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## Market Survey Results for Alternate Sensor Communications

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Sandia National Laboratories  
Albuquerque, New Mexico 87185 and Livermore, California 94550  
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# **Market Survey Results for Alternate Sensor Communications**

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## **ABSTRACT**

This document presents the results of a system analysis and market survey of commercially available alarm communication systems for potential use as an alternate sensor communication system. The communication systems surveyed include wireless radio frequency (RF) systems, spread spectrum systems, fiber optic systems, twisted pair/copper wire, cellular systems, and other types of communication equipment. All systems are commercially available, and most information was obtained by telephone conversations with the manufacturer, personal interviews at security conferences, and countless reviews of the manufacturers' data sheets. Many systems were identified, but only those that met a minimum set of system requirements were included. Other systems that appeared to be applicable usually did not provide adequate data encryption or could not interface directly to the system. While such features could be incorporated using additional hardware, doing so would make the system more expensive and conflict with the idea of purchasing a single unit that meets the minimum set of requirements. Several systems greatly exceed the scope of this project and utilizing such systems would mean investing in more capacity than is really needed.

# Market Survey Results for Alternate Sensor Communications

## Table of Contents

Introduction .....	1
Approach .....	1
Approach 1 .....	2
Approach 2 .....	2
Approach 3 .....	3
System Requirements .....	4
Commercial Systems Identified .....	5
Wireless Communication Systems .....	6
Inovonics - MCR16 Receiver/C200 Transmitter System .....	7
Northern Computers - SpreadCOM System .....	8
Ademco - Wireless Alarm Transmission System .....	9
Linear - Single-Channel Wireless System .....	10
Linear - Multiple-Channel Wireless System .....	11
Linear - Supervised Wireless System .....	12
Linear - Midrange Wireless System .....	13
NAPCO - Magnum Alert Wireless System .....	14
Visionic - SpiderAlert Universal Wireless System .....	15
Interactive Technologies Inc. - SX5 Wireless Alarm System .....	16
CRN - Radio Alarm Transmission System .....	17
Seaboard - RC-2 Series Wireless System .....	18
SNL - Universal Network Interface Module .....	19
SNL - Authenticated Item Monitoring System (AIMS) .....	20
SNL - Wireless Alarm Transmission of Container Handling (WATCH) System .....	21
Intellitech - Lookout Dispatcher .....	22
Fiber Optic Communication Systems .....	23
Math Associates - Fiberoptic Status Control Module .....	23
American Fiber - Fiberoptic Status Control Modules .....	24
Fibronics International - Miniature Fiberoptic and Twisted Pair Modems .....	25
Hardwire Communication Systems .....	26
Puelo Electronics, Inc. - Alarm Encoder/Decoder Reporting Link .....	26
Litton Poly Science - Intelligent Transceiver Node .....	27
Dantel, Inc. - Multiple Alarm Transmitter/Control Point Module .....	28
Cellular Communication Systems .....	29
Laser Communication Systems .....	30

Power-Line Communication Systems -----	31
Cyplex - PowerPlex Communication Module -----	31
Other Communication Systems-----	32
Stellar Systems - Remote Control Transponder -----	32
Stellar Systems - EFS2 Encryption System -----	33
Scientific Technologies Inc. - 551X Spread Spectrum Modem -----	34
United Marine - Intelligent Encryption Module -----	35
Wireless Video Communication Systems -----	36
Comparison Table #1 -----	37
Comparison Table #2 -----	38
Conclusions -----	39
Recommendations	
Approach 1 -----	39
Approach 2 -----	39
Approach 3 -----	40

# Market Survey Results for Alternate Sensor Communications

## Introduction

Sandia National Laboratories Safeguards and Security Center (7400) tasked the Nuclear Security System Center (5800) to evaluate subsidiary communication methods of transmitting sensor information and make recommendations for implementing an alternate sensor communications system. The objective of this document is to present the results of a system analysis and market survey of commercially available alarm communication systems. Only those systems that report alarm/sensor information to a central control panel were considered. Many systems were identified, but only those that met a minimum set of system requirements were included in this document. An outline of the system requirements and specifications is presented in the next sections. A detailed definition of the system requirements can be found in *System Requirements and Specifications for Alternate Sensor Communications* dated June 20, 1994. Many other alarm communication systems were also identified but were not included on this market survey because of interface compatibility issues. While such interfaces could be incorporated with additional hardware, doing so would make the system more expensive and conflict with the idea of purchasing a single unit that would interface directly to Sandia's main Alarm Multiplexing Communication System (AMCS). Other candidate systems were either too simple or too complex to be implemented as an alarm/repository communication system. Some systems greatly exceeded the scope of this project; utilizing such systems would mean investing in more capacity than is really needed. Other systems could not interface to AMCS at all and were not considered.

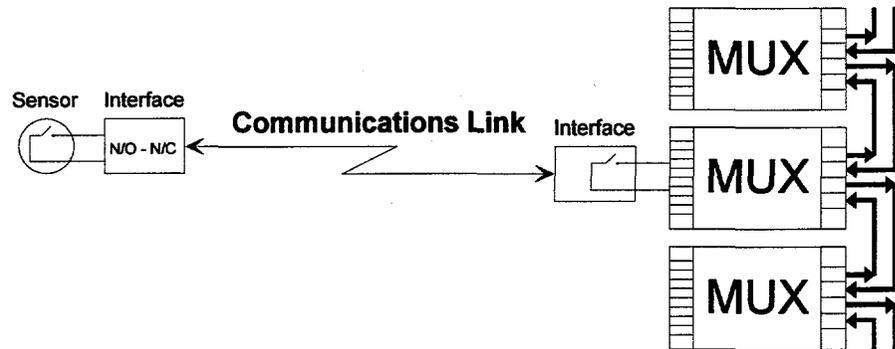
The communication systems described in this document are all commercially available and vary considerably in terms of cost, features, and capabilities. The systems surveyed include wireless radio frequency (RF) communication systems, spread spectrum communication systems, fiber optic communication systems, twisted pair/copper wire systems, cellular communication systems, and other communication equipment. Most of the information was obtained by telephone conversations with the manufacturer, personal interviews at security conferences, and countless reviews of the manufacturers' data sheets. In addition, other types of commercial alternate communications technologies and insights to wireless video transmission will be presented. Three possible system approaches will be explored in the next section. Each approach will take into account the level of line security required relative to system cost. Line protection should be addressed in terms of risk assessment relative to the security level of the asset being protected.

## Approach

This section presents three approaches that address the interface compatibility of the alternate sensor communications. The following three approaches comply with the system architecture specified in the system requirements and specifications.

## Approach 1

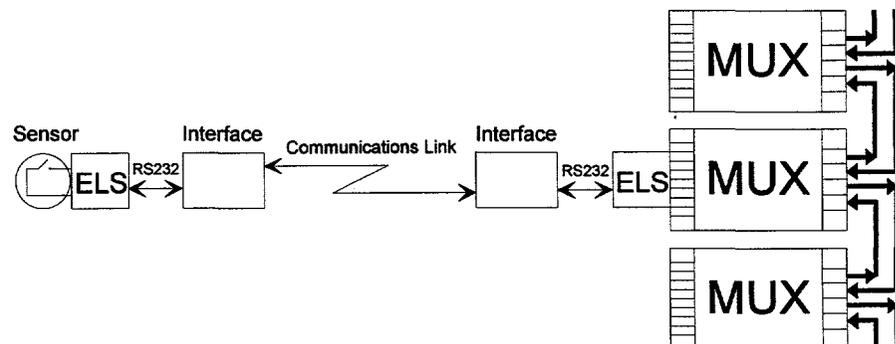
The first approach simply relays the sensor status (switch-closure status) to a receiver that is hardwired to an Alarm Multiplexer Communication System multiplexer (MUX) unit.



This approach is very simple to implement because it provides straight line relay connections between the sensor-communications interface and the communication-MUX interface. With this architecture, there are minimal or no requirements to engineer an interface to the system since many commercially available communication systems are already designed to relay switch-closure information. The output of the sensor will be a dry-switch closure that will connect directly to the sensor-communication interface via normally-open or normally-closed relays. The output of the communication-MUX interface is reversed and will connect directly to the input of the AMCS multiplexers via normally-open or normally-closed relays. Because of the simplicity of this system, the equipment cost is considerably lower than the next two approaches. However, this type of system architecture provides very limited communication line security because of built-in and existing characteristics of the manufacturer, e.g., spread spectrum, frequency hopping, etc.

## Approach 2

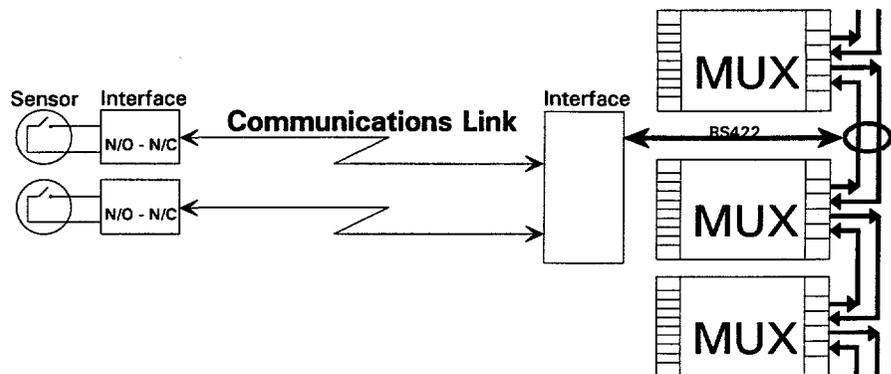
The second approach is similar to approach 1 except that an enhanced line security (ELS) module is placed between the sensor-communication and the communication-MUX interfaces. The ELS module encodes the sensor status and transmits the information using a specified format, usually RS-232 format. Another ELS module is necessary between the communication-MUX interface to decode the sensor information.



