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NASA  
Lewis Research Center      Communication Technology Division      Satellite Networks & Architectures Branch

# Satellite/Terrestrial Networks:

## End-to-End Communication Interoperability

### Quality-Of-Service Experiments

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## Quality of Service

QoS ?

VOICE  
FAX  
MEDICAL IMAGING  
TELECONFERENCING  
COMPRESSED VIDEO  
"REAL-TIME" DATA MANIPULATION

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## Goals



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- Determine Quality-of-Service Parameters that Satellites must provide to remain competitive in the Global Information Infrastructure.
- Evaluate the effect of transmission link quality and characteristics on overall QoS for various applications and protocols.

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## Strategy



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- Evaluate ATM over noisy link.
  - ATM was designed for “near” error free channels such as fiber. We need to understand the effect that various error characteristics have on the ATM QoS.
- Evaluate Digital Video over Satellites
  - Digital Video (particularly compressed video such as MPEG-II) is expected to require stringent QoS.
- Evaluate effect of layer protocols
  - Errors that occur in the lower layer of the protocol stacks tend to get magnified as one propagate through the upper layers.

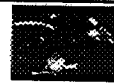
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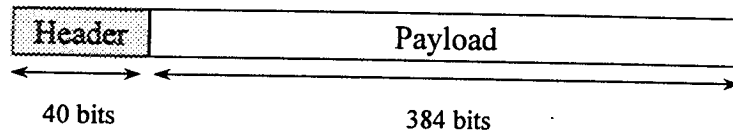


# ATM Performance Characteristics



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- CER Cell Error Ratio
  - One or more errors in the payload
- CLR Cell Loss Ratio
  - *Generally* 2 or more errors in the header
- SECBR Severely Errored Cell Block Ratio
- CMR Cell Misinsertion Rate
- CTD Cell Transfer Delay
- CDV Cell Delay Variation



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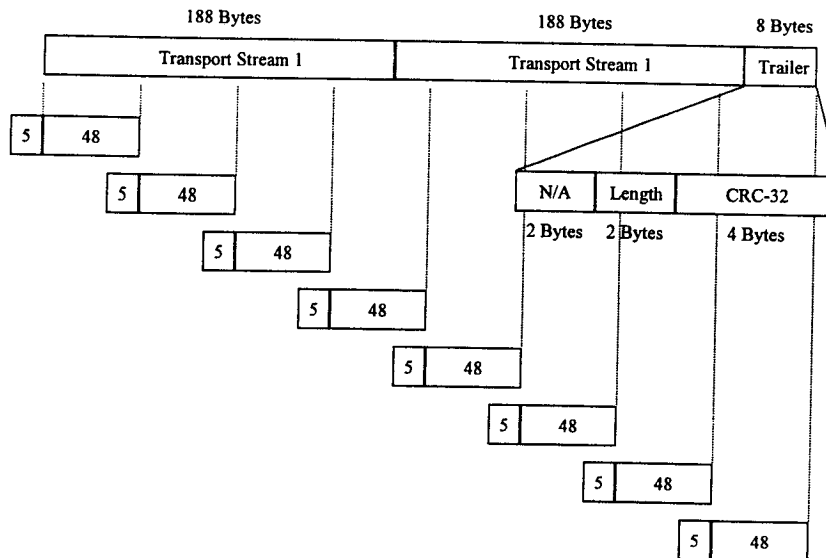
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# MPEG-2 Transport Stream Mapping to AAL-5



