient management, should receive significant attention in the planning of the logistics system.

Transportation

Transportation contributes significantly to the cost of operations and programs in isolated areas having extreme climates. This is mainly due to the remoteness, harshness of weather conditions, and inaccessibility of these regions.

In addition to limitations in the source and schedule frequency of transportation modes (air, sea, land/government, military, commercial, private) to these regions, lack of up-to-date information concerning shipping regulations and specifications further complicates the planning of transport logistics for these operations. Availability of up-to-date transportation information can greatly enhance the efficiency and cost effectiveness of operations in remote regions.

External Factors

Planning for logistics in extreme environments also includes a number of important external activities. Obtaining the necessary visas and permits may require a lengthy time, especially if the operation is to be performed in environmentally sensitive areas, or locations where special interest groups (ethnic/national/international) play a predominant and opposing role. Through strong local governments, the people of the Arctic, for example, are becoming much more involved in all matters that affect their lives, the wildlife, and the environment (Albert, 1989).

The people of the Arctic and other remote environments have rich and historical cultures and habits with an ever increasing degree of self-recognition and importance. Understanding, respect and conformity with these cultures and habits should also be emphasized in a logistics planning.

Critical Activities for a Hypothetical Operation

Network-scheduling models have long been recognized as important tools for the logistics planner. Early papers describe the application of such methods to aircraft and weapons system development (Goldfarb 1973; McGrath 1975). More recently, the Naval Electronic Systems Command has developed an Integrated Logistic Support (ILS) Management Control System comprised of two components, an ILS model network and a logistics information system (Gilmore and Parnell 1982).

The logistics involved in a typical offshore exploratory drilling project has been estimated to represent 27% of the total project cost. In such an environment, planning and scheduling of activity sequences for such operations as local facilities, telecommunications and transportation is vital (Piazza and Daher 1984).

Tedeschi and Calogero (1986) describe a milestone-based Integrated Logistic Support (ILS) plan developed by the Naval Sea Systems Command. A PERT network assists with scheduling operations based on key date inputs; a milestone table with action milestones as well as scheduled and actual dates is generated by the computer. Computer-generated graphics can assist the logistics manager by providing bar charts showing scheduled and actual dates plus graphs giving completion rates and/or funds expended as a function of time (McCready and Shamash 1983).

The provision of a realistic time required to implement the components of an operation in extreme environments poses an interesting academic exercise. The input of personnel involved with polar and remote regional experience clearly indicates that two realities strongly affect the expected time duration required to implement these components. These are the public sector reality and private sector reality. Primarily due to how problems are approached, the latter requires less time and money to perform the same logistical task (Sackett, 1991).

Development of realistic time estimates for a remote operation, directly and very strongly depend on specific knowledge of a given operation's characteristics. Where is the operation? How long will it last? How many people will it employ, etc? It is obvious that no two projects are the same, even if undertaken in the same geographic location.

With these limitations in mind, an attempt was made to develop a noncommercial, first approximation for the time required to carry out a logistics exercise for a typical research operation (one month duration, ten people) in the Arctic. The responses (seventeen) to a nationwide survey of individuals involved in logistics of remote operations were analyzed and the most likely time estimate for each subcomponent was determined. Individual experts were requested to provide an estimate of time required to procure, lease, arrange, and/or deliver these activities. The port of Seattle, Washington was selected as a hypothetical point of delivery destination.

Table 1 presents the optimistic, most likely, and pessimistic time estimates (in weeks) for each logistics component for a typical research operation. The three time estimates are averages of the survey responses. The mean and standard deviation of the estimates are also presented in Table 1. The mean time in weeks was calculated by

$$\bar{x} = \frac{a + 4m + b}{6} \qquad (1)$$

where $\bar{x}$ is the mean time, a is the optimistic, m is the most likely, and b is the pessimistic time estimate. The standard deviation is calculated by

$$\sigma = \frac{b - a}{6} \qquad (2)$$

The results of a PERT scheduling analysis for the hypothetical operation are presented in Table 2. Figure 2 shows the interaction between activities and the critical path which includes support staff, medical staff, mobile shelter, scientific equipment, waste management system, power generation and fuel--in that order. Based on the mean durations of each activity, the expected logistics-planning time for the operation was 56.2 weeks with a time variance of 20.5 weeks and a standard deviation of 4.5 weeks. Assuming the project duration is normally distributed, there is a 0.68 probability that the project will require between 51.7 (56.2 - 4.5) and 60.7 (56.2 + 4.5) weeks to be completed. Figure 3 provides a time line for each activity; early starts and late finishes are presented for consideration.