This approach is more complex than the first, but it provides a higher level of line security. The increased line security and the complexity of this approach also increase the cost of the system. With this approach, there may be some modifications or requirements to engineer a black-box interface to the multiplexer since the polling-side of the multiplexer requires switch-closure input.

### Approach 3

The third approach is the most complex because there is a requirement to interface to the backbone link of AMCS. This approach will most likely require the development of a black-box interface to the AMCS. This link consists of a multiplexer-reporting interface on an RS-422 format. The sensor-communication interface is similar to the other two approaches, but the communication-MUX interface is bypassed by interfacing directly to the RS-422 communication link of AMCS.

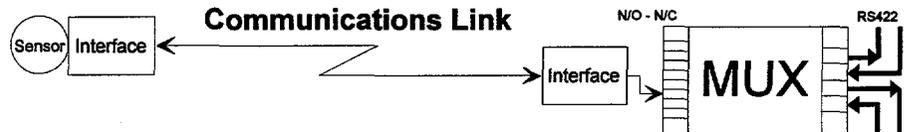


This approach provides the highest level of line security because the commercially available systems have built-in, proprietary line supervision and authentication algorithms. This enhanced line protection and complexity of this system is considerably higher than the other two, hence, a higher system cost. There will also be some additional cost involved in developing or engineering the interface to the RS-422 link of the AMCS system.

# System Requirements

An outline of the system requirements and specifications is presented in this section for reference purposes. For a more detailed description of the requirements refer to the *System Requirements and Specifications for Alternate Sensor Communications* document. The set of requirements included in this report act only as a guideline to classify potential systems and screen out futile systems. Shortly after the market survey was initiated, it was apparent that no commercial system would meet 100 percent of our requirements without being modified. Thus it was recommended that this set of requirements be used only as a guideline for this market survey.

## System Architecture



## Interface Requirements

The system must be compatible with the existing AMCS multiplexer interface. As a basis, the communications link must interface to the sensor and the AMCS multiplexers via either normally-open or normally-closed relays. Alternatively, the communication-MUX interface may link directly to the reporting-side of the multiplexer using an RS-422 format.

## Line Protection

The communication system must report a distinct alarm for the malfunction, short, open, or signal substitution. The line supervision must be continuously supervised to detect any system malfunctions or any attempts to short, open, or substitute bogus signals for the legitimate "no alarm" state. Alternatively, encryption may be used.

## Tamper Protection

The communication system must report a distinct tamper-indicating alarm.

## Multiplexing Capabilities

The communication-MUX interface/system must be able to multiplex a minimum of 8 communication transmitters/sensors.

## Transmission Distance

The transmission distance must cover a minimal range of 500 feet (line-of-sight). Distance limitations may be overcome by utilizing repeaters or amplifiers in the transmission path.

## Transmission Rate

The system must be compatible with the existing AMCS transmission scheme. Alternatively, the transmission rate shall be sufficiently fast to transmit/receive, within one second, the number of alarms equal to the number of discrete reporting sensors.

## Polling Rate

The polling rate shall be sufficient to poll at the fastest rate consistent with the transmission rate and polling mechanism of the AMCS Multiplexers.

## Portability/Size

The system shall be easily portable and must conform to the size limitations of the AMCS Multiplexer cabinets utilized by Department 7433.

## Power Supply/Battery Backup

The transmitter shall operate on battery power for no less than 4 months and input voltages of 12 volts dc (VDC). The receiver/multiplexer shall operate on input voltages of either 12 volts dc (VDC) or 115 volts ac (VAC) with battery backup power of no less than 4 hours.

## **Commercial Systems Identified**

Our goal was to identify commercially available communication systems that met 100 percent of our requirements. We soon discovered that no such commercial system was available (without making modifications to the system). Thus we were inclined to relax some of our requirements and specifications in order to perform this market survey. All of the systems included in this survey meet the majority of our requirements. The requirements that are not met are addressed in the "disadvantages" sections. Cost comparison tables are presented in pages 37 and 38. The following commercial sensor communication systems were identified and are included in this report.

### **Wireless Communication Systems**

- Inovonics - MCR16/C200 System
- Northern Computers - SpreadCOM System
- ADEMCO - Wireless Alarm System
- Linear - Single-Channel System
- Linear - Multiple Channel System
- Linear - Supervised Wireless System
- Linear - Midrange System
- NAPCO - Magnum Alert Wireless System
- Visionic - SpiderAlert Wireless System
- ITI - SX5 Wireless Alarm System
- CRN - Radio Alarm System
- Seaboard - RC-2 Wireless System
- SNL - UNIMod System
- SNL - Authenticated Item Monitoring System
- SNL - WATCH System
- Intellitec - Lookout Dispatcher

### **Fiber Optic Communication Systems**

- Math Associates - Fiberoptics Control Module
- American Fiber Tech - Status Control module
- Fibronics International - Fiberoptic Modems

### **Hardwire Communication Systems**

- Puleo Electronics - Alarm Encoder/Decoder
- Litton Poly Science - Intelligent Transceiver
- Dantel - Multiple Transmitter Module

### **Other Communication Systems**

- Cyplex - PowerPlex Module
- Stellar Systems - Monitoring Transponder
- Stellar Systems - EFS2 Encryption Module
- Scientific Technologies - 551X Modem
- United Marine - Intelligent Encryption Module

Many other communication systems were also identified but were not included on this market survey because of interface compatibility issues. Some systems provided their own interface but still required the purchase of additional equipment to interface to AMCS. Such interfaces could be accommodated with additional hardware, but doing so would make the system more expensive and conflict with the idea of purchasing a single unit that meets a minimum set of requirements. Other candidate systems were either too simple or too complex to be implemented as an alarm/repository communication system. These systems greatly exceeded the scope of this project; utilizing such systems would mean investing in more capacity than is really needed. Other systems could not interface to AMCS at all and were not considered.

## **Wireless Communication Systems**

The following section contains all identified wireless radio frequency communication systems except cellular systems (they will be discussed in a separate section). This section also includes several wireless transmission systems that use different types of modulation techniques such as spread spectrum, frequency hopping, and frequency shift keying.

## Inovonics - MCR16 Receiver/C200 Transmitter System

<b>Method of Transmission</b>	Radio frequency signals at 900 MHz using a dual frequency hopping method.
<b>Brief Description of System</b>	The system consists of a multichannel receiver for the remote monitoring of up to 16 independent universal transmitters. The transmitters may interface directly to any standard, normally-open or normally-closed contact sensors. The transmitters have a tamper protected case with low-battery warning and support for end-of-line resistors. The 900 MHz receiver decodes the transmitted signal and provides individual sensor status as well as individual relay output for each point. Additional information related to tamper, inactive, or low-battery status of each contact point can be obtained using a two-digit numeric LED status display. The system also offers a repeater for greater range of coverage.
<b>System Components (Size)</b>	C200 Universal Transmitter (6" X 1.25" X .75") C703 Receiver (13" X 10.25" X 2.5") C514 Device Programmer
<b>Frequency Band</b>	900 MHz region; dual frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open, normally-closed inputs, and RS-232 output
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter case and receiver case
<b>Multiplexing Capabilities</b>	16 transmitters per receiver
<b>Range of Transmission</b>	2000 feet nominal; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period is programmable from 10 seconds to 6 hours
<b>Power Supply</b>	Transmitter - 4.5 V alkaline battery pack, 3-year life Receiver - 12 VDC, 14 VAC; battery backup, 4.6 Ah
<b>Advantages</b>	Low cost Accepts normally-open, normally-closed sensors, and RS-232 output Good range Repeaters also available High-frequency carrier Programmable report period Multiplexes up to 16 transmitters per receiver Access control devices also available
<b>Disadvantages</b>	No line protection or data encryption The only line protection is frequency hopping No external or backup power supply on transmitter

## Northern Computers - SpreadCOM System

<b>Method of Transmission</b>	Radio frequency signals in the 902-928 MHz range using a spread spectrum technique.
<b>Brief Description of System</b>	The system consists of a Receiver/Control panel that accepts alarm status from an alarm zone transmitter. The transmitter supports four normally-closed alarm contacts and a supervisory alarm signal. The transmitter continuously monitors the status of the alarm contacts and sends out an alarm event during any status change. A supervisory signal is sent once every 30 seconds to the receiver.
<b>System Components (Size)</b>	N-4300 Zone Transmitter (6.5" X 3.5" X 1.5") N-4100 Central Transceiver Panel (16" X 14" X 4")
<b>Frequency Band</b>	902-928 MHz; Spread spectrum
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-closed alarm contacts only
<b>Line/Tamper Protection</b>	No line protection; tamper switches in zone transmitter and central transceiver
<b>Multiplexing Capabilities</b>	64 transmitters
<b>Range of Transmission</b>	2000 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Report period – 30 seconds Polling period – 45 seconds
<b>Power Supply</b>	Transmitter – 12 VDC from 110 VAC; battery backup, 4.6 Ah Receiver – 16 VDC, 12 VAC; 12 VDC battery backup, 3.0 Ah
<b>Advantages</b>	Spread spectrum transmission (partially secure signal transmission) Good range High-frequency carrier Multiplexes up to 64 transmitters per panel Remote units receive as well as transmit enabling the central control unit to poll the status of remote zones VAC power connection with battery backup
<b>Disadvantages</b>	High cost No line protection or data encryption Only normally-closed circuits are supported Polling and reporting periods are too long and not programmable