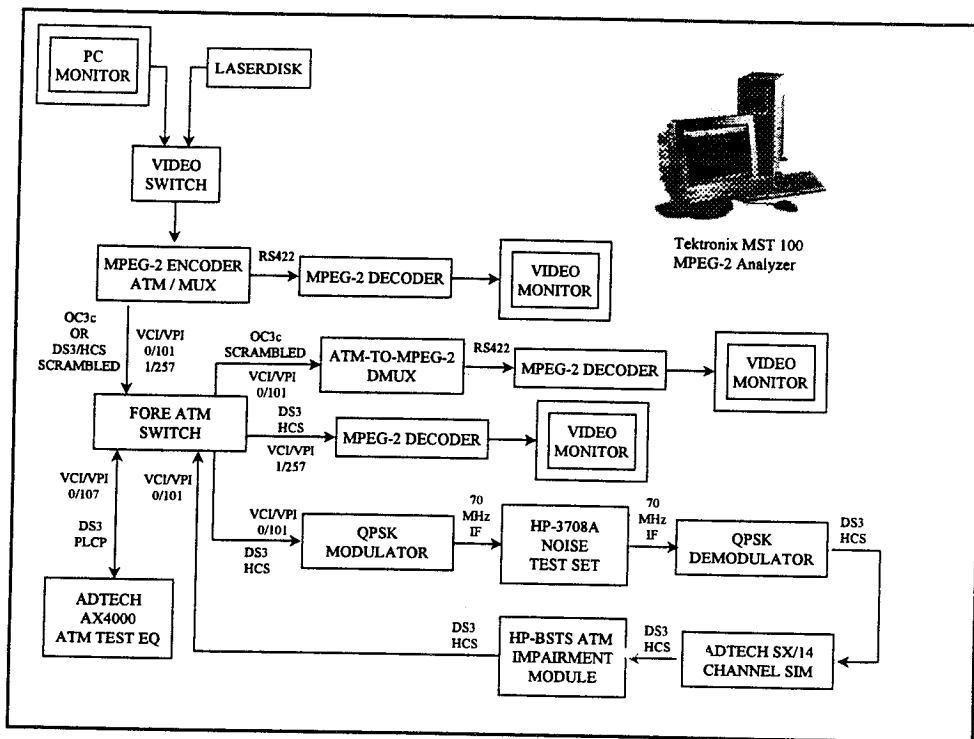
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## Compressed Video Tests Over ATM



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- MPEG-2 Transport Stream With Errors
  - Baseline without ATM
- MPEG-2 Over ATM With Binomial Errors
  - Digital Errors
- MPEG-2 Over ATM Over Emulated Satellite
  - Analog Errors
- Dual Decoder Test
  - Variations due to decoder implementation
- MPEG-2 over ATM Channel Characteristics
  - QoS dependence independently on CER and CLR

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## Observations and Discussion



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- MPEG-2 requires a link quality of  $10^{-10}$  BER or better regardless of underlying protocol.
- Block errors are far easier to tolerate than decoder resynchronization
- Higher encoding rates require slightly higher quality links
- Further study is necessary in order to determine the relationship between the video quality and the ATM QoS parameters - in particular between the visible errors per second and the CLR and CER as well as the affect different CER and CLR distributions have on the video

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## Status Digital Video over Satellites



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- Work was completed in September 1997 and reported to ITU-R Working Party 4B and T1A1.3
  - Paper is available via anonymous FTP
    - Site: <ftp.tl.org>
    - Directory: `/pub/t1a1/t1a1.3`
    - T1BBS FILE: `7a130840.doc`

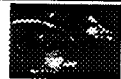
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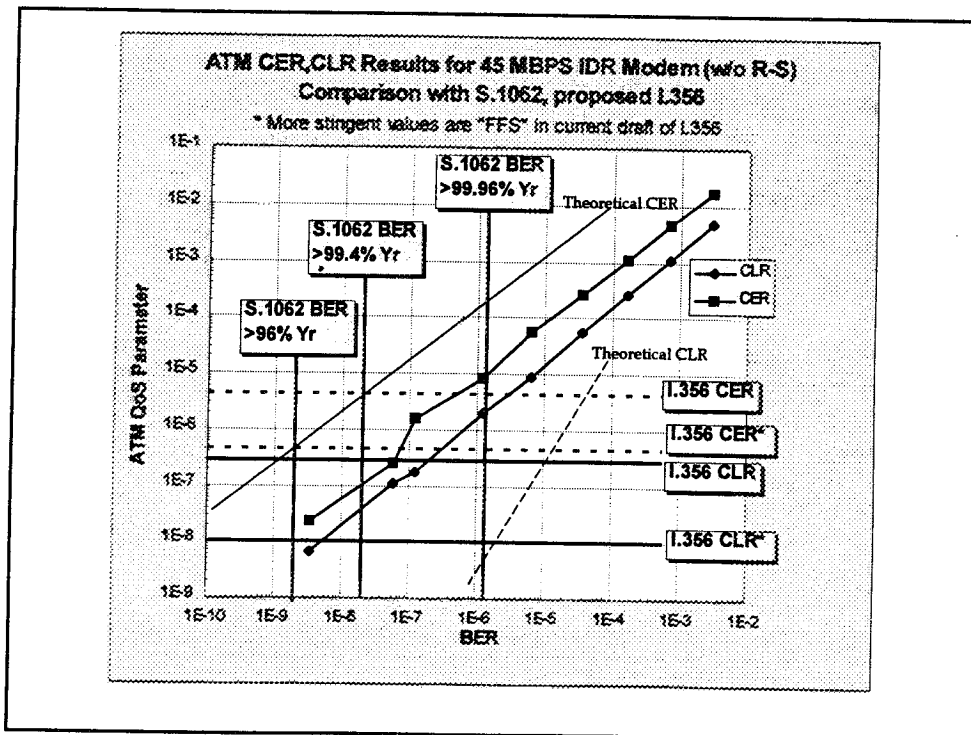


