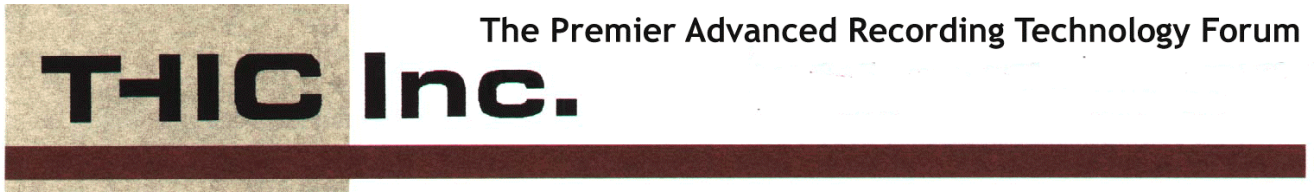

Care and Handling of Optical Discs

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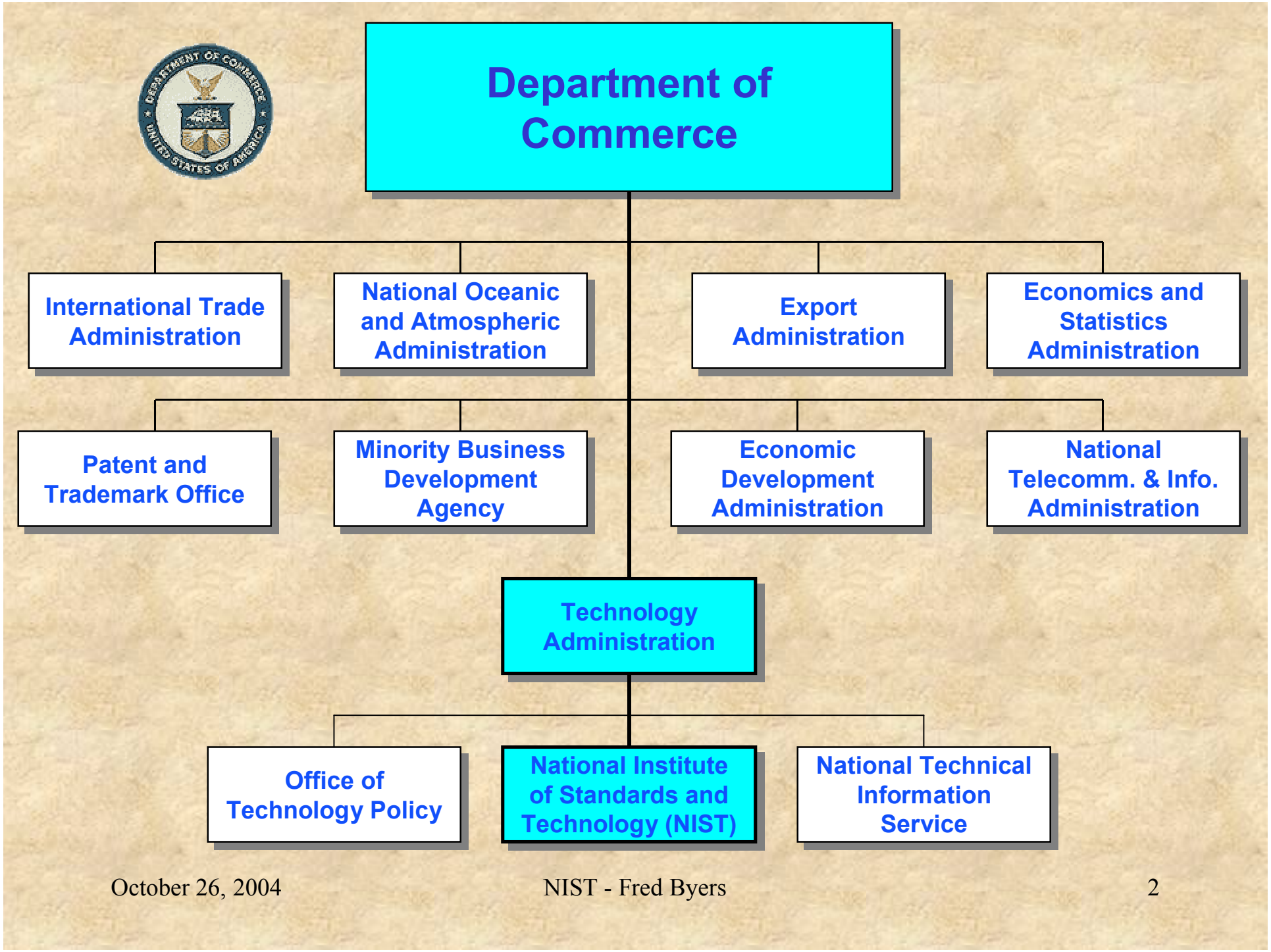
Department of Commerce
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