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April 16, 1995

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Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

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Re: CC Docket No. 92-297
Ex Parte Presentation

Dear Mr. Caton:

On April 16, 1995, representatives of Texas Instruments, Inc., met with FCC representatives to discuss matters related to the Commission's pending proceeding in CC Docket No. 92-297. The FCC was represented by Robert Pepper, Gregory Rosston, Amy Lesch, Robert James, Susan Magnotti, Karen Brinkmann, and Jill Luckett. Texas Instruments, Inc., was represented by Gene Robinson, Robert Pettit, and Paul Misener.

The enclosed materials, copies of which were handed out in the meetings, formed the basis for discussion. Frequency sharing plans for the 28 GHz band also were discussed.

An original and two copies of this letter are enclosed. Copies of this letter, without the enclosures, are being provided simultaneously to the FCC representatives identified above.

Respectfully submitted,

Paul E. Misener
Counsel for Texas Instruments, Inc.

Enclosure

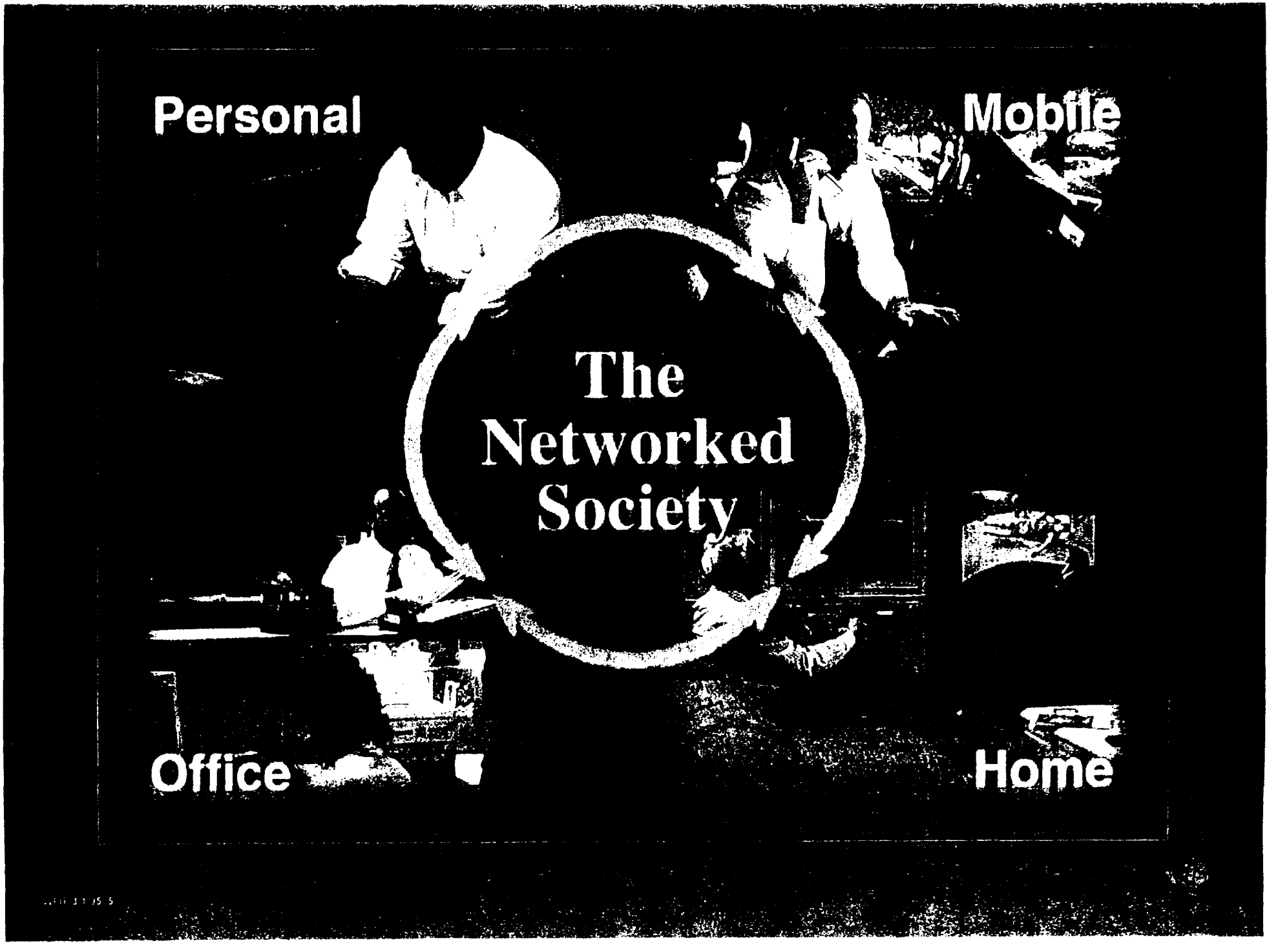
No. of Copies rec'd 0+2
List A B C D E

Presentation to the FCC
26-27 April 1995
Digital View of LMDS
At Texas Instruments

