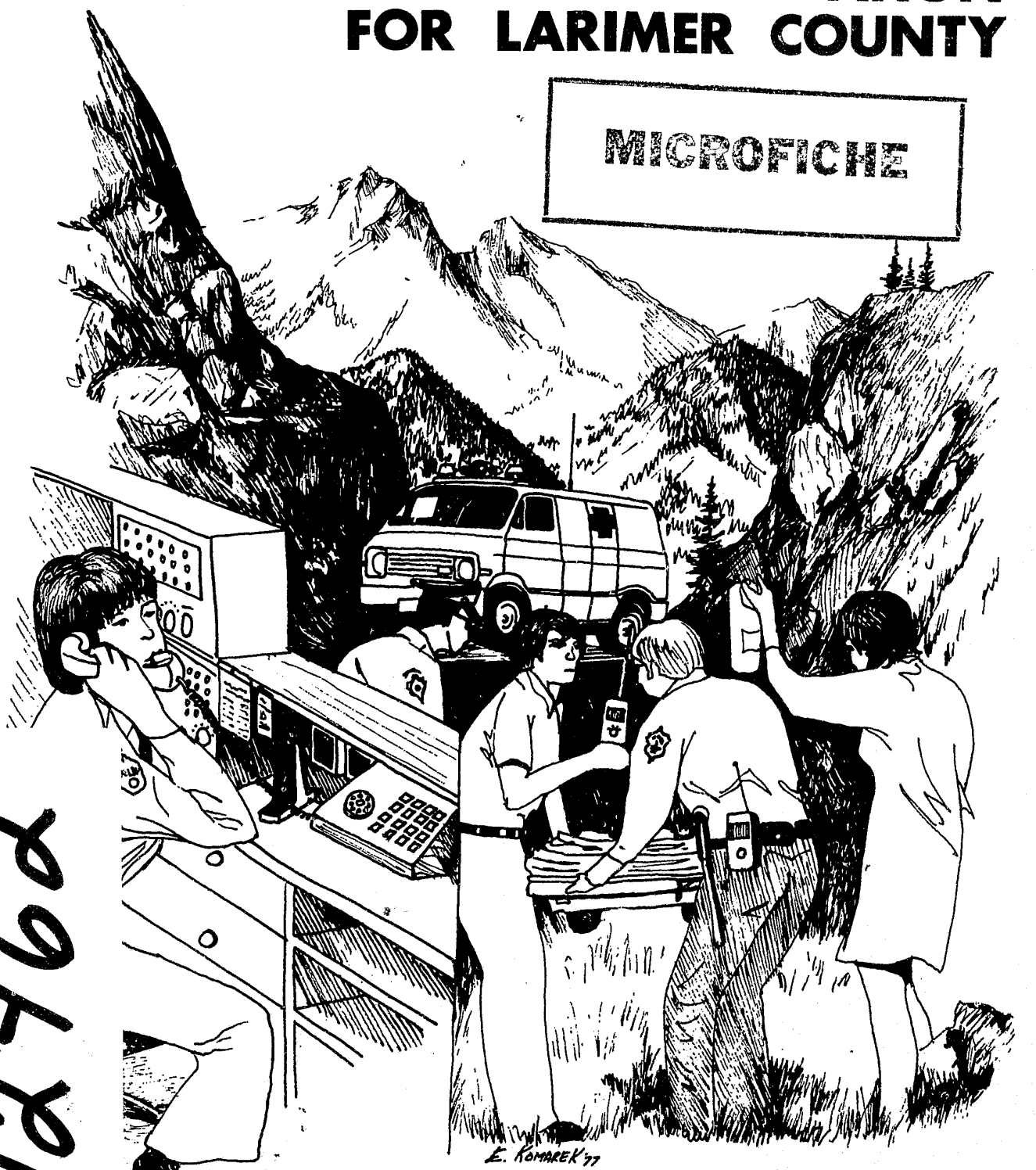
FEASIBILITY OF PUBLIC SAFETY COMMUNICATIONS CONSOLIDATION FOR LARIMER COUNTY



STANFORD RESEARCH INSTITUTE
Menlo Park, California 94025 · U.S.A.

APRIL 1977

Final Report *April 1977*

FEASIBILITY OF PUBLIC SAFETY COMMUNICATIONS CONSOLIDATION FOR LARIMER COUNTY

By: G.E. BARKER, T.I. DAYHARSH, and S.C. IVY

Prepared for:

LARIMER COUNTY, COLORADO
LARIMER COUNTY BOARD OF COMMISSIONERS
FORT COLLINS, COLORADO 80522

STANFORD RESEARCH INSTITUTE Project 6138

Approved by:

JOHN P. McHENRY, *Director*
Systems Development Department

ROY M. TIDWELL, *Executive Director*
Engineering Systems Division

The study was financed in part through a Discretionary Grant (No. 76-DF-08-0038) from the U.S. Department of Justice, under the provisions of the Crime Control Act of 1976, as amended.

CONTENTS

TABLES

I SUMMARY

In August 1976, a flash flood of the Big Thompson River resulted in a disaster that required the dedication of all available local, state, and national public safety and emergency resources to limit the loss of lives and property in Larimer County. However, the high degree of coordination among agencies necessary during the disaster was inhibited by the diverse radio systems, which caused severe compatibility and communications problems. The study reported here was undertaken to define a coordinated radio communication system that will prevent a recurrence of this lack of communications in the future. The coordinated system developed in this study will also provide less costly communications and improved levels of service to the public safety agencies and the citizens of Larimer County.

The study was financed in part through a Discretionary Grant (No. 76-DF-08-0038) from the U.S. Department of Justice, under the provisions of the Crime Control Act of 1976, as amended.

A. Current Operations at Public Safety Agencies

The first step in the study was to analyze the current levels of service provided by the communications operations in Larimer County. Seven law enforcement agencies (excluding the Colorado State Patrol) currently operate full-time or part-time communication systems in the County: Berthoud Police Department (PD), Colorado State University PD, Estes Park PD, Fort Collins PD, Larimer County Sheriffs Office (SO), Loveland PD, and Wellington PD. Our analysis of these operations indicates that the average delay from the time a telephone rings or a police car makes its initial radio contact with the dispatchers of these agencies to the time the dispatcher can respond to these requests for service can be over five minutes for one of the larger agencies and over 30 seconds for some of the other agencies. These average delays are

significantly long; for example, the "Criminal Justice Standards, Goals, and Recommendations" state in Section 23.1,

> "Emergency telephone calls should be answered within 30 seconds, and non-emergency telephone calls should be answered within 60 seconds."*

Furthermore, Standard 23.2 states,

> "Every police chief executive should immediately insure that delay time--the elapsed time between receipt of a complaint emergency call and the time of message radio transmission--in the case of an emergency call does not exceed two minutes, and in the case of a nonemergency call, does not exceed six minutes. By 1978, communications center delay time in case of emergency calls should not exceed 1 minute and in cases of nonemergency calls should not exceed 4 minutes."*

With average delays in responding to telephone and radio requests in excess of 30 seconds, it can be seen that the delay between complaint receipt and relay of information to the field can easily exceed the times designated above.

Fire protection services and their communications systems in Larimer County are varied. Two departments, the Fort Collins Fire Department (FD) and Loveland FD have full-time alarm centers. The remainder share services with other centers or use the telephone system. The latter should not be construed as ineffective systems since they do provide rapid access by the citizens to their volunteer fire departments, but the operations are lacking interagency coordination which could be provided through a centralized fire protection command and coordination function.

Emergency Medical Services (EMS) in Larimer County are formulating a coordinated communication effort under a program recently initiated by the Colorado Department of Health. Although this EMS coordination system must interface with any law enforcement and fire protection

---

*Criminal Justice Standards, Goals, and Recommendations of the National Advisory Commission on Criminal Justice Standards and Goals," prepared for the Law Enforcement Assistance Administration U.S. Department of Justice, Contract J-LEAA-027-74, Stanford Research Institute, Menlo Park, California 94025.

communication system, the particulars of this system are not needed until a detailed engineering design is undertaken.

B. Radio Equipment of Public Safety Agencies

The law enforcement agencies in Larimer County are currently using 12 very high frequency (VHF) and ultra high frequency (UHF) radio channels. Although delays are minimal on these channels at present, consideration must be given to their future congestion resulting from other users and the projected increases in population with their potential for increasing demands for law enforcement services.

The "Criminal Justice Standards, Goals, and Recommendations" provide the following standards for radio systems in Standard 23.3:

> "1. Every State should immediately establish common statewide police radio frequencies for use by State and local law enforcement agencies during periods of total disaster or other emergencies requiring interagency coordination.
>
> 2. Every agency should, by 1978, have a base station, mobile, and portable radio equipment capable of two-way operations on a common statewide police radio frequency.
>
> 3. Every agency should, by 1978, acquire and operate multichannel mobile and portable radio equipment capable of two-way operation on operational frequencies, daily car-to-car tactical frequencies, joint public safety tactical frequencies and statewide tactical frequencies.
>
> 4. Every agency should, by 1978, equip every on-duty uniformed officer with a portable radio transceiver capable of being carried with reasonable comfort on the person."*

Colorado has established the Colorado Law Enforcement Emergency Radio (CLEER) channel as a means of meeting these goals. Unfortunately, this channel is on UHF; VHF provides more suitable propagation characteristics to serve Larimer County (and most of the Rocky Mountain counties in Colorado). It would be possible to provide county-wide coordination and an interface to CLEER through proper communication system planning. The proximity of Larimer County to Wyoming suggests that coordination in this direction should also be investigated.

---

*Ibid.

The radio systems of the fire protection services of Larimer County are less complex than those of the law enforcement agencies but the requirements are similar. The major difference between the two services is that law enforcement radio traffic is relatively predictable, while fire protection radio traffic tends to be intermittent--being heavy during a major fire and relatively light during periods of no fire activity. Four fire protection radio channels are currently in use in Larimer County. These channels are used by the following fire departments and districts: Fort Collins FD, Poudre Valley FPD, and Loveland FD and RFPD.

A number of other agencies, including the Emergency Medical Services and National Park Services, should be integrated into a coordinated radio communication system along with law enforcement and fire protection agencies. Ultimately, not only should the connection to these agencies be considered, but the sharing of some of their existing remote sites should be considered in engineering a radio system to provide county-wide coverage.

C. Communication System Objectives

The objectives of a coordinated communication system can be summarized in a single sentence: The system shall provide a manageable, coordinated, radio network that will provide an improved level of communication at a reduced cost to the citizens of the county and its cities.

D. Alternative Communication Systems

Four alternative communication systems providing coordinated communication services in place of the seven law enforcement and two fire protection systems were developed to provide an average busy hour delay of 5 seconds (satisfactory to provide an overall communications delay of under one minute as established by the LEAA Standards and Goals). The four alternatives consist of:

- County-wide consolidation with combined telephone answering and dispatch (one-stage).

- County-wide consolidation with separate telephone answering and dispatch (two-stage).
- Separate north-county and south-county centers with single stage telephone answering and dispatch.
- Current nine dispatch centers augmented to provide level of service comparable to consolidated centers.

These alternatives are compared to the current operations, which are used as a baseline system.

The personnel requirements for each of these alternatives were established for current operations and estimated for projected work loads in the year 2000. In addition to the personnel requirements, the radio system, telephone system, and facility requirements were estimated. The cumulative costs of these systems from 1977 to 2000 were then estimated and compared with the current systems. The resulting cost estimates through the year 2000 are as follows:

Nine centers with current service levels	$13,671,000
Single-stage county-wide consolidation*	$11,204,000
Two-stage county-wide consolidation*	$14,416,000
Two-center county-wide consolidation*	$15,880,000
Nine centers with improved service levels	$19,106,000

E. Alternative Finance and Management Plans

A consolidated communications system can be financed and managed in several ways. It could be financed by a county-wide property tax or by a cost-sharing formula. It could be managed by contract, joint power agreements, or by creating special districts. County-wide tax rates for each alternative were developed, and several cost sharing formulas were explored. Although the county wide ad valorem property tax would be the most efficient and equitable funding arrangement, it may not be as acceptable to the potential participants as a cost-sharing formula.

---

*All consolidated alternatives provide improved service levels consistent with those specified in "Criminal Justice Standards, Goals, and Recommendations."

In the discussion of management alternatives, we conclude that a joint power agreement would probably be the most appropriate for Larimer County since it provides the most control to participant agencies.

F. Recommendations

SRI recommends that Larimer County and its cities develop a single county-wide public safety communication system. This system would provide improved communication services and coordination at less than current costs and would provide significant future savings.

This system could be operated under a joint power agreement among the participants and funded through one of several cost-sharing formulas.

To continue the development of this coordinated system we recommend that the following steps be taken by the potential system participants:

- Form a policy committee to determine the services to, and responsibilities of, the communication center and to establish mechanisms to insure member control of the center's operations. The future communications director, if desired, may be a member of this committee.
- Conduct a detailed engineering design to define firm initial and recurring costs, and specifications for the system.
- Establish personnel qualifications and training requirements.
- Obtain full commitment by all participants to the management, financing, and engineering design of the system.
- Obtain bids for system implementation and begin procurement of components.
- Begin personnel training and transfers as agreed on by member agencies.

II CURRENT COMMUNICATION SYSTEMS IN LARIMER COUNTY

The current dispatch operations of the public safety (law enforcement, fire protection, and emergency medical) systems in Larimer County are analyzed in the appendix to this report. They are summarized here to provide a basis for analysis of the current level of radio channel use and the costs of these systems.

A. Communications Operations

Queueing theory was used to analyze the operations of the current communication systems (see appendix). This method requires that measurements or estimates be made of the arrival of incoming telephone calls and requirements for dispatch action. The analysis provides statistical indications of the delays encountered by a dispatcher in responding to a variety of work units--such as answering the telephone, dispatching vehicles, maintaining the status of vehicles, making records checks, and so forth. The results of this analysis are summarized below.

1. Law Enforcement Communications

Larimer County is served by seven law enforcement agencies, not including the Colorado State Patrol. Five of these agencies--Colorado State University PD, Estes Park PD, Fort Collins PD, Larimer County Sheriff's Office (LCSO), and Loveland PD--provide their own full-time dispatching. Two agencies--Berthoud PD and Wellington PD, provide their own dispatching during normal working hours and are dispatched by the LCSO after hours and on weekends. The time loading of dispatchers (the percent of time they are occupied) and the average message delay encountered by an incoming message to these centers during the busy hour of each shift are summarized on Table 1.