It is important to note, however, that a significant savings in time for logistics planning of a remote operation may be gained by coordinating the logistic activities such as the search, procurement, lease, arrangement, and delivery. For example, as soon as the members of the support and medical staff are determined, the search and planning for a number of logistics components (such as shelter, equipment, water and waste management, power, foodstuffs, permits, transportation, etc.) may begin simultaneously. However, time will have to be allowed for any adjustments and modifications resulting from potential incompatibilities among logistics components.

An advantage of using network scheduling is the relative ease with which alternative activity sequences can be studied. For example, in Figure 2 "External Regulations" are shown occurring at the beginning of the project. It may be that inspection by governmental agencies will be required as part of site clearance toward the end of a project. If so, "External Regulations," or some part of this activity, would occur late in the project. Although not shown here, such a revision could be investigated and its impact on the overall schedule determined.

A PLANNING MODEL

The framework for a comprehensive and dynamic logistics planning model for remote operations is presented in Figure 4. The model incorporates three phases: a preoperational phase, an operational phase, and a post operational phase. The preoperational phase includes such activities as the operation's objectives, component selection criteria, procurement/arrangement/delivery, and transportation.

The operation phase deals with actual performance of project tasks. During this time, the performance of various components of the operation is closely monitored and results documented. This information, along with those observed and recorded during the preoperational and the final post operational phases (disassembly, site clearance, waste management) will form the basis upon which logistics planning of future remote operations may be modified and developed. The modification and updating of logistics plans, based on experiences of previous operations, will ensure the dynamic nature of the planning process, as well as improve operational productivity and efficiency of future programs in extreme environments..

General activities for the recommended three-phase logistics planning framework are presented in Figure 5. Noteworthy here is a list of criteria by which the available set of component options are evaluated and the most preferred component alternative selected. These criteria include cost, performance, maintenance/repair, availability, delivery time, operational complexity, training requirements, life-cycle/reuse potential, environmental impact, and potential safety hazards management.

The proposed model has provision for a feedback mechanism to monitor and document the performance of past and current logistics in remote regions. This is an important attribute of the model, i.e. it can learn from the past. This information will be invaluable for modifying and updating the logistics plan data bank and should enhance the choice of logistics component options for future remote operations.

CONCLUSIONS

The dramatic rate of global population growth in recent decades, and accompanying rise in the rate of resource consumption, has focused attention on the Arctic and other extreme environments for exploration and development of nonrenewable resources. It is anticipated that these activities will increase in the near future. To date, there is a lack of information on logistics and planning of operations in remote regions. The utilization of established information and planning approaches for the development of a centralized logistics information base and operation planning would greatly enhance the efficiency and cost effectiveness of future operations in extreme environments.

ACKNOWLEDGEMENTS

Portions of the study reported in this paper were supported by a grant from the Polar Ice Coring Office (PICO) at the University of Alaska Fairbanks.

The authors also wish to thank Ms. B. Chouinard, Ms. C. Owen, and Ms. S. Brower for their assistance in typing and editing the manuscript.

REFERENCES

Albert, T. (1989). Some thoughts from the perspective of the Slope Borough regarding the conduct of science in the U.S. Arctic. New Technological Developments in Support of Arctic Research, Proceedings of the 40th Annual Arctic Science Conference, Fairbanks, AK.

Benson, C. (1989). Future needs in arctic research--a view from the past. Proceedings of the 40th Annual Arctic Science Conference, Fairbanks, AK.

Cominco. (1991). Direct communication with the manager of operations, Polaris Mine, N.W.T., Canada.

Gilmore, K.M. and Parnell, R.K. (1982). A Management Control System for Logistics: An ILS Model Network and Logistics Information System. Society of Logistics Engineers Proceedings, Vol. 17.

Goldfarb, O A. (1973). A Network Approach to ILS Planning and Scheduling. Society of logistics Engineers Proceedings, Vol. 8.

Heintzenberg, J. (1989). Arctic haze: air pollution in Polar Regions. AMBIO, 18(1):50-55.

Kelley, J.J. (1989). New technological development in support of Arctic research--discussion. Proceedings of 40th Arctic Science Conf., Fairbanks, AK. pp. 36-38.

Koushki, P.A., Hulsey, J.L., Bennett, F.L., and Kelley, J.J. (1991). A Logistics Planning Model Framework for Remote Polar Operations. Paper presented at the First International Design for Extreme Environments Assembly, Houston, TX, Nov. 12-15.

Maxwell, J.B., and Barrie, L.A. (1989). Atmospheric and climate change in the Arctic and Antarctic. AMBIO, 18(1):42-49.