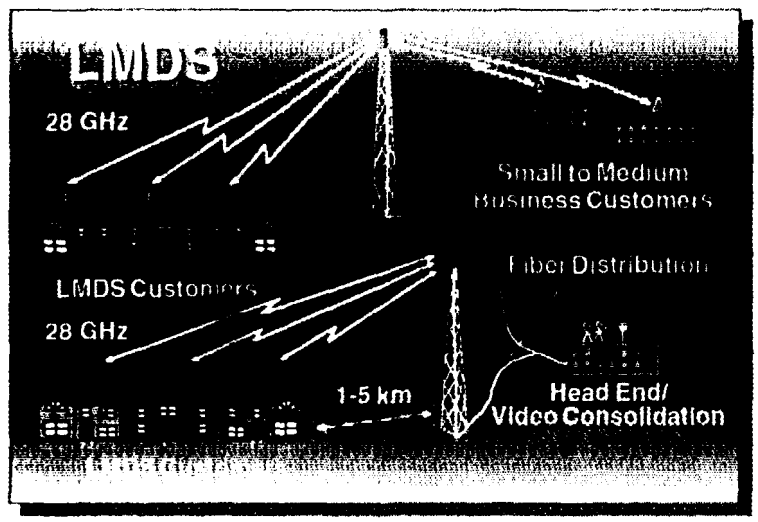
Gene Robinson, Senior Fellow

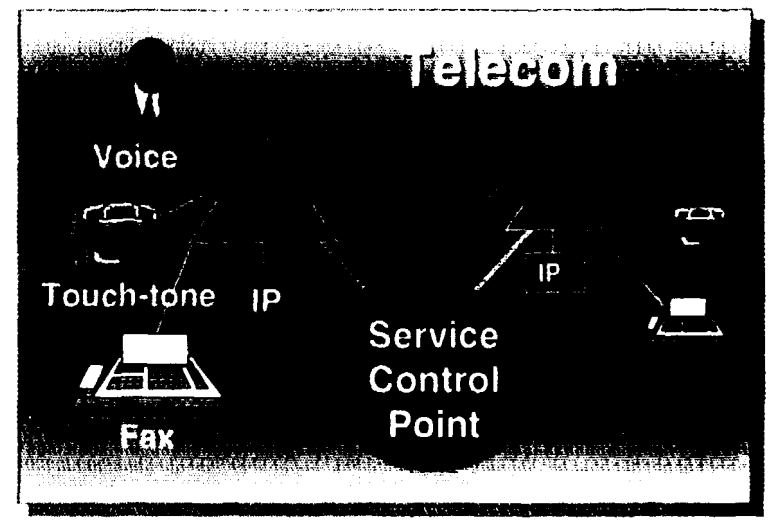
Wireless Communication and Local Multipoint Distribution Service at Texas Instruments

- Wireless Communication at Texas Instruments
- LMDS - TI's Digital System
- LMDS Digital System Parameters
- 28GHz LMDS Cost Model/Indices
- 28 GHz vs 40 GHz Technical Issues
- 28 GHz vs 40 GHz Economic Issues
- 28 GHz Interference/Coshare Issues
- Summary/Conclusions