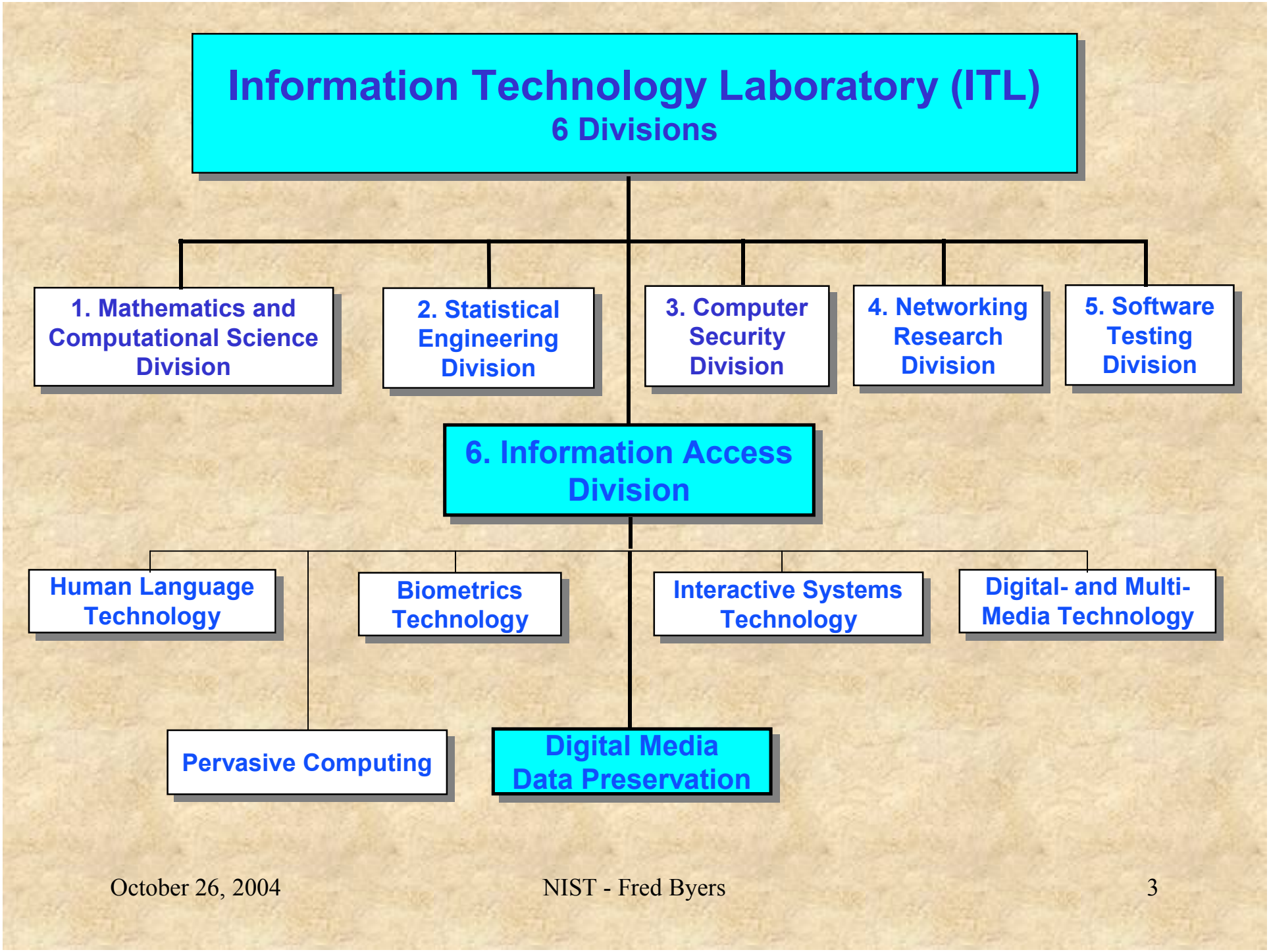
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Interactive Systems Technology
Digital- and Multi-Media Technology
Pervasive Computing
Digital Media Data Preservation

