IPRO 013
Monitoring Safety of Railway Tank Cars

Sponsored by Union Tank Car Company

Team Members

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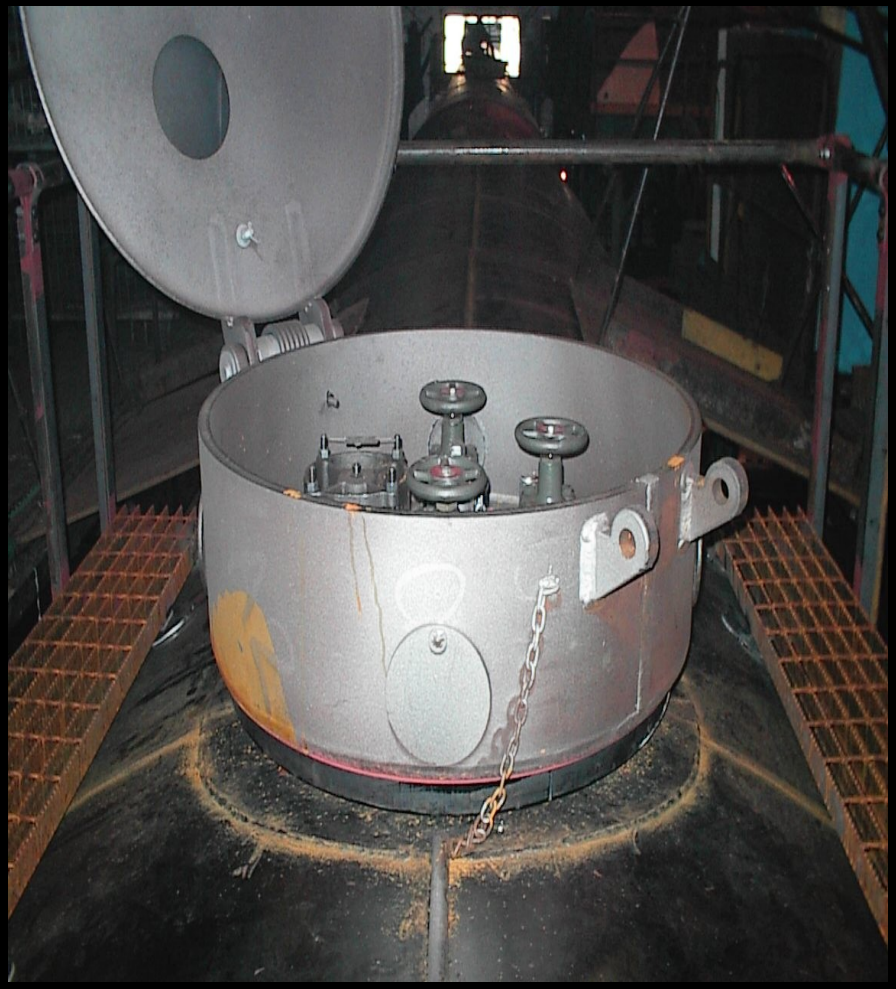
Union Tank Car Company

- UTLX provides railroad tank and covered hopper cars to companies for the shipment of their products
- Leases out ~50,000 tank cars
- Industry effort to eliminate Non-Accidental Releases (NARs).

Project Goal

- Detect small leaks while car is in transit using car-mounted sensors
- Alert the shipper of the leak from remote locations

Non-Accidental Releases



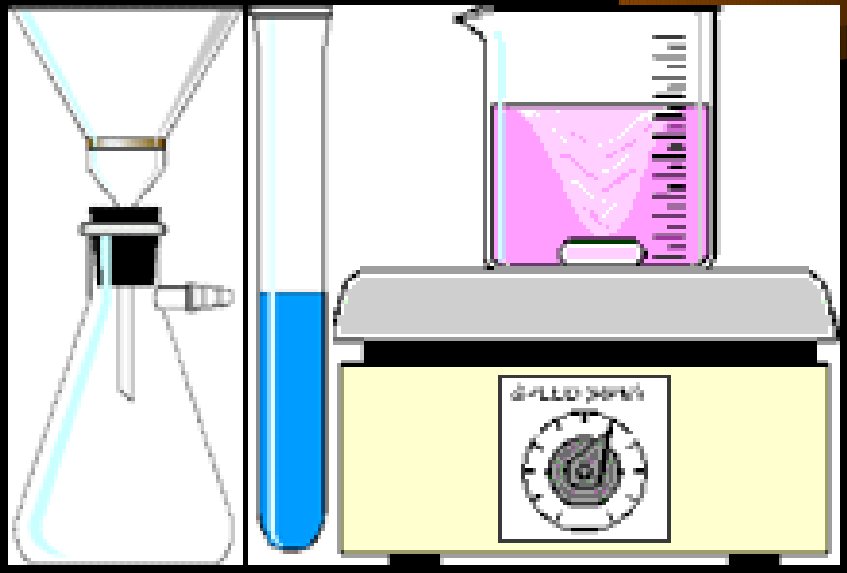
- NARs are small leaks occurring usually around the fitting assembly through
  - gaskets on safety, loading and unloading valves
  - thermal wells
- The fitting assembly is housed

Project Distribution

Three major areas needed to be researched:

- Commodities shipped in pressurized tank cars
- Sensors that can be used to detect these commodities
- A telemetry device to report alarms to a remote site