Table 1

LAW ENFORCEMENT DISPATCHER WORK LOADS AND DELAYS

	First Shift			Day Shift			Swing Shift		
	Time Expended (min)	Operator Loading (%)	Average Delay (s)	Time Expended (min)	Operator Loading (%)	Average Delay (s)	Time Expended (min)	Operator Loading (%)	Average Delay (s)
Berthoud PD	- *	-	-	4.3	10	2	- *	-	-
Colorado State University PD	12.5	28	7	13.5	30	8	13.2	29	8
Estes Park PD	11.8	26	7	26.6	59	36†	22.7	50	22†
Fort Collins PD	26.9	60	30†	37.5	83	87†	32.5	72	51†
Larimer County SO	27.0‡	60	38†	40.0	89	274†	42.0‡	93†	452†
Loveland PD	13.2	29	8	16.3	36	11	13.2	29	8
Wellington PD	- *	-	-	4.3	10	2	- *	-	-

*Answering and dispatching provided by Larimer County Sheriff's Office during this shift.

†See text for explanation of operator loading in excess of 50%.

‡Also includes Berthoud PD and Wellington PD.

The information in Table 1 was derived from either actual counts or estimates of the shift busy hour calls for assistance or dispatches (see appendix).

The average delay (Table 1) indicates how rapidly a dispatcher could respond to a citizen's or field unit's request for service and contributes to how rapidly a field unit could be dispatched (assuming a field unit were available for dispatch). It is generally accepted that an average busy hour delay of 10 seconds or less for emergency and priority events is a good level of service. It can be seen in Table 1 that several of the agencies have delays of more than 10 seconds during one or more shifts. When this occurs, several actions are frequently taken during busy periods to minimize otherwise unacceptable communications delays:

(1) Priorities for responding to particular work elements are established or altered (e.g., the dispatcher answers telephones before responding to radio messages).

(2) Particular functions may be intentionally or unintentionally omitted (e.g., log entries are omitted).

(3) The dispatchers may increase their efficiency for short periods.

(4) Additional personnel may assist the dispatcher.

Several agencies have indicated that additional personnel have been requested or have been used to assist the dispatchers during busy periods (see discussions in the appendix).

2. Fire Protection Communications

Fire protection services are provided primarily by the Berthoud Rural Fire Protection District (RFPD), Estes Park FD, Fort Collins FD, Loveland FD and RFPD, Poudre Canyon RFPD, Poudre Valley FPD, Red Feather Lakes RFPD, Sheriff's Office (for range fires), and Wellington RFPD. Service is also provided by the U.S. Forestry Service and National Parks Service. Several small areas of the county are protected by RFPDs that are principally in adjacent counties: Windsor-Severance in Weld County and Pinewood Springs and Allens Park in Boulder County.

Since the busy period of fire protection activities is generally unpredictable, communications systems must be designed and operated to provide a capability of handling the maximum demand that can reasonably be expected for an area. Therefore, in the appendix, we have based our analysis of fire communication needs on (1) a busy hour load that is derived from average daily demands, and (2) on an estimate of the load created by large incidents.

Table 2 summarizes the dispatcher work loads and queues for the fire protection agencies of Larimer County. The dispatcher work loads for these three groups are such that the busy hour delays are all quite low. (Note that the load and delays in nonbusy hour periods would be much lower.)

If the busy hour for all three groups occurred at the same time, one dispatcher would be busy 68% of that hour and a delay of 20 seconds would occur. This simultaneous load would be the equivalent of about four fires and 13 pieces of equipment in the field at the same time--a rare, but not impossible, situation. This analysis indicates, then, that a single fire dispatch position could dispatch all fire fighting forces in the county with only small delays.

3. Emergency Medical Communications

There are three hospitals in Larimer County that provide dedicated emergency medical and ambulance services: Poudre Valley Memorial in Fort Collins, Loveland Memorial in Loveland, and Elizabeth Knutson Memorial in Estes Park. The communications of these services have been analyzed by the Colorado State Division of Communications under contract with the Colorado Department of Health. The recommendations of that study are now being implemented to provide for UHF dispatching and coordination of hospitals and ambulance services.

The abovementioned study did not include estimates of EMS dispatch traffic. Generally, however, estimates of EMS dispatch traffic volumes are based on the assumption that this traffic is about 5% of the police dispatch traffic for the service area. This estimate results in

Table 2

SUMMARY OF BUSY HOUR DISPATCHER WORK LOADS
AND QUEUES FOR LARIMER COUNTY FIRE PROTECTION AGENCIES

Agencies	Work Loads		Queues	
	Busy Hour (%)	Busy Hour and Major Fire (%)	Busy Hour (s)	Busy Hour and Major Fire (s)
Fort Collins FD and Poudre Valley FPD	39	50	7.0	11.0
Loveland FD/FPD and Berthoud FPD	18	27	2.5	4.0
Sheriff, Estes Park FD, Poudre Canyon RFPD, Red Feather Lakes FPD, and Wellington FPD	11	20	1.6	2.9

an operator loading of approximately 15% and a delay of 4 seconds for a single dispatcher serving the Larimer County emergency medical services.

4. Other Services

In addition to the local public safety services in Larimer County described above, a number of state and national services also must be considered in developing a county-wide emergency communications systems. These services include the Colorado State Patrol, state and federal forestry services, and other national emergency service agencies. Direct dispatch of these agencies has not been treated in this feasibility study, but the connection of these agencies to any county-wide communication system must be considered in any detailed engineering design.

B. Current Radio Systems

This section gives an overview of the radio systems currently in use by the law enforcement and fire protection services and provides estimates of the radio channel utilization on the existing command channels. Data provided in this section were derived from discussions with agency officials and from responses by the agencies to a recent survey by the Larimer-Weld Council of Governments. The delays on these channels are derived from data presented in the appendix.

1. Law Enforcement Radio Systems

The radio frequencies currently in use by the law enforcement and fire protection agencies of Larimer County are listed in Tables 3 and 4. The use of these frequencies and their associated equipment is discussed below.

The Berthoud PD operates on a VHF simplex channel and can also access the LCSO command channel, the Berthoud FD channel, and the Loveland FD channel. The police radio channel is also shared with other Berthoud local government functions. Their 70-watt base station is located at the department building and feeds a 40 ft-high antenna. The department has not observed any radio coverage or interference problems within the town limits.

Table 3

RADIO FREQUENCY ASSIGNMENTS--BY AGENCY

Agency	Frequency (MHZ)	Use	No. of Mobiles	No. of Portables
Berthoud PD	155.100	Command	3	3
Colo. State University PD	155.190	Command	7	12
Estes Park PD	154.770/154.935	Command	7	4
	154.935	Tactical	7	4
	154.905	State emergency		
	156.000	Utilities & fire	5	0
Fort Collins PD	460.300/465.300	Command	54	13
	460.350/465.350	Tactical	54	13
	460.425	CLEER	8	0
	155.040	Utilities		
Larimer County SO	154.710	Command	31	23
	155.130/154.170	Command	31	23
	154.385	Fireground	15	7
	169.175	Fire/Rescue	15	7
Loveland PD	156.750	Command	8	5
	154.710	Coordination	8	5
Wellington PD	154.710	Command	2	2
Berthoud FD	154.010	Command/tactical	2	0
Estes Park FD	156.000	Command	5	0
Fort Collins FD	460.625/465.625	Command	8	
	460.625	Fireground	8	
Loveland FD	154.010	Command	13	10
	154.385	Coordination	2	
Poudre Valley FD	460.600/465.600	Command	6	

Table 4

RADIO FREQUENCY ASSIGNMENTS--BY FREQUENCY

Frequency (MHz)	Larimer County Users	FCC Service Class	Other Users
154.010	Berthoud FD Loveland FD	Fire (Mobile)	
154.385	Larimer County SO Loveland FD	Fire (Base-mobile)	
154.710	Larimer County SO Loveland PD Wellington PD	Police (Mobile)	
154.770	Colorado State Patrol Estes Park PD	Police (Mobile)	
154.905	Estes Park PD Larimer County SO	Police (Base-mobile)	
154.935	Colorado State Patrol Estes Park PD	Police (Base-mobile)	
155.040	Fort Collins utilities	Local Government (Base-mobile)	
155.100	Berthoud PD	Local Government (Base-mobile)	Berthoud local government and Longmont
155.130	Larimer County SO	Police (Base-mobile)	
155.190	Colo. State University PD	Police (Base-mobile)	University of Colorado
156.000	Estes Park FD	Local Government (mobile)	Estes Park local government
156.750	Loveland PD	Police (Base-mobile)	
169.175	Larimer County SO	Fire (Base-mobile)	Littleton FD
460.300	Fort Collins PD	Police (Base-mobile)	Denver metropolitan area
460.350	Fort Collins PD	Police (Base-mobile)	Denver metropolitan area
460.425	Fort Collins PD	Police (Base-mobile)	
460.600	Poudre Valley FD	Fire (Base-mobile)	Thornton FD
460.625	Fort Collins FD	Fire (Base-mobile)	Westminster FD
465.300	Fort Collins PD	Police (Mobile)	Denver metropolitan area
465.350	Fort Collins PD	Police (Mobile)	Denver metropolitan area
465.600	Poudre Valley FD	Fire (Mobile)	Thornton FD
465.625	Fort Collins FD	Fire (Mobile)	Westminster FD

The Colorado State University PD operates on a VHF simplex channel. The 12-watt base station feeds a 30 ft-high antenna located on the Campus Health Building. The equipment is old and is probably operating below the rated power. Due to system age and degradation, the department has difficulty communicating on the main campus, let alone with remote facilities with whom it must also try to communicate.

The Estes Park PD operates on a regional VHF duplex channel assigned to the Colorado State Patrol. A repeater is located in Estes Park on Mt. Prospect, but the department has proposed to move this unit to the roof of the department building. They believe this move will minimize their interference with Colorado State Patrol (CSP) vehicles out of the vicinity of Estes Park and will minimize CSP interference to Estes Park vehicles. The Estes Park PD can also access a state emergency frequency and the town's local government and fire department frequency.

The Fort Collins PD has just recently updated their radio system for operation on two UHF duplex channels--one command channel and a separate tactical channel. The 30-W command transmitter, 75-W tactical transmitter, and a mobile repeater are located at the police department. In addition to these channels, about eight cars have access to the Colorado Law Enforcement Emergency Radio (CLEER) channel and the dispatcher can access the city's local government channel. The system provides full coverage of the city. The department shares these command and tactical channels with other agencies in Denver metropolitan areas; interference has been observed in the past.

The Larimer County Sheriff's Office uses two separate radio systems--one primarily for law enforcement activities and the second for range fire protection services. The basic law enforcement system is comprised of a VHF duplex system employing a 110-W base and repeater transmitters with a mobile repeater located at a facility shared with the CSP on Buckhorn Mountain. The mobile frequency on this system can also be used either as a mobile-to-mobile tactical channel or as a second command channel when the repeater is not required. The primary fire ground frequency can be used once the units have arrived on the scene, but it is necessary to use the law enforcement command channel while fire fighting

units are en route. In addition to the fire ground and fire/rescue frequencies, the department also has access to several other frequencies for coordination with the U.S. Forestry Service and for directing aircraft. Whichever frequency is used, there are numerous areas of poor communication because of the varied and remote terrain over which the sheriff's law enforcement and fire fighting units must operate.

The Loveland PD operates a VHF simplex channel, and can access the LCSO frequency for coordination purposes. The base station is located at the department and no coverage or interference problems have been observed within the city limits, but the equipment is about 10 years old and due for replacement. Interference from the City of Cunningham has been observed.

The Wellington PD operates on the LCSO command channel with a base station located at the Wellington PD.

2. Fire Protection Radio Systems

The Berthoud FD has been operating on a single VHF simplex channel, which it shares with the Loveland FD. At the time of this printing, the Berthoud FD had been licensed for a new VHF channel with a base to be installed at department headquarters..

The Estes Park FD operates on a VHF simplex channel, which it shares with other Estes Park local government functions. The base station for this channel is located at the Estes Park PD. In addition to the above radio system, the department has 32 Plectrons and one pager.

The Fort Collins FD uses a UHF duplex channel for command, and the mobile frequency of this pair is used as a fireground frequency. The base station and mobile repeater for this channel are located at city hall. The Fort Collins FD dispatcher also has access through a remote station at the Poudre Valley FPD. The system has provided good coverage and there has been no interference, although the Westminster FD is currently sharing this channel, using a tone-coded squelch system.

The Loveland FD operates on a VHF simplex system. Initially, the base station was located at the fire department's headquarters, but the base has recently been moved to Station 2 with an improvement in coverage and reduction in interference. The department also employs 60 dual-tone Plectrons to notify volunteers.

The Poudre Valley FD has recently installed a UHF duplex radio system. The base station for this system is located at the department headquarters and can be remotely accessed by the Fort Collins FD.

3. Emergency Medical Service Radio Systems

The plan for the Region II EMS coordination radio system specifies a duplex coordination channel on 462.950/467.950 MHZ. A mobile relay is currently being implemented for this channel at the Point of Rocks in Weld County. All ambulances and public safety agencies in Larimer and Weld Counties will have access to this coordination channel, including the Colorado State Patrol, Colorado State University, Elizabeth Knuttson Hospital, Estes Park PD, Fort Collins PD, Larimer County SO, Loveland Memorial Hospital, Loveland PD, and Poudre Valley Hospital.

In addition to the above coordination channel, each ambulance and hospital will carry radio equipment operating on frequencies 463.000/468.000, 463.025/468.025, 463.050/468.050, and 463.075/468.075 MHz. The ambulances will also be able to access the remaining national EMS channels: 463.100/468.100, 463.125/468.125, 463.150/478.150, 463.175/468.175, 462.975/467.975, 458.025/468.025, 458.075/468.075, 458.125/468.125, and 458.175/468.175 MHz. As designed, this system should provide EMS radio coverage to all of Larimer and Weld Counties.

4. Other Radio Systems

Although the abovementioned radio systems serve as the primary local, municipal, and county public safety radio systems, a number of other systems must be considered to varying degrees in developing a county-wide consolidated communication system.

A primary radio system of this group is that of the National Park Service. This agency maintains an extensive radio system covering the Rocky Mountain National Park. In addition to interfacing this system with any county-wide system, it may be possible to share some of their existing repeater sites to improve the overall coverage of other city and county systems.

In addition to federal and state forestry systems, provisions should be made to receive and coordinate with citizen band and amateur radio emergency systems. These groups, particularly the latter, have made significant contributions in assisting communications during recent disasters in Larimer County and in other regions.

C. Present Communication System Costs

The annual operating costs of the emergency communication systems are presented in Table 5. These costs were derived primarily from responses by the agencies to an information request made by the Larimer-Weld Council of Government and were updated by interviews with agency officials. Many of the cost categories used in Table 5 are not readily extractable from city and county budgets. For example, a department may know the budgeted direct salaries of personnel but benefits such as insurance, uniform allowance, social security, etc., may be carried in a separate city budget. Wherever employee benefits were not readily available from the departments, we used a consistent percentage of the direct salaries, which appeared to be representative of the area. Similarly, maintenance and telephone costs were not always separated in terms of emergency and nonemergency communication costs, and it was therefore necessary to estimate costs assuming that similar size agencies would have similar maintenance and telephone costs.