Personal
Mobile
The Networked Society
Office
Home

Communications & Electronic Systems

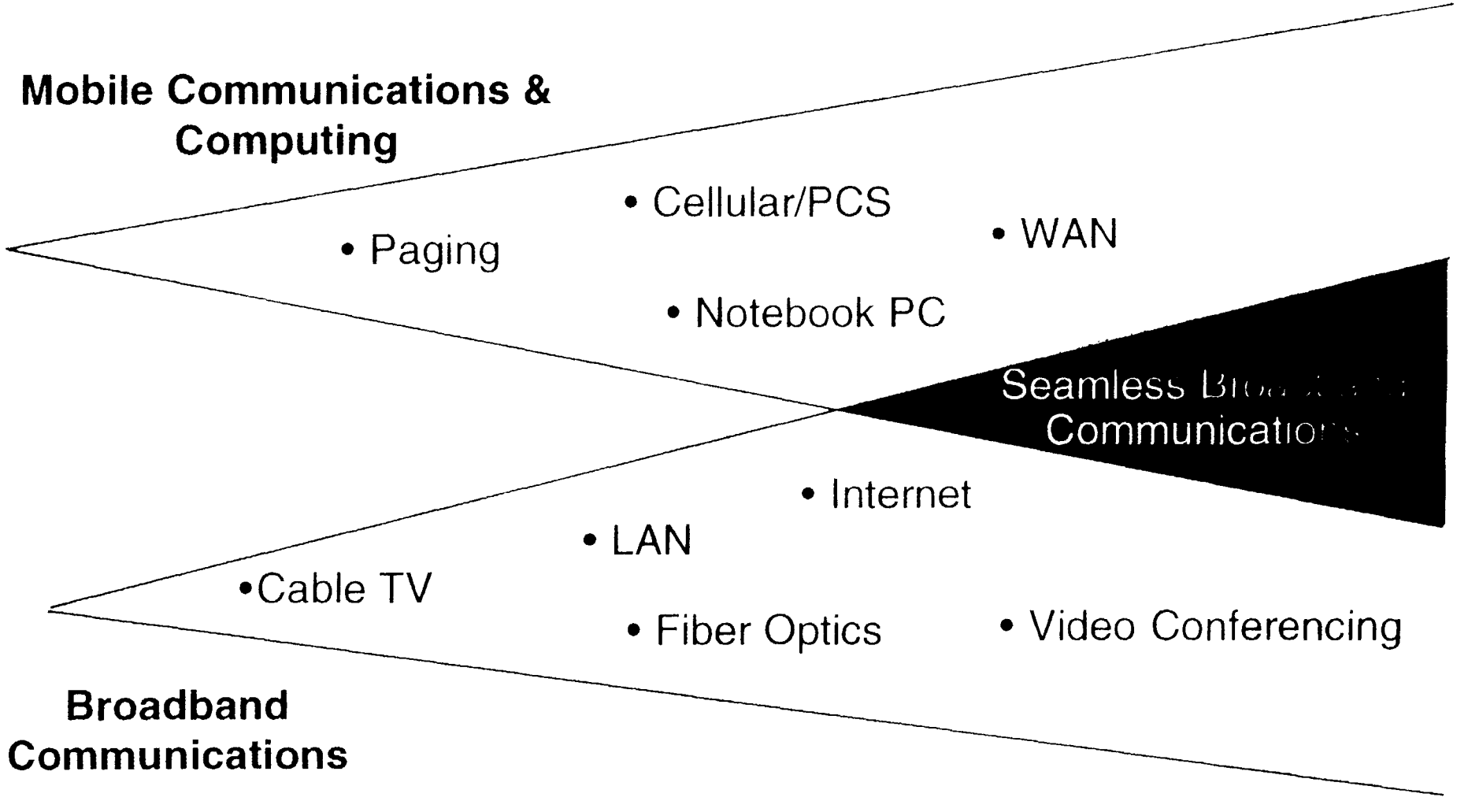




Strategic Growth

- Smart Antennas
- Satellite Applications
