The background of the slide is a photograph of a multi-lane highway filled with cars, likely during a traffic jam. The scene is captured at sunset or sunrise, with a warm orange and yellow glow in the sky. The cars are silhouetted against the bright light, and their taillights are visible. The overall atmosphere is one of a busy, congested roadway.

**TESTS AND ANALYSIS OF
ANALOG MODEMS FOR
REMOTE DATA COLLECTION
AT TELEMETERED TRAFFIC
MONITORING SITES (TTMSs)**

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Purpose of Study

- Identify and Resolve Incompatibilities Between Modems
- Develop Standards for Purchase of Modems
 - Identify Key Parameters
 - Develop Tests to Verify Standard Parameters
 - Focus on Low-Power DC Modems
- Resolve Inconsistent Modem Performance
 - One Modem can Call Site, Another Cannot

Approach

- Survey
 - Available DC Modems
 - Modem Chipsets Currently In Use
- Tests Using a Telephone Line Emulator
 - Attenuation and Noise Added
 - Multiple Combinations of Modems and Chipsets
- Analysis of and Experimentation with Modem Strings

Survey of DC Modems

DC MODEM	MODEM TYPE	RATE (in bps)	PROTOCOLS SUPPORTED	Vdc RANGE	Vdc	CURRENT (in mA)	MANUFACTURER
DLM 4100 ET		9600	A,B,C,D	12V/24V	12	300	Arc Electronics
IM-24LV	Cellular	2400	A,B,C,D,E,G	10V-36V	12	100	Arc Electronics
IM-14.4LV	Cellular	14400	A,B,C,D,E,G,I,J	10V-36V	12	140	Arc Electronics
IM-33.6LV	Cellular	33600	A,B,C,D,E,G,I,J	10V-36V	12	140	Arc Electronics
Starcomm	Cellular	9600	A,B,C,D,E,I,J,K,N	9V-18V	12	600	Starcomm
OEM CM900	Cellular	9600	A,B,C,D,I,J,K,M,N		5	800	Arc Electronics
MIU 2.4LV	Dial up	2400	A,B,C	9V-36V	12	65	Telenetics/ A.E.
V.3600	Dial up/ L.L.	33600	A,B,C,D,E,F,G,I,J,K	12V-60V			Telenetics/ A.E.
Ind. Modem 288	Dial up/ L.L.	28800	A,B,C,D,E,F,I,J,K	12V/24V	12		Arc Electronics
3342L	Dial up/ L.L.	33600	A,B,C,D,E,G,I,J,K,N	5.5V-14V	12	260	Star Comm/ A.E.
MIU 9.6LV	Dial up/ L.L.	9600	A,B,C,I,J,K,M	9V-36V	12	115	Telenetics/ A.E.
MIU 14.4LV	Dial up/ L.L.	14400	A,B,C,D,E,I,J,K,M	9V-36V	12	160	Telenetics/ A.E.
MIU 28.8LV	Dial up/ L.L.	28800	A,B,C,D,E,F,I,J,K,M	9V-36V	12	205	Telenetics/ A.E.
1442L	Dial up/ L.L.	28800	A,B,C,D,E,I,J,K,N	5.5V-14V	12	260	Star Comm/ A.E.
V.3400	Dial up/ L.L.	28800	A,B,C,D,E,F	12V-60V	12		Motorola
DSP 9600	Leased Line	9600	D	10V-53V	12		Telenetics/ A.E.
cascade 14.4	Dial up	14400	A,B,C,D,E,I,J,K,M	5.5V-14V	6		Diamond
cascade 33.6	Dial up	33600	A,B,C,D,E,F,G,I,J,K,M	5.5V-14V	6		Diamond
Starcomm	Dial up	14400	A,B,C,D,E,I,J,K	9V	9		Arc Electronics

Survey of DC Modems (cont.)