Commodities Shipped and their Properties



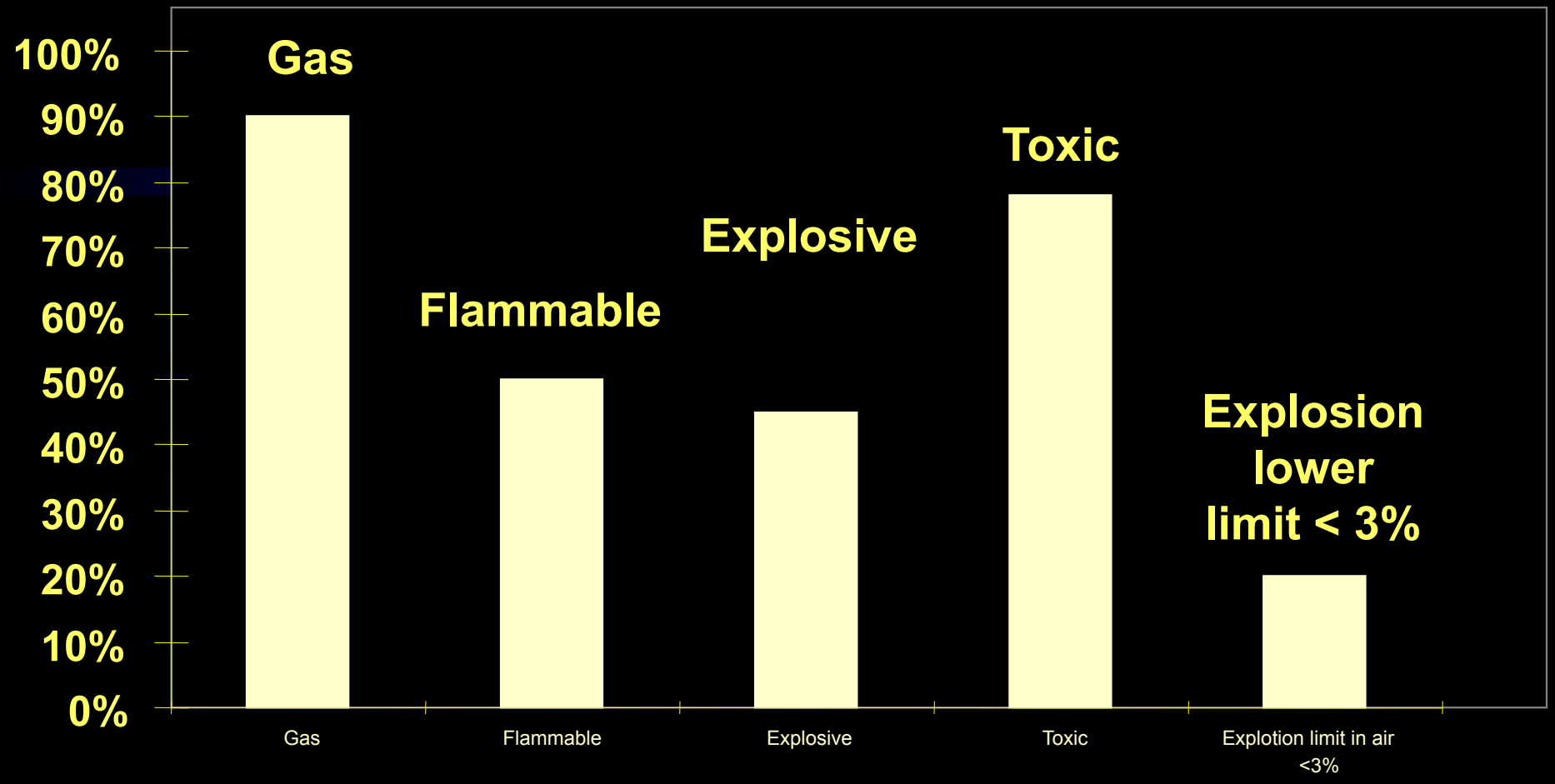
Chemicals Shipped in Tank Cars

- According to BOE-6000-R over 100 chemicals may be transported in pressurized tank cars
- Examples of chemicals shipped:
  - Halogenated hydrocarbons such as Chloroethylene, Refrigerants.
  - Hydrocarbons such as LPG, ethylene.
  - Gases such as HCl, Chlorine, CO, etc..

Commodities' Properties

- Gases at room temperature
- Boiling points between 0°C and 20°C
- 40% of chemicals that can be shipped have dangerous mixing concentration ranges with air
- 50% of these chemicals are flammable
- Majority are toxic

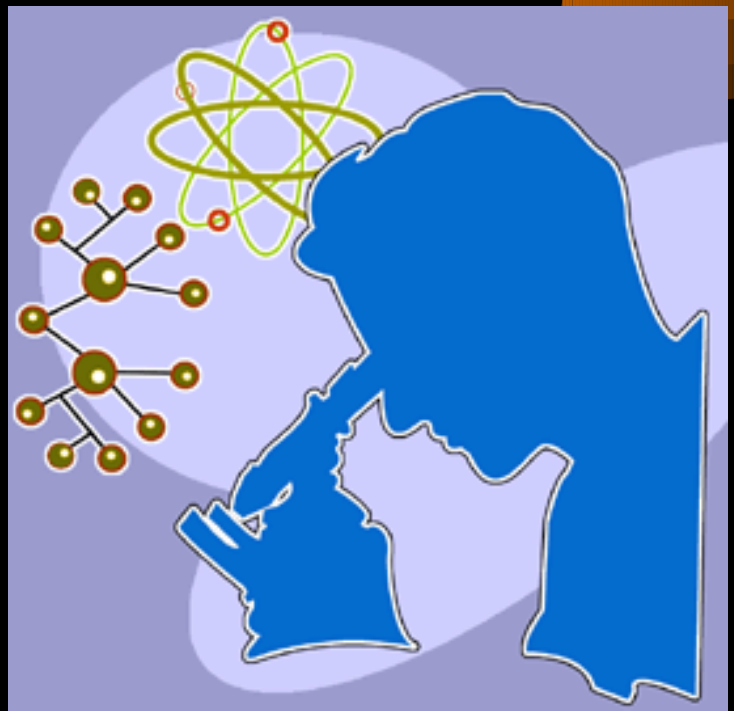
Commodities' Properties



Physical Properties of Selected Commodities

Materials	Physical State at RT	Explosive level in air	Vapor pressure	Vapor density	Flammability	Toxicity
LPG (propane)	gas	upper 9.5% lower 2.1%	8.42 atm/21.1C 190 psi/37.7C	1.5	yes	Yes
Chloro-ethene	gas	upper 33% Lower 3.6%	--	2.2	yes	Yes
Ethylene oxide	gas/liquid (bp.10.7C)	upper100 % lower 3.0%	--	1.5	yes	Yes
CO	gas	upper 74% lower 12.5%	--	0.97	yes	yes