- Voice Applications
- Wireless Tail

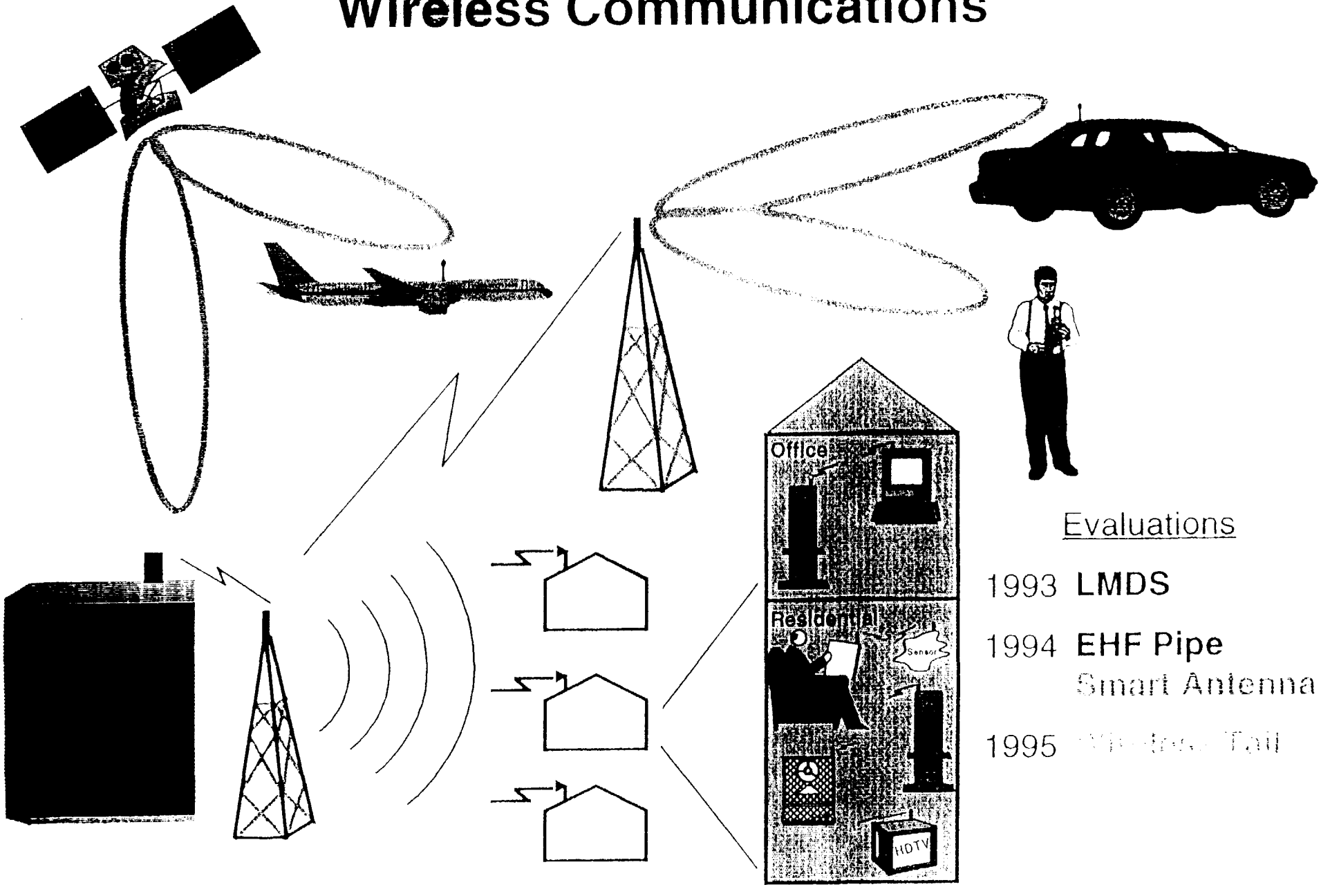
C&ES sees broadband connectivity as the inevitable merging of two high growth communication segments.