## Ademco - Wireless Alarm Transmission System

<b>Method of Transmission</b>	Radio frequency signals at 350 MHz, transmitting over a single frequency.
<b>Brief Description of System</b>	The system consists of a receiver that can handle up to 64 zones. The transmitters can handle two or three zones independently and input normally-open or normally-closed circuits. The receiver can also handle transmitters that can be triggered by input voltage. The system provides a programming/learn mode that allows the system to be programmed with an ID code (from a range of over 16 million codes) for each transmitter.
<b>System Components (Size)</b>	5816 2-Zone Transmitter (3" X 1.5" X 1") 5817 3-Zone Transmitter (3" X 1.5" X 1") 5881 Receiver (8" X 5" X 1") 4140 XMPT2 Alarm Panel 4204 Relay Module
<b>Frequency Band</b>	350 MHz region; single frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	5816 Transmitter – 2 normally-open 5817 Transmitter – 2 normally-open, 1 normally-closed
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter case and receiver case
<b>Multiplexing Capabilities</b>	Up to 64 transmitters maximum per panel
<b>Range of Transmission</b>	400 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period from 70 to 90 minutes; not programmable
<b>Power Supply</b>	Transmitter – 3 V lithium battery, no external power Receiver – 12 VDC, 16.5 VAC; battery backup, 4.0 Ah
<b>Advantages</b>	Low cost Multiplexes up to 16 transmitters per receiver
<b>Disadvantages</b>	No line protection or data encryption Limited range Single frequency operation Low-frequency carrier may not penetrate thin-metal walls Report period is too long and not programmable No external or backup power supply on transmitter

## Linear - Single-Channel Wireless System

<b>Method of Transmission</b>	Radio frequency signals at 303.875 MHz, transmitting over a single frequency.
<b>Brief Description of System</b>	The system components are a single-channel transmitter and a single-channel receiver. The transmitter accepts normally-open or normally-closed circuits and encodes the signal using an eight-position DIP switch. The system consists of a single channel transmitter/receiver pair, thus it requires one transmitter and one receiver for each set of contact closures. The components, however, are very inexpensive.
<b>System Components (Size)</b>	D-21A N/O circuit transmitter (4.7" X 2.4" X .9") D-24A N/C circuit transmitter (4.7" X 2.4" X .9") DX-12 receiver (4.9" X 3.8" X 1.3")
<b>Frequency Band</b>	303.875 MHz; single frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter case and receiver case
<b>Multiplexing Capabilities</b>	Single channel; one transmitter, one receiver per sensor contact
<b>Range of Transmission</b>	300 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Transmitter needs to be externally activated for transmission. Continuous transmission while transmitter is activated.
<b>Power Supply</b>	Transmitter – 9 V battery, no external power supply Receiver – 11-24 VDC, 12-16 VAC
<b>Advantages</b>	Very low cost 256 selectable codes using an eight-position DIP switch
<b>Disadvantages</b>	No line protection or data encryption Limited range Requires one receiver for each transmitter Single-frequency operation Low-frequency carrier may not penetrate thin-metal walls Status reporting must be externally activated No external or backup power supply on transmitter

## **Linear - Multiple-Channel Wireless System**

<b>Method of Transmission</b>	Radio frequency signals in the 303.875–318.000 MHz range, transmitting over a multiple-channel spectrum.
<b>Brief Description of System</b>	The system consists of two-channel, four-channel, or eight-channel receivers that accept signals from the previous Linear D21A and D24A transmitters. The transmitter accepts normally-open or normally-closed circuits and encodes the signal using an eight-position DIP switch.
<b>System Components (Size)</b>	D-21A N/O circuit transmitter (4.7" X 2.4" X .9") D-24A N/C circuit transmitter (4.7" X 2.4" X .9") D-2, D4, D8 Receivers (4.8" X 4.2" X 1.3")
<b>Frequency Band</b>	303.8–318 MHz; multiple-channels
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter case and receiver case
<b>Multiplexing Capabilities</b>	Up to 8 transmitters per receiver
<b>Range of Transmission</b>	300 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Transmitter needs to be externally activated for transmission. Continuous transmission while transmitter is activated.
<b>Power Supply</b>	Transmitter – 9 V battery, no external power supply Receiver – 11-24 VDC, 12-16 VAC
<b>Advantages</b>	Low cost 256 selectable codes using an eight-position DIP switch Multiple channels
<b>Disadvantages</b>	No line protection or data encryption Limited range Low-frequency carrier may not penetrate thin-metal walls Status reporting must be externally activated No external or backup power supply on transmitter

## Linear - Supervised Wireless System

<b>Method of Transmission</b>	Radio frequency signals at the 303.8–315 MHz range using a supervised multiple-channel method.
<b>Brief Description of System</b>	The system consists of a receiver panel that accepts up to 32 supervised transmitters which connect to normally-open and normally-closed inputs. The transmitter encodes the signal using an eight-position DIP switch. The receiver interfaces with virtually any type of hardwire panel and annunciates six different transmitter conditions.
<b>System Components (Size)</b>	ST Transmitter (3.95" X 2.4" X .9") SSR-32 Receiver (6.55" X 7.92" X 1.28")
<b>Frequency Band</b>	303.8–315 MHz
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 32 transmitters per receiver Eight output zones
<b>Range of Transmission</b>	300 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period every 1.2 hours; not programmable
<b>Power Supply</b>	Transmitter – 9 VDC battery, no external power supply Receiver – 12 VDC, no external power supply
<b>Advantages</b>	Low cost 256 selectable codes using an eight-position DIP switch Multiplexes up to 32 transmitters per receiver
<b>Disadvantages</b>	No line protection or data encryption Limited range Low-frequency carrier may not penetrate thin-metal walls Report period too long, not adjustable or programmable No external or backup power supply on system

## Linear - Midrange Wireless System

<b>Method of Transmission</b>	Radio frequency signals at 27.145 MHz using high-power, single-channel transmission.
<b>Brief Description of System</b>	The system consists of one-channel, four-channel, or eight-channel transmitter and receiver combination. The system accepts normally-open and normally-closed circuits and provides an ID code (from over 64,000 codes) for each input. The system is also weather-resistant for exterior applications.
<b>System Components (Size)</b>	MR161T/MR164T/MR168T Transmitters (4.2" X 2.5" X 9.75") MR161R/MR164R/MR168R Receivers (4.2" X 2.5" X 9.75").
<b>Frequency Band</b>	27.145 MHz
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits
<b>Line/Tamper Protection</b>	No line protection; tamper switch in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 8 transmitters per receiver Over 64,000 codes
<b>Range of Transmission</b>	From 3/4 to 5 miles; line-of-sight
<b>Transmission/Polling Rate</b>	Transmitter needs to be externally activated for transmission. Continuous transmission while transmitter is activated
<b>Power Supply</b>	Transmitter – 9 AAA batteries or 12–13.5 VDC external power supply Receiver – 12-13.5 VDC from external power supply
<b>Advantages</b>	Good range VAC power supply with battery backup
<b>Disadvantages</b>	High cost No line protection or data encryption Low-frequency carrier may not penetrate thin-metal walls Status reporting must be externally activated

## NAPCO - Magnum Alert Wireless System

<b>Method of Transmission</b>	Radio frequency signals in the UHF radio band using a spread spectrum technique.
<b>Brief Description of System</b>	The system consists of a receiver panel that handles up to 14 transmitters. The transmitters provide a powerful signal that penetrates through common obstructions and has a free-air maximum range of 500 feet. The transmitters also provide up to 16,000 encrypted link codes with a compressed data format. The system is based on a unique, super spread spectrum wireless receiver that incorporates an auto-learn mode that memorizes the transmitters' codes. The system is also fully-supervised. The transmitters communicate the alarm status, supervisory data, tamper status, and low battery status.
<b>System Components (Size)</b>	T1000WD Transmitter (3.3" X 1.5" X .88") R1000 Receiver (5.5" X 3.1" X 1.75") R1008e Control panel (4.5" X 5.2" X .9")
<b>Frequency Band</b>	UHF radio frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 14 transmitters per receiver
<b>Range of Transmission</b>	3500 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period every four hours; not programmable
<b>Power Supply</b>	Transmitter – Long life lithium batteries, no external supply Receiver – 12 VDC lithium battery
<b>Advantages</b>	Low cost Spread spectrum transmission (partially secure signal transmission) Multiplexes up to 14 transmitters per receiver Good range
<b>Disadvantages</b>	No line protection or data encryption Low-frequency carrier may not penetrate thin-metal walls Report period not adjustable No external or backup power supply on transmitter