Sensor Selection



Sensors

Three categories of chemical sensors

- Reactive Sensors
- Physical Property Sensors
- Sorption Sensors

Reactive Sensors

- Electrochemical Sensor - responds to gases that can be electrolytically reduced or oxidized on a metallic catalyst
- Solid State Semiconductor Sensors - consists of a bead of tin oxide around two fine coils of Pt wire
- Combustible Gas Sensor - gas combusts on surface of Pt wire and increases coil temperature
- Chemiluminescence - certain chemical reactions generate light which can be measured

Physical Property Sensors

- Spectroscopic Sensors - measures light absorption of a gas
- Photoacoustic Sensors - a short pulse of infrared light is passed through an absorbing gas and sudden expansion generates an acoustic wave

Sorption Sensors

- Microbalances - when a coated quartz crystal absorbs the gas, it's change in vibrational frequency is measured
- Adsistor - electrical resistance across a polymer containing carbon particles increases with absorbed gas

Sensor Selection

Commodities which can be oxidized or reduced

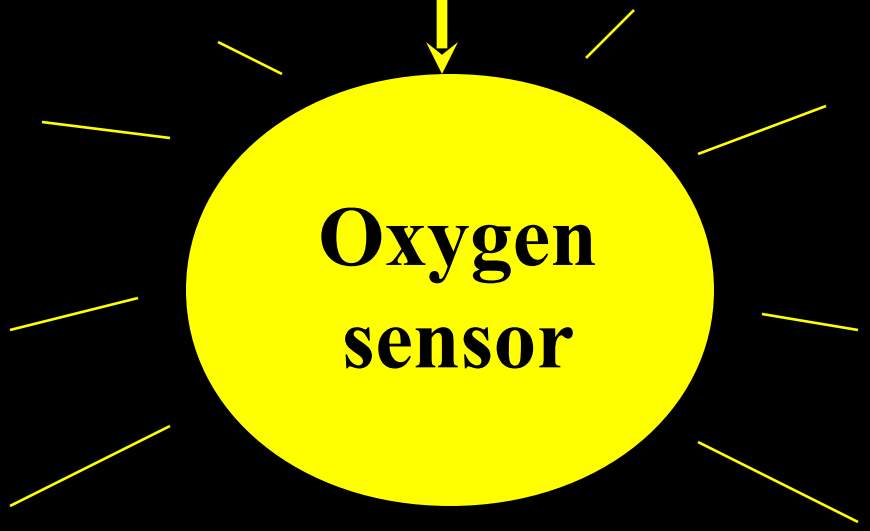
Electrochemical Sensor

Gases and vapors which include hydrocarbons which cannot be oxidized or reduced under normal conditions

Adsistor Sensor

Sensor Selection

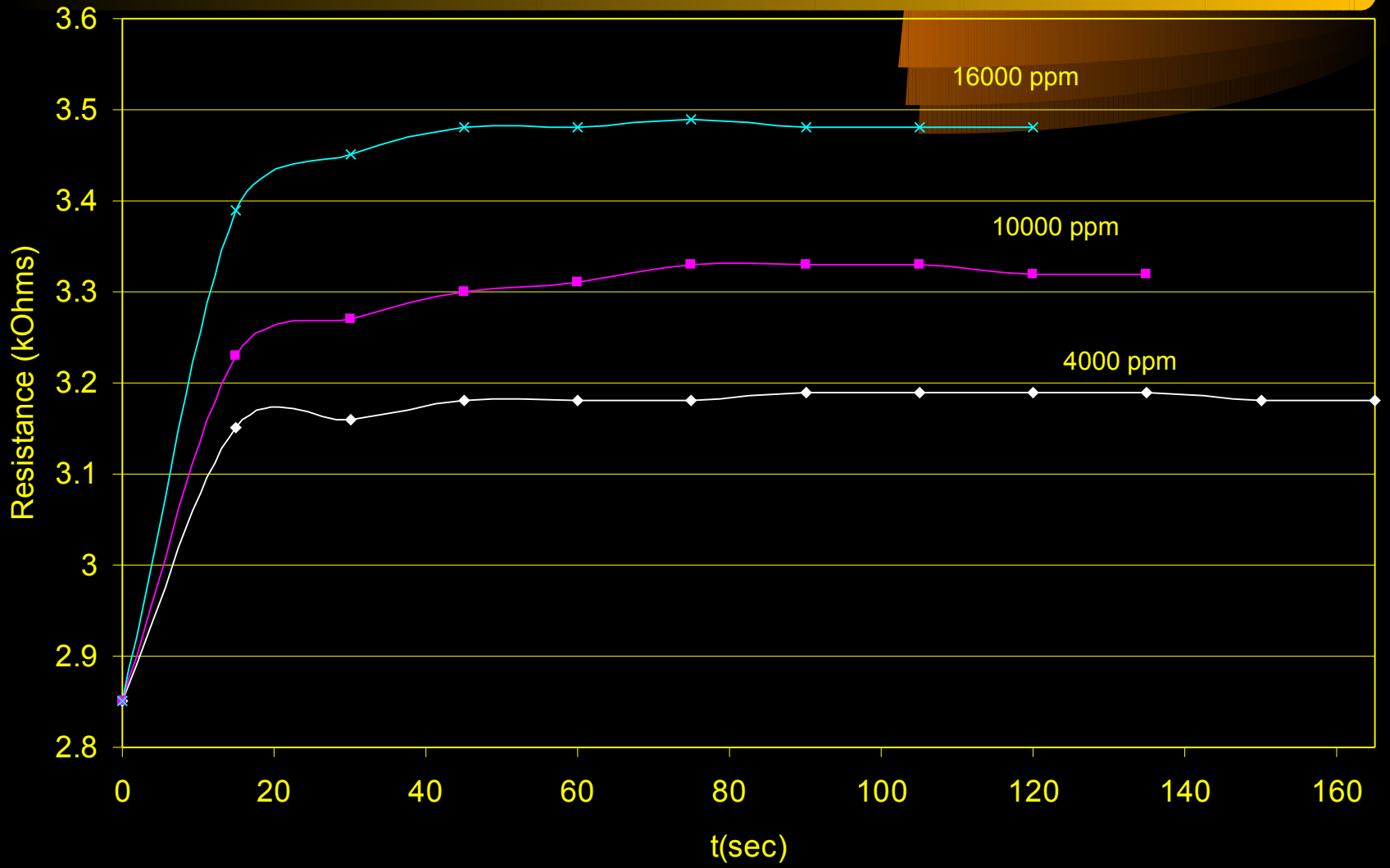
A chemical leak will cause a decrease in the concentration of oxygen in the air