NII Applications

- Entertainment
  - VOD
  - Games
- Commerce
  - Shopping
  - Financial transactions
- Home office
  - Video conferencing
  - Enterprise net
- Education
  - Distance learning
- Other
  - Video
  - Internet browse
  - E-travel
  - Smart home

Wireless Communications



Evaluations

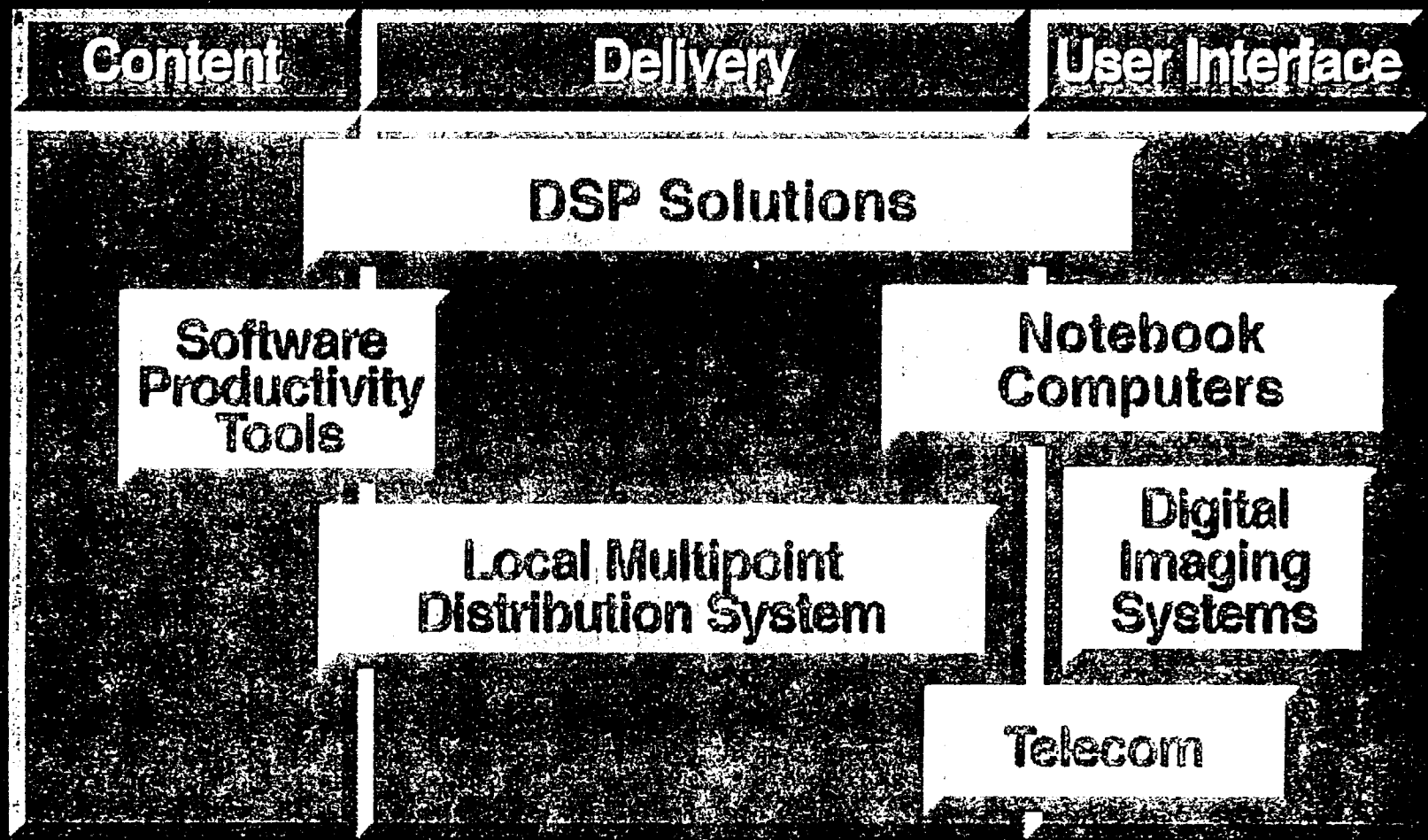
1993 **LMDS**

1994 **EHF Pipe**

Smart Antenna

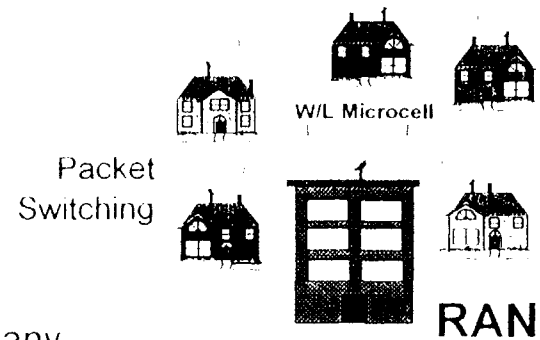
1995 [illegible] Tail

Making Digital Connections Easy and Useful

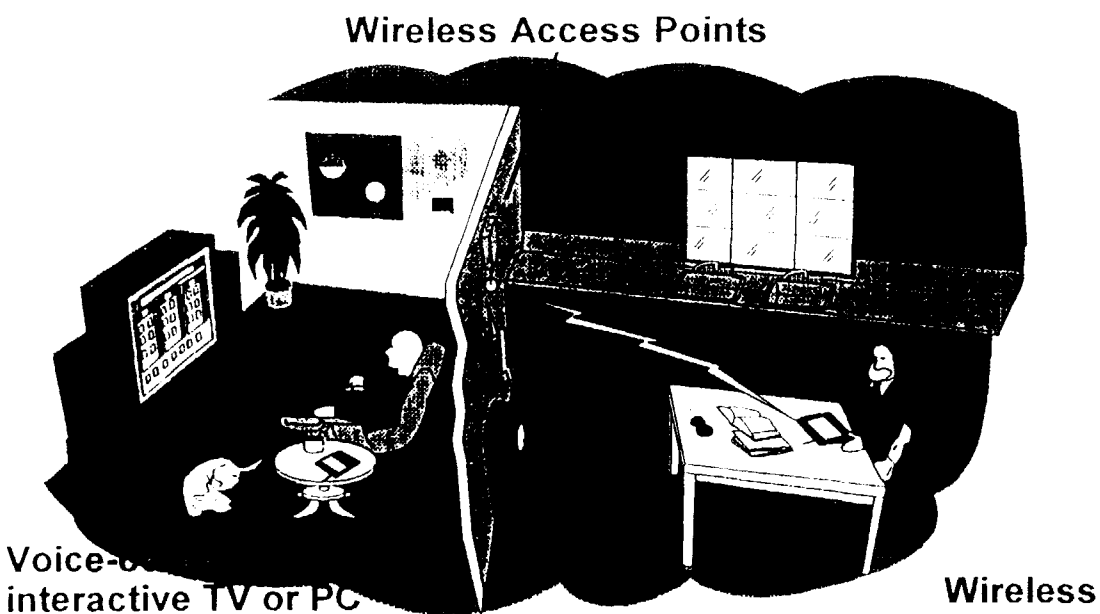


Home Communications
(Residential Area Network (RAN)/Digital Home)

Needs
- Home broadband com
  - NII access
  - Interactive TV
  - Video conferencing
- Multiple users/home
- Paperless home
- In-home ubiquity (any room, any chair, any time)
- Maintain classic decor



System Integration Network Management Software



Digital Home

Drivers/Discontinuities
- Digital A/V
- Internet
  - Info
  - Transactions
- Broadband to the home
- Home PCs
- PCS (LOS)
- IEEE 802.11

TI Opportunity
- LMDS
- W/L microcells
- ATM components
- TSG
- Telco relations
- In home W/L
- STB
- PPP
- Speech tech
- PCMCIA
- DMD