McCready, L.D., and Shamash, M.B. (1983). ILS Programs Visibility and Report Methodologies. Society of Logistics Engineers Proceedings, Vol. 18.

McFadden, T.T., and Bennett, F.L. (1991). Construction in Cold Regions: A Guide for Planners, Engineers, Contractors, and Managers. New York: John Wiley & Sons, Inc.

McGrath, F.M. (1975). "ILS Scheduling and Control--A Network Approach." Society of Logistics Engineers Proceedings, 10:353-356.

Moslehi, O., and Poulton, C. (1990). Planning and control of remote projects. Journal of Management in Engineering, ASCE, 7(1):83-97.

Piazza, L.-P. and Daher, J-M. (1984). "Integrated Logistics Support Applied to Exploration Drilling Offshore." Society of Logistics Engineers Proceedings, Vol. 19.

Porter, R.T. (1989). Epilogue. Proceedings of 40th Annual Arctic Conf., Fairbanks, AK. pp. 39-41.

Roederer, J.G. (1989). Concluding remarks. Proceedings of 40th Annual Arctic Conf., Fairbanks, AK. p. 35.

Sackett, R. (1991). Remarks on the questionnaire response, GDM, Inc., Fairbanks, AK.

Seager, J. (1990). The State of the Earth Atlas. Simon and Schuster, Inc., New York.

Tedeschi, L.C. and Calogero, R. (1986). "Automated ILS Plan Preparation." Society of Logistics Engineers Proceedings, Vol. 21.

Wang, C.J. (1971). Arctic logistics support technology. Arctic Institute of North America, Proceedings of a symposium held at Hershey, PA., Nov 1-4.

Table 1. Logistics mean time requirements of a typical research operation in the Arctic.

Activity Code and Name (1)		Mean Estimated Time Requirement (Weeks) Optimistic (a) (2)	Most Likely (m) (3)	Pessimistic (b) (4)	Mean (5)	SD (6)
A.	Support Staff	1.9	5.6	10.8	5.9	1.5
B.	Medical Staff	3.0	7.5	15.1	8.0	2.0
C.	Semipermanent Shelter	4.4	8.6	16.9	9.3	2.1
D.	Mobile Shelter	4.4	10.8	17.6	10.9	2.2
E.	Field Shelter	3.1	5.5	9.5	5.8	1.1
F.	Permits	3.6	7.4	22.1	9.2	3.1
G.	Scientific Equipment	5.1	10.3	17.8	10.7	2.1
H.	Water Supply	4.3	9.1	16.1	9.5	2.0
I.	Waste Management	5.2	9.6	15.5	9.9	1.7
J.	Communication Equipment	4.3	8.3	13.3	8.5	1.5
K.	External Regulations	2.1	4.8	10.8	5.3	1.4
L.	Shipping Regulations	1.5	3.2	5.9	3.3	0.7
M.	Power Generation	2.9	6.0	10.1	6.2	1.2
N.	Fuel	2.7	4.7	7.3	4.8	0.8
O.	Food Stuff	3.4	5.9	10.3	6.2	1.2
P.	Materials	2.3	4.3	7.9	4.6	0.9
Q.	Visas	2.2	4.2	11.6	5.1	1.6
R.	Air Transport	2.2	4.4	7.9	4.6	1.0
S.	Land Transport	1.9	5.1	8.4	5.1	1.1
T.	Sea Transport	3.2	6.2	11.2	6.6	1.3