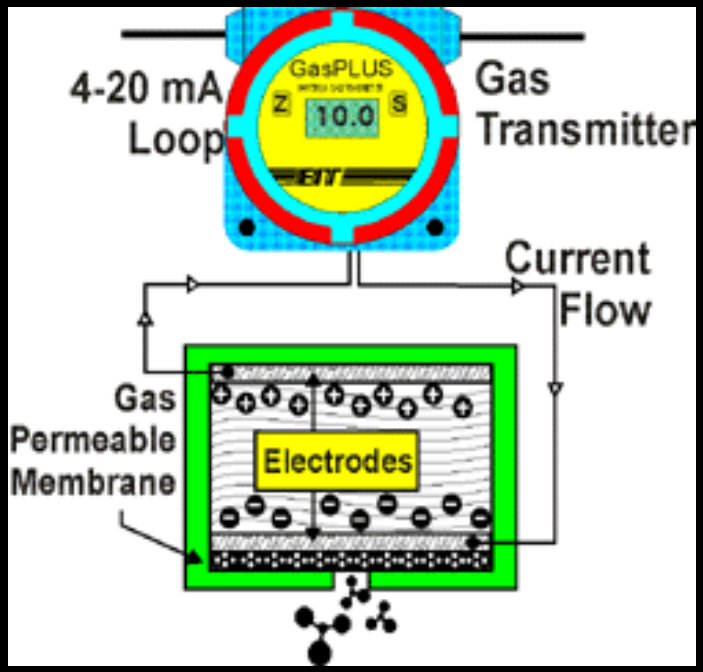
Adsistor Sensor

- Base is a non-conductive, resilient polymer
- Coated to make it sensitive to gas vapors
- Conductive particles embedded in the polymer
- Requires no power to operate