Issues/Risks
- Broadband to the home cost/coverage/schedule
- Consumer/commodity

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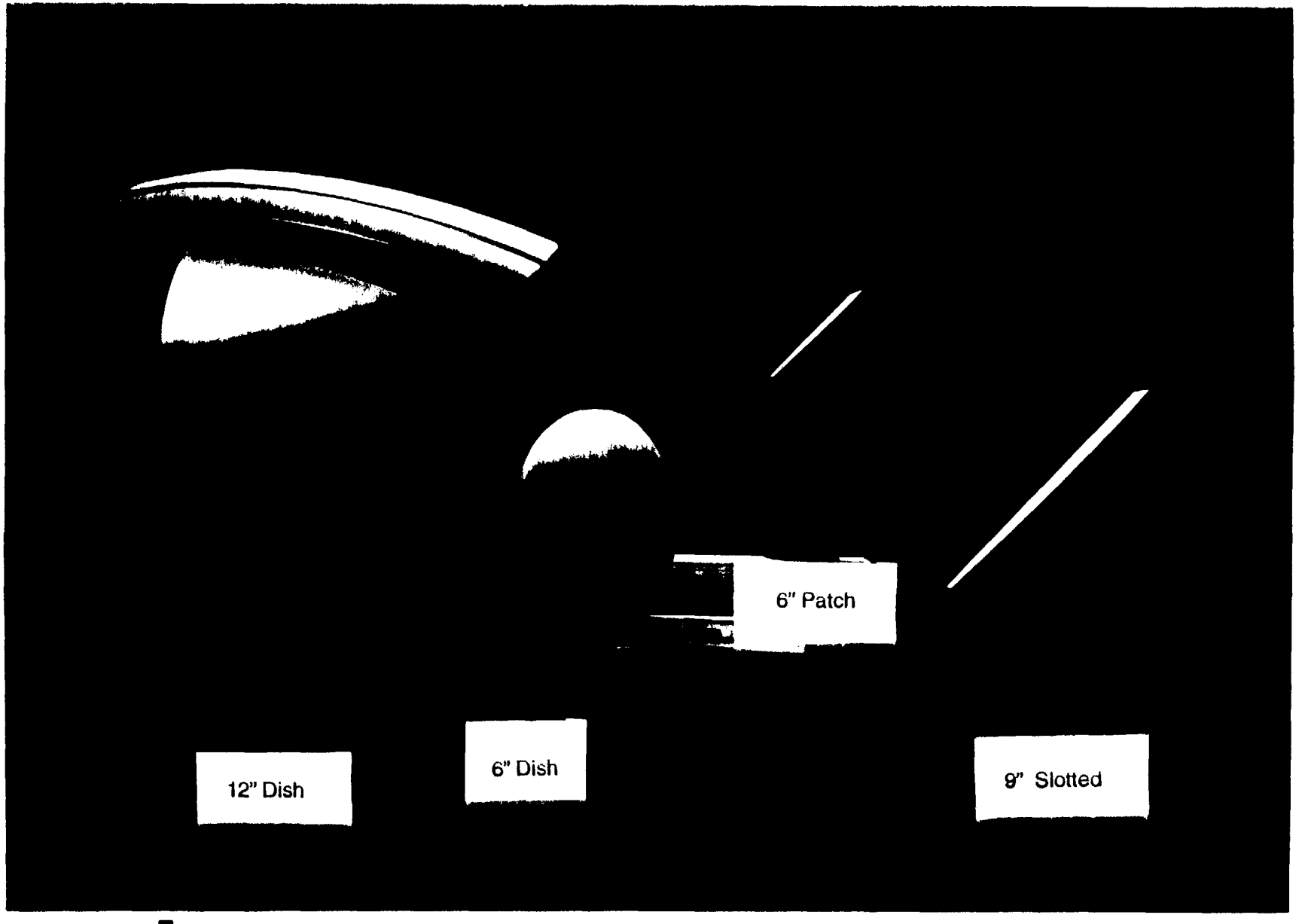
Texas Instruments