In addition to budgeted costs, there also can be an indirect cost associated with the facilities currently in use by the departments. Table 5 provides an estimate of the space currently allocated to

Table 5

PRESENT PUBLIC SAFETY COMMUNICATION SYSTEM COSTS

Agency	Personnel		Annual Maintenance Costs ($)	Annual Telephone Costs ($)	Facilities		Total Annual Costs ($)
	Number	Annual Costs ($)			Approx. Dimensions	Annual Costs ($)	
Berthoud PD	1	$ 8,300*	$ 300	$ 800	5 ft X 10 ft	$ 400	$ 9,800
Colorado State University PD	5	54,600*	1,100	800†	10 ft X 10 ft	700	57,200
Estes Park PD	4.5	44,700*	- ‡	4,500	10 ft X 12 ft	800	50,000
Fort Collins PD	6	66,500	5,500	3,400	20 ft X 20 ft	2,800	78,200
Larimer County SO	5	61,200*	1,200	7,200	10 ft X 20 ft	1,400	71,000
Loveland PD	5	50,000	1,200†	900†	5 ft X 10 ft	400	52,500
Wellington PD	1	8,300†	300†	800†	5 ft X 10 ft†	400†	9,800
Total	27.5	$293,600	$9,600	$18,400		$6,900	$328,500
Fort Collins FD	4	45,900*	1,200	2,000†	10 ft X 17 ft	1,200	50,300
Loveland FD	1	11,500†	1,200	7,500	9 ft X 11 ft	700	20,900
Total	5	$ 57,400	$2,400	$ 9,500		$1,900	$ 71,200

*Fringe benefits estimated at 15% of direct salaries.

†Estimated from costs of similar departments.

‡Maintenance is approximately $275 per year, which is paid by the state in return for dispatching services.

dispatching services.* The annual cost of this space has been estimated at $7 per square foot--which is the estimated annual cost of renting office space in the Fort Collins area.

The most significant fact to be noted from Table 5 is that approximately 90% of the total communication system costs are personnel salaries. These personnel salaries must be interpreted with care since many of the individuals represented in the salaries are performing multiple functions, and the total amount of the salaries shown may not necessarily be removed if the communication function were to be relocated away from the department. For example, some of the departments would still require records clerks if the dispatching communication functions were relocated, but less costly personnel could possibly be used for the records functions. Table 6 is an estimate of the personnel that could be made available from each department for a consolidated operation.

To place the operating costs in another perspective, we have provided yearly costs per capita and costs as a function of assessed valuation in Table 7. The costs per capita show a considerable variation, with the largest population paying the least for communication services and the smaller populations paying considerably more.

Another interpretation of the costs of emergency communication services is provided in the cost per $1000 assessed valuation. Two factors must be remembered in analyzing this column:

(1) The costs of Berthoud PD and Wellington PD are probably not representative since the dispatchers spend little time in communication functions and most of their time in other functions.

(2) All of the citizens of the cities and county contribute $0.19 per $1000 ad valorem to the county system in addition to supporting their local city systems, yet those citizens in the unincorporated areas receive the most direct benefits from the LCSO communication system.

---

*A room, approximately 30 ft X 60 ft, in the basement of the Larimer County Court House has been designated as an Emergency Operating Center. This facility may be sufficient as a temporary or permanent facility for a consolidated communications center, which could reduce the costs listed in Table 5.

Table 6

ESTIMATED CURRENT PERSONNEL POTENTIALLY AVAILABLE FOR A CONSOLIDATED COMMUNICATION SYSTEM

	Current Dispatchers	Potentially Available Dispatchers
Berthoud PD	1	0
Colorado State University PD	5	1-2
Estes Park PD	4.5	1-2
Fort Collins PD	6	5-6
Larimer County SO	5	5
Loveland PD	5	1-2
Wellington PD	1	0
Fort Collins FD	4	4
Loveland FD	1	1
Total	32.5	18-22

Table 7

PUBLIC SAFETY COMMUNICATION SYSTEMS COSTS PER CAPITA AND PER ASSESSED VALUATION--1976

	Total Communications Costs ($)	Population	Costs Per Capita	Assessed Valuation A.V.	Cost Per $1000 A.V.
Berthoud PD	9,800	2,800	$ 3.50	$ 4,700,000	$2.09
Colorado State University PD	57,200*	17,400	3.29	--†	--
Estes Park PD	50,000	2,200	22.73	15,400,000	3.25
Fort Collins PD	78,200	68,000‡	1.15	127,600,000	0.61
Larimer County SO	71,000	27,700	2.56	378,800,000	0.19
Loveland PD	52,500	25,900	2.03	72,500,000	0.72
Wellington PD	9,800	1,100	8.91	1,400,000	7.00
Fort Collins FD	50,300	68,000	0.74	127,600,000	0.39
Loveland FD	20,900	25,900	0.81	72,500,000	0.29

*Funding from State.

†Included in Fort Collins Assessed Valuation.

‡Includes Colorado State University.

III COMMUNICATION SYSTEM OBJECTIVES

This section sets forth the broad design and development objectives that an alternative future communication system must meet. The objectives are based on previous SRI experience and on recent knowledge of the local conditions of Larimer County and its cities. The objectives can be viewed as a set of criteria against which any existing or alternative communication system for Larimer County can be judged.

A. Operational Objectives

The operational objectives are as follows:

(1) The system must provide mutually agreed on levels of service to the citizens and user agencies (e.g., an average busy hour response time of less than 5 seconds is suggested in this report).

(2) The system must provide for coordination among member agencies as well as with outside agencies such as the Colorado State Patrol, the U.S. Forestry Service, and agencies in adjoining counties.

(3) Flexibility must be provided to permit adding staff and equipment in the event of a major incident.

(4) System design and operation must not be subject to catastrophic failure in the event of a major disaster or event, but must instead degrade gracefully.

B. Technical Objectives

The following technical objectives are seen:

(1) The system must provide median radio coverage to at least 90% of the geographical service area of any agency. This provides an area coverage of approximately 96%.

(2) The telephone system must provide easy citizen access to all emergency service agencies and be compatible with current or future implementation of 911 service, as requested by the local agencies and citizens.

(3) All radio and telephone messages must be recorded on logging tape recorders.

(4) The system should be compatible with, and easily adapted to, computer-aided dispatch (CAD) techniques desired or required in the future.

(5) The facilities must be reasonably secure against natural disasters and unwanted personnel intrusion.

(6) Emergency operating power must be available to the system to insure 24 hour continuous operation.

(7) The system must be designed for expansion to accommodate future population growth, work load increases, and changes in desired levels of service in the county.

(8) Radio coordination must be provided among dissimilar agencies.

C. Managerial Objectives

Managerial objectives are envisioned as follows:

(1) The management mechanism must provide all participating agencies and political units with sufficient control over the communications systems to ensure that it is responsive to their needs.

(2) The management mechanism must provide participants with: authority to control operating policy, needed fiscal control, and definite legal responsibilities of communication system participants.

(3) The participants must have effective recourse for grievances.

(4) Levels of service information must be readily available to participants, and participants should have direct and rapid mechanisms for adjusting service levels.

D. Financial Objectives

The financial objectives are as follows:

(1) The system should provide satisfactory levels of service to the agencies and citizens at minimum cost.

(2) An equitable cost sharing mechanism among cities and agencies must be provided.

(3) The selected funding mechanism should provide for financing the system to be implemented and provide for system evolution.

IV ALTERNATIVE COMMUNICATION SYSTEMS

Four ways of providing consolidated public safety communication services to Larimer County are discussed in this section. These alternatives are presented from operational, technical, and cost viewpoints. Management and financing of a consolidated system are discussed in Section V.

A. Alternative System Configurations

Four alternative system configurations were investigated:

(1) County-wide consolidation with single-stage telephone answering and dispatch.

(2) County-wide consolidation with two-stage telephone answering and dispatch.

(3) Separate north-county and south-county centers with single-stage telephone answering and dispatch.

(4) Current dispatch centers augmented to provide response times comparable to that provided by alternatives 1-3.

The work loads and personnel requirements for these alternatives were estimated from the data presented in Tables A-2 through A-11 in the appendix. In some cases, the number of telephone calls received by each law enforcement agency that potentially could be dispatched must be reduced from those presented in Tables A-2 through A-8, since many of the present telephone answering and dispatch personnel are also answering administrative calls--particularly during the first and swing shifts. The telephone call volumes shown in Table 8 were derived by assuming that the calls for all departments except the Estes Park PD and the Larimer County SO are of a priority nature, as viewed by the citizen, and would be first received at the dispatch center. For the Estes Park PD and Larimer County SO, we assumed that 65% of the calls to a consolidated dispatch center would be dispatchable (e.g., the number of busy hour dispatches were divided by 65% to establish the number of busy

hour calls) and that the remaining calls would be answered by, or referred to, the administrative switchboard of the respective department.

Table 8

SUMMARY OF BUSY HOUR LAW ENFORCEMENT TELEPHONE CALLS

Agency	First Shift	Day Shift	Swing Shift
Berthoud PD	1	2	1
Colorado State University PD	5	5	5
Estes Park PD	5	6	8
Fort Collins PD	8	9	9
Larimer County SO	6*	8	6*
Loveland PD	5	6	5
Wellington PD	1	2	1
Total	31	38	35

*Does not include after hours answering for Berthoud PD and Wellington PD.

The number of law enforcement dispatch activities (dispatches, status checks, information checks, and log entries) were extracted directly from Tables A-2 through A-8 and are summarized in Tables 9, 10, and 11. Note that the log entries for the incoming telephone calls are not included in these tables.

Table 9

SUMMARY OF FIRST SHIFT LAW ENFORCEMENT BUSY HOUR DISPATCH ACTIVITIES

Agency	Dispatches	Status Checks	Information Checks	Log Entries
Berthoud PD	1	2	1	4
Colorado State University PD	3	8	3	14
Estes Park PD	3	6	3	12
Fort Collins PD	5	19	12	36
Larimer County SO	4*	8*	4*	16*
Loveland PD	3	10	3	16
Wellington PD	1	2	1	4
Total	20	55	27	102

*Does not include Berthoud PD and Wellington PD.

Table 10

SUMMARY OF DAY SHIFT LAW ENFORCEMENT BUSY HOUR DISPATCH ACTIVITIES

Agency	Dispatches	Status Checks	Information Checks	Log Entries
Berthoud PD	1	2	1	4
Colorado State University PD	3	11	3	17
Estes Park PD	4	8	4	16
Fort Collins PD	6	39	15	60
Larimer County SO	5	10	5	20
Loveland PD	4	12	4	20
Wellington PD	1	2	1	4
Total	24	84	33	141

Table 11

SUMMARY OF SWING SHIFT LAW ENFORCEMENT BUSY HOUR DISPATCH ACTIVITIES

Agency	Dispatches	Status Checks	Information Checks	Log Entries
Berthoud PD	1	2	1	4
Colorado State University PD	3	10	3	16
Estes Park PD	5	10	5	20
Fort Collins PD	6	24	15	45
Larimer County SO	4*	8*	4*	16*
Loveland PD	3	10	3	16
Wellington PD	1	2	1	4
Total	23	66	32	121

*Does not include Berthoud PD and Wellington PD.

The number of staffed positions for the law-enforcement section of communication consolidation Concept 1 are estimated in Table 12. It is worth noting that the estimates presented in Table 12 (and following tables) are possibly high because it is assumed that the busy hour for all departments occurs simultaneously.*

*Actual traffic counts should be made and analyzed as part of an engineering study should the cities and county proceed with the implementation of consolidated dispatching.

Table 12

STAFFED POSITIONS REQUIRED FOR SINGLE-STAGE COUNTY-WIDE CONSOLIDATION OF LAW ENFORCEMENT COMMUNICATIONS

Element	First Shift		Day Shift		Swing Shift	
	Number	Time(min)	Number	Time(min)	Number	Time(min)
Telephone answering (60 s/call)	31	31.0	38	38.0	35	35.0
Dispatches (20 s/dispatch)	20	6.7	24	8.0	23	7.7
Status checks (10 s/check)	55	9.2	84	14.0	66	11.0
Information check (40 s/check)	27	18.0	33	22.0	32	21.3
Log entries (10 s/entry)	133	22.2	179	29.8	156	26.0
Total	266	87.1	358	111.8	312	101.0
Positions required for average busy hour delay of less than 5 s.	4		4		4	

The personnel calculations are based on an average busy hour communication delay of less than 5 seconds, which is an excellent level of service and is better than that currently being provided by some of the larger departments in Larimer County. This level of response time will assure provision of an overall response of one minute to emergency complaints, as recommended by the LEAA Standards and Goals.

Separating the telephone answering and dispatching functions as suggested in consolidation Concept 2, requires adding an extra 10 seconds to the call answering time to account for the logging of telephone calls; this time is then subtracted from the dispatcher logging time. The times and answerer and dispatcher requirements are shown in Table 13. Seven telephone calls have been added to each busy hour call volume to account for incoming fire alarms and EMS requests, which would be answered by the call answerers and routed to the proper dispatcher. As can be seen in the final entry in Table 13, "Total Positions," two additional full-time positions would be required for a two-stage system compared with the single stage system of Table 12.

The final consolidation concept considers separation of the northern and southern portion of the county into separate centers. For this concept, we have assumed that the Town of Berthoud, Town of Estes Park, City of Loveland, and approximately one-half of the Larimer County Sheriff Office's dispatch would be served by the southern center and the remainder of the county would be served by the northern center. The number of answering/dispatch positions required for this alternative are shown in Table 14.

The final concept investigated was the number of personnel that would be necessary to improve the existing communication services to provide a response time comparable to that of the above system concepts. This includes logging all events, which is currently not accomplished by some agencies. These projections are shown in Table 15.