Adsistor Test Results

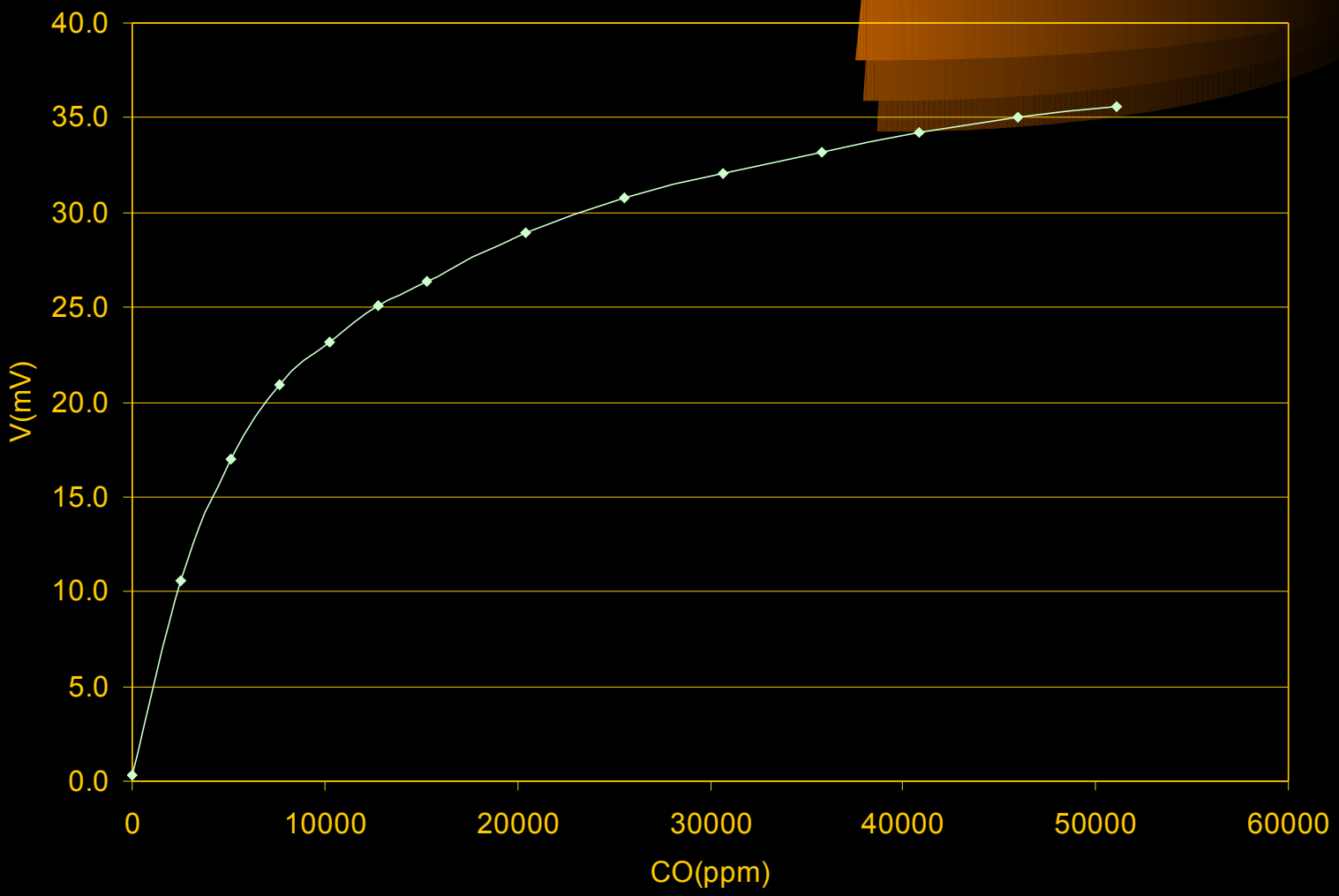


Electrochemical Sensors

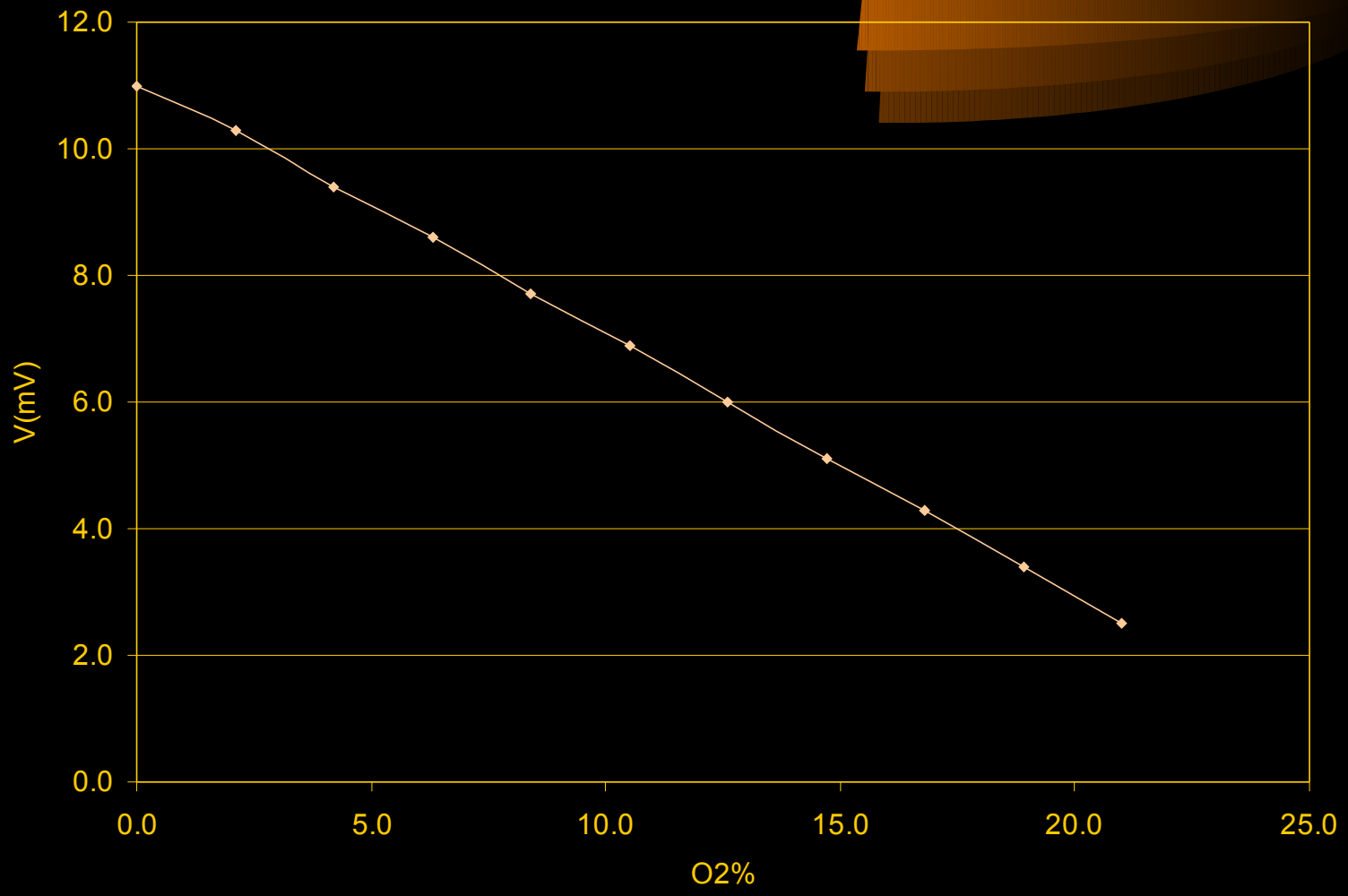


- Gas diffuses through a membrane and reacts at the electrolyte-catalyst surface
- This process creates a current which can be translated into gas concentration