Topics

- ✓ Concerns/questions about optical discs
- ✓ Care and handling
- ✓ Recording quality
- ✓ Discs for archiving
- ✓ Test method proposal
- ✓ Optical disc compared to tape
- ✓ Monitoring disc performance

*Survey of the Government Information Preservation Working Group

- All agencies are expecting exponential growth in the volume of their digital assets.
- Media specific concerns are:
  1. Capacity of medium
  2. Reliability, durability – long-term accessibility of complete data on the medium.
  - Also:
  3. Would like media designed for long-term storage use.
  4. Would like media analysis tools.

*Source: GIPWoG Survey, Dec. 2003

Common User Questions About Using Optical Discs

- Can I trust optical discs for long-term or archival storage?
- How long will the content on my disc last?
- What is the minimum number of years I can expect?
- Which disc should I buy?
- What should I look for in a disc?
- Does price or brand make a difference?
- Does the recorder make a difference?

These above points are not unique to optical discs.

Most Commonly Asked Question:

How long will optical discs last?

Answer -
It depends on:

1. Care and handling
   - Physical handling
   - Environmental influences
2. Initial recording quality
   - Condition of disc before recording
   - Quality of burn (depends on disc and burner)
3. Disc construction
   - Materials
   - Manufacturing process, quality control

What the user can control to effect disc longevity

- √ Proper handling
  - No scratches, CD label-side, fingerprints, etc.
- √ Proper storage
  - Avoid high heat/moisture and direct sunlight, UV light
- ? Initial recording quality
  - Good disc – clean, defect free, good recorder
- × Disc construction
  - Dependant on manufacturer

√ Care and Handling

Do Not Scratch the Disc

- Scratches going around the disc can be worse than scratches going outward from the center.
- Scratches on the label side of CDs can be more harmful than the other side.
  - That's where the data is.
  - Scratches on the label side can not be repaired.
- Use "CD Safe", alcohol-based or water based-markers for labeling.
- No hard points on CDs.

√ Care and Handling

Repairing

- What works?
  - Professional or commercial disc repair machines work the best.
    - Cost - in several hundred dollar range
- The others:
  - Pastes?
  - Hand crank devices?
  - Electrical powered devices?
- Disaster recovery from water effect
  - Drying out test

√ Care and Handling

Cleaning

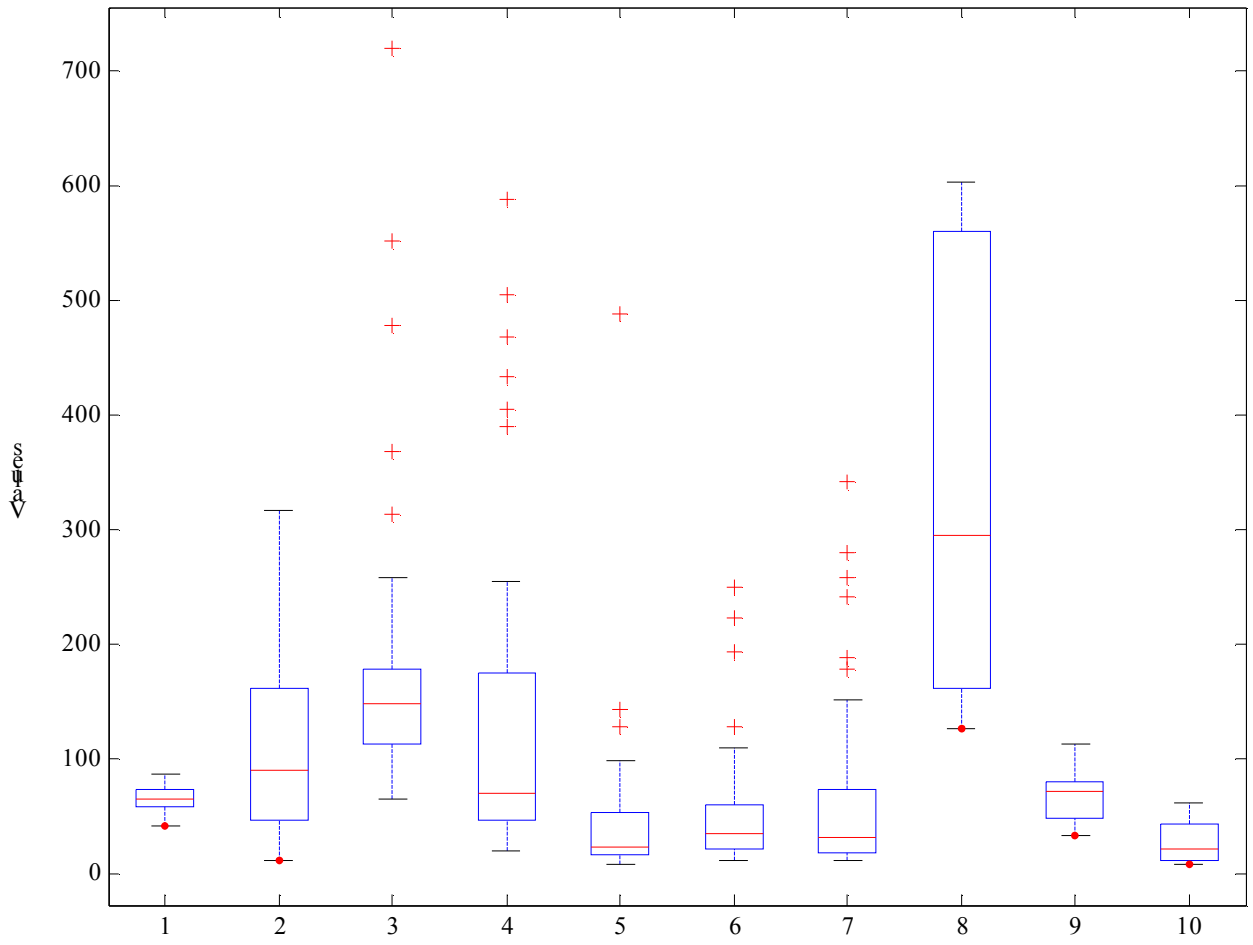
- What is okay?
  - Dry cotton cloth or other clean/soft material that will not scratch the disc
  - Water
  - Disc cleaning solution
  - Lens cleaning solution
  - Alcohol/Rubbing Alcohol
  - Compressed air/gas duster or blaster