## Visionic - SpiderAlert Universal Wireless System

<b>Method of Transmission</b>	Radio frequency signals at 315 MHz over a single-channel transmission.
<b>Brief Description of System</b>	The system consists of a receiver that can multiplex up to 4 transmitters. The transmitters accept normally-open and normally-closed circuits. The system also offers a repeater for greater range coverage. The system also requires a central control unit that is used to program the transmitters and receivers.
<b>System Components (Size)</b>	WT-100 Transmitter (2.5" X 4.25" X 1.0") WR-200 Receiver (2.5" X 4.25" X 1.0") WRP-500 Repeater WMX-16 Multiplexer
<b>Frequency Band</b>	315 MHz; single frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 4 transmitters per receiver
<b>Range of Transmission</b>	500 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Transmitter needs to be externally activated for transmission. Continuous transmission while transmitter is activated.
<b>Power Supply</b>	Transmitter – 9 V alkaline battery; no external power supply Receiver – 12 VDC from external power supply
<b>Advantages</b>	Low cost Repeaters available
<b>Disadvantages</b>	No line protection or data encryption Limited number of transmitters per receiver Low-frequency carrier may not penetrate thin-metal walls Status reporting must be externally activated No external or backup power supply on transmitter

## Interactive Technologies Inc. - SX5 Wireless Alarm System

<b>Method of Transmission</b>	Radio frequency signals at 319.5 MHz, transmitting over a single frequency.
<b>Brief Description of System</b>	The system is composed of a receiver panel that receives the transmitted signal from a single-channel transmitter. The transmitter may interface to normally-open or normally-closed circuits. The system also provides a learning mode technology that allows the system to program each transmitter with a code from a range of over 16 million codes.
<b>System Components (Size)</b>	SX5 System, 60-135 Alarm Transmitter (no data) SX5 System, 60-125 Receiver Panel (no data)
<b>Frequency Band</b>	319.5 MHz; single frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to a single normally-open or normally-closed input
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 61 transmitters maximum
<b>Range of Transmission</b>	1000 feet nominal; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period every 69 minutes; not programmable
<b>Power Supply</b>	Transmitter – 3 V lithium battery; no external power Receiver – 12 VDC. 16.5 VAC; battery backup, 4.0 Ah
<b>Advantages</b>	Low cost Adequate range Multiplexes up to 61 transmitters per receiver
<b>Disadvantages</b>	No line protection or data encryption Single frequency operation Low-frequency carrier may not penetrate thin-metal walls Report period not adjustable or programmable No external or backup power supply on transmitter

## CRN - Radio Alarm Transmission System

<b>Method of Transmission</b>	Radio frequency signals in the 450–512 MHz range using a frequency shift key algorithm.
<b>Brief Description of System</b>	The system consists of a transmitter and a receiver pair. The transmitters consist of a data encoder and an RF transmitter that sends a supervisory test signal at programmable intervals. Input channels are triggered by voltage input (6 to 12 VDC), contact closure, or TTL. There are three transmitter models with 6-channel mode, 12-channel mode, and a total-data transfer mode. The receiver receives the signal, decodes it, and generates a signal level output.
<b>System Components (Size)</b>	CRN6E and CRN12E Transmitters (2.875" X 7.825" X 1.625") CRNRU Receiver (4.2" X 2.5" X 9.75")
<b>Frequency Band</b>	450–512 MHz
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to voltage input (6–12 VDC), contact closures, and TTL
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 8 transmitters per receiver
<b>Range of Transmission</b>	Up to 6 miles; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period programmable from 10 minutes to several hours
<b>Power Supply</b>	Transmitter – 12.5 VDC; no external power supply Receiver – 12–13.5 VDC from external power supply
<b>Advantages</b>	Provides proprietary line supervision Accepts voltage input, contact closures, and TTL Good range Repeaters also available to extend range of coverage High-frequency carrier
<b>Disadvantages</b>	Very high cost Report period too long Low-frequency carrier may not penetrate thin-metal walls No external or backup power supply on transmitter

## Seaboard - RC-2 Series Wireless System

<b>Method of Transmission</b>	Radio frequency signals in the 450–470 MHz range using a frequency shift key algorithm.
<b>Brief Description of System</b>	The system consists of up to 243 individually addressable receivers. Each receiver accepts up to 40 transmitters. The entire system can handle up to 10,000 transmitters. The transmitter accepts normally-open or normally-closed circuits. The transmitter sends a unique coded signal to the receiver; the receiver decodes the information and activates one of eight integral relays. An RS-232 output port provides the communications to an annunciator/computer.
<b>System Components (Size)</b>	RC-1/TX Transmitter (5" X 2.75" X 1.2") RC-1/RX Receiver (11.25" X 15.25" X 4.25")
<b>Frequency Band</b>	450–470 MHz
<b>System Architecture</b>	Approach 3
<b>Interface/Sensor Input</b>	Interfaces to normally-open, normally-closed, and voltage input (6–12 VDC)
<b>Line/Tamper Protection</b>	Proprietary line supervision; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 243 transmitters per receiver
<b>Range of Transmission</b>	Up to 30 miles
<b>Transmission/Polling Rate</b>	Status reporting is triggered by voltage input
<b>Power Supply</b>	Transmitter – 12.6 VDC @ .75 A, 4 Ah batteries with 110 VAC charger Receiver – 12.6 VDC battery or external power supply
<b>Advantages</b>	Provides proprietary line supervision Excellent range Repeaters also available to extend range of coverage Multiplexes up to 243 transmitters per receiver VAC power supply with battery backup
<b>Disadvantages</b>	Very high cost Status reporting must be externally activated Low-frequency carrier may not penetrate thin-metal walls

## **SNL - Universal Network Interface Module**

<b>Method of Transmission</b>	Radio frequency signals in the narrow UHF band and VHF range.
<b>Brief Description of System</b>	The system consists of a transceiver unit that acts as a transmitter, receiver, and repeater to communicate alarm status. The transmitter wakes up every 1/8 second and transmits a data encryption standard (DES) encoded signal of the alarm status to the receiver. The transmitter has six relay inputs that can interface to normally-open or normally-closed inputs. The receiver performs the reverse function with six relay outputs. The receiver unit has the capability to talk RS-485 to provide sensor status from up to 2000 transmitters. The report period is dependent on the number of transmitters reporting to the receiver. The units also have programmable system power capabilities that allows the devices to utilize their power more efficiently.
<b>System Components (Size)</b>	Transmitter/Receiver/Repeater (4" X 2" X 1.5")
<b>Frequency Band</b>	UHF (450-500 MHz) and VHF (140-174 MHz)
<b>System Architecture</b>	Approach 1, approach 2, and approach 3
<b>Interface/Sensor Input</b>	Interfaces to normally-open, normally-closed inputs, and RS-485 output
<b>Line/Tamper Protection</b>	Provides DES line protection; no tamper indicating switch is implemented in the enclosure at this time, but one of the six relays could act as a tamper indicating switch.
<b>Multiplexing Capabilities</b>	Up to 2000 reporting transmitters
<b>Range of Transmission</b>	Up to 50 miles at maximum power; line-of-sight
<b>Transmission/Polling Rate</b>	Reporting period programmable from 0.125 second up to several hours
<b>Power Supply</b>	Transmitter/receiver - Eight AA batteries; no external power supply
<b>Advantages</b>	Moderate cost Provides DES line encryption Accepts normally-open, normally-closed sensors, and RS-485 output Excellent range Repeaters available to extend range of coverage Multiplexes up to 2000 transmitters to a single receiver
<b>Disadvantages</b>	No tamper protection in transmitter/receiver Low-frequency carrier may not penetrate thin-metal walls No external or backup power supply on unit

## **SNL - Authenticated Item Monitoring System (AIMS)**

<b>Method of Transmission</b>	Radio frequency signals in the 900 MHz range using a frequency hopping technique.
<b>Brief Description of System</b>	The system consists of authenticated alarm transmission modules. The transmitter can interface to normally-open or normally-closed inputs and relay an authenticated code to the receiver that contains the sensor status. The receiver decodes the data and relays the information to a central processing unit using an RS-422 link.
<b>System Components (Size)</b>	Transmitter (2.5" X 2.5" X 2") Receiver—portable computer unit ≈ (10.0" X 12.0" X 6")
<b>Frequency Band</b>	900 MHz
<b>System Architecture</b>	Approach 3
<b>Interface/Sensor Input</b>	Interfaces to normally-open, normally-closed circuits and RS-232 output
<b>Line/Tamper Protection</b>	Proprietary line authentication; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 2048 reporting transmitters
<b>Range of Transmission</b>	2000 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Polling rate is user programmable from 10 seconds
<b>Power Supply</b>	Transmitter - One AA size lithium battery; no external or backup power Receiver - 12 VDC, 14 VAC; battery backup @ 4.6 Ah
<b>Advantages</b>	Provides proprietary line authentication Frequency hopping for higher line security Accepts normally-open, normally-closed sensors, and RS-232 output Good range Multiplexes up to 2048 transmitters to a single receiver High-frequency carrier
<b>Disadvantages</b>	Relatively high cost No external or backup power supply on transmitter