CO Sensor Test Results



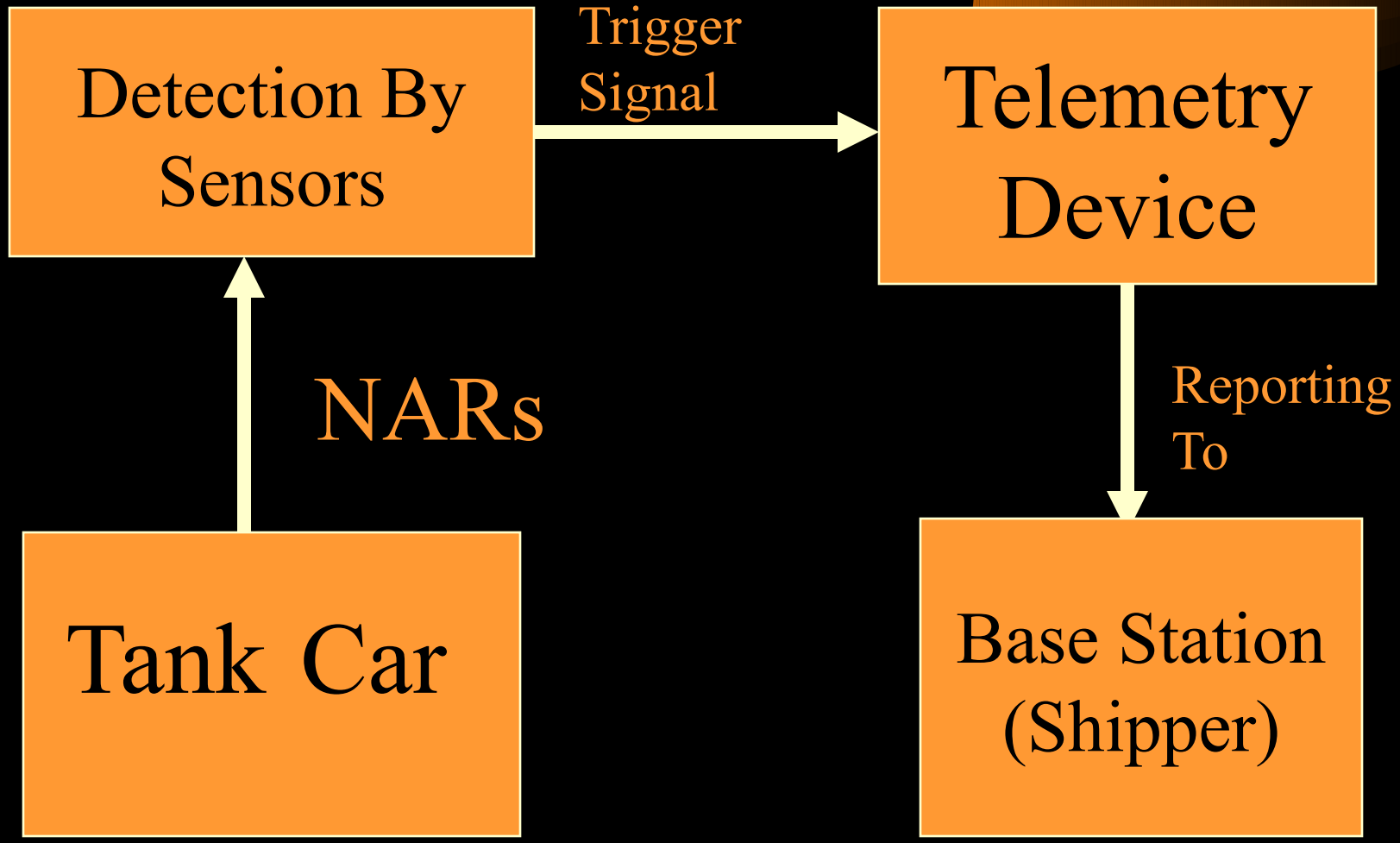
Oxygen Sensor Test Results



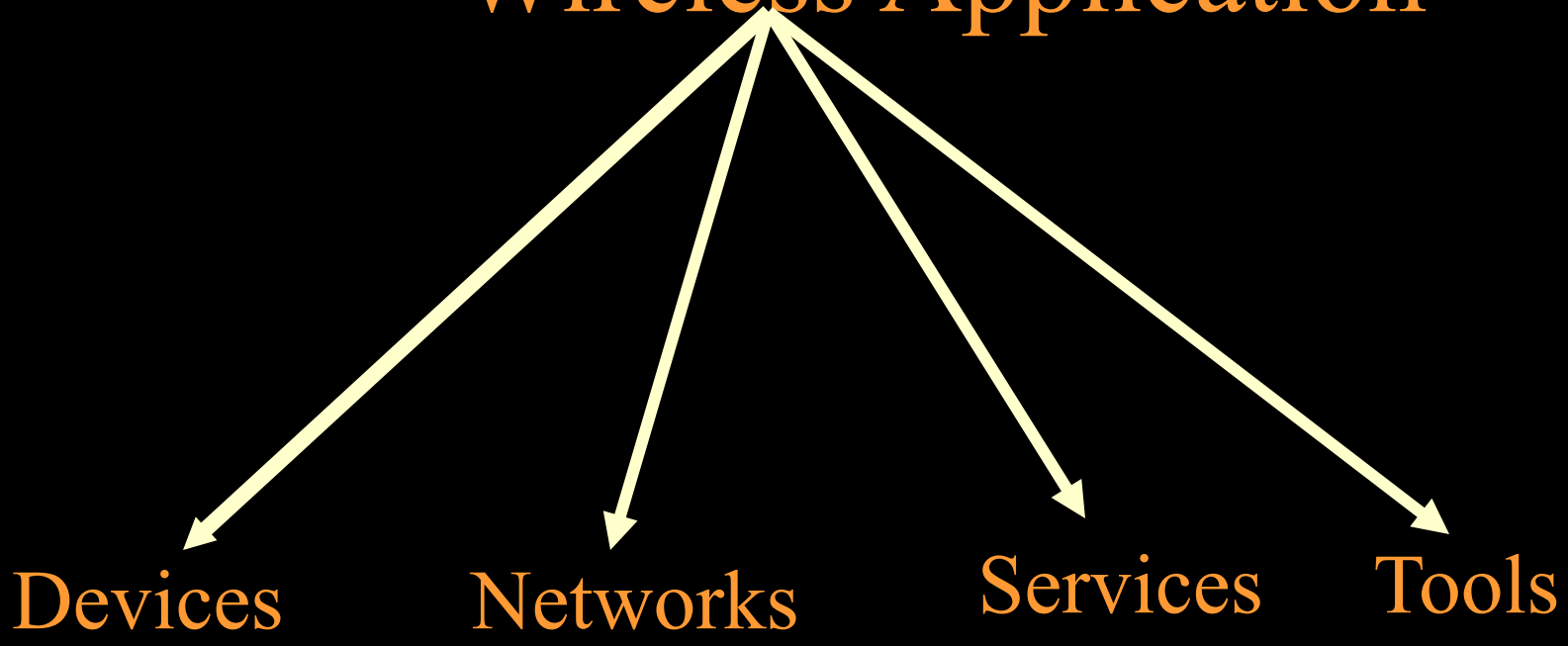
Telemetry


Wireless Communicators
marco
envoy
Wireless Modems
RPM
CDPD
TECHNOLOGY
TECHNOLOGY
DataTAC
CelTAC
AirMobile
Wide Area Networks
Software

General Block Diagram

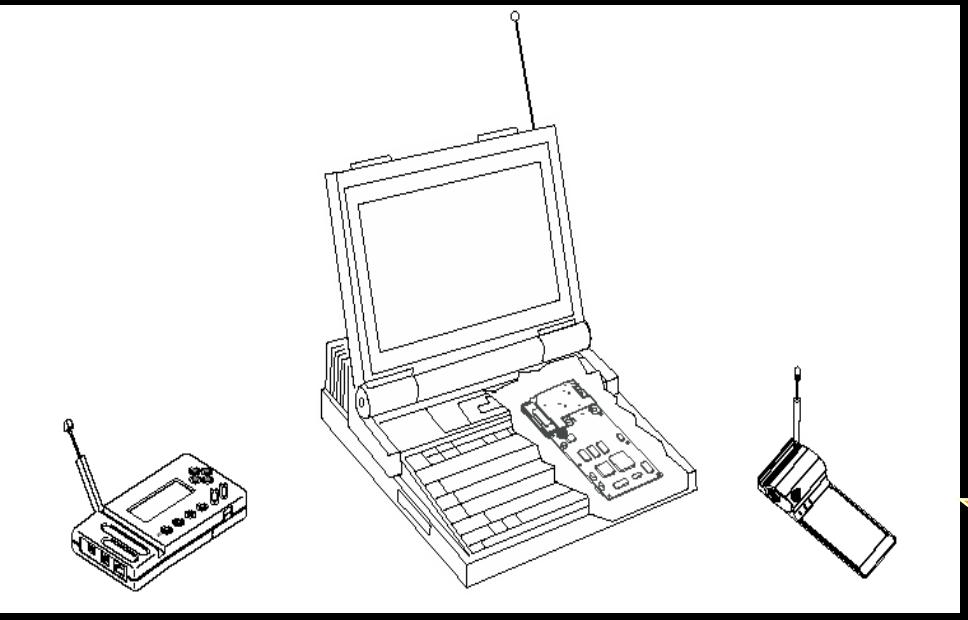


Wireless Data Communication Choices



Device Types

• A wireless device usually consists of a computing unit together with a modem which enables it to send data by radio.