LMDS Digital System

LMDS Node

Texas Instruments



TEXAS INSTRUMENTS

TI's LMDS Digital System

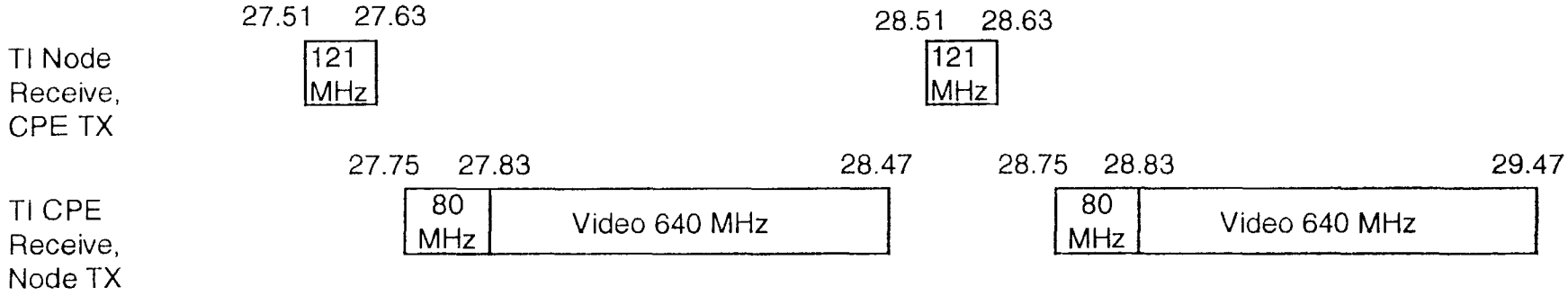
- TI's LMDS system is a two-way 28 GHz digital system with video, data and telephony services.
- System elements consist of nodes/hubs, customer premise equipment (CPE's), and central office servers for video and data.
- The 5 Km coverage radius and system capacity is designed to serve 16,000 (4,000 per quadrant) subscribers (205 subscribers/Km^2).
  - 1000 simultaneous DSO's/80 MHz per sector with 200 video control, 800 voice or data channels.
  - 56 video broadcast channels per sector.
  - 200 video on demand channels per sector.

TI's LMDS Digital System

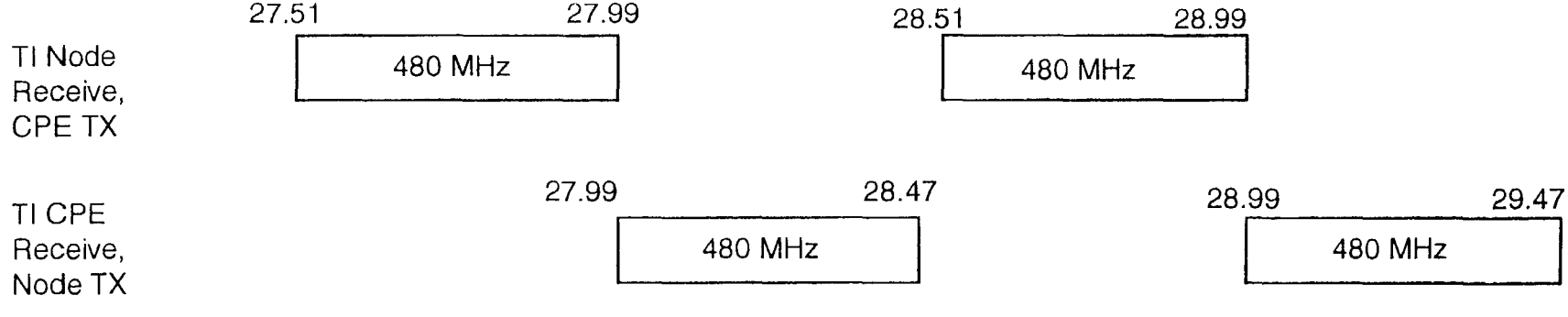
- LMDS frequency plan, (Figure 1):
  - Two 1 GHz bands (A/B)
  - Symmetrical up/down links for data/telephone
  - Asymmetrical for video, data, and telephony
- Nodes/hubs are solid state, 30 dBm maximum transmitter power per channel with 12 dBi antenna gain and uses QPSK modulation with a 54 MBPS digital rate.
- CPE's provide for video channels, a 64 KBPS data port and two pot lines.
- The link budget accommodates 3.7 dB/Km (21 mm/hr rain rate) attenuation for rain with sector power control.

TI's 28 GHz Frequency Plan

Asymmetrical Frequency Plan



Symmetrical Frequency Plan



TI's LMDS Digital System Parameters

- LMDS Outbound
- LMDS Inbound
- QPSK Threshold
- QPSK Interference Allocations

TEXAS INSTRUMENTS LMDS SYSTEM PARAMETERS - OUTBOUND

	PARAMETER		
1.	Frequency, (GHz)	27.5 - 29.5	
2.	Digital Rate, (MBPS)	54	
2a	Modulation, Node	QPSK	
3.	Node TX Power, (dBm)	30.0	
4.	Node TX Antenna Gain, (dBi)	12.0	(1)
5.	Path Length, (Km)	5	
6.	Path Loss, (dB)	136.0	
7.	Atmospheric Att., (dB)	0.5	
8.	Rec. Antenna Gain, (dBi)	34.0	(2)
9.	Rec. Signal Level, (dBm)	-61.5	
10.	Rec. Thermal Threshold, (dBm)	-75.3	
11.	Path Margin, (dB)	13.8	
12.	Rain Loss (99.9% dB/Km)	3.7	
13.	Effective Path Length, (Km)	4.1	