√ Long-Term Storage

- Store in:
  - Cool (≤ 20ºC) cooler is better
  - Dry (< 50%RH) dryer is better
  - Out of direct sunlight or other UV light
  - Vertical position

? Initial Recording Quality

- How do you know?
  - If you are fortunate enough to have access to a disc analyzer
  - Word-of-mouth, or experience with the recorder and media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Disc Construction:

"Archival", "More Durable" Media?

- Discs marketed for long-term storage
  - How are they different from regular discs?
  - How many years will they last? Longer LE?
  - How does manufacturer A compare to manufacturer B?
  - How are they determined to be longer lasting?
- No standard short test for measuring these discs.
- Existing LE standard test is time consuming, expensive:
  - Typically one to two years – too long for bringing disc to market
  - Need equipment , space, expertise
  - Cost of skilled labor resource, or cost of out sourcing

Proposed Method for “Archival Disc” Test

- Industry Standard Test Method
  - Level the playing field for testing
- A test that industry accepts
  - Industry support
- Labeling for consumers
  - Statement of meeting test requirement or a logo

Existing CD-R Standard LE Test:

Constants:	Derived from test data:	Calculate:
K, T (Temp.), RH	A, ΔH, B	T_{50} (Time)

$$T_{50} = Ae^{\Delta H/kT}e^{(B)RH} \quad \text{OR} \quad \ln T_{50} = \ln A + \Delta H/kT + (B)RH$$

Existing CD-R Standard LE Test:

Constants:	Derived from test data:	Calculate:
K, T (Temp.), RH	A, ΔH, B	T_{50} (Time)

$$T_{50} = Ae^{\Delta H/kT}e^{(B)RH} \quad \text{OR} \quad \ln T_{50} = \ln A + \Delta H/kT + (B)RH$$

Alternative Use of Existing Equation

Constants:	Derived from T_{50}= 50:	Do not Calculate T_{50} :
K, T (Temp.), RH, T_{50}	A, ΔH, B	Make T_{50} = 50years (example)