* SD: Standard Deviation

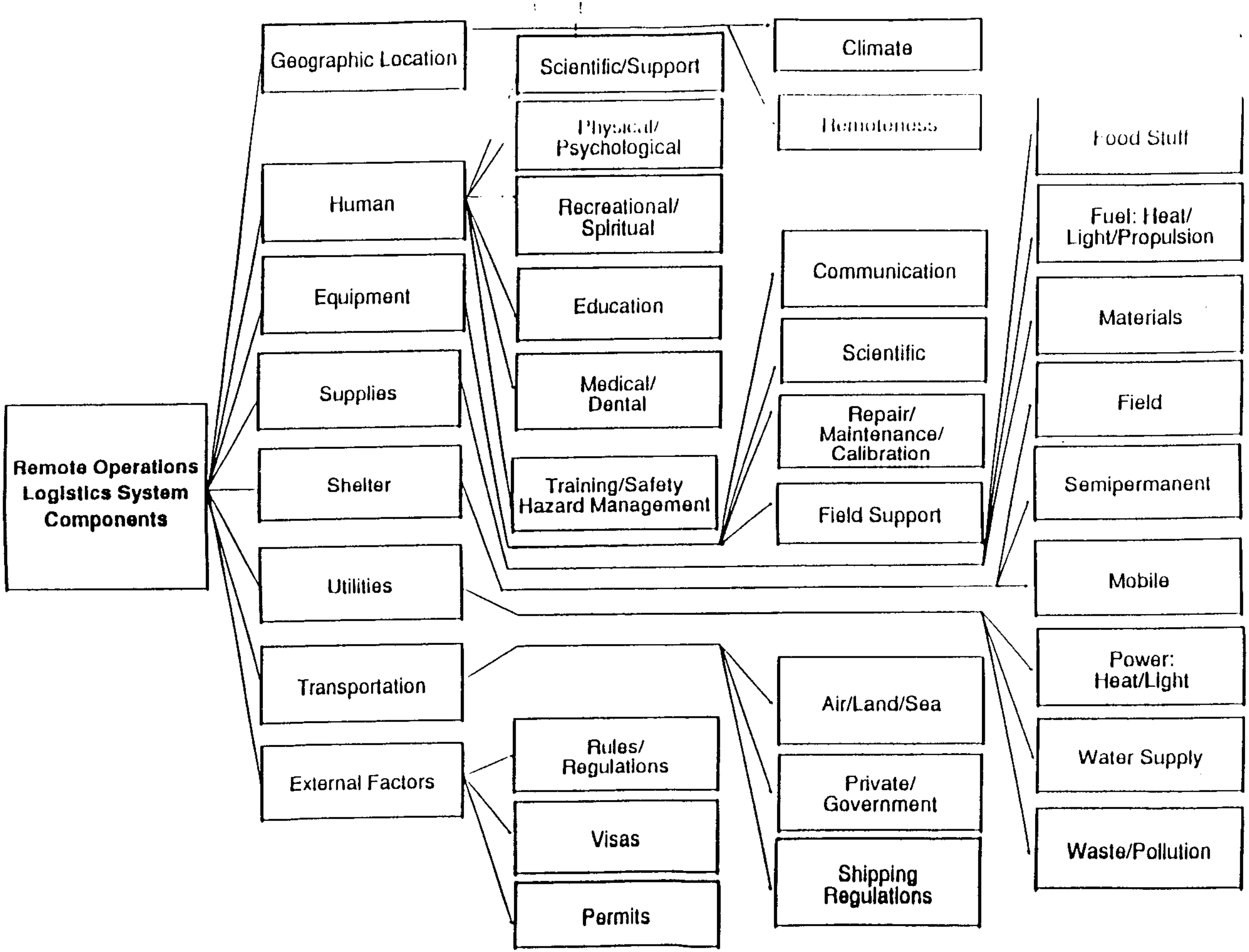
Table 2. Results of Network Scheduling Analysis of Typical Research Operation in the Arctic.

Activity Code and Name (1)		Earliest Start (a) (2)	Earliest Finish (m) (3)	Latest Start (b) (4)	Latest Finish (5)	Slack (6)
A.	Support Staff	0.0	5.9	0.0	5.9	0.0
B.	Medical Staff	5.9	13.9	5.9	13.9	0.0
C.	Semipermanent Shelter	13.9	23.2	15.5	24.8	1.6
D.	Mobile Shelter	13.9	24.8	13.9	24.8	0.0
E.	Field Shelter	13.9	19.6	19.0	24.8	5.1
F.	Permits	0.0	9.2	37.1	46.4	37.1
G.	Scientific Equipment	24.8	35.4	24.8	35.4	0.0
H.	Water Supply	35.4	44.9	35.8	45.3	0.4
I.	Waste Management	35.4	45.3	35.4	45.3	0.0
J.	Communication Equipment	35.4	43.9	36.8	45.3	1.4
K.	External Regulations	0.0	5.3	45.8	51.1	45.8
L.	Shipping Regulations	9.2	12.6	46.4	49.7	37.1
M.	Power Generation	45.3	51.5	45.3	51.5	0.0
N.	Fuel	51.5	56.2	51.5	56.2	0.0
O.	Food Stuff	5.9	12.1	50.0	56.2	44.2
P.	Materials	5.9	10.5	51.7	56.2	45.8
Q.	Visas	13.9	19.0	51.1	56.2	37.2
R.	Air Transport	12.6	17.2	51.6	56.2	39.1
S.	Land Transport	12.6	17.7	51.1	56.2	38.6
T.	Sea Transport	12.6	19.1	49.7	56.2	37.1