## SNL - Wireless Alarm Transmission of Container Handling (WATCH) System

<b>Method of Transmission</b>	Radio frequency signals in the 900 MHz range using a frequency hopping technique.
<b>Brief Description of System</b>	The WATCH system consists of a wireless universal RF transmitter/receiver pair. The WATCH system is the unauthenticated version of AIMS. The transmitter interfaces to normally-open or normally-closed contacts/sensors. The receiver can collect data from up to 16 transmitters and generates an array of switch closures. With the assistance of an LED status array on the receiver, the status of each specific sensor can be determined.
<b>System Components (Size)</b>	Transmitter (4" X 2.25" X 1") Receiver - 16-Channel Receiver (13" X 10.25" X 2.5)
<b>Frequency Band</b>	900 MHz region; dual frequency
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed circuits and RS-232 output
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	The receiver can collect data from up to 16 transmitters. The receiver provides 12 normally-open switches, 4 type-C switches, and a two-digit numeric LED status display.
<b>Range of Transmission</b>	2000 feet; line-of-sight
<b>Transmission/Polling Rate</b>	Polling rate is user programmable from 10 seconds up to 6 hours
<b>Power Supply</b>	Transmitter - AA size lithium battery, no external power supply Receiver - 12 VDC, 14 VAC; battery backup @ 4.6 Ah
<b>Advantages</b>	Low cost Frequency hopping for higher line security Accepts normally-open, normally-closed sensors, and RS-232 output Good range Multiplexes up to 16 transmitters per receiver High-frequency carrier
<b>Disadvantages</b>	No significant line protection or data encryption No external or backup power supply on transmitter

## **Intellitech - Lookout Dispatcher**

<b>Method of Transmission</b>	Radio frequency signals in the UHF range of 450–470 MHz.
<b>Brief Description of System</b>	The system consists of a receiver that handles up to 12 transmitters. The transmitters support a wide range of commercially available sensors and normally-closed, and normally-open switch closures. The receiver provides eight DC outputs that can be set to activate on a specific alarm condition. The system can also be interfaced to many conventional alarm panels.
<b>System Components (Size)</b>	Transmitter (8" X 3" X 1.5") Receiver (15" X 11" X 3.5")
<b>Frequency Band</b>	450–470 MHz
<b>System Architecture</b>	Approach 3
<b>Interface/Sensor Input</b>	Eight dual polarity supervised inputs and 4 unsupervised switch closures
<b>Line/Tamper Protection</b>	No line protection; tamper switches in transmitter and receiver
<b>Multiplexing Capabilities</b>	Up to 12 transmitters per receiver
<b>Range of Transmission</b>	Up to 1 mile
<b>Transmission/Polling Rate</b>	Reporting period programmable from 15 seconds to several hours
<b>Power Supply</b>	Transmitter - Two 9 V batteries; no external power supply Receiver - 12 Volt DC, 12 VAC; battery backup, 7.5 Ah
<b>Advantages</b>	Good range Repeaters also available Multiplexes up to 12 transmitters per receiver Programmable report period
<b>Disadvantages</b>	Very high cost No line protection or data encryption Low-frequency carrier may not penetrate thin-metal walls No external or backup power supply on transmitter

## **Fiber Optic Communication Systems**

This section describes potential fiber-optic alarm communication candidate systems and includes only systems that will report alarm status using a fiber optic communication link. This section does not, however, include RS-232/422 format fiber optic transmission systems; there are numerous types of RS232/422 fiber-optic systems in the market and are too many to list. Rather, this section concentrates on inexpensive alarm-reporting fiber-optic systems.

### **Math Associates - Fiberoptic Status Control Module**

<b>Method of Transmission</b>	Fiber optic communication link between modules; reporting module is hard-wired to the sensor.
<b>Brief Description of System</b>	The system takes a TTL level, DTL level, or a switch closure and transmits the change to a receiver using fiber optic link. The input level is monitored on the output port of the receiver and activates an alarm interface. These devices will interface to practically any alarm control panel.
<b>System Components (Size)</b>	SC 1000A source module (3" X 1.5" X 1") RC 1000A receiver module (3" X 1.5" X 1")
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Eight TTL or DLL level inputs; or eight contact closures
<b>Line/Tamper Protection</b>	J-box enclosures with signal lines in metal conduit recommended. Normally-closed or high-TTL level for output status recommended
<b>Multiplexing Capabilities</b>	These units may be used in conjunction with one another but must have external control over addressing and decoding locations.
<b>Range of Transmission</b>	850 nm or 1300 nm options available
<b>Transmission/Polling Rate</b>	N/A
<b>Power Supply</b>	Transmitter/receiver modules - 12 VDC/VAC or battery available
<b>Advantages</b>	Relatively low cost per channel Available in Analog Current Loop configuration for line supervision Battery backup available
<b>Disadvantages</b>	Cost of module does not include the cost of the fiber cable No line supervision; needs to be added externally (conduit)

## **American Fiber - Fiberoptic Status Control Modules**

<b>Method of Transmission</b>	Fiber optic link between communication modules. Hardwires between the reporting module and the sensor.
<b>Brief Description of System</b>	The system consists of a fiber optic source module and a receiver module. The system multiplexes up to 8 channels of contact closures or TTL on one multimode glass fiber. The source module accepts either TTL level or a switch closure and transmits the status from the transmitter to the receiver using fiber optics. The receiver module then converts the fiber light into a TTL or switch closure output.
<b>System Components (Size)</b>	MT-80 Transmitter module (5.5" X 2.4" X 1.12") MR-80 Receiver module (6" X 3.75" X 1.2")
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Interfaces to either TTL or contact closures
<b>Line/Tamper Protection</b>	No line protection. J-box tamper enclosures with signal lines in metal conduit recommended.
<b>Multiplexing Capabilities</b>	8-channel TTL or 8-channel contact closures rated at 0.5 A/channel
<b>Range of Transmission</b>	850 nm or 1300 nm options available
<b>Transmission/Polling Rate</b>	2 milliseconds maximum
<b>Power Supply</b>	Transmitter/Receiver Modules - 12 VDC/VAC or battery available
<b>Advantages</b>	Low cost per channel Good transmission distance
<b>Disadvantages</b>	Cost of module does not include the cost of the fiber cable No built-in line supervision; needs to be added externally No tamper protection mechanism

## Fibronics International - Miniature Fiberoptic and Twisted Pair Modems

<b>Method of Transmission</b>	Multimode fiber optic or twisted pair copper.
<b>Brief Description of System</b>	These modems are used for local data distribution, providing full or half duplex, synchronous or asynchronous connections. The modems feature a DTE/DCE switch and are available with either male or female connectors. This is a relatively common product; several sources are available.
<b>System Components (Size)</b>	FM060 asynchronous fiberoptic modem. FM065 synchronous fiberoptic modem. FM049 asynchronous twisted pair modem. FM048 synchronous twisted pair modem.
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	RS-232 digital data
<b>Line/Tamper Protection</b>	None
<b>Multiplexing Capabilities</b>	None
<b>Range of Transmission</b>	1.25 miles on multimode fiber or IBM type 1, 2 copper cable
<b>Transmission/Polling Rate</b>	Data rates; up to 19.2 Kbaud
<b>Power Supply</b>	None required
<b>Advantages</b>	Requires no power supply Very small size: 1" x 2" x 4" Other access control devices available
<b>Disadvantages</b>	Very high cost per channel No line protection or data encryption No tamper protection

## **Hardwire Communication Systems**

This section describes potential hardwire, twisted-pair type of alarm reporting systems. This section, however, is not an all inclusive RS-232/422 format survey; there are numerous types of RS232/422 hardwire, twisted-pair systems in the market and are too many to list. Rather, this section contains some hardwire type of alarm reporting systems that will transmit RS-232/422 format for the application of approach 2. These alarm systems are included only for risk assessment and line security comparisons. These systems can also be used with the (Approach 2) enhanced-line security modules to increase the sensor-MUX line protection.

### **Puleo Electronics, Inc. - Alarm Encoder/Decoder Reporting Link**

<b>Method of Transmission</b>	RS-232 data communications over twisted pair.
<b>Brief Description of System</b>	Remote alarms are multiplexed into an asynchronous RS-232 data circuit. An encoder chassis monitors and continuously reports the status of up to 48 discrete alarm inputs over an RS-232 data link to a decoder chassis. The decoder chassis drives a corresponding set of up to 48 outputs whose status reflects those of the encoders' inputs. The open collector outputs can sink a maximum of 200 mA each. Optional dry contact relay output boards may be used for further isolation and increased current carrying capability.
<b>System Components (Size)</b>	PE903-016 rack mountable encoder with power supply and modem PE903-017 rack mountable decoder with power supply and modem
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 2
<b>Interface/Sensor Input</b>	Either open collector or contact closures
<b>Line/Tamper Protection</b>	Upon loss of encoder signal, the decoder outputs can be turned off or placed in a sleep mode
<b>Multiplexing Capabilities</b>	48 alarm inputs multiplexed over a single RS-232 data link
<b>Range of Transmission</b>	4 to 5 miles
<b>Transmission/Polling Rate</b>	0.13 seconds at 1200 baud
<b>Power Supply</b>	11 to 13 VDC, 125 mA, 5% or better regulation
<b>Advantages</b>	Encodes/decodes up to 48 alarms over a single RS-232 data link Communications link loss detection Significant distances achievable depending on the type of RS-232 modem Near instantaneous alarm reporting
<b>Disadvantages</b>	Very high cost No tamper protection No external or backup power supply on unit