A more exact comparison of the concepts can be made by including the fire/EMS answering and dispatcher requirements, as shown in Table 16. The total number of personnel shown in Table 16 were derived by multiplying

Table 13

STAFFED POSITIONS REQUIRED FOR TWO-STAGE COUNTY-WIDE CONSOLIDATION OF LAW ENFORCEMENT COMMUNICATIONS

	First Shift		Day Shift		Swing Shift	
	Number	Time(min)	Number	Time(min)	Number	Time(min)
Telephone Answering						
Telephone Answering (70 sec/call)	38	44.3	45	52.5	42	49.0
Call Answers required for average delay of less than 5 s	3		3		3	
Dispatching						
Dispatches (20 s/dispatch)	20	6.7	24	8.0	23	7.7
Status checks (10 s/check)	55	9.2	84	14.0	66	11.0
Information checks (40 s/check)	27	18.0	33	22.0	32	21.3
Log entries (10 s/entry)	102	17.0	141	23.5	121	20.2
Total	204	50.9	282	67.5	242	60.2
Positions required for average delay of less than 5 s	3		3		3	
Total positions	6		6		6	

Table 14

STAFFED POSITIONS REQUIRED FOR TWO-CENTER COUNTY-WIDE CONSOLIDATION OF LAW ENFORCEMENT COMMUNICATIONS

	First Shift		Day Shift		Swing Shift	
	Number	Time(min)	Number	Time(min)	Number	Time(min)
North County Center						
Telephone answering (60 s/call)	17	17.0	20	20.0	18	18.0
Dispatches (20 s/dispatch)	11	3.7	13	4.3	12	4.0
Status checks (10 s/check)	33	5.5	57	9.5	40	6.7
Information checks (40 s/check)	18	12.0	22	14.7	21	14.0
Log entries (10 s/entry)	79	13.2	112	18.7	91	15.2
Total	158	51.4	224	67.2	182	57.9
Dispatchers required for average delay of less than 5 s	3		3		3	
South County Center						
Telephone answering (60 s/call)	14	14.0	18	18.0	17	17.0
Dispatches (20 s/dispatch)	9	3.0	11	3.7	11	3.7
Status checks (10 s/check)	22	3.7	27	4.5	26	4.3
Information checks (40 s/check)	9	6.0	11	7.3	11	7.3
Log entries (10 s/entry)	54	9.0	67	11.2	65	10.8
Total	108	35.7	134	44.7	130	43.1
Dispatchers required for average delay of less than 5 s	2		3		3	
Total positions	5		6		6	

Table 15

STAFFED POSITIONS REQUIRED TO IMPROVE
EXISTING LAW ENFORCEMENT COMMUNICATIONS

Agency	First Shift	Day Shift	Swing Shift
Berthoud PD	-	1	-
Colorado State University PD	1	1	1
Estes Park PD	1	2	2
Fort Collins PD	2	3	2
Larimer County SO	2	3	3
Loveland PD	1	2	1
Wellington PD	-	1	-
Total	7	13	9

Table 16

COMPARISON OF PERSONNEL REQUIREMENTS
FOR ALTERNATIVES - PRESENT REQUIREMENTS

	Staffed Positions			Total Personnel
	First Shift	Day Shift	Swing Shift	
Present Systems				32.5*
Single Stage County-Wide Consolidation				
Law enforcement	4	4	4	
Fire and EMS	1	1	1	
Total	5	5	5	24
Two-Stage County-Wide Consolidation				
Telephone answering	3	3	3	
Law enforcement dispatch	3	3	3	
Fire/EMS dispatch	1	1	1	
Total	7	7	7	34
Two-Center County-Wide Consolidation				
North county law enforcement	3	3	3	
North county fire protection and EMS	1	1	1	
South county law enforcement	2	3	3	
North county fire protection and EMS	1	1	1	
Total	7	8	8	37
Nine centers with improved service	8*	14*	10*	51

*Includes four dispatchers for Fort Collins FD and one dispatcher for Loveland FD.

the number of positions to be staffed in each shift by 1.6. This factor is an average figure, which accounts for coverage on weekends and holidays plus vacation leave, sick leave, etc. In actual operation, it may be possible to reduce the total number of personnel shown through judicious staggering of shifts, but the numbers shown here are representative for comparative purposes.

B. Impact of Population Growth on Future Communication Personnel Requirements

The population of Larimer County is projected by the Larimer-Weld Council of Governments to increase approximately linearly from a 1976 population of 128,000 to a year 2000 population of 270,000. The impact of this population increase on future public safety communications operational personnel requirements can be estimated under the following assumptions:

- The future population will be distributed in the county approximately as it is distributed today.
- Calls for public safety service will increase in proportion to population.
- Public safety agency service policies (responses to service requests) will remain constant, e.g., agencies will add personnel to satisfy these policies as demands for service increase.
- No technological improvements such as digital communications and/or computer-aided dispatch will be implemented.

The number of communications personnel required in the year 2000 based on these assumptions is shown in Table 17 for each alternative and the current operations. An average annual dispatcher salary (including benefits) of $10,800 can be calculated using the current personnel costs presented previously in Table 5. Using this average salary and assuming no increase to account for inflation (the reader may insert a representative inflation rate, but the relative comparison of costs will remain the same) results in initial (1976) and cumulative personnel costs through the year 2000 shown in Table 18.

As can be seen in Table 18, a single-stage county-wide system will result in long-term savings in personnel costs in excess of $3 million.

Table 17

COMMUNICATION PERSONNEL REQUIREMENTS--YEAR 2000

	First Shift		Day Shift		Swing Shift		Total
	Time	Dispatchers	Time	Dispatchers	Time	Dispatchers	Dispatchers
Nine Centers with Current Level of Service							
Berthoud PD	--	--	9.1	1	--	--	1
Colorado State University PD	12.5	1	13.5	1	13.2	1	5
Estes Park PD	24.9	1	56.1	2	47.9	2	8
Fort Collins PD	56.7	2	79.1	3	68.6	2	11
Larimer County SO	57.0	1	84.4	3	88.6	3	11
Loveland PD	27.8	2	34.4	2	27.8	2	10
Wellington PD	--	--	9.1	1	--	--	1
Fort Collins FD	36.7	2	26.7	2	36.7	2	10
Loveland FD	17.3	1	17.3	1	17.3	1	5
Total dispatchers							62
Single-Stage County-Wide Consolidation							
Law enforcement	183.7	6	235.8	7	213.0	7	32
Fire/EMS	64.3	2	64.3	2	64.3	2	10
Total dispatchers							42
Two-Stage County-Wide Consolidation							
Telephone answering	93.4	5	110.7	5	103.4	5	24
Law enforcement dispatching	107.4	4	142.4	5	127.0	5	22
Fire/EMS dispatching	64.3	2	64.3	2	64.3	2	10
Total personnel							56
Two-Center County-Wide Consolidation							
North county law enforcement dispatch	108.4	4	141.8	5	122.1	5	22
North county Fire/EMS dispatch	41.8	2	41.8	2	41.8	2	10
South county law enforcement dispatch	75.3	3	94.3	4	90.9	4	18
South County Fire/EMS Dispatch	22.5	2	22.5	2	22.5	2	10
Total personnel							60
Nine Centers with Improved Service							
Berthoud PD	--	--	9.1	1	--	--	1
Colorado State University PD	12.5	2	13.5	2	13.2	2	10
Estes Park PD	24.9	2	56.1	3	47.9	3	13
Fort Collins PD	59.6	3	82.3	4	71.7	3	16
Larimer County SO	62.2	3	95.0	4	99.1	4	18
Loveland PD	27.8	2	34.4	2	27.8	2	10
Wellington PD	--	--	9.1	1	--	--	1
Fort Collins FD	36.7	2	36.7	2	36.7	2	10
Loveland FD	17.3	1	17.3	1	17.3	1	5
Total personnel							84

Table 18

CUMULATIVE PERSONNEL COSTS FOR ALTERNATIVE SYSTEMS

	1976 Personnel Costs ($)	Cumulative Personnel Costs Through Year 2000 ($)
Maintain current service level	$351,000	$12,247,000
Single-stage county-wide system*	280,800	9,072,000
Two-stage county-wide system*	388,800	12,182,000
Two-center county-wide system†‡	442,800	13,608,000
Nine centers with improved service	550,800	17,496,000

*Costs include salary for center director and secretary.
†Costs include salaries for two center directors and secretaries.
‡Single-stage systems.

Furthermore, any of the consolidated alternatives will save at least $4 million in personnel costs over the next 24 years compared with individual agency improvement to existing services.

C. Radio System Considerations

Command channel use by the law enforcement and fire protection agencies was estimated from the information in Tables A-2 through A-11 in the appendix. Estimates for current and future workloads are shown in Table 19.

The total time that the law enforcement command radio channels are required was estimated from the radio time required for dispatches, status checks, and information requests. The resulting time was divided by the total channel time available in one hour (60 minutes) to obtain the percent utilization. The number of channels required was estimated using queueing analysis and restricting the average channel waiting time to less than 5 seconds. If the average message length is 10 seconds, as assumed here, a radio channel can carry 20 minutes of traffic (33%

Table 19

BUSY HOUR RADIO TRAFFIC

Agency	Message Time			1976			2000		
	Dispatch	Status	Information Checks	Total Time(min)	Channels	Occupancy (%)	Total Time(min)	Channels	Occupancy (%)
Law Enforcement									
Berthoud PD	0.3	0.3	0.3	0.9	1	1.5	1.9	1	3.2
Colorado State University PD	1.0	1.8	1.0	3.8	1	6.3	3.8	1	6.3
Estes Park PD	1.6	1.6	1.6	4.8	1	8.0	10.1	1	16.9
Fort Collins PD	2.0	6.5	5.0	13.5	1	22.5	28.5	2	23.8
Larimer County SO	1.7	1.7	1.6	5.0	1	8.3	10.5	1	17.6
Loveland PD	1.3	2.0	1.3	4.6	1	7.7	9.7	1	16.2
Wellington PD	0.3	0.3	0.3	0.9	1	1.5	1.9	1	3.2
Total Law Enforcement with Channel Sharing				33.5	2	27.9	66.4	4	27.7
Fire Protection									
Fort Collins FD	7.2	--	--	7.2	1	12.0	15.2	1	25.3
Loveland FD and RFPD	8.2	--	--	8.2	1	13.7	17.3	1	28.8
Sheriff and Other RFPDs	4.9	--	--	4.9	1	8.2	10.3	1	17.2
Total Fire Protection with Channel Sharing				20.3	2	16.9	42.8	3	23.8

occupancy) before the average channel access delay exceeds five seconds. Thus, it can be seen on Table 19 that the current radio channels are relatively lightly loaded.

Estimates of the radio traffic for the year 2000 were derived assuming the radio traffic will increase in proportion to the population (current population of 128,000 and 2000 population of 270,000). As can be seen in Table 19, only one department, Fort Collins PD, would be required to add another command channel by 2000. Finally, the channel requirements were determined assuming the channels could be shared by the departments and the traffic could be evenly distributed. This assumption results in a requirement for two command channels currently and four channels in 2000--this compares to the nine law enforcement channels (excluding CLEER) currently is use in Larimer County (see Table 4).

The utilization of the fire protection command radio channels was estimated using the data presented in Tables A-9 through A-11, as shown in Table 19. The resulting analysis shows that the county could currently be served by two command channels instead of the five channels currently in use, or the channels could be distributed to provide better fire ground and command coverage.

Using the year 2000 radio channel loadings, a tentative channelization plan can be developed without assigning specific frequencies at this time, as shown in Table 20.* With proper planning of duplex and simplex radio systems it should be possible to provide this plan in Larimer County with existing radio channels.

Of particular interest are the VHF and UHF coordination channels. Since it is impractical for each mobile unit to carry radio equipment for both frequency ranges, conversion should be made at base stations or mobile repeater sites. The most common method of providing this conversion is to connect the received audio of one receiver (i.e., VHF) to the microphone input of the alternate transmitter (UHF, in this case) at the

---

*In addition to these channels, the EMS channels discussed in Section II-B-3 would also be in use in Larimer County.

Table 20

TENTATIVE RADIO CHANNELIZATION PLAN

Channel	Use	Agencies	Year 2000 Occupancy
VHF-1	Command	Berthoud PD, Larimer County SO, Wellington PD	28%
VHF-2	Command	Estes Park PD, Larimer County SO, Loveland PD	28%
VHF-3	Administrative, Undercover, Coordination	Berthoud PD, Estes Park PD, Larimer County SO, Loveland PD	--*
UHF-1	Command	Colorado State University PD, Fort Collins PD	27%
UHF-2	Command	Fort Collins PD	27%
UHF-3	Administrative, Undercover, Coordination	Colorado State University PD, Fort Collins PD	--*
VHF-4	Command	Loveland FD and RFPD	29%
VHF-5	Command	All other RFPDs	17%
VHF-6	Fireground Coordination	Loveland FD and all RFPDs	--*
UHF-4	Command	Fort Collins FD and Poudre Valley RFPD	25%
UHF-5	Fireground, Coordination	Fort Collins FD and Poudre Valley RFPD	--*

*Variable, depending on activities.

communication center. This same principle can be applied by connecting a VHF and UHF transceiver "back-to-back" at a mobile repeater site. Although this latter method has been used in military applications, there is currently no "off-the-shelf" equipment in the land mobile frequency range since there has been no demand to warrant "type testing."

Table 21 provides a budgetary cost estimate to implement the frequency plan of Table 20. The following assumptions have been made to develop this estimate:

- The existing law enforcement VHF base stations and mobile repeaters may require relocation and frequency changes to adapt to new frequency plan.
- The Fort Collins PD base stations could provide two of the three required UHF law enforcement base stations. One new UHF base station may be required.
- Each law enforcement mobile and portable radio, except those of the Colorado State University PD and Fort Collins PD will require frequency changes on one channel to adapt to the plan. Fort Collins PD will require no changes and the Colorado State University PD will require new radios to adapt to UHF.
- Two of the six VHF fire protection base stations could be provided by those currently in use by the Larimer County SO.
- The UHF base stations of the Fort Collins FD could serve for the UHF fire protection channels.
- Each fire protection mobile and portable radio will require frequency changes on one channel.

Table 21 indicates a total equipment cost of approximately $80,000 to provide a consolidated law enforcement and fire protection communication system. This figure must be used cautiously since final equipment requirements will require a detailed design and investigation to establish a final frequency plan and to assess the age, condition, and adaptability of all radio equipment currently in use. The final system design must also accommodate necessary radio interfaces to state and national law enforcement and fire protection systems as well as those in adjoining counties and provide connections to the proposed regional emergency medical coordinating system.

D. Telephone System Considerations

Larimer County is currently served by seven telephone company central offices operated by Mountain Bell Telephone Company: Allens Park, Berthoud, Estes Park, Fort Collins, Loveland, Red Feather Lakes, and Wellington. Trunk lines, known as foreign exchange telephone lines, will be required to provide toll-free calls from each of the areas served by these central offices to a central communication operation. Table 22 estimates the number and cost of lines required to provide for a P01 grade of service--only one call in 100 will encounter a busy signal in the busy hour (this is a common grade of service for 911 systems)--for each of these central

Table 21

BUDGETARY COST ESTIMATES OF COORDINATED RADIO SYSTEM

Equipment	Estimated Cost
Law Enforcement Equipment	
Base stations:	
1 ea VHF-1, 2 ea VHF-2, 3 ea VHF-3 — Available from existing equipment of Estes Park PD, Larimer County SO, and Loveland PD	
Cost to relocate and recrystal (if necessary)	$ 6,000
1 ea UHF-1, 1 ea UHF-2 — Available from existing equipment of Fort Collins PD. Current location and frequency satisfactory	
1 ea UHF-3 New base station required	6,000
Mobile and portable radio equipment:	
Berthoud PD--frequency changes, 3 mobiles, 3 portables	600
Estes Park PD--frequency changes, 7 mobiles, 4 portables	1,100
Fort Collins PD--no changes required	0
Larimer County SO--frequency changes, 31 mobiles, 35 portables	6,600
Loveland PD--frequency changes, 8 mobiles, 5 portables	1,300
Wellington PD--frequency changes, 2 mobiles, 2 portables	400
Colo. State University PD--purchase 7 mobiles	11,200*
purchase 12 portables	18,000*
Total law enforcement radio equipment costs	$51,200†
Fire Protection Equipment	
Base stations	
2 ea VHF-4 Available from Larimer County SO	
Cost to relocate and recrystal (if necessary)	2,000
2 ea VHF-5 New base stations required	12,000
2 ea VHF-6 New base stations required	12,000
1 ea UHF-4, 1 ea UHF-5 Fort Collins FD and Poudre Valley FPD — Available from existing equipment at	0
Mobile and Portable radio equipment	
Berthoud FD--frequency changes, 2 mobiles	200
Estes Park FD--frequency changes, 5 mobiles	500
Fort Collins FD--no change	0
Loveland FD--frequency changes, 13 mobiles, 10 portables	2,300
Poudre Valley FD--frequency changes, 6 mobiles	600
Total fire protection radio equipment costs	$29,600†

*May be covered through state funds.