External Modem

Internal Modem

PCMCIA Card

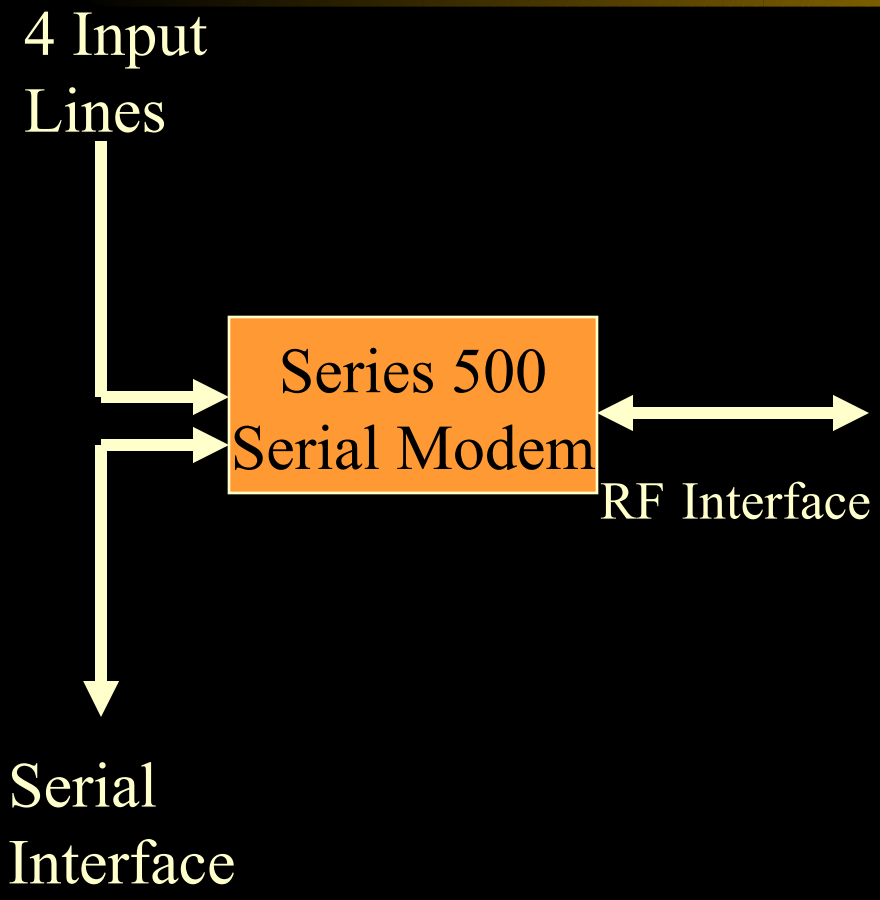
- Specific Device- Pager
- Multipurpose, Intelligent Device -Laptops
- ★Dedicated Device such as Telemetry Device.

The External Wireless Modems

Features of the series 500 Integrated wireless Modems :

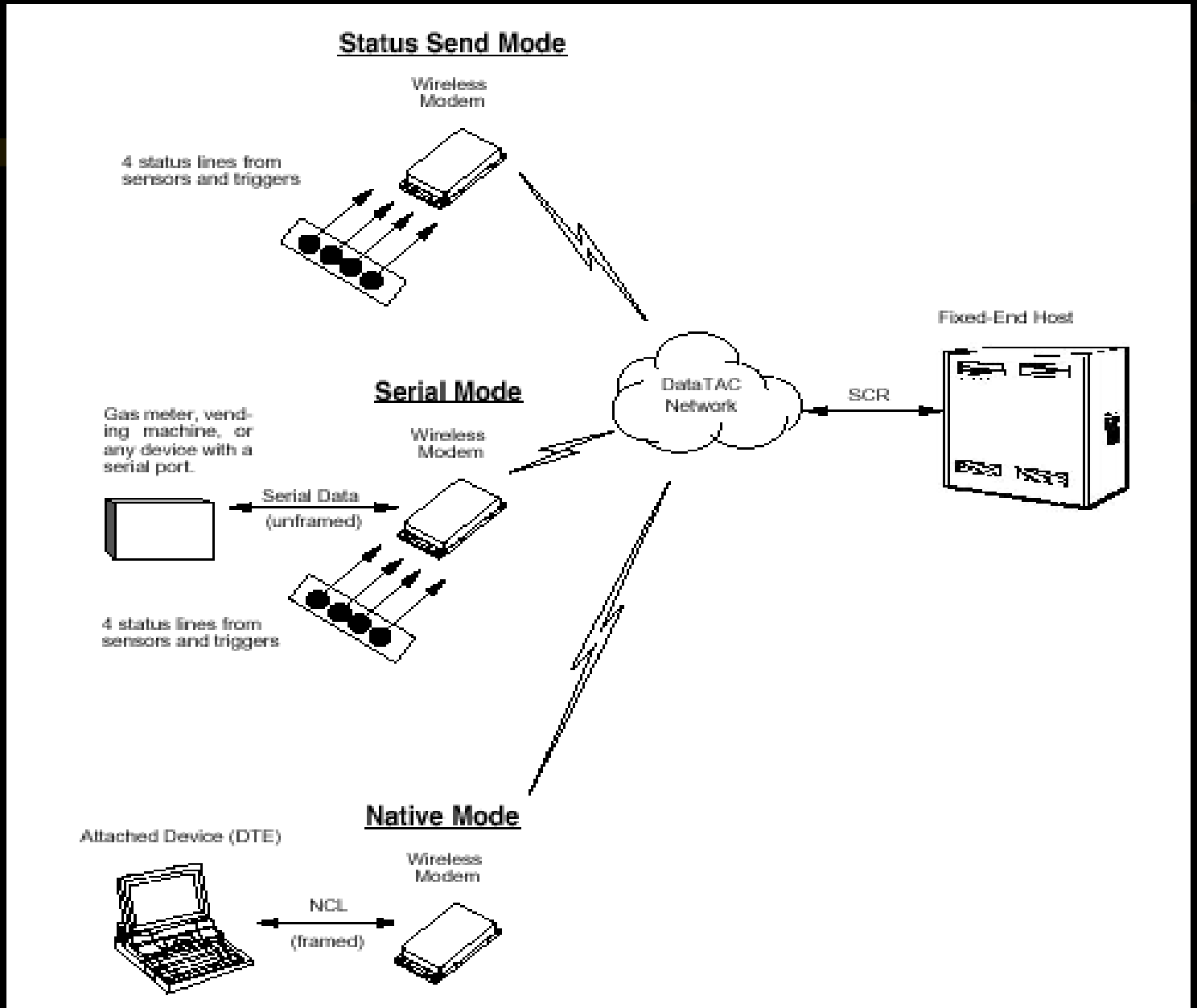
- Easy,flexible integration
- Compact, Lightweight
- Efficient Power Management
- Status Send -Telemetry Feature
- Built in diagnostics.