# Proposal



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- ITU-T Rec. I.356 Class I, stringent class, objectives for CLR, CER should be at least  $1.0E-8$  and  $1.0E-7$  respectively in order to acceptably carry such services as MPEG-2 compressed video and may require even better performance



## Test Results

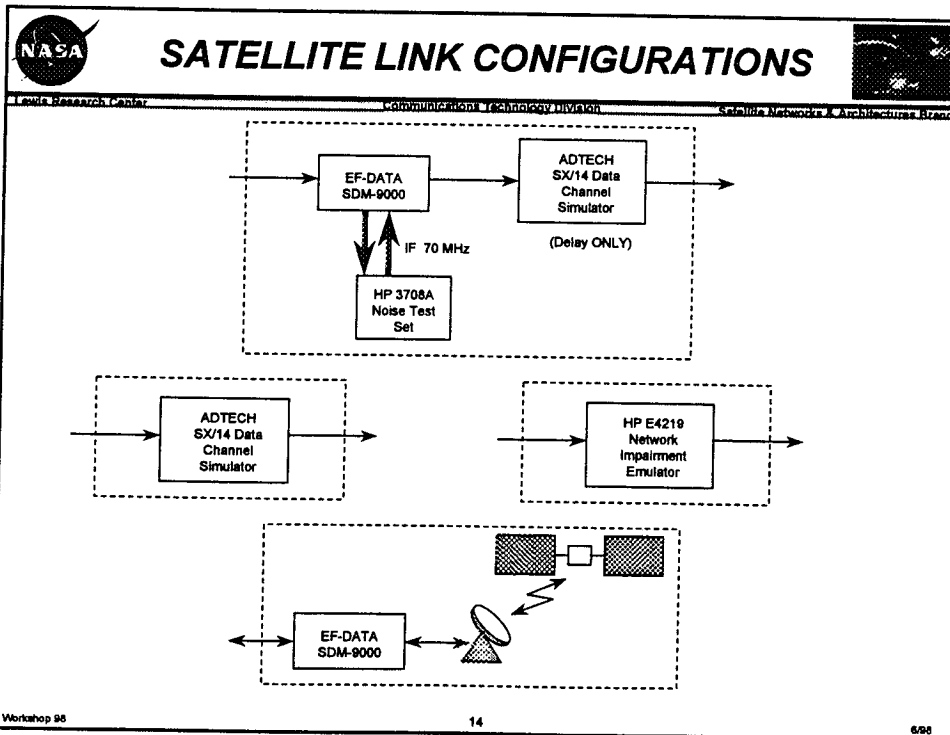
Test Interval (Minutes)	E/N <sub>0</sub>	BER <sup>1</sup>	CLR <sup>2</sup>	EMMI	Comms/traffic	Voice	Fax
3	10.3	5.0E-11	0	Excellent	Video and Audio OK	Excellent	Excellent
14	9.4	5.7E-10	0	no change	no change	no change	no change
8	8.7	6.0E-9	0	Maybe flickering on solid color. Still very good quality.	no change	no change	no change
7	8.2	5.0E-8	0	Small amount of shimmering on skin tones. Still very good quality.	Streaks	no change	Small font difficult to read
5	7	5.0E-7	2.8E-7	Small amount of shimmering. Acceptable quality.	OK	no change	
14	6.5	4.2E-6	7.7E-6	Movement is jerky at times. Some shimmering.	Few black streaks, streaks, white streaks.	Heard noise burst then lost call. Reestablished call, quality is good when call is up. Heard 2 to 3 seconds of very choppy speech then called dropped.	Third page did not come through and had to be retransmitted. Slight loss of sharpness.
5	5.4	7.5E-5	8.2E-5	Movement breaking up into a bit. Freezing on video. Booming ball appears to freeze in mid bounce and pause as it bounces. Shimmering on skin tones. Blur on letters and race signs.	Streaks, tearing. Audio beginning to break up.	Breaking up. Noise bursts, then connection gone. Now unusable. Stays up less than one minute.	Receive stop. Could not transmit.
5	4.5	2.9E-3	1.2E-2	Video freeze. Maybe 75% of frames received. Audio breaking up.	Picture or freeze.	Cannot get up a call (5 attempts). Secondary dial tone, but no ring back or ringing.	Could not transmit.