†These costs may vary significantly depending on the final frequency plan and the age and condition of existing radio equipment.

Table 22

ESTIMATED MONTHLY COST OF INCOMING TELEPHONE LINES
TO A CONSOLIDATED COMMUNICATION SYSTEM

Central Office	Main Stations	Served Population	Busy Hour Calls*	Lines Required†	Miles to Fort Collins	Monthly Cost($)
Allens Park	500	1,300	0.5	2	40	$ 369
Berthoud	1,500	3,800	1.3	2	19	221
Estes Park	3,300	8.200	2.9	2	28	282
Fort Collins‡	31,100	78,000	27.4	4	0	554§
Loveland	13,500	33,900	11.9	3	13	257
Red Feather Lakes	300	800	0.3	2	31	295
Wellington	800	2,000	0.7	2	10	176
Total	51,000	128,000	45	17		$2,411

*Includes fire protection and EMS calls.

†Minimum of two lines to assure P01 grade of service, 10 second ring down.

‡Includes Colorado State University which is on its own Centrax system.

§Monthly termination charge.

offices. The number of lines is based on the number of telephone subscribers (main stations) as a percentage of population. The costs shown in Table 22 may also be viewed as the cost of providing a basic county-wide 911 emergency telephone system to Larimer County if a consolidated communication center were available.

In addition to the incoming telephone lines, there should be direct telephone lines from the communication center to each agency served and lines to radio repeater sites. For budgetary purposes, one can assume the cost of these direct lines to be comparable to the cost of the incoming lines (e.g., the total monthly telephone bill for a county-wide consolidated center would be approximately twice that shown in Table 22, or $5,000). The cost of a two-center operation would be similar to that presented above. Since many agencies would still maintain all or part of their current telephone lines to handle administrative calls, there would probably not be a significant reduction in individual agency telephone costs.

Microwave radio systems should be considered as an alternative to leased telephone phone lines to carry communications from consolidated communication centers to remote radio repeaters and public safety agencies, particularly on paths requiring several lines or channels. Low capacity (12 channel) microwave systems are becoming relatively inexpensive (approximately $40,000* for a 20-mile path) and are cost effective if compared to the lease cost of telephone lines amortized over ten years. In addition to potential long-term cost savings, microwave systems provide additional system reliability and protection if telephone lines become inoperative in the event of a natural disaster.

Although they are not appropriate for all applications, microwave links should be considered during the engineering design of a county-wide communication system. In addition to a public safety application, microwave systems could possibly be shared with other users such as county

---

*An additional $10,000 may be incurred if a passive repeater must be installed to direct the path over mountainous terrain.

public works and other functions to reduce the overall cost to each of the user agencies.

E. Cost Comparison of Alternative Systems

The costs of personnel, radio equipment, and telephone equipment are compared in Table 23. The following assumptions were made in making the comparison:

- No immediate radio systems or telephone system improvements would be made if the agencies elected to continue their current operations.
- Dispatch console costs are estimated at $10,000 each. We have assumed at least two consoles would be available from existing law enforcement operations to supplement those required by the consolidated alternatives. One console in Fort Collins FD could be used to consolidate fire protection communication operations.
- Over the years, it will be necessary for the individual agencies to make minimal radio system improvements costing at least $80,000, as outlined in this report. In addition, new radio consoles must be added to each alternative as additional dispatchers are required.
- The annual cost of maintenance is estimated at 5% of new equipment acquisition costs plus the current annual cost of $12,000.
- Although additional telephone equipment will be required by the agencies to maintain the current level of service, no cost has been estimated for this equipment.
- Each dispatch position requires 100 square feet of floor space, at $7 per year.
- Because of the population increase, it was assumed the cost of telephone system improvements would increase proportionally to population for the two unconsolidated systems.
- An inflation factor has not been included in this table.

Table 23 shows that a county-wide consolidated system, as specified, provides better communication response time than is currently being provided, would cost the citizens approximately 18% less than the present system over the next 24 years, and would cost only 60% of the cost of improving the present systems to provide a comparable service.

Table 23

COST COMPARISONS OF ALTERNATIVE COMMUNICATIONS SYSTEMS

	Nine Centers with Current Level of Service	Single-stage County-wide Consolidation	Two-stage County-wide Consolidation	Two-stage County-wide Consolidation	Nine Centers with Improved Service
Initial Costs					
Law enforcement radio systems	$ 0	$ 51,000	$ 51,000	$ 51,000	$ 51,000
Fire protection radio systems	0	30,000	30,000	30,000	30,000
Law enforcement dispatch consoles	0	20,000	40,000	40,000	40,000
Fire protection dispatch consoles	0	0	0	10,000	0
Total initial costs	$ 0	$ 101,000	$ 121,000	$ 131,000	$ 121,000
Cumulative Recurring Costs Through Year 2000					
Personnel	$12,247,000	$ 9,072,000	$12,182,000	$13,608,000	$17,496,000
Law enforcement dispatch console and radio system improvements	91,000	30,000	40,000	30,000	50,000
Fire protection dispatch consoles and radio system improvements	40,000	10,000	10,000	20,000	10,000
Radio system maintenance	367,600	433,000	463,000	475,000	469,000
Telephone system	688,000	1,440,000	1,440,000	1,440,000	688,000
Facilities	238,000	118,000	160,000	176,000	272,000
Total recurring costs through Year 2000	$13,671,000	$11,103,000	$14,295,000	$15,749,000	$18,985,000
Total costs through Year 2000	$13,671,000	$11,204,000	$14,416,000	$15,880,000	$19,106,000

V FINANCE AND MANAGEMENT CONSIDERATIONS

In any system involving a number of participants, there is no simple solution to all questions of finance and management. All participants are interested in these issues since decisions about funding and management establish the permanent controls over the operation. Much is at stake during these discussions, and sufficient time must be allowed for all questions to be thoroughly discussed and answered. If this is not done, the ultimate success of a new system could be jeopardized because potential participants will be afraid that they may be adversely affected. By discussing various financing and management plans before selecting a system, it will be possible to isolate and resolve potential areas of conflict. The following two sections address these problems and offer alternatives.

A. Finance Considerations

Any funding mechanism must be capable of fulfilling the following criteria.

- It must be perceived as equitable by all participants, and it must not unduly burden any one area.
- It must be designed to provide annual funding with minimal problems; i.e., it must be reliable.
- It must adapt to reasonable increases in operating costs, and all participants should realize that costs will increase over time. Participants must be prepared to meet these costs (realizing that cost increases will also be experienced in any system).
- No one agency should benefit at the expense of another agency; that is, no agency should be able to profit through the provision of this crucial public service.

There are two general mechanisms that will allow a consolidated communications system to meet these criteria, taking into consideration the varying size and resources of potential participants such as those in Larimer County.

- A county-wide tax can be levied equally on all taxable property that will be served by the new center. This can be done by the county or through the formation of a special district.
- A cost-sharing formula can be adopted, with each participant agreeing to provide a certain percentage of the annual costs. These percentages can be determined in a variety of ways, with the equity of the costs determined through agency agreement..

Either funding mechanism can be used in combination with different management agreements, if all participants agree that the combined financing and management plan is acceptable.

There is a third way to finance such a service, but it is a variation of cost sharing and is normally used when one agency contracts with others to provide a service. In this situation, the contracting agency bills the users according to an agreed on formula, which is in reality a cost-sharing mechanism.

The following sections discuss the two basic funding mechanisms and provide concrete examples of both.

1. Ad Valorem Property Tax

This is the most straightforward way to finance a county-wide service such as consolidated communications. The ad valorem tax is often used since it is the only major source of revenue controlled at the local level. Thus, it can be adjusted to meet local needs. All citizens living in incorporated areas pay taxes toward municipal public safety communications as well as county communications. Thus, citizens in unincorporated areas are being indirectly subsidized by revenue from incorporated areas through their contributions to the county-wide ad valorem tax. A single county-wide tax would adjust this situation. While the county tax rate would necessarily increase to cover the total cost of the consolidated system, municipal rates could be reduced in proportion to the amount of revenue they will save because of consolidation.

Table 24 shows the tax rates necessary to support each alternative and the present systems during the first operating year. In addition,

Table 24

COMPARISON OF FIRST-YEAR TAX RATES AND AVERAGE ANNUAL OPERATING COSTS FOR ALTERNATIVE COMMUNICATION SYSTEMS

	First Year Costs ($)	County-Wide Tax Rate First Year* ($)	Average Annual Costs Through Year 2000 ($)
Nine centers with current level of service	$399,700	$1.06	$569,600
Single-stage county-wide system	360,000	0.95	466,800
Two-stage county-wide system	470,600	1.24	600,700
Two-center county-wide system	526,700	1.39	661,700
Nine centers with improved service	606,000	1.60	796,100

*Costs per $1,000 assessed valuation, based on 1976 assessed valuation of $378,800,000.

it gives the first year operating costs and the average annual costs through the year 2000. The single-stage county-wide center has the lowest annual recurring cost and the lowest first year costs, which could be supported with the lowest tax rate. This rate is less than that which would be necessary to support existing services if they were funded in this manner. The totally consolidated alternative would cost approximately $40,000 less during the first operating year, and would average $100,000 less annually through the year 2000.

This funding mechanism has the following advantages:

- It is an equitable way to finance consolidated communications since all property-owning citizens would be contributing equally to the cost of the system.
- It is a reliable funding mechanism, since it would be collected annually to support this service. It eliminates the possibility of an agency suddenly deciding to withhold funds in an attempt to dominate a policy issue.

- The property tax is the only major source of revenue that local agencies control; as a consequence, this mechanism can be adjusted by local governments.

Furthermore, when a county is directly responsible for collecting revenue to support a service necessary to all, there is always some concern that the county government will benefit unduly from the situation. In addition, there is usually a certain amount of concern that the county will seize control of the system because it is collecting the funds. Both of these concerns can be alleviated under this funding mechanism. First, the operating budget and the rate to be collected for this purpose should be written into the management agreement. Second, the same agreement should specify that the county must allocate these funds for the support of county-wide communications. If these safeguards are established there should be little chance that the perceived ills will occur.

The county-wide tax can be used to support a communications system operated through a joint power agreement or a special district.

2. Cost Sharing

Cost sharing is often used as a funding mechanism by local agencies to consolidate a necessary service. It places the bill with the agencies rather than directly on the taxpayer. This has some advantages and disadvantages. First, it allows more than one revenue source to support the costs of service. This may reduce the burden on local property owners. However, such a scheme tends to obscure the fact that local taxpayers ultimately pay the bill. In addition, it tends to perpetuate the double taxation noted in the previous section, when overlapping jurisdictions tax the same individuals to pay for duplicate services (e.g., municipal and county governments and municipal governments and fire districts). These facts should be kept in mind whenever a cost-sharing formula is used.

Table 25 presents several common ways current systems costs could be allocated and provides a data base for distribution of costs for consolidated systems. Current expenditures, population, and assessed valuation are generally used to determine the percentage that any one

Table 25

CURRENT COSTS DISTRIBUTED BY POPULATION AND ASSESSED VALUATION

Jurisdiction	1976 Communication Costs		1976 Population		1976 Assessed Valuation (AV)		Cost per Capita	Cost per $1,000 AV
	Cost ($)	Percent	Number of Citizens	Percent	AV	Percent	($)	($)
Berthoud	$ 9,800	2.5%	2,800	2.2%	$ 4,700,000	1.2%	$ 3.50	$2.09
Colorado State Univ.	57,200	14.3	17,400	13.6	*	*	3.29	*
Estes Park	50,000	12.5	2,200	1.7	15,400,000	4.1	22.73	3.25
Fort Collins	128,500†	32.1	50,600‡	39.6	127,600,000	33.7	1.89	1.00
Larimer County	71,000	17.8	27,700	21.7	157,200,000	41.5	2.56	0.45§
Loveland	73,400**	18.4	25,900	20.3	72,500,000	19.1	2.84	1.01
Wellington	9,800	2.5	1,100	0.9	1,400,000	0.4	8.91	7.00
	$399,700		127,700		$378,800,000			

*The University is nontaxable property and has been excluded from these measures. If cost were to be allocated by one of these measures, an equitable billing procedure must be established.

†Includes Fort Collins FD.

‡Does not include Colorado State University.

§Cost for unincorporated portion of assessed valuation. If entire county assessed valuation ($378,800,000) were used, the cost would be $0.19.

**Includes Loveland FD and RFPD.

agency will pay. One measure may be used exclusively or two may be combined. All figures are from 1976, and the percentages are shown beside the base measures. In addition, the last two columns give the per capita cost for each jurisdiction and the cost per $1,000 assessed valuation.

Table 25 shows that communications costs are distributed relatively unevenly (as is generally the case). While Berthoud is currently spending $3.50 per capita for police communications, Fort Collins is spending $1.89 per capita for police and fire. Estes Park has the highest per capita figure ($22.73) because they must maintain a substantial force to cope with the influx of summer visitors.

If the total cost of public safety communications were born by the property tax, the rates shown in the last column would be necessary to maintain existing operations. This is a more realistic measure of expenditure since it is based on a jurisdiction's ability to pay. The county's rate (as shown in the footnote of Table 25) is inordinately low because they tax the total assessed valuation within the county, not just the unincorporated property. A more reflective rate is shown in the footnote, although it is still quite low. However, this verifies that citizens in different areas must contribute varying amounts to support these services.

In Table 26, the cost of the single county alternative is shown as it compares with existing budgets, distributed according to various cost-sharing formulas and the costs to the individual agencies to improve their communication services to realize the service level benefits which could be derived from a consolidated system. Other alternatives can be costed by using the percentages under each heading. In each case, the agencies should compare their current costs and those costs for an improved system (which includes only the current costs of telephone systems, maintenance, facilities, and total personnel which are required to provide response times comparable to those that are naturally derivable through a consolidated operation).