The Advanced Telemetry Mode



- A bi-directional serial port using RS-232 signaling.
- Four programmable counter/alarms that can be self triggered , polled or reset remotely.
- An auto feature for the battery operated, infrequent alarm scenarios.

The Three Modes of Modem Communication



The Wireless Network Support

- The Mobitex Network
- ARDIS Network
- RAM
- CPCD
- GSM etc...

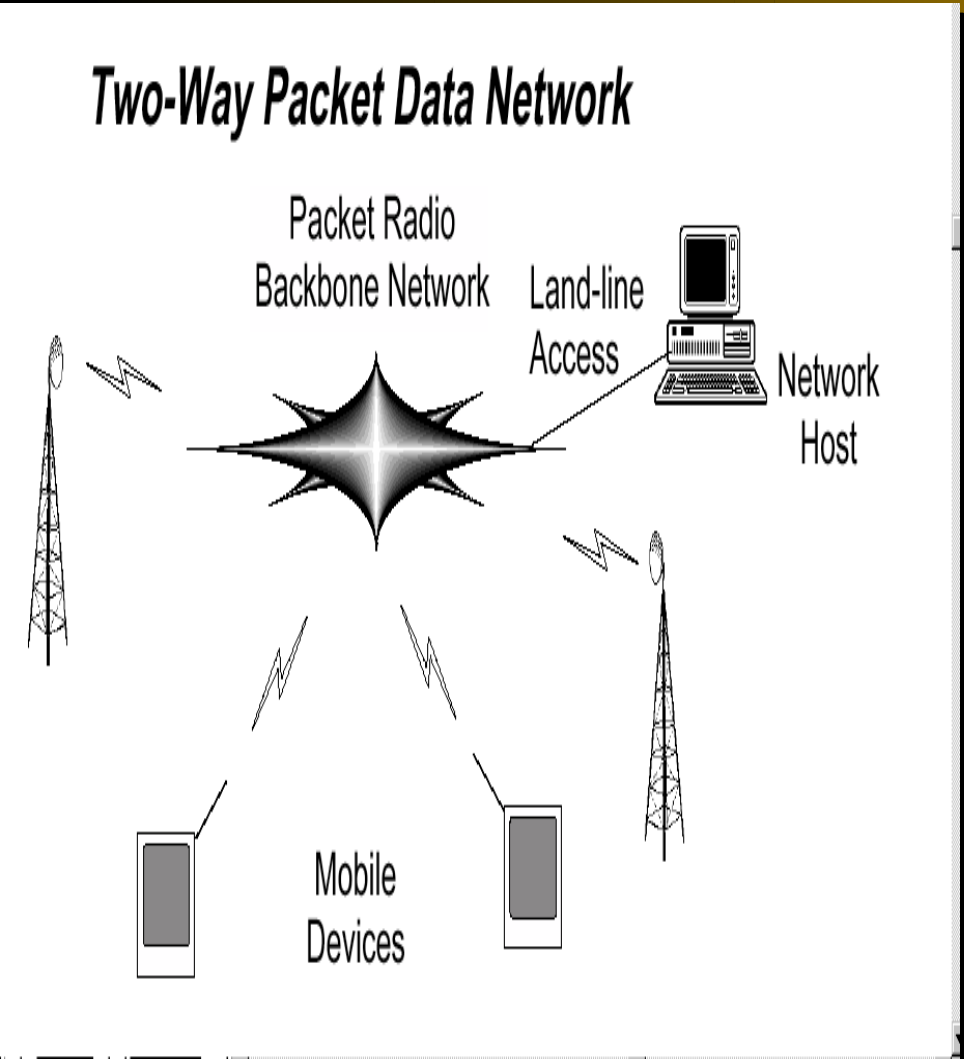
Features Of ARDIS Network

- Operating for over 10 years.
- *Largest* Wireless data communication network in the U.S.

  - Over 40,000 subscribers including- AT&T, Sears, Pitney Bowes, IBM, AVIS, Lanier, Lucent, Otis Elevators etc..
- *Coverage* in over 400 metropolitan areas and 10,700 cities and towns.

Coverage Of ARDIS Network

Significant Features Of ARDIS Networks



- Data is segmented into 240 or 512 bytes packets.
- Error Checking and correction features.
- Allows multiple devices to communicate with the network.
- Charged for data actually passed and not for the time connected.
- Most optimal for transmission of small amounts of data.

Team Conclusions

- Use of Adsistor along with the O_2 and CO electrochemical sensors
- Use of Series 500 Modem (SD505) along with ARDIS network support
- Final report sets groundwork for testing and development of a prototype device
- Visit our website at www.iit.edu/~ipro013

Tasks for Future Developers

- Further testing of sensors with varying parameters
- Testing sensors in an environment similar to valve housing on tank cars (rapid air flow)
- Design and testing of the telemetry device
- Cost estimation

Acknowledgements

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