## **Litton Poly Science - Intelligent Transceiver Node**

<b>Method of Transmission</b>	Signal communication over a twisted pair to RCP or other ITN.
<b>Brief Description of System</b>	The system consists of an intelligent transceiver electronic panel that can be remotely located. It interfaces to alarm input points, control outputs, access control inputs, and other devices. This transceiver connects to its master controller or other alarm communication panels. The transceiver has an on-board intelligent database and multiplexes up to 8 alarm input zones. Each zone has the expansion capability of up to 24 contact points.
<b>System Components (Size)</b>	SP3981 Intelligent Transceiver Node (10.25" X 3.5" X 5") SP3980 Communications Port Contender (18" X 12" X 5") SP3930 CPU Control Unit (10.25" X 3.5" X 5")
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Packaged, programmable, hard-wire interface
<b>Line/Tamper Protection</b>	Built-in feature of this system, it is built into each unit at the module level
<b>Multiplexing Capabilities</b>	Four SP3981 ITN per SP3930 CPU Control Unit
<b>Range of Transmission</b>	Twisted pair $\approx$ 1000 ft Fiber optic conversion in the 850 to 1300 nm range
<b>Transmission/Polling Rate</b>	Programmable
<b>Power Supply</b>	8-25 VDC; lithium battery backup
<b>Advantages</b>	Built-in line supervision and tampering Battery backup
<b>Disadvantages</b>	Relatively high cost No multiplexing capabilities

## **Dantel, Inc. - Multiple Alarm Transmitter/Control Point Module**

<b>Method of Transmission</b>	Half duplex, asynchronous, continuous data stream over a single twisted pair.
<b>Brief Description of System</b>	Discrete alarms (contact closures) from remote sites are reproduced as contact closures at a central location. The two modules used are the multiple alarm transmitter (MAT) and the control point module (CPM). The MAT, available with either 16- or 32-alarm inputs, continuously transmits the status of the alarm points to the CPM over a single twisted-pair copper cable. When an alarm is received by the MAT, the corresponding control point on the CPM is activated, thereby reproducing the alarm as a contact closure. A single CPM will reproduce up to 16 discrete alarms.
<b>System Components (Size)</b>	Model 46009 MAT with 32 ground activated alarm inputs Model 46010 MAT with 16 ground activated alarm inputs Model 46028 CPM with 16 remotely operated control outputs
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Ground activated alarm inputs. Needs 300 uA sink to activate
<b>Line/Tamper Protection</b>	None
<b>Multiplexing Capabilities</b>	Up to 32 alarm channels are multiplexed over a single twisted pair. Any number of MATs or CPMs may be collocated with up to 14 modules on the same chassis.
<b>Range of Transmission</b>	Dependent on type of modem used; (50 feet with no modem)
<b>Transmission/Polling Rate</b>	Delay time for transmitting an alarm through this medium is almost negligible; (far less than 1 second).
<b>Power Supply</b>	48 VDC modular power supply
<b>Advantages</b>	Loss of communications link detection Good transmission distances through flexible system design Reproduces 32-alarm switch closures over a single twisted pair Almost instantaneous alarm reporting
<b>Disadvantages</b>	High cost No line protection or data encryption No tamper protection No backup power supply on unit

## **Cellular Communication Systems**

This section describes cellular communication systems applicable to alarm reporting systems. The primary application for cellular technology to alarm systems appears to be as a backup for hardwire telephone-line-based systems. Because of this limitation and the high cost of cellular equipment, all cellular alarm communication systems were omitted from this market survey.

### **Cellular Communication Systems**

#### **Method of Transmission**

Most cellular alarm communication systems use proprietary cellular networks for alarm transmission.

#### **Brief Description of a Typical System**

A typical cellular alarm transmission system consists of a panel that accepts a wide variety of inputs, from switch closures to RS-485 inputs. The control panel is an intelligent device that typically calls in the alarm status on a preprogrammed or a voltage trigger basis. The controller panels are usually very expensive devices that input a large number of contacts. Besides paying for the expensive controller panels, the subscriber must also pay for air transmission time.

#### **Advantages**

No advantages to the use of this technology were identified.

#### **Disadvantages**

The primary application for cellular technology to alarm systems appears to be as a backup for hard-wired telephone-line-based systems. High cost is also another disadvantage; it becomes very expensive for large alarm systems because of equipment cost and transmission time.

# **Laser Communication Systems**

This section describes laser communication systems; although no commercially available systems were identified. This section provides some insight as to how a laser system could be applied for repository alarm reporting.

## **Laser Communication Systems**

### **Method of Transmission**

The approach to a laser-based alarm communication system was investigated. The method analyzed made use of laser diodes to transmit information to a centralized receiver within a line-of-sight area. This information would then be relayed using another laser diode or hard-wired to a control panel.

### **Brief Description of a Typical System**

No such system could be identified. However, several components that perform one or more functions as described above were identified. Because the requirements and application specifications of our system, a laser communication system was not available at this time for alternate sensor/alarm reporting.

### **Advantages**

Laser diodes, transmitters, and receivers are very inexpensive.

### **Disadvantages**

Transmission must be line-of-sight.  
A system that meets most of our requirements is not yet commercially available.

## **Power-Line Communication Systems**

This section describes power-line communication systems. The concept is to send alarm status signal using power-line transmission systems. The alarm signal would be superimposed on the power lines at the source and reversibly extracted at its destination.

### **Cyplex - PowerPlex Communication Module**

<b>Method of Transmission</b>	The Power-Plex power line communication modem uses an adaptive frequency-hopping spread-spectrum communication technology.
<b>Brief Description of System</b>	The system consists of two modules. One module is the actual modem that generates the spread spectrum signals that are superimposed in the power lines. The other module is a line coupler that allows the coupling of the communication modem to the VAC power lines. The system can transmit RS-232 format and can be configured to transmit other types of formats. The system is designed specifically for supervisory control and data collection applications.
<b>System Components (Size)</b>	Power-Plex 1000 Module (2.6" X 1.5" X .360") PoweLink Coupler (2.6" X 1.5" X 1.025")
<b>Frequency Band</b>	9 kHz to 95 kHz
<b>System Architecture</b>	Approach 1
<b>Interface/Sensor Input</b>	Possibly switch closure inputs; interface not fully defined
<b>Line/Tamper Protection</b>	None
<b>Multiplexing Capabilities</b>	None
<b>Range of Transmission</b>	Unknown (Range is also limited by the number of transformers in the path)
<b>Transmission/Polling Rate</b>	Transmission rate is 300 bps and 1200 bps
<b>Power Supply</b>	+5 VDC @ 150 mA; -5 VDC @ 100 mA
<b>Advantages</b>	Low cost per input Small design/packages
<b>Disadvantages</b>	The system may require the design of our own interface to the power-line coupler. There are too many communication and interface unknowns about this system and the design effort has not been fully investigated at this time.

## **Other Communication Systems**

This section provides information on other alarm reporting systems or products encountered while performing this market survey. Some of these systems or devices must be implemented with the approaches discussed in this document. This market survey was projected to cover all applicable communication systems. Many categories of systems were identified, but some did not or could not lend themselves to our requirements or to the AMCS interface. Some equipment was necessary to provide adequate line security or interface to the existing AMCS system. The following devices provide this kind of requirement mitigation.

### **Stellar Systems - Remote Control Transponder**

<b>Method of Transmission</b>	Fiber optic, RS-422, or RS-232C communications to a multiplexer control unit at 300-19,200 baud.
<b>Brief Description of System</b>	This remote data unit (RDU) performs an identical function to the existing TROS-8/4 currently used by Sandia. The remote control transponder could be used to emulate the alarm collection from different types of repository sensors. This alarm monitoring and communication device typically communicates with higher level systems.
<b>System Components (Size)</b>	RDU-300 Monitoring Transponder
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 2
<b>Interface/Sensor Input</b>	Switch closures to four input devices
<b>Line/Tamper Protection</b>	4 inputs are line supervised; tamper protection built into the enclosures
<b>Multiplexing Capabilities</b>	Up to 256 alarm input per RDU
<b>Range of Transmission</b>	Depends on site requirements
<b>Transmission/Polling Rate</b>	Data rate; 300 to 9600 baud
<b>Power Supply</b>	9-24 VDC @ 110 mA; no battery backup
<b>Advantages</b>	Partial proprietary line supervision Very versatile Multiplexes up to 256 transmitters per receiver
<b>Disadvantages</b>	High cost Only 4 inputs per unit are line supervised No battery backup

## Stellar Systems - EFS2 Encryption System

<b>Method of Transmission</b>	Fiber-optic, modem, RF, RS-422, or RS232 operation.
<b>Brief Description of System</b>	The EFS2 encryption system is a point-to-point alarm transmission system that protects the sensor communication link by converting the information into an encrypted signal. The system consists of two EFS2 transceivers. Sensor information is converted into a DES encrypted data stream and transmitted to another EFS2 module which decodes the encrypted sensor information. The modules can talk to each other using copper wires, telephone modems, dual fiber optic cables or radio frequency.
<b>System Components (Size)</b>	EFS-2 encryption modules (5.0" X 5.4" X 1.0")
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	May be implemented with approach 2
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed contacts, and RS-232 output
<b>Line/Tamper Protection</b>	Proprietary line encryption; tamper protection built into the enclosures
<b>Multiplexing Capabilities</b>	Up to 2 sensor inputs per device
<b>Range of Transmission</b>	Depends on site requirements
<b>Transmission/Polling Rate</b>	Data rate; 9600 baud
<b>Power Supply</b>	12 VDC @ 0.25 A; no battery backup
<b>Advantages</b>	Provides proprietary data encryption Very versatile Appropriate for approach 2
<b>Disadvantages</b>	High cost per input Only 2 inputs per unit Limited multiplexing capabilities No battery backup power on unit