### NOTES

<sup>1</sup> Bit Error Ratio measured by the satellite modem.

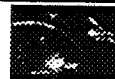
<sup>2</sup> CLR is the Uncorrected or Discarded Cell Ratio (DCR) i.e. all cells with two or more errors in the header.

Notice that at low BERs there is not enough statistical confidence on the CLR measurement.





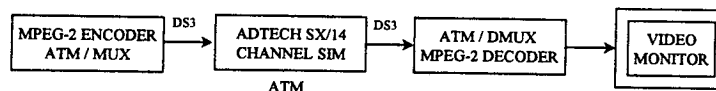
## MPEG-2 Over ATM With Binomial Errors



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- Purpose
  - Determine dependance on CLR and CER
  - Determine dependence on encode rate
- Conclusions
  - BER of 1.0E-8 or higher is definitely unacceptable
  - Higher encode rates are slightly less susceptible to errors

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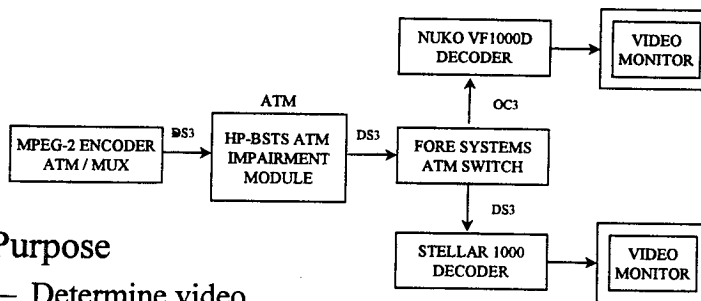
## MPEG-2 over ATM Channel Characteristics



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- Purpose
  - Determine video degradation relative to CLR only and CER only
- Conclusion
  - CLR has far more affect on the video than CER

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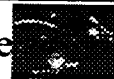
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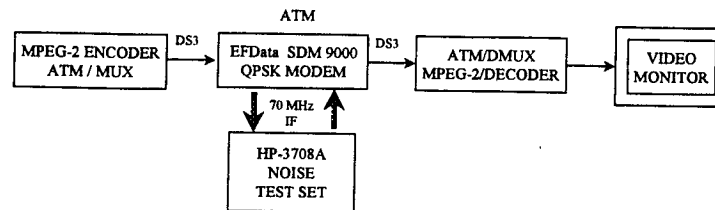
## MPEG-2 Over ATM Over Emulated Satellite



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- Purpose
  - Evaluate video quality when errors are inserted at the RF link (different CLR and CER distribution)
- Conclusion
  - Unacceptable link quality at BER 1.0E-8, CLR 1.0E-7 and CER 1.0E-6

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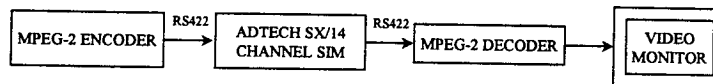
## MPEG-2 Transport Stream With Errors



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- Purpose
  - Baseline MPEG-2 Video
  - Determine dependence on encode rate (compression)
- Conclusions:
  - BER of 1.0E-8 or higher is definitely unacceptable
  - Higher encode rates are slightly less susceptible to errors

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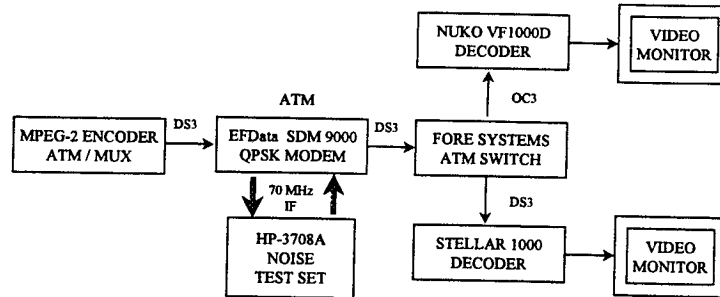
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## Dual Decoder Test



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- Purpose
  - Determine if different decoder react similarly to errors
- Conclusion
  - The two decoders tested degrade at the same point