It will be noted in Table 26 that, in each case, one or more agency will be required to contribute more than they are currently spending

Table 26

EXAMPLES OF FIRST YEAR OPERATING COST DISTRIBUTIONS
FOR COUNTY-WIDE CONSOLIDATED COMMUNICATIONS

Jurisdiction	Current System Costs ($)	Apportionment of Costs by Alternative Cost Sharing Formulas										Cost to Jurisdiction to Improve Communications*
		Current Budgets		Population		Assessed Valuation		Population and Assessed Valuation		Current Budgets and Population		
		Percent	Cost ($)	Percent	Cost ($)	Percent	Cost ($)	Percent	Cost ($)	Percent	Cost (S)	
Berthoud	$ 9,800	2.5%	$ 8,800	2.2%	$ 7,900	1.2%	$ 4,500	1.7%	$ 6,100	2.3%	$ 8,400	$ 9,800
Colorado State Univ.	57,200	14.3	51,500	13.6	49,100	--	†	--	†	14.0	50,200	57,200
Estes Park	50,000	12.5	45,000	1.7	6,200	4.1	14,600	2.9	10,500	7.1	25,600	82,400
Fort Collins	128,500‡	32.1	115,700	39.6§	142,600	33.7	121,300	43.5	156,500	35.9	129,100	193,300
Larimer County	71,000**	17.8	63,900	21.7	78,100	41.5	149,400††	31.6	113,700	19.7	71,100	157,400
Loveland	73,400‡‡	18.4	66,300	20.3	73,000	19.1	68,900	19.7	70,900	19.3	69,600	84,200
Wellington	9,800	2.5	8,800	0.9	3,100	0.4	1,300	0.6	2,300	1.7	6,000	9,800
Total	$399,700		$360,000		$360,000		$360,000		$360,000		$360,000	$594,100

*Includes current cost plus additional personnel required to provide same service level as consolidated operations.

†The Colorado State University is nontaxable property and has been excluded from these measures. If costs were to be allocated by one of these measures, an equitable billing procedure must be established.

‡Includes Fort Collins PD and FD.

§Population of Colorado State University not included in this figure.

**This cost is paid by both the incorporated and unincorporated areas of the county.

††Cost proportioned on unincorporated area of county only.

‡‡Includes Loveland PD, FD, and RFPD.

for communications. The only case in which this is not true is when costs are shared on a basis of current budgets. Although immediately effective, we do not believe this latter sharing mechanism would be equitable over the long term since cities may not grow at the same rate. In an urbanized county, costs are generally distributed on a basis of assessed valuation. But due to the mix of urban and rural areas in Larimer County and the fact that public safety services are delivered to people instead of property (particularly in the case of law enforcement services), we believe that cost sharing on the basis of population would provide the most equitable distribution.

Cost-sharing formulas have the following advantages and disadvantages.

- They are less equitable for the citizens, although they may be equitable to the agencies involved.
- Any formula would be reliable if all participants signed contractual agreements to provide the necessary funds each year. Failure to develop such an agreement would impair reliability.
- The amounts contributed can be easily adjusted by adherence to the agreed-on formula.
- A cost-sharing formula reduces the fear that any one agency could take control of the communications function. In addition, no single agency is likely to benefit disproportionately.

A cost-sharing formula is the most functional when the communications function is operated under a joint power agreement.

B. Management Considerations

Three basic management forms are useful in operating a consolidated communications system: (1) a contractual agreement with an existing agency providing service, (2) a joint powers agreement between all participants, and (3) a special district formed for this purpose. The advantages and disadvantages of each are discussed in turn.

All management agreements must encompass the following points if they are to be successful.

- The system must be accountable to the member agencies; they must be able to influence day-to-day operations.
- There must be a grievance procedure in case of unsatisfactory service.
- Responsibility for operational policy must be clear, and all participants must feel that they have an effective voice in the policy.
- Annual funding must be described, with any formula clearly spelled out.
- Technical standards, levels of service, and the location of facilities must be clearly defined.

In addition, a group of agencies may want to define management considerations that are unique to their local situation, but the above are minimally necessary to create a functioning system.

1. Contractual Agreements

When a management contract is used, the providing agency writes an individual contract with each member agency describing the commitments of each party. Generally, the contracting agency would be a county or major city. This management plan is most useful in areas in which there is one agency with the acknowledged capacity to operate such a system, and where there is great trust among various agencies. A board of users is usually established to define operational policy and an agreement is developed to cover the following points:

- Membership on the policy committee
- Billing rates and procedures
- Technical capacities and service levels
- Grievance procedures.

Larimer County or the City of Fort Collins would be two likely candidates under this management plan. If the county were to assume responsibility for providing communications, the logical funding mechanism would be a county-wide tax. A cost-sharing formula could also be utilized. If Fort Collins were to provide the service, a cost-sharing mechanism would probably be the most useful.

Given the political situation in Larimer County, it seems unlikely that this type of management plan will be acceptable. There are too many medium-sized cities and departments to permit a simple contract with either of the major agencies, who are probably equally unwilling to contract with each other. Under these circumstances, another management form will be more useful.

2. Joint Power Agreements

A joint power agreement is signed by all system participants, and creates a new entity specifically designed to provide communications service. This entity has no taxing power and must rely on specified contributions from member agencies. Generally, there are two operating boards: a policy board and a user board. The policy board collects and disburses funds, and decides on general issues. The user board deals with operational policy, and decides on day-to-day procedures. The policy board is generally elected, while the user board is made up of individuals appointed from each member agency. In Colorado, both boards must be predominantly law enforcement personnel to ensure access to the Colorado Crime Information Center (CCIC), although representatives of fire and emergency medical services must be included as well.

The joint power agreement must spell out:

- The duties of the user committee and the policy board
- Monetary contributions from each member
- Technical capacities and service levels
- Steps in a grievance procedure.

The most logical funding mechanism under this management form is a cost-sharing formula, which will reinforce the independence of the new service. However, a county-wide property tax could be used, with the amount to be collected specified in the joint power agreement. There is some precedent for this in Larimer County, in which the Youth Service Bureau is financed in this manner. However, because public safety communications must remain closely tied to user agencies, the agencies may prefer to make direct financial contributions rather than rely on the

county to collect and provide the funds. If the latter system were acceptable, it would be more equitable for the citizens involved.

This management form is probably the most acceptable to the county, cities, and agencies in Larimer County since it clearly provides for user control and eliminates the possibility that any one entity could "take over." It has been used successfully in other areas that were attempting similar consolidations, and it would provide adequate operational control.

3. Special District Formation

A special district to provide public safety communications could be formed to operate the consolidated system. This would provide an independent agency with the power to tax throughout the county. In Colorado, the governing board of the special district would have to be drawn from law enforcement officials to ensure access to CCIC. In addition, a user committee should be included to develop and oversee operational policy. Provision must be made for grievance procedures, and technical standards must be defined.

Because Colorado requires a general election before a special district can be developed, it is probably advisable to avoid this management form. However, if this election could be successfully held, a special district would be one way to provide consolidated communications. We do not recommend this form because of the proliferation of special districts in the area and the difficulty generally associated with the election procedure.

CONTINUED

1 OF 2

VI RECOMMENDATIONS

SRI recommends that Larimer County and its public safety agencies proceed toward unifying their dispatch communication operations into a single consolidated center. This recommendation is based on consideration of the factors described below.

Recent disasters have made the lack of coordinated communication systems in Larimer County very apparent. Additionally, analyses provided in this report and observations made by the departments have shown significant delays in communications and dispatch operations. As the population of Larimer County increases, the requirement for additional communication personnel and radio channels will increase substantially if system planning is not undertaken in the near future. An analysis of alternative means of improving communication services and providing for future growth while minimizing future cost increases has shown that consolidation provides major benefits.

First, but not necessarily most important, a single county-wide center provides the most cost-effective operation. It is estimated that this form of consolidation will result in a savings of nearly 8 million dollars between now and the year 2000 compared with the cost of individual agencies making improvements necessary to provide the level of service that could be provided by a single consolidated operation. During this same period, a consolidated system will provide a savings of 1.5 million dollars compared with the cost of agencies making improvements only necessary to maintain their current levels of service.

A single center provides the maximum degree of coordination. The system, as outlined in this report, provides for full-time dedicated dispatchers (not personnel who must share their dispatching functions with other records and clerical duties) for all law enforcement and fire protection agencies in Larimer County. These dispatchers will also have immediate radio and/or telephone access to the emergency medical

coordination system being implemented in Larimer County as well as access to state and national services such as the Colorado State Patrol and National Parks Service. This provides for highly trained dispatchers who will have a continuing awareness of critical situations as they develop in and around the county.

Locating this operation in a single center* permits a higher degree of physical security than is currently available to some of the agencies. With proper planning, this operation could also form the core operation for coordination of numerous agencies in the event of a future natural or man-made disaster.

The consolidation of all public safety services permits easy implementation of the universal emergency telephone number, 911. With 911, the citizens and visitors to Larimer County will no longer be required to determine which public safety agency to contact for assistance--one easily remembered telephone number could provide access to all public safety services.

The consolidation of communication services will also ease the implementation of computer-aided dispatch and provide for improved dispatch record maintenance.

Finally, the consolidation of communication services will promote greater sharing and better use of critical radio channels that are in limited supply. We estimate that by the year 2000 the law enforcement and the fire protection agencies of Larimer County would require 11 radio channels if they continued their current individual operations. This would require the use of local government channels--channels carrying public works and other lower priority traffic--by the public safety agencies.† With proper radio channel sharing, the public safety agencies

---

*Space allocated as an Emergency Operating Center in the County courthouse has been suggested by some.

†Significant delays could result in the event of a flood or broken water main if the fire department, police department, and roads department were attempting to use the same radio channel while responding to the same incident.

could conduct primary operations on 7 dedicated public safety channels and still have extra channels for coordination activities.

We recommend management by joint power agreement since it is the most appropriate for the Larimer County situation and will facilitate system development. This management form will provide adequate agency control and reduce concerns that one agency will dominate the communication system. Such a management agreement can be funded in one of two ways. A county-wide ad valorem property tax is the most efficient plan, but many agencies may fear it would lead to county dominance. Because of this fear, we recommend that each agency contribute in accordance with an agreed-on cost-sharing formula. A cost-sharing formula based on population appears to be the most equitable. To insure funding reliability, each agency must agree to continue the support as part of the joint power agreement.

To continue the development of this coordinated system, we recommend the following general steps:

- Form a policy committee to determine the services to and responsibilities of the communication center and to establish mechanisms to insure the control of the center operations. A future communications director, if desired, may be a member of this committee.
- Conduct a detailed engineering design defining final system initial and recurring costs, and specification.
- Establish personnel qualifications and training requirements.
- Obtain a full commitment to the management, finance, and engineering design by all system participants.
- Obtain bids for system implementation and begin procurement of components. Begin personnel training and transfer of personnel as agreed on by member agencies.

Appendix

CURRENT COMMUNICATION SYSTEMS--WORK LOADS AND RESPONSE TIMES

Appendix

CURRENT COMMUNICATION SYSTEMS--WORK LOADS AND RESPONSE TIMES

Basic information on which the alternative communication system concepts for Larimer County were developed is presented in this appendix. The preliminary results of the analysis of work loads and response times presented here have been reviewed by Larimer County public safety officials and operational personnel.

A. Law Enforcement Communications

Law enforcement services are provided by seven agencies in Larimer County, excluding the Colorado State Patrol. First, we provide an overview of the techniques used to analyze the work loads and response times of the command centers of these agencies and the assumptions employed for the analyses. Then, the individual department operations are described.

1. Analysis Techniques

Data for the analysis of work loads and response times of the communication operations of the Larimer County law enforcement agencies were obtained from interviews with agency officials and operational personnel. Wherever possible, data were extracted from agency records; however, in some cases the best estimates by agency officials were used, and in other cases we relied on extrapolation of data from previous public safety communication studies performed by SRI for similar departments.

The results of the analyses (Tables A-2 through A-8) were separated to provide information for the busiest hour of each shift--first shift (0000 to 0800 hours), day shift (0800 to 1600 hours) and swing shift (1600 to 2400 hours). The general methodology and associated variables of the analysis are discussed below.

The initial step in the analysis was to determine the peak hourly dispatch volume or telephone call volume for each agency. In most cases, only limited information was available for either of these factors. The derivation of the number of these events is discussed for each agency in the subsections that follow.

None of the agencies had explicit information on the time consumed answering an average telephone call. Previous studies performed by SRI have shown that telephone call lengths vary from 30 to 90 seconds. For this study we have used a representative average call length of 60 seconds.

The average time to dispatch a field unit was estimated at 20 seconds--derived from monitoring and actual measurement on previous studies. This time includes only the relaying of the dispatch information.

Status checks were assumed as two per dispatch (one on "arrival" and one on "clear") plus one additional "welfare" check for each vehicle in the field during the shift busy hour. Each status check was assumed to use 10 seconds of dispatcher time to communicate with the vehicle.

Information checks includes checks into local records and entries into the CCIC. Previous studies have shown a ratio of about one information request per dispatch. We used this ratio consistently unless other data were available. The time to service an information request was estimated at 40 seconds: 10 seconds of dispatcher time to take the request from the field; 20 seconds to enter and receive the request through a terminal; and 10 seconds to communicate the information to the field unit.

The final entries in the tables are the number and time spent on log entries. This is a difficult number to estimate for several reasons:

- The status of units is maintained differently by the various agencies.
- The number of entries and the time required to make entries varies with each agency.
- The accurate maintenance of these records is generally one of the first functions to be dispensed with in a heavily-loaded environment.

Generally, there is one entry for each call received, one for each dispatch, one for each status update, and one for each information request. We consistently used this number of entries and a value of 10 seconds per entry to arrive at the logging time.

The final step in the analysis (before computing the input/output waiting times or queue delays) was to determine the total work units and the total time expended and then compare the total time expended with the amount of available dispatcher time. Available dispatcher time was calculated by multiplying the number of dispatchers available by 60 minutes and a factor of 75%. The latter figure is a commonly used efficiency factor for telephone answering personnel. This factor does not infer that time is intentionally wasted but accounts for the average lost time when a person performs multiple functions. Actually, it has been demonstrated that a person performing multiple duties--such as in a single-stage dispatching system--is somewhat less than 75% efficient.

Personnel work load was then calculated using the ratio of the total time spent on the listed tasks to the total time available. The dispatcher queue was derived considering the average work unit length, the number of work units per busy hour, and the number of servers (dispatchers). These queues represent the average delay a person (citizen or patrolman) would encounter trying to contact the dispatcher assuming that the medium for accessing the dispatcher--the telephone circuit or radio channel--were free. This analysis is based on the following assumptions:

- Traffic waits in the queue without departing and therefore fits an Erlang "C" distribution.
- All work units (e.g., telephone calls, radio transmissions, information requests) are of equal priority.
- Average lengths of work units are comparable to those we have observed in similar operations.
- Dispatcher efficiency is 75%. This number is used throughout despite the fact that servers performing a single function (telephone operators) are generally more efficient than the single stage dispatcher performing multiple functions.

- Delays caused by the unavailability of field units are not included.
- The effect of the nondispatch functions is not considered (e.g., we do not include monitoring of closed circuit TV or the provision of service at a front desk).
- All messages are passed to their intended recipient with minimum delay.