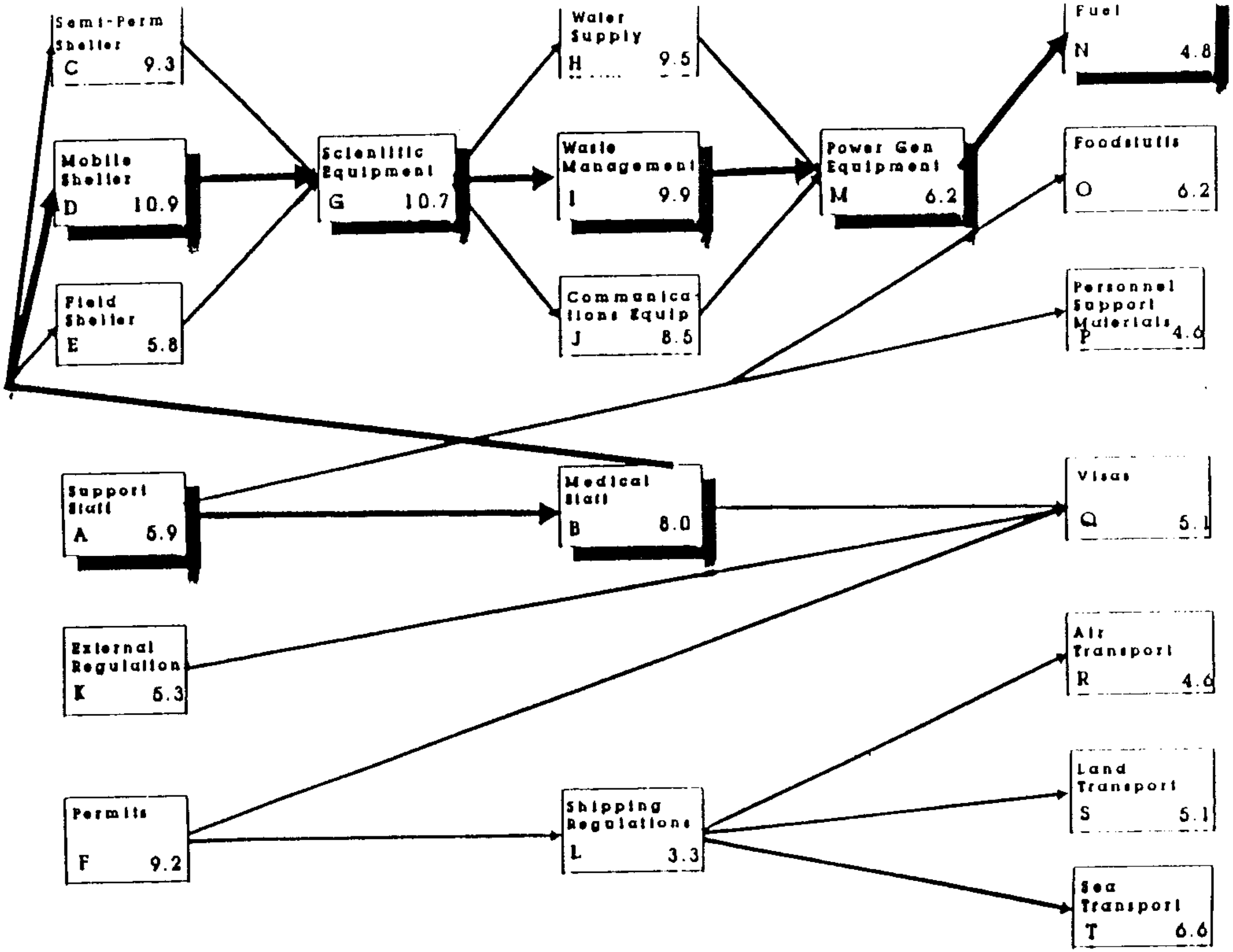
FIGURE LEGEND

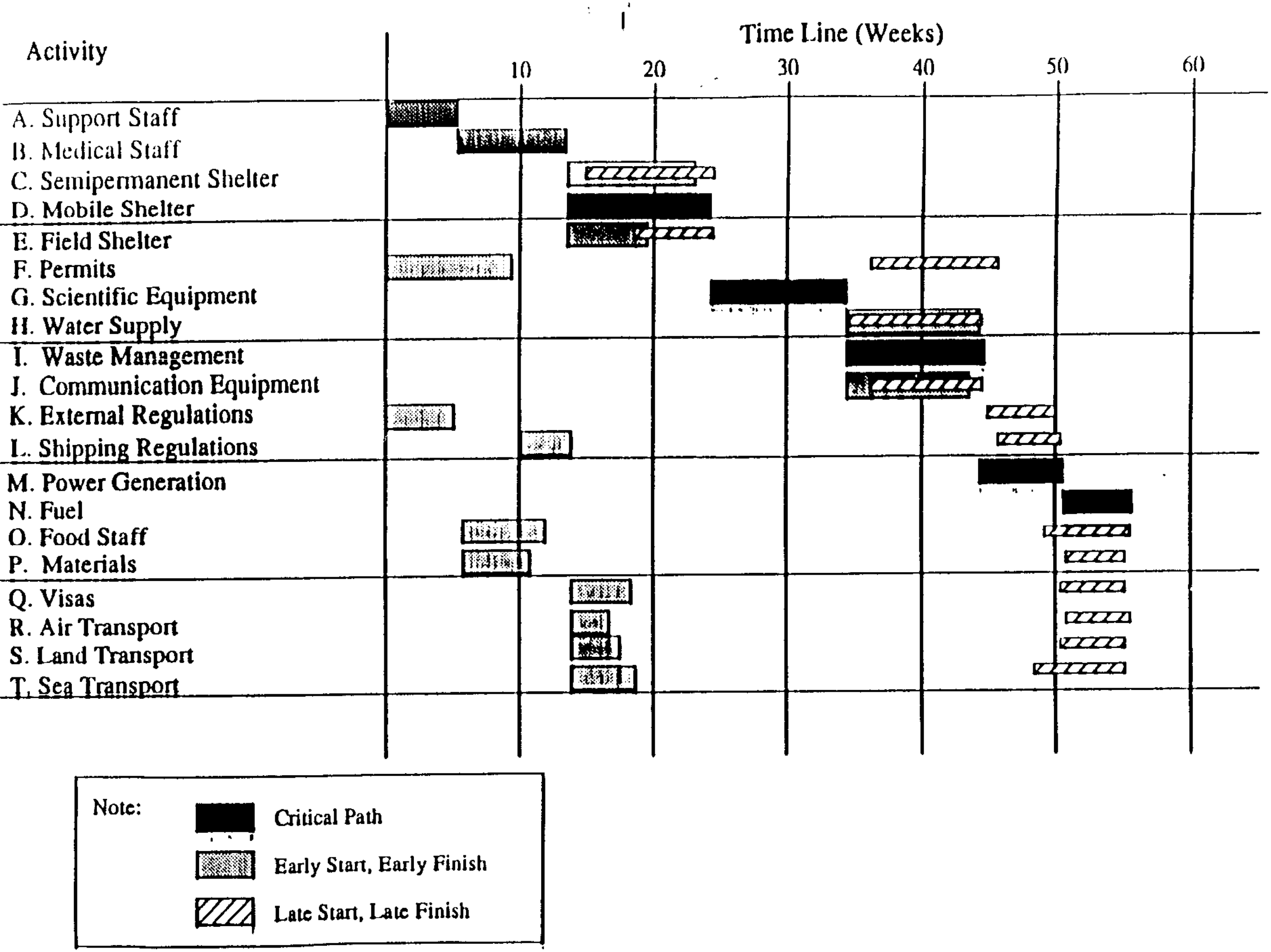