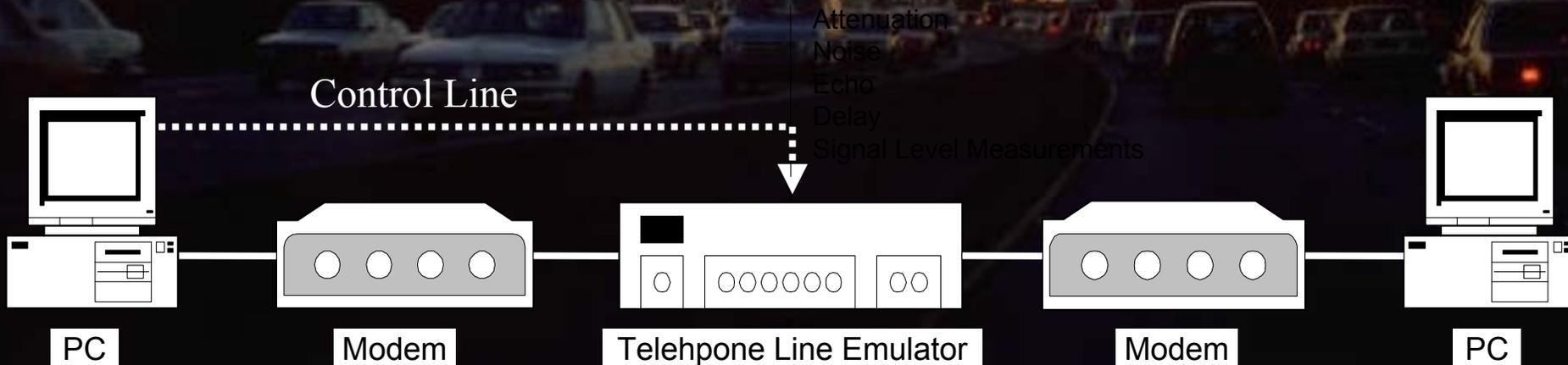
A: BELL 103 -----	0 – 300bps						
B: BELL 212A-----	1200 bps	Highlighted Modems are the ones tested					
C: V.22bis -----	1200, 2400 bps						
D: V.32 -----	4800, 9600 bps						
E: V.32bis -----	4800, 7200, 9600, 12000, 14400 bps						
F: V.34 -----	2400, 4800, 7200, 9600, 12000, 14400, 16800, 19200, 21600, 24000, 26400, 28800 bps						
G: V.34bis:-----	2400, 4800, 7200, 9600, 12000, 14400, 16800, 19200, 21600, 24000, 26400, 28800, 33600 bps						
H: V.90 -----	56K, ...						
I: V.42bis -----	SETS THE COMPRESSION RATIO AT 4:1						
J: MNP 5 -----	SETS THE COMPRESSION RATIO AT 2:1						
K: V.42 -----	ERROR CONTROL PROTOCOL (MNP1 - MNP4)						
L: MNP 7 -----	SETS THE COMPRESSION RATIO AT 3:1						
M: MNP 10 -----	OLDER SPECIAL FEATURED PROTOCOL FOR CELLULAR ENVIRONMENT						
N: MNP 10EC -----	ENHANCED MNP 10 PROTOCOL						
TABLE 1 - LIST OF PROBABLE MODEMS							