The analysis yields the average delay caused by personnel work load that is encountered by messages in the dispatch queue. This analysis shows that personnel overload occurs in some agencies in Larimer County. When overload occurs, the "analysis" can provide misleading results because of changes made in the normal operations, for example:

(1) The dispatcher may cease performing some of the tasks that he is assumed to do; consequently, some of the work units may expire in the queue (e.g., log entries may be overlooked). The functions that are dropped and the order in which they are dropped frequently varies with the situation and among agencies in a way that is not well-known at this time.

(2) In some systems, other personnel (clerks, managers, data system personnel, etc.) assist the dispatcher at peak times, providing either two dispatchers, a two-stage system, or a hybrid of the two depending on the capabilities of the assistant.

The average delay time for a message in a queue is a function of the length of the average work unit (or the holding time) and the load on the servers handling the queue. For traffic loads that are keeping all servers busy from 50% to 90% of the time, Table A-1 provides multipliers of the average work unit length for one to four servers. For example, if the mean message length (work unit length) were 10 seconds, at 70% loading (Table A-1) average delay time for one server would be 23 seconds (2.3 X 10), while the average delay time for one server loaded 90% would be 91 seconds (9.1 X 10). It can be seen that delays for a single dispatcher for a given work load are higher than delays for multiple dispatchers. For example, if the average work unit length is 10 seconds, at 80% loading one server would have an average delay time of 40 seconds (4.0 X 10), while the average delay for four servers would be 7.3 seconds (0.73 X 10). This illustrates the potential advantage of

combining dispatch facilities to provide more servers for the combined queue with a resultant lower time delays in handling peak traffic.

Table A-1

AVERAGE DAILY TIME AS A FUNCTION OF WORK UNIT LENGTH

Busy Traffic Load (%)	Number of Servers			
	1	2	3	4
90	9.1	4.2	2.7	2.0
80	4.0	1.7	1.1	0.73
70	2.3	0.97	0.54	0.36
60	1.5	0.56	0.29	0.17
50	1.0	0.34	0.16	0.08

2. Town of Berthoud Police Department (PD)

The Berthoud PD performs its own dispatching during normal working hours and is dispatched by the Larimer County Sheriff's Office after hours and on weekends. Therefore, we have shown only the day shift busy hour activities in Table 2. If the department were to provide its own dispatching on a 24-hour basis, we estimate that similar workloads and delays would be encountered on the other shifts.

Since the department normally deploys only one car during each shift, we have assumed that the one car would be dispatched during the busy hour and would make one information request through the dispatcher. Since no additional units are normally in the field, we have assumed that only the two dispatch related status checks occur during the busy hour. Previous studies by SRI have shown that approximately 65% of the telephone calls received by a police department result in a dispatch--this ratio was used to establish the calls for the two busy hours.

The analysis shows that the dispatcher is currently lightly loaded with dispatching functions, which means there is minimal

communications delay. The dispatcher is currently performing other clerical duties that may increase the delay indicated in Table A-2.

Table A-2

BERTHOUD POLICE DEPARTMENT COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls		2	
Total telephone time		2.0 min	
Number of dispatches		1	
Total dispatching time		0.3 min	
Number of status checks		2	
Total status time		0.3 min	
Number of information checks		1	
Total information time		0.7 min	
Number of log entries		6	
Total logging time		1.0 min	
Total time expended		4.3 min	
Available time		45.0 min	
Operator loading		10%	
Communications queue		2 s	

3. Colorado State University Police Department (CSUPD)

The CSUPD performs its own dispatching services on a full-time basis, dispatching vehicles to 20 to 25 incidents per day. Typically, 10% of the daily incidents of a police department will occur in the busy hour; therefore, we have estimated three busy hour incidents. Because of the nature of the university operations, we have assumed that the three dispatches could occur on any whift as shown in Table A-3. The number of telephone calls necessary to create these dispatches was estimated assuming that 65% of the telephone calls result in a dispatch.

The number of status checks was estimated assuming two checks per dispatched vehicle plus one check for each vehicle deployed during the shift--the department indicated that they typically deploy two units during the first shift, five during the day shift, and four during the swing shift.

The analysis shows that, under this activity, the dispatcher is responding to the various work elements in under 10 seconds on the average.

Table A-3

COLORADO STATE UNIVERSITY POLICE DEPARTMENT COMMUNICATIONS WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls	5	5	5
Total telephone time	5.0 min	5.0 min	5.0 min
Number of dispatches	3	3	3
Total dispatching time	1.0 min	1.0 min	1.0 min
Number of status checks	8	11	10
Total status time	1.3 min	1.8 min	1.7 min
Number of information checks	3	3	3
Total information time	2.0 min	2.0 min	2.0 min
Number of log entries	19	22	21
Total logging time	3.2 min	3.7 min	3.5 min
Total time expended	12.5 min	13.5 min	13.2 min
Available time	45.0 min	45.0 min	45.0 min
Operator loading	28%	30%	29%
Communications queue	7 s	8 s	8 s

4. Town of Estes Park Police Department

The Estes Park PD provides full-time dispatching services for itself as well as for one station of the Larimer County Sheriff's Office, the Colorado State Patrol, Colorado Fish and Game, Estes Park Fire Department, and the Estes Park Ambulance Service. During some periods of the year, it monitors and provides dispatching services for the National Park Service.

The department estimates that it receives 165 calls on an average day. This call volume is approximately 2.5 calls per 1000 population, assuming a population of 65,000, which is not unrealistic during the summer tourist season. Thus, the analysis shown in Table A-4 could represent the summer work load but could overestimate the winter work load.

Table A-4

ESTES PARK POLICE DEPARTMENT COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls	5	16	11
Total telephone time	5.0 min	16.0 min	11.0 min
Number of dispatches	3	4	5
Total dispatching time	1.0 min	1.3 min	1.6 min
Number of status checks	6	8	10
Total status time	1.0 min	1.3 min	1.6 min
Number of information checks	3	4	5
Total information time	2.0 min	2.7 min	3.3 min
Number of log entries	17	32	31
Total logging time	2.8 min	5.3 min	5.2 min
Total time expended	11.8 min	26.6 min	22.7 min
Available time	45.0 min	45.0 min	45.0 min
Operator loading	26%	59%	50%
Communications queue	7 s	36 s	22 s

Two assumptions were required to derive the busy hour call volumes from the busy day figures provided by the department. First, we assumed the calls to be similar to those received by departments we have observed in the past; 10% of the daily calls were received in the busy hour. Second, we assumed the department's deployment of field units--one on first shift, three on day shift, and two on swing shift--was proportional to the number of calls for service during each shift. Using these assumptions, we developed the busy hour call volumes shown in Table A-4.

The department stated that 15% to 20% of the day shift calls resulted in a dispatch and all after hour calls were dispatched. To determine the number of dispatches during busy hours, we used the above criteria but assumed that the number of dispatches would not exceed two dispatches per available police department vehicle plus one dispatch for the Sheriff's Office vehicle. Since all available units were dispatched, we assumed only two status checks per dispatch and one information request per dispatch.

The analysis shows that the dispatcher is handling the work elements quite rapidly during the first shift but that significant delays could occur in the day and swing shifts. Possibly the department is reducing these delays by providing additional assistance in answering the incoming telephone calls during these shifts. Again, we believe that the analysis shown in Table A-4 represents the summer months, but with the winter work loads for the day and swing shifts probably being closer to the first shift busy hour shown in Table A-4.

5. City of Fort Collins Police Department

The Fort Collins PD provides its own full-time dispatching as well as full-time answering of the city's 911 telephone system, and answering of city administrative calls.

The department has maintained good statistics on the hourly number of incidents dispatched. These dat show the average busy hour incidents for the first, day, and swing shifts to be four, five, and

five, respectively. Generally, the number of incidents in a busy day will exceed those of an average day by 25%; this factor was used to estimate the number of busy hour dispatches shown on Table A-5. The department does not maintain statistics on the number of telephone calls received by the dispatchers; to determine the number of busy hour telephone calls, we estimated that 65% of received calls are dispatched.

The number of status checks was estimated assuming two status checks per dispatch, plus one check per unit deployed--where the department indicated that the typical deployment for first, day, and swing shift is 9, 27, and 12 vehicles, respectively. Department records show a ratio of approximately 164 teletype messages sent per day for 65 reported incidents. This results in a ratio of approximately 2.5 information checks per dispatch; this number was used to derive the number of information requests in Table A-5. Since telephone calls (except 911 calls) are not logged, the number of log entries was estimated by assuming that dispatches, status checks, and information checks are logged.

There are several important observations that can be made from the communication analysis presented in Table A-5. The dispatchers are heavily occupied during the busy hour of each of the three shifts, which could cause long delays if they do not adapt their operations to the load. When these excessive work loads occur, one of four actions may be taken to minimize communications delays:

1. Priorities to responding to particular work elements are established or altered (e.g., respond to radio before telephone).
2. Particular functions may be intentionally or unintentionally omitted (e.g., omit log entries).
3. The dispatchers may increase their efficiency for short periods.
4. Additional personnel may assist the dispatchers.

The department indicated that an additional clerk is already used to assist the dispatcher by answering telephones in busy periods. The effects of this additional person can be seen in the footnote of Table A-5--the utilization of a second dispatcher could reduce the communication delay to under 5 seconds.

Table A-5

FORT COLLINS POLICE DEPARTMENT COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls	8	9	9
Total telephone time	8.0 min	9.0 min	9.0 min
Number of dispatches	5	6	6
Total dispatching time	1.7 min	2.0 min	2.0 min
Number of status checks	19	39	24
Total status time	3.2 min	6.5 min	4.0 min
Number of information checks	12	15	15
Total information time	8.0 min	10.0 min	10.0 min
Number of log entries	36	60	45
Total logging time	6.0 min	10.0 min	7.5 min
Total time expended	26.9 min	37.5 min	32.5 min
Available time	45.0 min	45.0 min	45.0 min
Operator loading	60%	83%	72%
Communications queue	30 s*	87 s*	51 s*

*The department indicated that they attempt to provide a second person in the dispatch room, as required, during the busy parts of the day and swing shifts. If this person were available, the communication queues would be reduced to approximately 2, 4, and 3 seconds for the first, day, and swing shifts, respectively.

6. Larimer County Sheriff's Office (LCSO)

The LCSO provides full-time dispatching of its own units and dispatches for the Berthoud PD and Wellington PD after hours and on weekends. The dispatchers also make the initial dispatch for range fires, for which the county is responsible for fire protection services.

Data from the LCSO indicate that 30 calls are received in a typical day shift busy hour and that a similar number of calls occur on

the swing shift when the dispatcher must also answer the county administrative lines. We estimate the first shift busy hour call volume to be approximately one-half this amount. Data were not readily available for the number of hourly dispatches, but a quick review of some recent dispatch cards indicated five to six dispatches per hour. The number of dispatches in Table A-6 were estimated assuming one dispatch for each unit in the field--four on the first shift, five on the day shift, and four on the swing shift--plus one dispatch each for Berthoud PD and Wellington PD on the first and swing shifts. Since all available units were assumed to be dispatched, we have only allocated two status checks per dispatch. One information request was estimated for each dispatch. Since telephone calls are not logged, only the dispatches, status checks, and information checks were included in the count of log entries.

Table A-6

LARIMER COUNTY SHERIFF'S OFFICE COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls	15	30	30
Total telephone time	15.0 min	30.0 min	30.0 min
Number of dispatches	6	5	6
Total dispatching time	2.0 min	1.7 min	2.0 min
Number of status checks	12	10	12
Total status time	2.0 min	1.7 min	2.0 min
Number of information checks	6	5	6
Total information time	4.0 min	3.3 min	4.0 min
Number of log entries	24	20	24
Total logging time	4.0 min	3.3 min	4.0 min
Total time expended	27.0 min	40.0 min	42.0 min
Available time	45.0 min	45.0 min	45.0 min
Operator loading	60%	89%	93%
Communications queue	38 s	274 s	452 s

The analysis of these data shows significant communication delays if only one dispatcher is available (Table A-6). The Communications Division has requested additional support and has used other personnel in the department to assist in these periods of high activity. If two people were available to perform the dispatching tasks, the communication queues would be reduced to approximately 3, 8, and 9 seconds for the first, day, and swing shifts, respectively.

7. City of Loveland Police Department

The Loveland PD performs its own full-time dispatching. In addition to the communication functions, the dispatcher also serves as a receptionist and records clerk.

Since no radio or telephone traffic data were readily available from the Loveland PD, it was necessary to use common estimators of the dispatcher work loads for Table A-7. The number of busy hour telephone calls was derived by assuming two calls per 1000 population (present population of approximately 26,000) and assuming that 10% of these calls occur during an average busy hour. During a busy day, the call volume will increase 25%. Thus, six calls were assumed for the busy hour of the day shift with 65% assumed to be dispatchable. Two status checks were assumed for each dispatch, plus one additional check for each unit in the field (the department typically fields four patrol units for each shift). One information request was assumed for each dispatch and a log entry was assumed for each event.

The resulting analysis shows that the communications queue is 8 to 11 seconds during the busy periods, which is a reasonable response but which does not account for other activities (front desk and records) that the dispatcher may be performing during these busy periods.

Table A-7

LOVELAND POLICE DEPARTMENT COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls	5	6	5
Total telephone time	5.0 min	6.0 min	5.0 min
Number of dispatches	3	4	3
Total dispatching time	1.0 min	1.3 min	1.0 min
Number of status checks	10	12	10
Total status time	1.7 min	2.0 min	1.7 min
Number of information checks	3	4	3
Total information time	2.0 min	2.7 min	2.0 min
Number of log entries	21	26	21
Total logging time	3.5 min	4.3 min	3.5 min
Total time expended	13.2 min	16.3 min	13.2 min
Available time	45.0 min	45.0 min	45.0 min
Operator loading	29%	36%	29%
Communications queue	8 s	11 s	8 s

8. Town of Wellington Police Department

The Wellington PD performs its own dispatching during the day shift but receives support communication service from the LCSO during nonworking hours and weekends.

Because of the small department size, one dispatch resulting from two telephone calls was assumed for the day shift busy hour, as shown in Table A-8. The dispatch was assumed to result in two status checks and one information request for the department's one field unit.

Table A-8

WELLINGTON POLICE DEPARTMENT COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Magnitude of Elements		
	Busiest First Shift Hour	Busiest Day Shift Hour	Busiest Swing Shift Hour
Number of telephone calls		2	
Total telephone time		2.0 min	
Number of dispatches		1	
Total dispatching time		0.3 min	
Number of status checks		2	
Total status time		0.3 min	
Number of information checks		1	
Total information time		0.7 min	
Number of log entries		6	
Total logging time		1.0 min	
Total time expended		4.3 min	
Available time		45.0 min	
Operator loading		10%	
Communications queue		2 s	

B. Fire Protection Communication Systems

Fire protection services in Larimer County are provided by city fire departments (FDs), rural fire protection districts (RFPDs), the Sheriff's Office, and federal fire protection units in the national forest area. These services are provided by full and part-time employees and by volunteers. These services are contacted through radio and/or telephone systems.