APPENDIX I. Notation

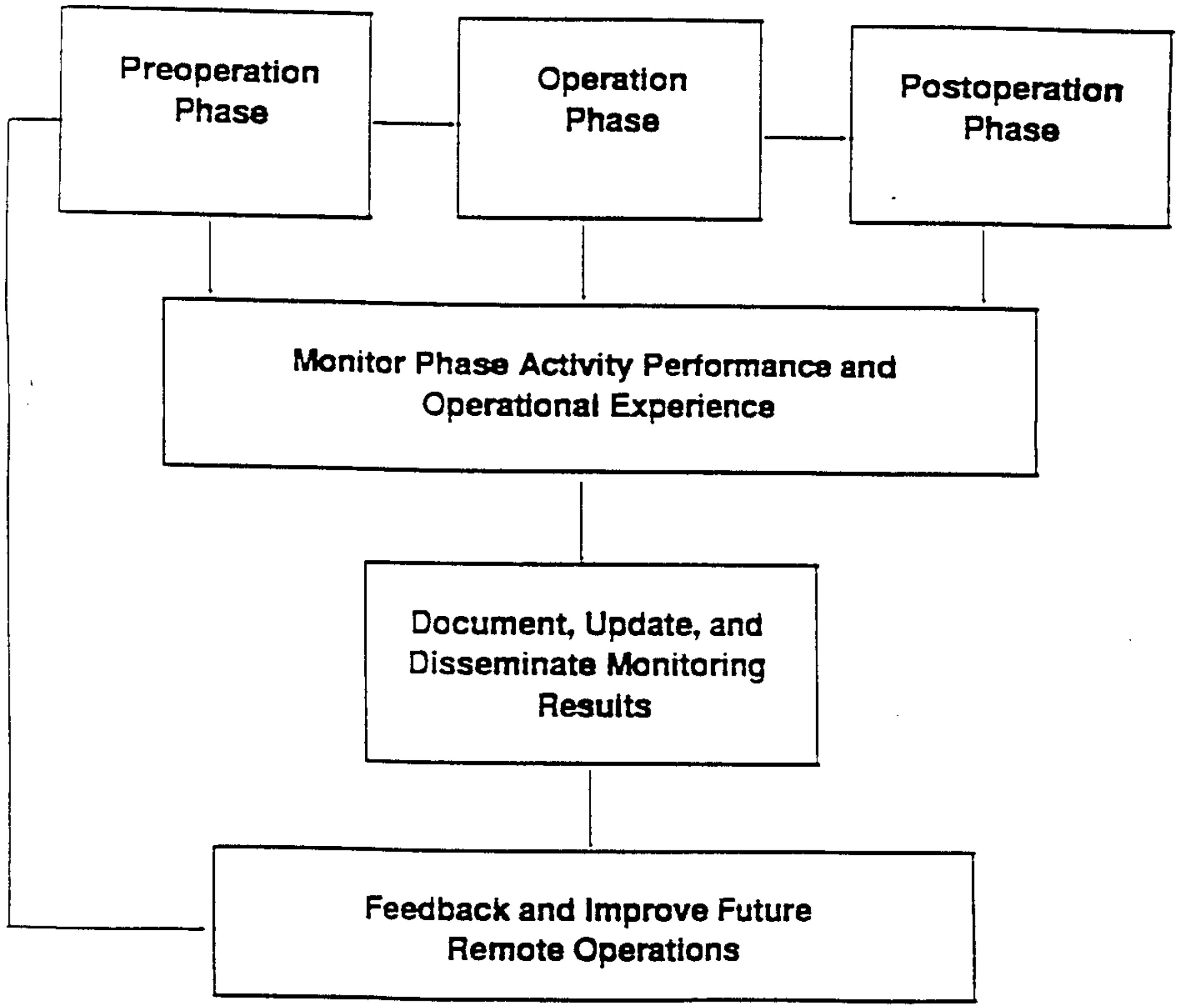
a	=	optimistic time estimate
b	=	pessimistic time estimate
m	=	most likely time estimate
$\overline{x}$	=	mean time
σ	=	deviation