## **Scientific Technologies Inc. - 551X Spread Spectrum Modem**

<b>Method of Transmission</b>	Spread spectrum radio frequency signals transceived in the 905–928 MHz and 2.4–2.478 GHz bands.
<b>Brief Description of System</b>	This system consists of a spread spectrum, RF modem. This system uses several frequencies across a broad band to enhance data security and reliability. It is used in pairs designed for RS-232/RS-485 data transmission. Two models, transparent and intelligent, are available. The transparent model is designed to automatically handle asynchronous data without any port setup. The intelligent model performs error checking and packetizing on data to ensure integrity. The modems may also be used as repeaters to increase total transmission distance for the communication link.
<b>System Components (Size)</b>	Model-5510: 900 MHz transparent-transceiver (1.52 x 4.17 x 5.0") Model-5512: 2.4 GHz transparent-transceiver (1.52 x 4.17 x 5.0")
<b>Frequency Band</b>	905–928 MHz and 2.4–2.478 GHz spread spectrum bands
<b>System Architecture</b>	May be implemented with approach 2
<b>Interface/Sensor Input</b>	RS-232 data port
<b>Line/Tamper Protection</b>	None
<b>Multiplexing Capabilities</b>	The modems may be used in a “broadcast” mode; however, some software control, such as a polling scheme, would be required to avoid interference. The units may be used on one of up to 19 to 37 channels depending on which model is selected.
<b>Range of Transmission</b>	Indoor: 800–1500 ft; Nominal: 800 ft Outdoor: 1–1.5 mi.; clear line-of-sight
<b>Transmission/Polling Rate</b>	N/A. (Data: 1.2-19.2 Kbaud/asynchronous, 16-128 Kbaud/synchronous.)
<b>Power Supply</b>	Transmitter/Receiver - 12 VDC; no external power supply
<b>Advantages</b>	Reliable and secure method of spread spectrum technology Range of up to 1.5 miles Separate subchannels allows multiple units in the same range High-frequency carrier
<b>Disadvantages</b>	Very high cost No significant line protection or data encryption No tamper protection No battery backup on unit

## **United Marine - Intelligent Encryption Module**

<b>Method of Transmission</b>	Three conductor bi-directional communication loop.
<b>Brief Description of System</b>	The IEM3000 intelligent encryption module is a microprocessor-based communication interface to encrypt, decrypt, and process status changes from standard detection devices. The IEM3000 has input channels for normally-open and normally-closed alarm contacts along with an output channel to allow control of optimal self-test within the detection device.
<b>System Components (Size)</b>	IEM3000 encryption module (5.2" X 1.4" X 0.6")
<b>Frequency Band</b>	N/A
<b>System Architecture</b>	Approach 2
<b>Interface/Sensor Input</b>	Interfaces to normally-open and normally-closed contacts
<b>Line/Tamper Protection</b>	Proprietary line encryption; tamper protection built into the enclosures
<b>Multiplexing Capabilities</b>	None
<b>Range of Transmission</b>	Up to 2000 feet
<b>Transmission/Polling Rate</b>	N/A
<b>Power Supply</b>	7-16 VDC @ 100 mA; no battery backup
<b>Advantages</b>	Provides proprietary data encryption Very versatile Appropriate for approach 2
<b>Disadvantages</b>	High cost per input No multiplexing capabilities No battery backup on unit

## **Wireless Video Communication Systems**

This section provides information on wireless transmission systems encountered while performing this market survey. Unfortunately, a feasible and cost-effective system that incorporated both wireless alarm status and video transmission could not be identified. We found out that Charles Ringler and Chris Hoover of Department 5849 were already performing a related, more extensive market survey on wireless video transmission and video authentication. We decided that instead of allocating resources on a similar survey, we would instead refer to this more comprehensive study. This document is scheduled to be released by June, 1995. The systems below are from potential manufacturers that will be reviewed in the Wireless Video Transmission and Video Authentication Survey.

### **Wireless Video Communication Systems**

<b>Method of Transmission</b>	Several transmission methods exist, but spread spectrum and UHF are the most prominent method of video transmission.
<b>Brief Description of a Typical System</b>	Most systems consist of a transmitter/receiver pair. Some systems offer repeaters to extend the transmission distance. They use a wide variety of transmission methods, but spread spectrum is probably the most reliable and secure method of video transmission. The systems below are commercially available for wireless video transmission.
<b>Systems</b>	Wireless Technology Inc. – FS-925 Fixed Video Transmission System Wireless Technology Inc. – FS-935 Fixed Video Transmission System Wireless Technology Inc. – PS-991 Portable Video Transmission System Fiber & Wireless – WVL-90 Wireless FM Video System Micro Tex – MiniLink Wireless Video Transmission System Universal Security – V_9900 Wireless Video Transmission System Watec – WAT-510 Wireless Transmission System Pelco – WLV500KT Wireless Video Link Pelco – WLV1000KT Wireless Video Link SNL – Image Transmission System VICON – Air Link Wireless Video Transmission System Covert Security – Wireless Video Transmission System Clear Data – A900 Wireless Video System
<b>Advantages</b>	N/A
<b>Disadvantages</b>	N/A

# Comparison Table #1

This comparison table provides a quick reference for the system costs, advantages, and disadvantages for the wireless RF communication systems.

Manufacturer/System	Cost of Components	Advantages	Disadvantages
<b>Inovonics-MCR16/C200 System</b>	Transmitter - \$34 Receiver - \$390 Programmer - \$116	<ul style="list-style-type: none"> <li>• Relative low cost per channel</li> <li>• Supports n-o, n-c, and RS-232 format</li> <li>• Good range and repeaters also available</li> <li>• High-frequency carrier</li> <li>• Programmable report period</li> <li>• Multiplexes up to 16 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Northern Computers-SpreadCOM System</b>	Transmitter - \$99 Receiver - \$645	<ul style="list-style-type: none"> <li>• Spread-spectrum is more secure</li> <li>• Good range</li> <li>• High-frequency carrier</li> <li>• Multiplexes up to 64 transmitters per panel</li> </ul>	<ul style="list-style-type: none"> <li>• High cost</li> <li>• No line protection or data encryption</li> <li>• Only n-c circuits supported</li> <li>• Reporting periods not programmable</li> </ul>
<b>ADEMCO - Wireless Alarm System</b>	Transmitter - \$41 Receiver - \$120 Control Panel - \$140	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Multiplexes up to 16 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Limited range</li> <li>• Single frequency operation</li> <li>• Low-frequency carrier</li> <li>• Reporting periods not programmable</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Linear - Single-Channel System</b>	Transmitter - \$27 Receiver - \$43	<ul style="list-style-type: none"> <li>• Very low cost</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Limited range</li> <li>• Single frequency operation</li> <li>• Low-frequency carrier</li> <li>• Status reporting must be externally activated</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Linear - Multiple-Channel System</b>	Transmitter - \$27 Receiver - \$76	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Multiple channels</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Limited range</li> <li>• Low-frequency carrier</li> <li>• Status reporting must be externally activated</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Linear - Supervised Wireless System</b>	Transmitter - \$27 Receiver - \$100	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Multiple up to 32 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Limited range</li> <li>• Low-frequency carrier</li> <li>• Status reporting must be externally activated</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Linear - Midrange System</b>	Transmitter - \$118 Receiver - \$1137	<ul style="list-style-type: none"> <li>• Good range</li> <li>• Low cost</li> <li>• VAC power supply w/ battery backup</li> </ul>	<ul style="list-style-type: none"> <li>• High cost</li> <li>• No line protection or data encryption</li> <li>• Low-frequency carrier</li> <li>• Status reporting must be externally activated</li> </ul>
<b>NAPCO - Magnum Alert Wireless System</b>	Transmitter - \$79 Receiver - \$189	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Good range</li> <li>• Multiplexes up to 16 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Low-frequency carrier</li> <li>• Reporting periods not programmable</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Visionic - SpiderAlert Wireless System</b>	Transmitter - \$29 Receiver - \$27 Multiplexer - \$50	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Repeater available</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Limited number of transmitters</li> <li>• Low-frequency carrier</li> <li>• Status reporting must be externally activated</li> <li>• No external or backup power on transmitter</li> </ul>
<b>ITI - SX5 Wireless Alarm System</b>	Transmitter - \$26 Receiver - \$294	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Adequate range</li> <li>• Multiplexes up to 61 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• Single frequency operation</li> <li>• Low-frequency carrier</li> <li>• Reporting periods not programmable</li> <li>• No external or backup power on transmitter</li> </ul>
<b>CRN Radio Alarm System</b>	Transmitter 1-\$205 Transmitter 2-\$229 Receiver - \$695	<ul style="list-style-type: none"> <li>• Provides proprietary line supervision</li> <li>• Supports voltage, contact closures, and TTL</li> <li>• Good range and repeaters also available</li> <li>• High-frequency carrier</li> </ul>	<ul style="list-style-type: none"> <li>• Very high cost</li> <li>• Reporting periods too long</li> <li>• Low-frequency carrier</li> </ul>
<b>Seaboard RC-2 Wireless System</b>	Transmitter - \$449 Receiver - \$2695	<ul style="list-style-type: none"> <li>• Provides proprietary line supervision</li> <li>• Excellent range and repeaters available</li> <li>• Multiplexes up to 243 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• Very high cost</li> <li>• Status reporting must be externally activated</li> <li>• Low-frequency carrier</li> </ul>
<b>SNL - UNIMod System</b>	Transmitter ≈ \$500 Receiver ≈ \$500	<ul style="list-style-type: none"> <li>• Relatively low cost for features provided</li> <li>• Provides DES line protection</li> <li>• Supports n-o, n-c, and RS-485 format</li> <li>• Excellent range and repeaters also available</li> <li>• Programmable report period</li> <li>• Multiplexes up to 2000 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No tamper protection on transmitter/receiver</li> <li>• Low-frequency carrier</li> <li>• No external or backup power on unit</li> </ul>
<b>SNL - AIMS</b>	Transmitter - \$150 Receiver - \$300 Processing Unit - \$5000	<ul style="list-style-type: none"> <li>• Provides proprietary line authentication</li> <li>• Supports n-o, n-c, and RS-232 format</li> <li>• Good range</li> <li>• Multiplexes up to 2048 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively high cost</li> <li>• No external power supply on transmitters</li> </ul>
<b>SNL - WATCH System</b>	Transmitter - \$39 Receiver - \$390	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Supports n-o, n-c, and RS-232 format</li> <li>• Good range</li> <li>• High-frequency carrier</li> <li>• Programmable report period</li> <li>• Multiplexes up to 16 transmitters per receiver</li> </ul>	<ul style="list-style-type: none"> <li>• No line protection or data encryption</li> <li>• No external or backup power on transmitter</li> </ul>
<b>Intellitech - Lookout Dispatcher</b>	System - \$2500	<ul style="list-style-type: none"> <li>• Good range and repeaters are available</li> <li>• Multiplexes up to 12 transmitters per receiver</li> <li>• VAC power supply with battery backup</li> <li>• Programmable reporting period</li> </ul>	<ul style="list-style-type: none"> <li>• Very high cost</li> <li>• No line protection or data encryption</li> <li>• Low-frequency carrier</li> <li>• No external or backup power on transmitter</li> </ul>