Modem Chipsets Currently in Use

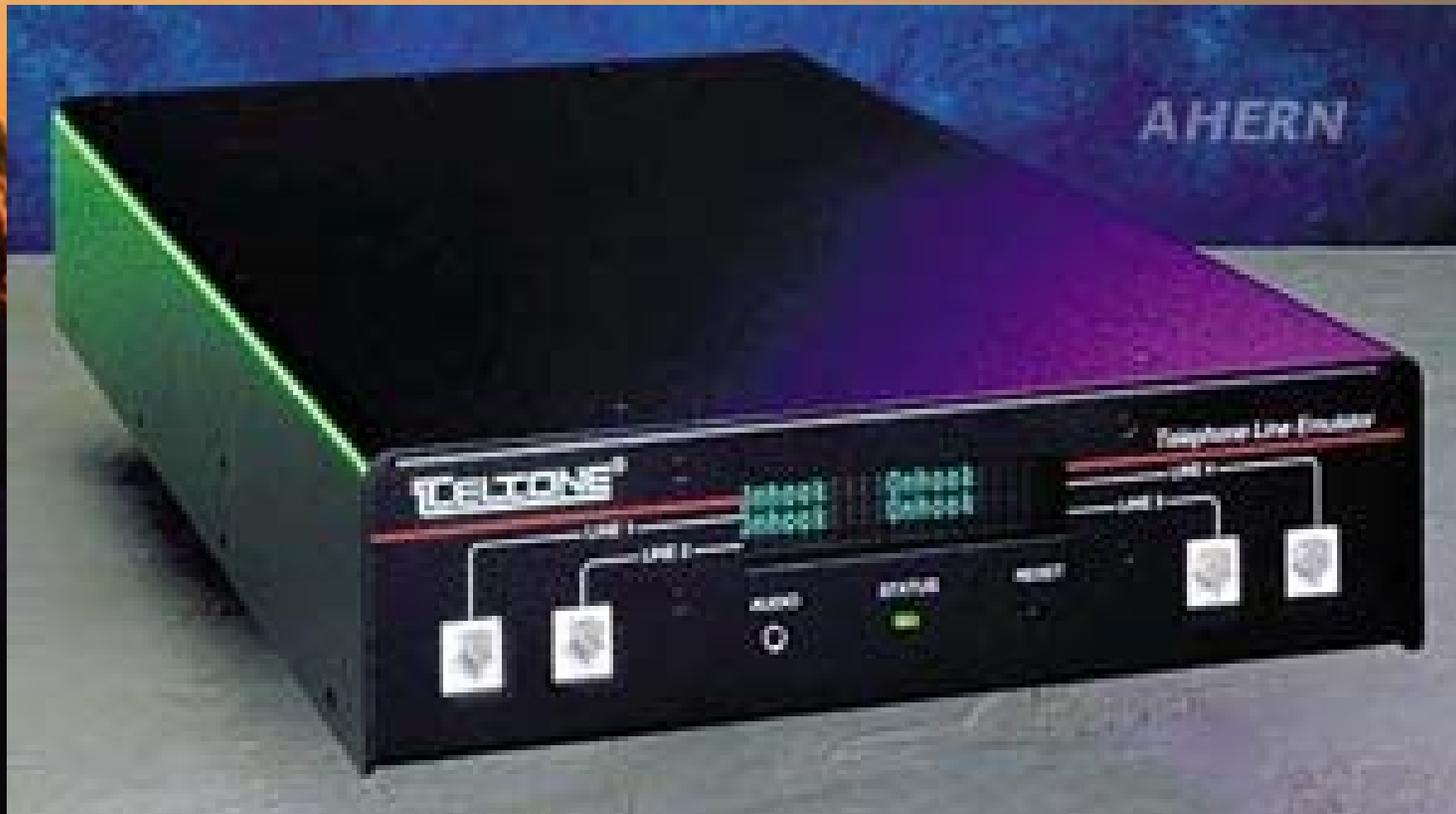
- US Robotics
 - Only Popular Modem with Own Chipset
- Rockwell (now Covenant)
 - Very Popular in Commercial/Industrial Equipment
- Lucent
 - Also Popular in Commercial Equipment
- Motorola
 - Only Found in Own Modems
- Other Older Chipsets Mostly Abandoned
- **Any Compatibility Issues?**

Telephone Line Emulator Testing

- Equipment
 - Two PCs
 - Teltone TLE-A01 Telephone Line Emulator
 - Two Modems



Teltone TLE-A01 Telephone Line Emulator



Modem Test Plan

- Compatibility Tests – Ideal Line Conditions
 - Vary Chipsets, Manufacturers, Speeds (protocols)
- Attenuated Line Tests
 - Add Signal Power Losses
- “Noisy” Line Performance
 - Additive White Gaussian Noise
- Combination Tests
 - Noise + Attenuation; Focused Tests

Modem Compatibility Tests

- Under Ideal Line Conditions All Modems Connected With All Others
- All Connections Were at the “Best” Speeds and Protocols
- Incompatible Protocols (compression, modulation, etc) Were Resolved by Modems
- No Special Modem Strings Were Required
 - Other Than Answer on Ring