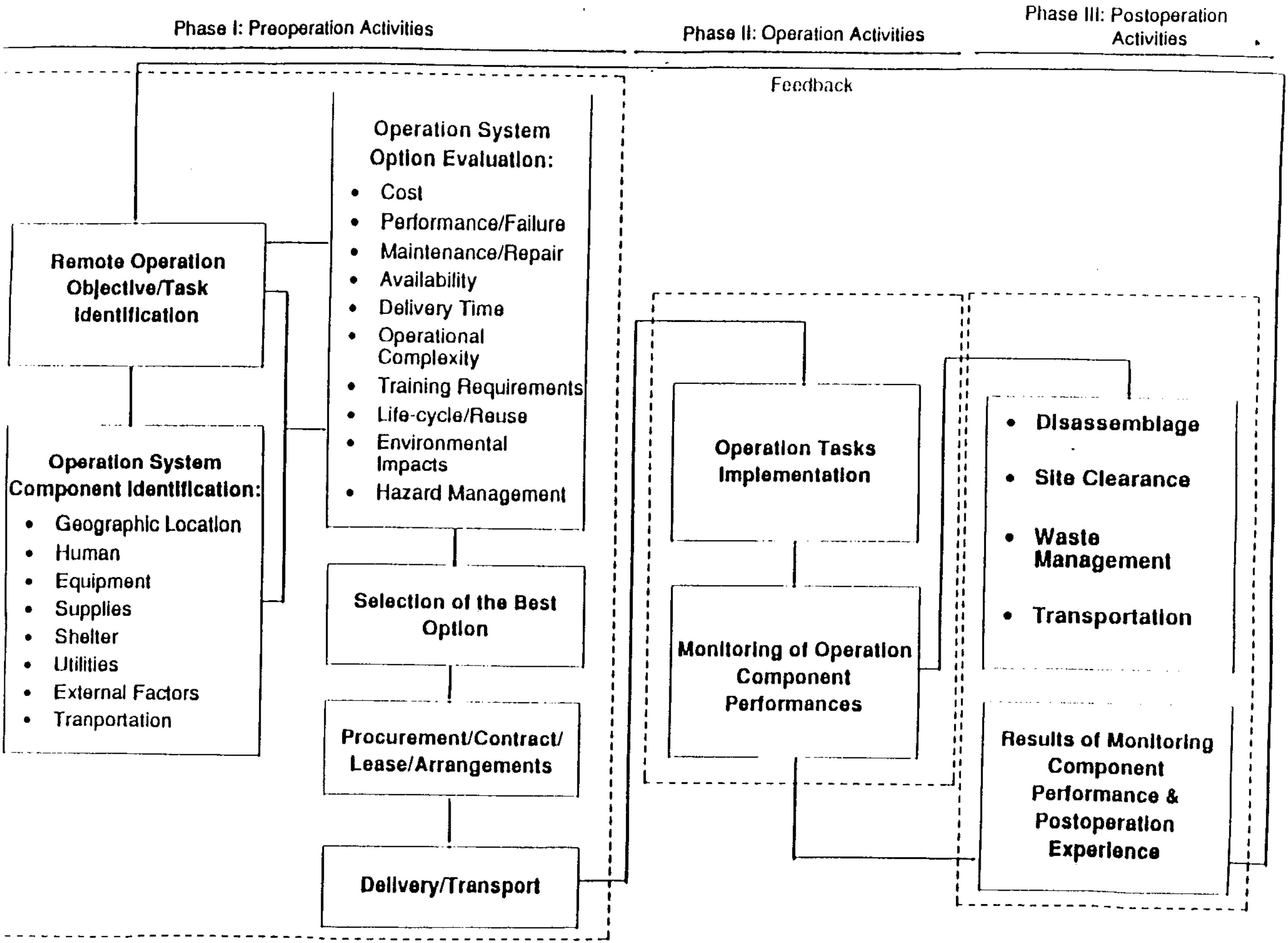


Remote Operations Logistics System Components
Geographic Location
Human
Equipment
Supplies
Shelter
Utilities
Transportation
External Factors
Scientific/Support
Physical/ Psychological
Recreational/ Spiritual
Education
Medical/ Dental
Training/Safety Hazard Management
Rules/ Regulations
Visas
Permits
Climate
Communication
Scientific
Repair/ Maintenance/ Calibration
Field Support
Air/Land/Sea
Private/ Government
Shipping Regulations
Fuel: Heat/ Light/Propulsion
Materials
Field
Semipermanent
Mobile
Power: Heat/Light
Water Supply
Waste/Pollution


Semi-Perm Shelter C 9.3
Mobile Shelter D 10.9
Field Shelter E 5.8
Scientific Equipment G 10.7
Water Supply H 9.5
Waste Management I 9.9
Communications Equip J 8.5
Power Gen Equipment M 6.2
Fuel N 4.8
Foodstuffs O 6.2
Personnel Support Materials P 4.6
Support Staff A 5.9
Medical Staff B 8.0
Visas Q 5.1
External Regulation K 5.3
Permits F 9.2
Shipping Regulations L 3.3
Air Transport R 4.6
Land Transport S 5.1
Sea Transport T 6.6


Activity
Time Line (Weeks)
10
20
30
40
50
60
A. Support Staff
B. Medical Staff
C. Semipermanent Shelter
D. Mobile Shelter
E. Field Shelter
F. Permits
G. Scientific Equipment
H. Water Supply
I. Waste Management
J. Communication Equipment
K. External Regulations
L. Shipping Regulations
M. Power Generation
N. Fuel
O. Food Staff
P. Materials
Q. Visas
R. Air Transport
S. Land Transport
T. Sea Transport
Note:
Critical Path
Early Start, Early Finish
Late Start, Late Finish


Preoperation Phase
Operation Phase
Postoperation Phase
Monitor Phase Activity Performance and Operational Experience
Document, Update, and Disseminate Monitoring Results
Feedback and Improve Future Remote Operations


Phase I: Preoperation Activities
Phase II: Operation Activities
Phase III: Postoperation Activities
Feedback
Remote Operation Objective/Task Identification
Operation System Component Identification:
• Geographic Location
• Human
• Equipment
• Supplies
• Shelter
• Utilities
• External Factors
• Tranportation
Operation System Option Evaluation:
• Cost
• Performance/Failure
• Maintenance/Repair
• Availability
• Delivery Time
• Operational Complexity
• Training Requirements
• Life-cycle/Reuse
• Environmental Impacts
• Hazard Management
Selection of the Best Option
Procurement/Contract/ Lease/Arrangements
Delivery/Transport
Operation Tasks Implementation
Monitoring of Operation Component Performances
• Disassemblage
• Site Clearance
• Waste Management
• Transportation
Results of Monitoring Component Performance & Postoperation Experience