Direct radio dispatch is provided from Loveland FD, Fort Collins FD, the Sheriff's Office in Fort Collins, and the Estes Park Communications Center. These four locations provide 24-hour dispatch service for themselves and for the Berthoud RFPD (from Loveland FD) and Poudre Valley FPD (from Fort Collins FD). Volunteers from Berthoud and Poudre Valley

RFPDs are alerted by radio paging systems and Plectrons. Additionally, the Estes Park Communications Center dispatches federal fire units in their area, and the Sheriff coordinates fire fighting activities by radio with federal fire units in the national forest areas. Fort Collins FD provides fire protection service to CSU.

Telephone dispatch systems are used for the Poudre Canyon RFPD, the Red Feather Lakes RFPD, and the Wellington FPD. The Sheriff's fire fighting force frequently coordinates operations and provides support to these volunteer RFPDs.

Several small areas of the county are protected by RFPDs that are principally in adjacent counties; these RFPDs are Windsor-Severence in Weld County, Pinewood Springs in Boulder County, and Allens Park in Boulder County.

1. Service Demand

The demand for fire protection services varies widely from hour to hour and from day to day. There is also considerable variation depending on the service area and the season of the year. In urban and suburban areas, a high need for fire service generally occurs between 10:00 a.m. and 2:00 a.m., with relatively low demand from 2:00 a.m. to 10:00 a.m. In range and forested areas, fire danger is highest during dry periods and lightning storms.

Because of the emergency nature of most calls for fire protection services, communication systems must be designed and operated to provide worst-case capabilities to cope with the maximum demand that can reasonably be expected for a particular jurisdiction. Because of the wide variations of communication system use with fire and no-fire conditions, the average use of the communication system is low and is a poor indicator of the actual need for fire service communication during periods of peak activity. For this reason, we believe that the need for fire service communications should be based on (1) a busy hour load that is derived from average daily demands, and (2) on an estimate of the load created by major incidents.

To estimate average daily loads on the Larimer County fire protection agencies, we have made estimates using (1) the size of the population served by the agencies; (2) the types of fires (building or range/forest) they fight, and (3) typical fire statistics for these types of agencies. These estimates provide a consistent basis for comparing the communications systems of these agencies with alternative communication systems and are adequate for this feasibility study.

In estimating dispatch loading for a busy hour, we used the following assumptions:

- Each dispatch and status message requires 10 seconds of dispatcher time.
- An average of eight messages are estimated to be used for each dispatched unit. These eight are selected from: dispatch to scene, all points bulletin (APB), in-service message, subsequent information, arrival message, additional requests or unit-to-unit, no further assistance, APB when under control, out-of-service, and back-in-service.
- An average of three units are dispatched for each response.

To estimate the load imposed by a major (multiple alarm) fire, we assumed that all units of a fire agency would respond and that four messages (dispatch, in-service, arrival, and one car-to-car) for each unit would be required.

We further assumed that each emergency call that comes to a fire agency results in the dispatch of fire equipment. These calls are assumed to require an average of 60 seconds of the dispatcher's time. An important time element that requires dispatcher time is logging events associated with telephone answering and dispatching. We allowed 10 seconds of dispatcher time for each logging event. The final time element we assumed was 30 seconds for address verification and running card checks for each event.

These assumptions on event rates and their associated use of time are used in the following sections to determine the loading on the dispatch personnel in the Fort Collins and Loveland departments. We will discuss the other agencies but will aggregate their call volumes to determine dispatcher loading.

2. Fort Collins Fire Department

The communications section of the Fort Collins FD provides a 24-hour, 7-day dispatch service for that department and for the Poudre Valley FPD. Fire claims can be received directly from the citizen through a seven digit telephone number or through the 911 system answered at the Fort Collins Police Department. The department also has a direct line from the city ambulance company and the Colorado State University Police Department. We estimated that the population served by these two departments is about 90,000. This population results in an average of about 9 fire calls per day with about 1.8 calls occurring during the busy hour--see Table A-9. Because of the nearly equal probability that such a peak hour could occur during any one of the three shifts, we developed a single busy hour estimate. The implications of this assumption is that the fire dispatch positions should be similarly manned at all times.

Table A-9

FORT COLLINS FIRE DEPARTMENT COMMUNICATIONS
WORK LOADS AND RESPONSE TIMES

Element	Busy Hour Magnitudes
Number of telephone calls	1.8
Total telephone time	1.8 min
Number of radio messages	43.2
Total message time	7.2 min
Number of address/running card checks	1.8
Total card time	0.9 min
Number of log entries	45.0
Total logging time	7.5 min
Total time expended	17.4 min
Available time	45.0 min
Operator loading*	39%
Communications queue*	7 s

*Major fire with 7 units: Operator loading = 50% and communications queue = 11 seconds.

Using this call rate and the assumptions described in the previous section, a dispatcher loading of 39% and communications queue of 7 seconds were derived for the busy hour.

If a major fire occurred that required the dispatch of additional fire units in the busy hour, the dispatcher would have an additional load of four messages per dispatched unit. For Fort Collins, this would be an additional four units, which would require an additional 5.3 minutes for dispatch and logging of dispatches. Using these assumptions, as operator loading of 50% and communication queue of 11 seconds were derived (Table A-9). The additional work load of a major fire would not increase waiting time significantly, as shown in this analysis. It is worth noting that this analysis does not include any additional effort required by the dispatchers when they operate the Fort Collins light and power radio system after hours.

3. Loveland Fire Department and Rural Fire Protection District

The Loveland FD and RFPD dispatch function is supported jointly by the city of Loveland and the Loveland Fire District. Fire units capable of fighting both building and range/forest fires are available in two stations at Loveland with additional equipment at Cedar Cove and Drake Canyon. The Loveland FD and RFPD have 13 paid personnel and 43 volunteers.

Dispatch is provided by the paid personnel on a 7-day, 24-hour basis for Loveland FD and RFPD and for the Berthoud RFPD (which is a volunteer department). Volunteers are alerted by radio pagers in the event of an emergency.

We estimated that about 40,000 citizens are served by the three fire agencies. This number of people would create an average daily demand of abour 4.25 calls with a busy hour demand of 0.85 calls. These estimates lead to the operator loading and communication queue data shown in Table A-10.

Table A-10

LOVELAND FIRE DEPARTMENT AND FIRE PROTECTION DISTRICT
COMMUNICATIONS WORK LOADS AND RESPONSE TIMES

Element	Busy Hour Magnitudes
Number of telephone calls	0.9
Total celephone time	0.9 min
Number of radio messages	20.4
Total message time	3.4 min
Number of address/running card checks	0.9
Total card time	0.4 min
Number of log entries	21
Total logging time	3.5 min
Total time expended	8.2 min
Available time	45.0 min
Operator loading*	18%
Communications queue*	2.5 s

*Major fire with 6 units: Operator loading = 27%; communications queue = 4 seconds.

Although the Loveland FD and RFPD have a considerable amount of equipment, we estimated that six fire units would be used against either a major structure or a range/forest fire. The work load and time delay associated with this additional load during the busy hour would be 27% and 4 seconds. These values indicate that Loveland FD and RFPD dispatch would not have large delays even with a large fire in the busy hour.

4. Larimer County Sheriff's Office Fire Fighting Force

This agency has five paid personnel and 135 volunteers who fight mainly range and forest fires. Fire units are all located in Fort Collins at the County building with dispatch also provided from that facility.

A fire dispatch position is manner eight hours a day, five days a week, with the Sheriff's law enforcement dispatchers providing fire

dispatch for the remainder of the time. In addition to fire equipment, a mountain rescue unit is also manned and dispatched from this facility.

Because the Sheriff's Office fire fighting force relies heavily on volunteers and because of the generally remote areas in which its fire fighting efforts occur, the dispatch and coordination of work crews require considerable effort over a fairly long period of time--days as opposed to hours for a building fire. During 1976, 28 fires were fought by these forces with a maximum of eight occurring in one day.

Considering the relatively few fires, their long duration, and the logistic requirements of this fire fighting force, we believe that it will be necessary for any consolidated communications facility that may be designed to provide needed dispatch and coordination work from initial dispatch through long-term coordination. This capability would include provision of the sheriff's fire dispatch frequency and coordination frequencies at the fire dispatch console(s) and extra telephones for coordination of the fire fighting crews. Additionally, frequency access to U.S. Forest Service frequencies and, perhaps, to airborne units may be required from the fire dispatch console(s).

5. Estes Park Fire Department

The Estes Park FD is dispatched by the Estes Park PD Communications Center. Fire fighting equipment of the U.S. Forest Service can also be dispatched from the Estes Park PD. The service area of the Estes Park FD is larger than the city limits, with calls for service outside the city limits coordinated with the sheriff.

The department is an all-volunteer (25-30) agency with five units (two pumpers, two jeeps, and one equipment truck) that fights 55-60 fires a year. This number of fires would put a very small average work load (one fire every six to eight days) on the dispatchers, so that independent computation of a busy hour call volume and work load is meaningless.

6. Poudre Canyon Rural Fire Protection District, Red Reather Lakes Rural Fire Protection District, and Wellington Fire Protection District.

These three fire protection districts provide fire service to about 15,000 residents of Larimer County. They are volunteer companies that are alerted through telephone systems. Generally, the sheriff's fire fighting forces will coordinate activities with them on range/forest fires. Approximately 20 fires per year may occur in areas served by these agencies.

7. Combined Dispatcher Work Loads for Sheriff, Estes Park, Poudre Canyon, Red Feather Lakes, and Wellington Fire Protection Services.

The combined population served by these agencies is about 37,000. Although some are served by radio dispatch and some by telephone dispatch, they are treated as a group to estimate dispatcher loading in any projected consolidated center.

These areas would create an average daily demand of about four calls per day, or 0.8 in the busy hour. Of these calls, about 40% would be telephone-dispatched and 60% would be radio-dispatched. For a telephone dispatch, the dispatcher would have to dial the agency's emergency number and/or alert the volunteers with a radio pager or Plectron system. We estimated that the dispatcher may spend one minute in this process and have four logging events associated with each incident. For radio dispatch, we used the same assumptions used earlier for the other radio-dispatched agencies.

The results of applying this assumption to these departments are shown in Table A-11. The combined busy hour load of these departments is 11% with a communications queue of 1.6 seconds. Dispatching an additional three units (assuming radio dispatch) to a large fire would increase these values to 20% and 2.9 seconds, respectively.

C. Emergency Medical Services

Under a contract with Colorado Department of Health, the state Division of Communications has analyzed the emergency medical communications situation in State Planning Region II. The recommendations of that study (called Project No. 7625-2614-300) are in the process of being implemented and, consequently, should be used as the basis for designing an emergency medical dispatch capability into any projected consolidated communications system.

In this section, we discuss the elements of the current system, the elements of the proposed system, the probable communications work load of the proposed system, and operational considerations.

Table A-11

COMBINED COMMUNICATIONS WORK LOADS AND RESPONSE TIMES FOR SHERIFF, ESTES PARK FIRE DEPARTMENT, POUDRE CANYON RURAL FIRE PROTECTION DISTRICT, RED FEATHER LAKES RURAL FIRE PROTECTION DISTRICT, AND WELLINGTON FIRE PROTECTION DISTRICT

Element	Busy Hour Magnitudes
Number of telephone calls	0.8
Total telephone time	0.8 min
Number of radio messages	9.6
Total message time	1.6 min
Number of address/running card checks	0.8
Total card time	0.4 min
Number of telephone/pager alerts	0.3
Total alerting time	0.3 min
Number of log entries	11
Total logging time	1.8 min
Total time expended	4.9 min
Available time	45.0 min
Operator loading*	11%
Communications queue*	1.6 s

*Major fire with 6 units: Operator loading = 20%; communications queue = 2.9 seconds.

1. Current Emergency Medical Services (EMS)

Three hospitals in Larimer County provide dedicated emergency medical services: Poudre Valley Memorial in Fort Collins, Loveland Memorial in Loveland, and Elizabeth Knuttson Memorial in Estes Park. Of these, only the hospital in Estes Park lacks radio contact with the local ambulance service.

The three full-time ambulance services at Estes Park, Loveland, and Fort Collins have radio communications capability. In Estes Park, ambulances are dispatched directly by the Estes Park Communications Center. The ambulances can communicate with the center and with the Estes Park PD but not with the hospital, as indicated above, because it has no radio communications equipment. In Loveland, incoming 911 calls for ambulance service are answered at the Loveland PD and are routed to the ambulance company through direct ring-down telephone. The Loveland ambulances carry radio units operating on the Loveland PD channel. Communications between the Loveland ambulance and hospital is handled through a telephone patch. In Fort Collins, 911 calls for ambulance service are transferred to the ambulance office at the Poudre Valley Memorial. Ambulances are then dispatched from a radio console in that office. An additional ambulance service, a volunteer service at Red Feather Lakes, does not have radio communications capability.

Additional hospitals and ambulance capabilities exist in Weld County, which is also part of the EMS Communications Region II. These capabilities will have to be considered in developing communication consolidation plans for Larimer County.

2. Proposed EMS Communication System

The proposed EMS communications system provides two radio subsystems: one for coordination and the other for medical telemetry. The EMS coordinating subsystem is the system of interest because it provides the dispatch and coordination of ambulance services plus coordination with hospitals and clinics. The EMS medical subsystem will provide biomedical telemetry between the hospitals and ambulances and is of interest

primarily because of the need to coordinate ambulance/hospital use of the telemetry channels in conjunction with dispatch operations.

The EMS coordination subsystem will use the UHF frequency pair 462.950/467.950 MHZ in full duplex operation using a mobile relay at Point of Rocks in Weld County. Coverage studies performed as part of the EMS coordination plan indicate excellent radio reception throughout Larimar County from that site.

3. Communications Work Load for EMS Dispatching

The abovementioned planning document does not include estimates of EMS dispatch traffic. Generally, however, estimates of EMS dispatch traffic volumes are based on the assumption that this traffic is about 5% of the police dispatch traffic for the service area. Using this value, we estimated that the operator loading for Larimer County would be about 15% with a delay of about 4 seconds for a single dispatcher. This number is adequate for evaluation purposes, but it should be refined for final engineering design of any consolidated facility.

4. Operational Considerations

The inclusion of EMS dispatching in a combined communication center will require consideration of the training to be provided dispatchers. The abovementioned document emphasizes the need for such training and we concur with that need.

It will be important to provide effective operational guidance to EMS dispatchers. Not only will they be dispatching a fairly scarce resource (ambulances) but they could determine the availability of hospital/clinic resources to receive patients. The EMS community will have to make known their operational needs to the communication center.

Finally, telephone communication links between the communication center and the EMS community will have to be defined to assure an adequate coordination capability.

END