Attenuated Line Tests

- Teltone Line Emulator Used to Attenuate Signal Received by Each Modem
 - Note: Can be Different in Each Direction
- Attenuation Increased Until Connection Could Not be Established or Maintained
- Attempted Most Combinations and Calling Directions (focused on calling DC Modems)

Example Attenuated Line Test

Attn (dB)	Starcomm 14.4 Modem (Rockwell)	Zoom 56K Modem (Lucent)	Signal Level	Signal Quality
4	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	17	6--8
14	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	27	6--9
24	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	36	10--14
26	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	38	14--19
28	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	38	14--19
29	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	42	18--26
30	57600 / V32 / LAPM/ V.42bis / 14400	115200/V.32/LAPM/V42bis/14400	42	19-29

- Connection could not be maintained above 28 dB Attenuation

Performance With AWGN

- Teltone Emulator Capable of Adding Noise
 - Again Direction Specific
- Noise Measured in dBrn
 - dBrn = dB relative to reference noise (-90 dBm)
- Noise Increased Until Connection Could Not be Established or Maintained
- Attempted Most Combinations and Calling Directions (focused on calling DC Modems)

Attenuation + AWGN and Focused Tests

- Several Specific Tests Were Performed
 - Fixed Noise One Direction; Varied in Other
 - Fixed Attenuation in One Direction; Varied in Other
- Did Not Demonstrate Any Significant Variations Between Modems (Other than previously noted)

Conclusions of Modem Tests

- For the Most Part Chipsets Had No Significant, Consistent Affect on performance
 - US Robotics 56K Modem Performance with 14.4K and Below Modems an Exception
- It Has Been Reported that Identical Modems Best
 - Tested only Starcomm 14.4K
(Performance on Par With Other Pairs)
- Conclusion: Other Considerations Must be Taken
 - Modem Strings
 - Power Requirements (solar/battery)

Analysis & Tests of Modem Strings

- Current Effort
- Current Practice at FDOT
 - Select Low-Power DC Modems for TTMS
 - Send to Traffic Monitoring Equipment Vendor to Get Proper Modem Strings for Modem
 - Requires Specific Modem Strings for Desktop or Calling Modems as Well
- Problem: Certain Pairs Sometimes Seem Incompatible

Example Modem String

(Starcomm 14.4 on Peek ADR3000)

```
Q0
V1E0F0L0N1W2M1
&C1&D2&K0&Q5&R1
\A3\G0\N6
%C3%E1
S0=1S24=120S7=90
&W0
```

White = Modem Default

E0 = No Command Echo
F0 = Autodetect
(N1 overrides and is default)
W2 = Report DCE Speed
&K0 = Disable Flow Ctrl
\A3 = Max MNP Blocks
%E1 = Line Detect & Retrain
S0 = Answer on Ring 1
S24 = Delay to Sleep
S7 = Wait for Carrier Time

2nd Example Modem String (All Modems on Diamond)

Modem Setup #1 :

ATE0Q0V0S0=2

Modem Setup #2 :

ATX1&C1&D2

Setup #1 – Fixed

Setup #2 - Changeable

E0 = No Command Echo

White = Modem Default

Test With Minimal Modem String

- Starcomm 14.4 Each End to ADR3000
- String Used
 - Host (PC):
&FS7=90&Y0&W0
 - Remote Site:
&FS0=1S24=120S7=90&Y0&W0
- Connection Worked Perfectly

Conclusions

- Apparently Chipsets Not a Common Problem
 - Exc. One US Robotics Tested
- Some Moderate Variations in Performance
 - Best Desktop Modem Not Always Best for Communicating with Slower DC Modems
 - Using Identical Modems May Increase Reliability, But Little Performance Increases

Conclusions (cont.)

- Modem Strings Can Be a Problem
 - Complicated Strings Often Unnecessary
(can lead to errors in setting)
 - Primary Setting at Remote Site: Answer Ring
(and Flow Control?)
 - Others Can Optimize Performance to Some Degree
 - Minimize Modem Strings (don't repeat defaults)
- Environmental Ratings of Modems for Remote Sites
 - Noted Some “Industrial” Modems Rated Only to 125°F