(1) Node Tx Antenna
- Omni (90 degree sectors)
- Elevation Coverage - At elevations greater than 0°, the elevation mask shall be within the following limits in dB, ("a" is in degrees, sine is in radians)

$0° \leq a \leq 4.0°$	$20 \log ((\sin \pi x)(1/\pi x))$, where $x=(a+1)/7.5$
$4.0° \leq a \leq 7.7°$	$7.7 - 3.85a$
$a > 7.7°$	-22

(2) Receive Antenna Sidelobes
-25dB ± 5 degrees
-40dB ± 20 degrees

TEXAS INSTRUMENTS LMDS SYSTEM PARAMETERS - INBOUND

	PARAMETER		
1.	Frequency, (GHz)	27.5 - 29.5	
2.	Digital Rate, (MBPS)	3.33	
3.	Modulation	QPSK	
4.	CPE TX Power, (dBm)	20.0 max	
	Clear Air, (dBm)	10.0 min	
5.	CPE TX Antenna Gain, (dBi)	34	
6.	Path Length, (Km)	5	
7.	Path Loss, (dB)	136	
8.	Atmospheric Att., (dB)	0.5	
9.	Rec. Antenna Gain, (dBi)	12	(1)(2)
10.	Rec. Signal Level, dBm	-71.5	
11.	Rec. Thermal Threshold, dBm	-89	
12.	Path Margin, (dB)	17.5	
13.	Rain Loss (99.9% dB/Km)	3.7	
14.	Effective Path Length	4.1	

(1) Receive Antenna Beamwidth 2.5 degrees

(2) Receive Antenna Sidelobes
-25dB ± 5 degrees
-40dB ± 20 degrees

QPSK THRESHOLD

1) QPSK Bit Error Rate performance:

E_b/N_o Theoretical for 10-9 BER	12.5dB
Rate 3/4 FEC Gain	4.5dB
Theoretical $E_b/(N_o+I_o)$	8.0dB
Implementation Margin (*)	3.0dB
Expected Performance	11.0dB

(*) Implementation Margin Reserved for

a. Phase noise
b. Carrier phase error
c. Ch. delay and amplitude distortion/intersymbol
d. Sampling accuracy

2) Receiver Sensitivity

$P_r = KT * NF * ((E_b/(N_o+I_o)) * (\text{Data Rate})$
$= -174 + 8 + 77.2 + 11.0$
$= -77.8$ dBm

3) Digital Thermal Noise Performance:

Required Total $E_b/(N_o+I_o)$	0.079
Minus Interference E_b/I_o	-0.034
Resulting Thermal $E_b/(N_o$	0.045
Relative $E_b/(N_o$	13.5dB

Thermal noise receiver sensitivity with interference contributions

$P_r = KT * NF * (\text{Data Rate}) * (F\ ber)$
$= -174 + 8 + 77.2 + 13.5$
$= -75.3$dBm

TEXAS INSTRUMENTS LMDS INTERFERENCE ALLOCATIONS

QPSK ALLOCATION	(E_b/I_o)	
	Relative, dB	**Linear**
Adj. Channel	-22	0.006
Ch. Crosstalk	-35	0.0003
Adj. Node	-30	0.001
TX Intermod.	-35	0.0003
RX Intermod.	-35	0.0003
TX Noise to RX	-20	0.01
Other Services/Sources	-20	0.01
Node Cross Pole Energy	-25	0.003
CPE Cross Pole Energy	-25	0.003
TOTAL	-14.7dB	0.034

TI's 28 GHz LMDS

Cost Model/Indices

TI's LMDS 28 GHz Cost Model/Indices

Cost Model/Indices

• LMDS Subscriber cost Indices		100
– CPE		90
• Antenna/electronics	21	
• Terminal	32	
• Set top box	37	
– Node		6
• RF System	3	
• Telecom	2	
• Video	1	
– Central Network		4

Assumptions

- Node with 5 Km radius,
  360 degree coverage,
  4 sectors and
  16,000 subscribers.
- 1000 simultaneous DSO's,
  80 MHz per sector for
  200 video control and
  800 voice or data channels.
- 56 video broadcast channels per sector.
- 200 video on demand channels per sector.
- 3 MBPS per video channel, average data rate.
- 2 telecom subsystems for 1000 simultaneous DSO calls per sector.

LMDS
At
28 GHz vs 40 GHz
Technical and Economic Issues

LMDS Technical Issues at 28 GHz vs 40 GHz

- Technical issues
  - Power generation capability, 28/40 GHz.
  - Frequency generation/stability and noise, 40 GHz.
  - CPE noise figure/down converter, 28/40 GHz.
  - Rain attenuation, 28 GHz vs 40 GHz.
  - Node radius/coverage; subscribers per node.