## Comparison Table #2

This comparison table provides a quick reference for the system costs, advantages, and disadvantages of fiber optic, hardwire, and other communication systems.

Manufacturer/System	Cost of Components	Advantages	Disadvantages
<b>Math Associates - Fiberoptics Control Module</b>	Transmitter - \$300 Receiver - \$320	<ul style="list-style-type: none"> <li>• Relatively low cost</li> <li>• Available in analog current loop</li> <li>• Battery backup available</li> </ul>	<ul style="list-style-type: none"> <li>• Cost does not include the cost of the fiber</li> <li>• No line supervision or tamper protection</li> </ul>
<b>American Fiber - Fiberoptic Status Control Modules</b>	Module/pair - \$800	<ul style="list-style-type: none"> <li>• Relatively low cost per channel</li> <li>• Good transmission distances</li> </ul>	<ul style="list-style-type: none"> <li>• Cost does not include the cost of the fiber</li> <li>• No line supervision</li> <li>• No tamper protection</li> </ul>
<b>Fibronics International - Fiber-optic Modems</b>	Modem pair 1-\$580 Modem pair 2-\$980	<ul style="list-style-type: none"> <li>• Relatively small size</li> <li>• Requires no power supply</li> </ul>	<ul style="list-style-type: none"> <li>• Very high cost per channel</li> <li>• No line supervision or data encryption</li> <li>• No tamper protection</li> </ul>
<b>Puleo Electronics - Alarm Encoder/Decoder</b>	System - \$3960	<ul style="list-style-type: none"> <li>• Encodes/decodes up to 48 discrete alarms</li> <li>• Near instantaneous alarm reporting</li> <li>• Communications link loss detection</li> <li>• Good range</li> </ul>	<ul style="list-style-type: none"> <li>• Very high cost</li> <li>• No tamper protection</li> <li>• No battery backup on unit</li> </ul>
<b>Litton Poly Science - Intelligent Transceiver</b>	Transmitter - N/A Receiver - N/A	<ul style="list-style-type: none"> <li>• Built-in line supervision and tampering</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively high cost</li> <li>• No multiplexing capabilities</li> </ul>
<b>Dantel - Multiple Transmitter Module</b>	Transmitter - \$398 Receiver - \$495	<ul style="list-style-type: none"> <li>• Loss of communication link detection</li> <li>• Good transmission distances</li> <li>• Reproduces 32/closures in a twisted pair</li> <li>• Near instantaneous alarm reporting</li> </ul>	<ul style="list-style-type: none"> <li>• High cost</li> <li>• No line protection or data encryption</li> <li>• No tamper protection</li> <li>• No battery backup on unit</li> </ul>
<b>Cyplex - PowerPlex Communication Module</b>	System ≈ \$200	<ul style="list-style-type: none"> <li>• Low cost per input</li> <li>• Small compact design</li> </ul>	<ul style="list-style-type: none"> <li>• System may require an AMCS interface</li> <li>• Design effort has not been fully investigated</li> </ul>
<b>Stellar - Remote Control Transponder</b>	System ≈ \$829	<ul style="list-style-type: none"> <li>• Partial line supervision</li> <li>• Multiplexes up to 256 transmitters per receiver</li> <li>• Very versatile</li> </ul>	<ul style="list-style-type: none"> <li>• High cost</li> <li>• Only 4 inputs per unit are supervised</li> <li>• No battery backup on unit</li> </ul>
<b>Stellar - EFS2 Encryption Module</b>	Module ≈ \$506 each A pair is required.	<ul style="list-style-type: none"> <li>• Provides proprietary data encryption.</li> <li>• Very versatile</li> <li>• Appropriate for Approach 2</li> </ul>	<ul style="list-style-type: none"> <li>• High cost per input</li> <li>• Only 2 inputs per unit</li> <li>• Limited multiplexing capabilities</li> <li>• No battery backup on unit</li> </ul>
<b>Scientific Technologies - 551X Modem</b>	Transmitter - \$1790 Receiver - \$2390	<ul style="list-style-type: none"> <li>• Spread spectrum technology</li> <li>• Good range</li> <li>• High-frequency carrier</li> </ul>	<ul style="list-style-type: none"> <li>• Very high cost</li> <li>• No significant line protection</li> <li>• No tamper protection</li> <li>• No battery backup on unit</li> </ul>
<b>United Marine - Intelligent Encryption Module</b>	System ≈ \$695	<ul style="list-style-type: none"> <li>• Provides proprietary data encryption</li> <li>• Very versatile</li> <li>• Appropriate for Approach 2.</li> </ul>	<ul style="list-style-type: none"> <li>• High cost per input</li> <li>• No multiplexing capabilities</li> <li>• No battery backup on unit</li> </ul>

## Conclusions

The communication systems described in this document are all commercially available and vary considerably in terms of cost, features, and capabilities. Only a few systems were found to be useful because a significant percentage did not provide an interface directly compatible with the existing alarm system. Those systems that appeared to be applicable usually did not provide adequate data encryption, alarm supervision, transmission range, or battery backup. While such features could be incorporated using additional hardware, doing so would make the system more expensive and conflict with the idea of purchasing a single unit that meets the minimum set of requirements. Also, several of the systems greatly exceed the scope of this project; utilizing such systems would mean investing in more capacity than is really needed.

## Recommendations

Three possible system approaches were explored, and the results were described in this document. Each approach took into account the level of line security relative to cost. Approach 1 was the least secure but the least expensive of all systems. Approach 3 was the most secure but also the most expensive. Line protection should be addressed in terms of risk assessment relative to the security level of the asset being protected. Thus, it is recommended that all three approaches be evaluated to accurately assess their capabilities, fully understand equipment installation, and the cost necessary for each level of security protection. All of the systems evaluated fall into one of the three system approaches. At least one system from each category should be purchased for further investigation.

The systems should be installed at Sandia and should undergo an intensive evaluation to determine in more detail the strengths and weaknesses of each system. The acquisition of the following systems is recommended for an in-house evaluation.

### Approach 1

- Inovonics – MCR16/C200 System
- Northern Computers – SpreadCOM System
- ADEMCO – Wireless Alarm System
- ITI – SX5 Wireless Alarm System
- Linear – Single-Channel System
- Linear – Multiple-Channel System
- Linear – Supervised Wireless System
- Linear – Midrange System
- NAPCO – Magnum Alert Wireless System
- Visionic – SpiderAlert Wireless System
- CRN – Radio Alarm System
- SNL – WATCH System
- SNL - Universal Network Interface Module

### Approach 2

- Scientific Technologies – 551X Modem
- Stellar Systems – RDU-300 Transponder
- Stellar Systems – EFS2 Encryption Module

**Approach 3**

- SNL – Authenticated Item Monitoring System

The evaluation process will concentrate on installation, cost, security level, and line protection issues. It will also evaluate any interface requirements, interface compatibilities with the existing AMCS system, and any design requirements for black-box interfaces. The outcome of this evaluation will be a prioritized list of the systems that hold any promise. The list will consider the risk assessment and levels of protection relative to the level of line security required for the asset being protected.

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