$\ln T_{50}$ for 50 years = 12.99 at 20ºC, 50%RH

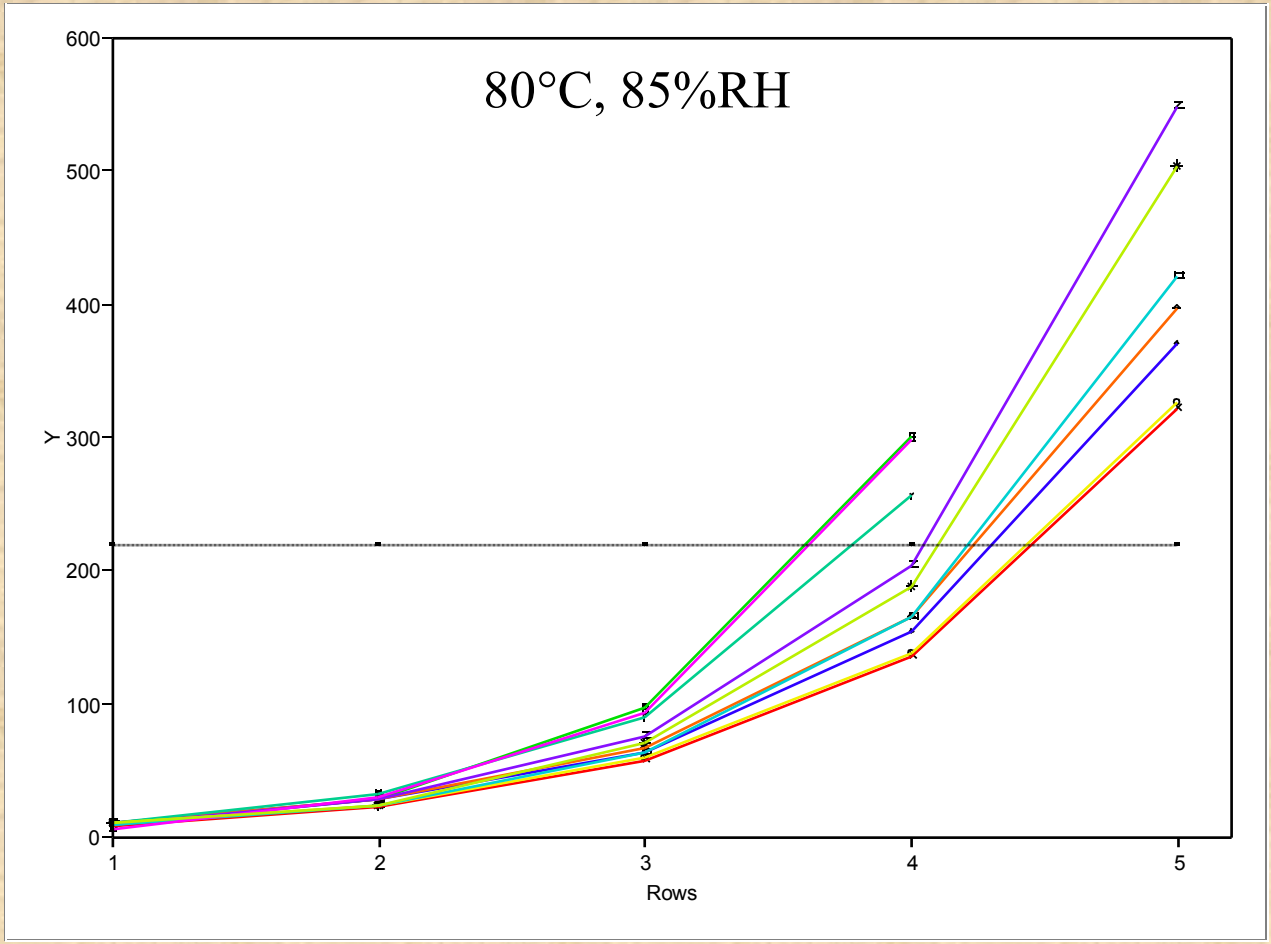
$\ln T_{50} = 12.99$

$\ln 12.99 = \ln A + \Delta H/kT + (B)RH$

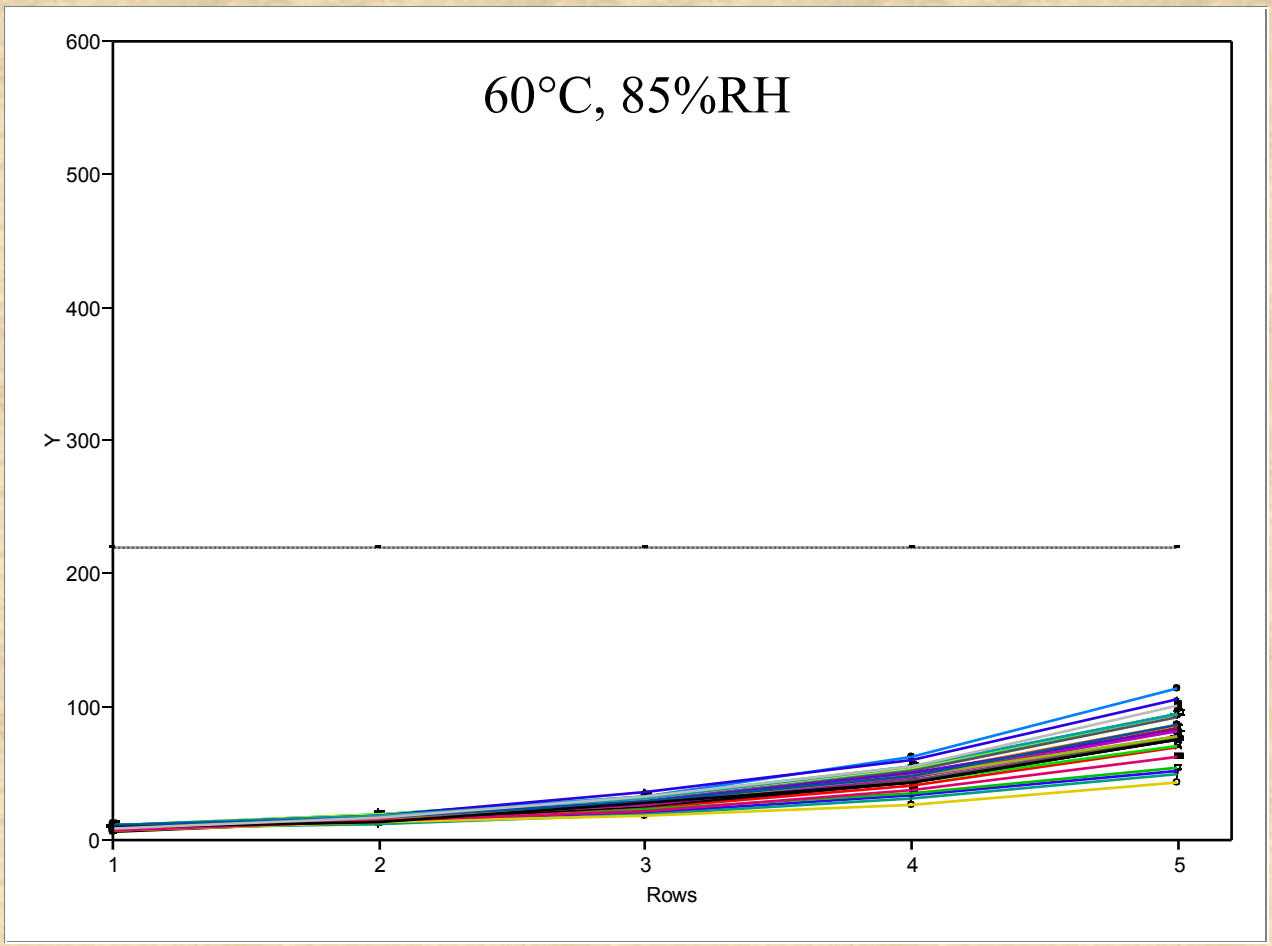
Performing the short test

- Test at three stress test levels (instead of five) long enough to determine A, ΔH, B.
  - "Long enough" time needs to be determined.
  - Need shorter total test time (ideally less than 10 weeks total).
  - Will also need shorter incubation time intervals.
- Compare A, ΔH, B against predetermined minimum values that calculate to T_{50} = 50 years at 20ºC, 50%RH

First Stress Test Set
500 hour intervals x 4



Fifth Stress Test Set
1000 hour intervals x 4



Consumer/Industry Benefits From "Archival Grade" Test Method

- Consumer
  - Consumer uncertainty reduced
  - More realistic consumer expectation
  - Better, or more confident migration planning
- Industry
  - Industry-wide standard test method
  - Time to market
  - Testing cost (compared to existing LE testing)
  - Pricing (cost/margin recovery for testing, QC, etc.)

Primary Optical Disc Choices

Infrared Laser	Red Laser	Blue-Violet Laser
CD-R, CD-RW	DVD-R, DVD+R, DVD-RW, DVD+RW, DVD-RAM	Blu-Ray HD-DVD UDO PDD Holographic (soon?)

Disc Capacities

CD-R, CD-RW	one-sided	650-700MB
DVD-R, DVD+R, DVD-RW, DVD+RW	one-sided	4.7GB
DVD+R	one-sided, dual layer	8.5GB
DVD-RAM	one-sided	4.7GB
DVD-RAM	two-sided	9.4GB
BluRay	one-sided	23-27GB
HD-DVD	two-sided	30GB
ProData Disc	one-sided	23GB
UDO	two-sided	30GB
Holographic (soon?)	one-sided	200GB

Market Drivers

Initial Market Application	
CD-R, CD-RW	Audio
DVD-R, DVD+R, DVD-RW, DVD+RW	Video
DVD-RAM	Data Storage
BluRay	HD-Video
HD-DVD	HD-Video
ProData Disc	Data Storage
UDO	Data Storage
Holographic	Data Storage

Compared to Tape

Recordable Optical Disc Advantages	
Life expectancy	Longer Life Expectancy
Write-once protection	True WORM available (R, or Replicated (ROM))
Random File Access	Faster Access Time
Portability	CD/DVD drives are more pervasive than tape drives
Relative Stability	Maintenance cycles longer
Distribution	Replicate for large distribution

Compared to Tape

Recordable Optical Disc Disadvantages/Limitations	
Large files or data-sets	Cannot fit all on one disc.
High data volume	More discs and physical space to manage.
Cost	TCO may be less with tape?
Familiarity	Infrastructure, experience, already in place for tape.

Optical Disc, Tape Comparisons

Medium	Storage Capacity	Write Transfer Rate
DVDR DL - 16X	8.5GB	22.16MBps
DVDRW - 4X	4.7GB	5.54MBps
DVD-RAM – 4X	9.4GB	5.54MBps
UDO	30GB	5.54MBps
PDD	23.3GB	9MBps
Holographic	200GB	20MBps?
DAT	36GB	3.5MBps
DLT-600	300GB	36MBps
LTO-2	200GB	28.5MBps
AIT	100GB	12MBps
SAIT	500GB	30-78MBps

*Request for Analysis Tools

A suggestion for drive manufacturers

*GIPWoG Survey, Dec. 2003

- Measuring Performance - Early Warning Indicator

- Could also be called:
  - Error Alert
  - Check Disc
- A warning about error rates that are approaching BLER-max (CD) or PI-SUM8 max (DVD).
  - May also consider burst errors, reflectance or other parameters
- Could be:
  - A light as an indicator
  - A pop-up window giving suggestions for corrective action
  - Actual number shown (good for initial error rate)
- Could be included in every drive or only high-end drives.

Consumer/Industry Benefits From "Early Warning Indicator"

- Consumer
  - Easy monitoring of disc performance
  - Copy disc before uncorrectable errors occur
  - Significantly reduce the chance of a catastrophic failure
- Industry
  - Value added drives
  - Higher-end drives?
  - Drives as testers

Disc Management Opportunity?

- Using RFID
  - Imbedded?
  - Track recording date
  - Errors at last use?
  - Manufacturer number
  - Format version

What Users Can Do

- Define what “archival” means or what length of time is needed for long-term storage requirements.
  - Determine the minimum length of time needed the medium must last to satisfy your requirements?
  - What is the ideal length of time?
- Does longevity of the medium matter over the storage time needed?
- Determine which media will satisfy volume or data sets sizes?
- Determine if write speed, transfer rate, or access speed matters?
- Try to determine the TCO over the total expected storage time using each medium type.

Thank you!

NIST

Information Access Division

Information Technology Laboratory

Digital Data Preservation

Fred Byers, Oliver Slattery, Jian Zheng

http://www.itl.nist.gov/div895/preservation/

Care and Handling Guide

http://www.itl.nist.gov/div895/carefordisc/

Incubation + Testing Time

No. of Chambers	Incubation time	No. of weeks	Testing time (2 analyzers)	Total Time
1	13,000 hrs	78 wks	6 wks	84 wks
2	7,000 hrs	42 wks	6 wks	48 wks
3	5,000 hrs	30 wks	6 wks	36 wks
4	4,000 hrs	24 wks	6 wks	30 wks

LE - Accelerated Aging Times

Stress Test-Set	Stressed at (T_{inc}, RH_{inc})	Incubation duration	Minimum total time	Specimen quantity
1	80ºC, 85%	500 hrs	2000 hrs	10
2	80ºC, 70%	500 hrs	2000 hrs	10
3	80ºC, 55%	500 hrs	2000 hrs	15
4	70ºC, 85%	750 hrs	3000 hrs	15
5	60ºC, 85%	1000 hrs	4000 hrs	30
			13,000 hrs total	80 total

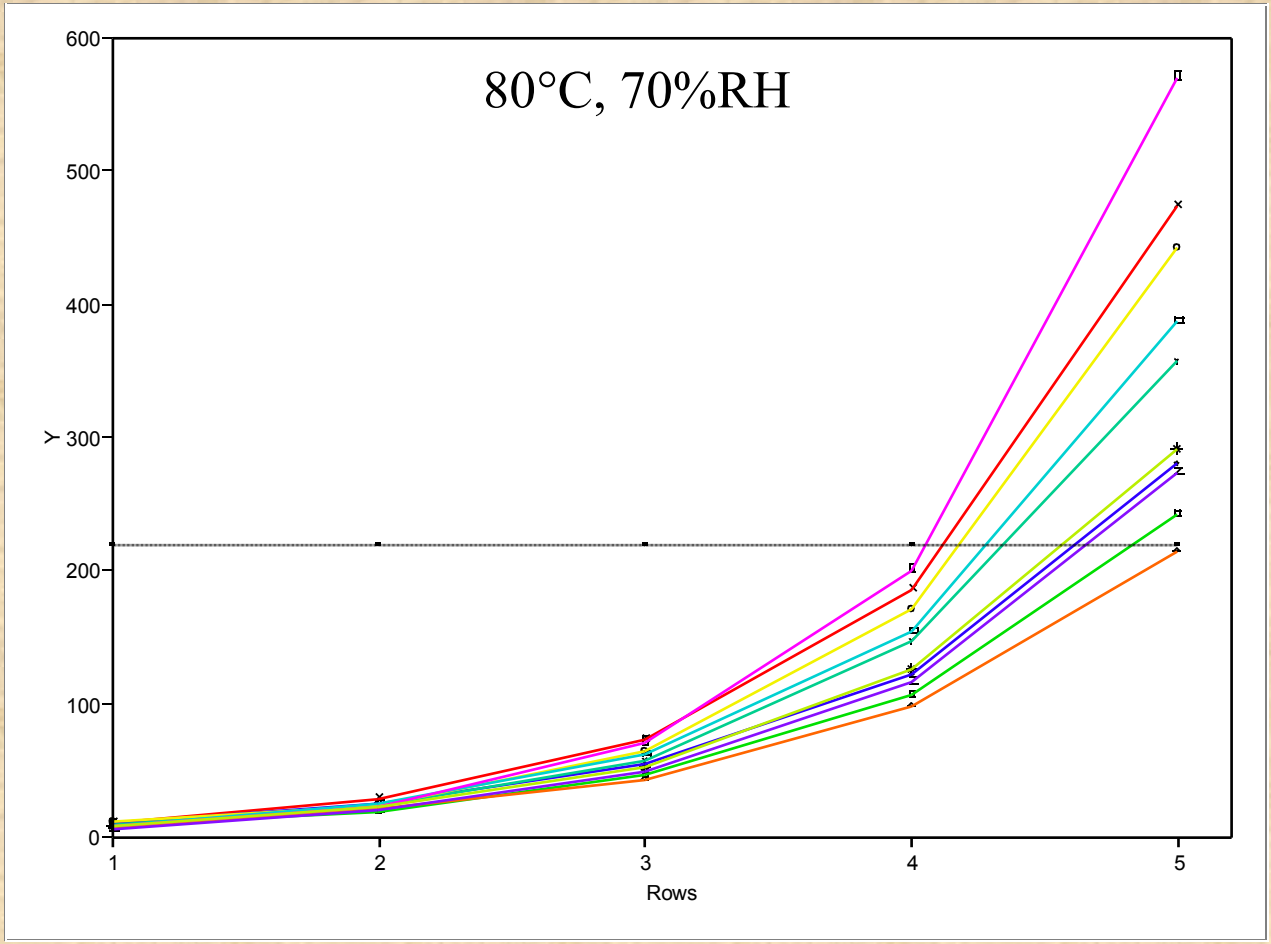
CD-R LE Test Standard Data Calculated

Using the standard's data for 14.7 years

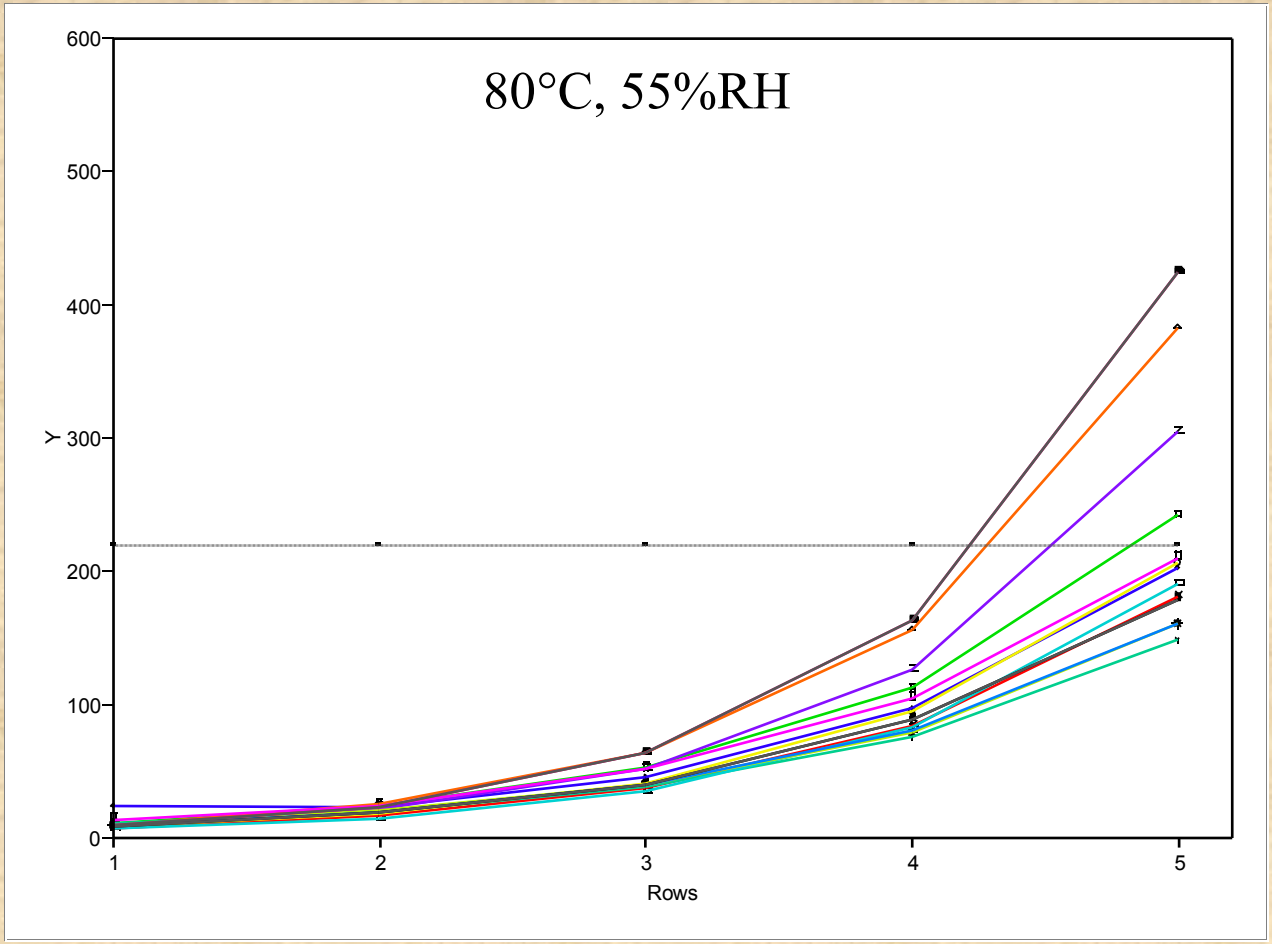
			Condition Variables			
	Condition	**Celcius**	**T**	**RH%**	**H/k / T**	**B(RH)**
Storage	25C/50%RH	25	298.15	50	2.63E+01	-4.86E-01
Storage	20C/50%RH	20	293.15	50	2.67E+01	-4.86E-01

ln(t50) = ln mean =	**Projected Time to Failure**	
ln(A) + (ΔH/k)/T + B(RH)	**EXP(ln(t50)) = Hours**	**Years**
11.77	129220.77	14.75
12.22	202238.79	23.09

Second Stress Test Set
500 hour intervals x 4



Third Stress Test Set
500 hour intervals x 4



Fourth Stress Test Set
750 hour intervals x 4