

# Optical Surface Quality: A Gauge R&R of the Scratch Standard

Presented to the OP1 working group of OEOSC

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**Jonathan McGuire**

Optical Engineer  
Northrop Grumman Corporation

# An Imperfect Standard

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- **Everyone is aware this standard is subjective**
- **The depth and breadth of this subjectivity is the focus of the study**
  - Both Northrop Grumman Rolling Meadows and Laser Systems have performed GR&R studies to date

# Design of Experiment

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- **Gauge Repeatability and Reproducibility experiment**
- **6 Inspectors**
  - 3 from receiving, 3 from the floor
- **10 sample artifacts**
  - Actual Brysen standards, cut in two
  - 2 mirrored, 8 transparent
- **Two Standards, “Old” (out of cal, but unopened) and current (in calibration)- dubbed “New” herein**
  - Old is to serve as a reference/control only
- **Randomized Inspection**
  - Each sample is inspected twice/standard
  - 240 total data points

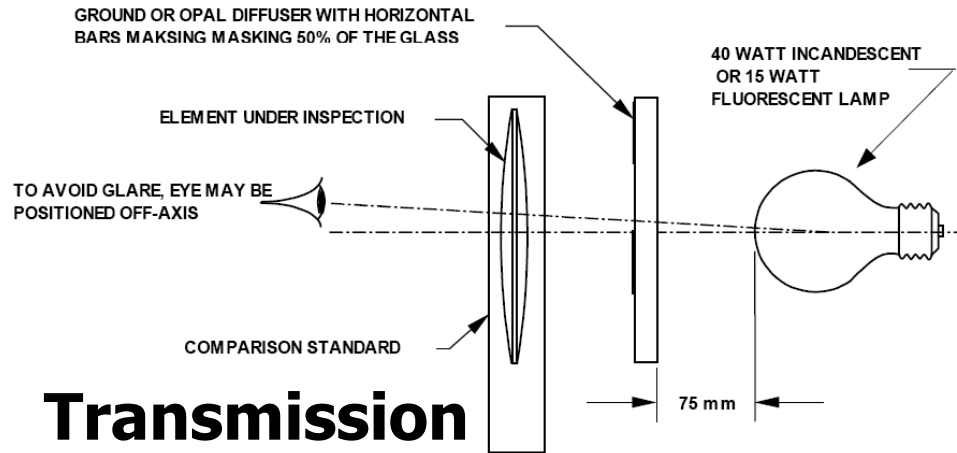
# Potential Sources of Error

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- **Small Sample Size**
  - Large Confidence Intervals
- **Lighting Conditions**
  - Test conditions held constant as best as possible
- **Contamination**
  - Artifacts
    - SEM analysis shows minimal contamination
  - Standards
    - Old standard has not been opened since last Calibration; March 2001- Some contaminants (dust, etc.)
    - New standard in Cal – Some contaminants
- **Human Error**
  - Inspectors instructed to inspect as they normally would under normal conditions

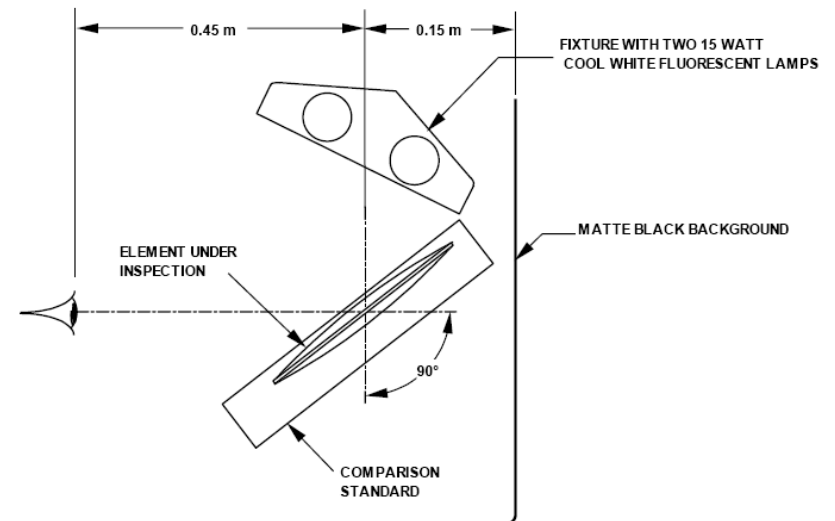
# Chosen Inspection Methods

- Taken from ANSI/OEOSC OP1.002-2006



## Transmission

## Reflection



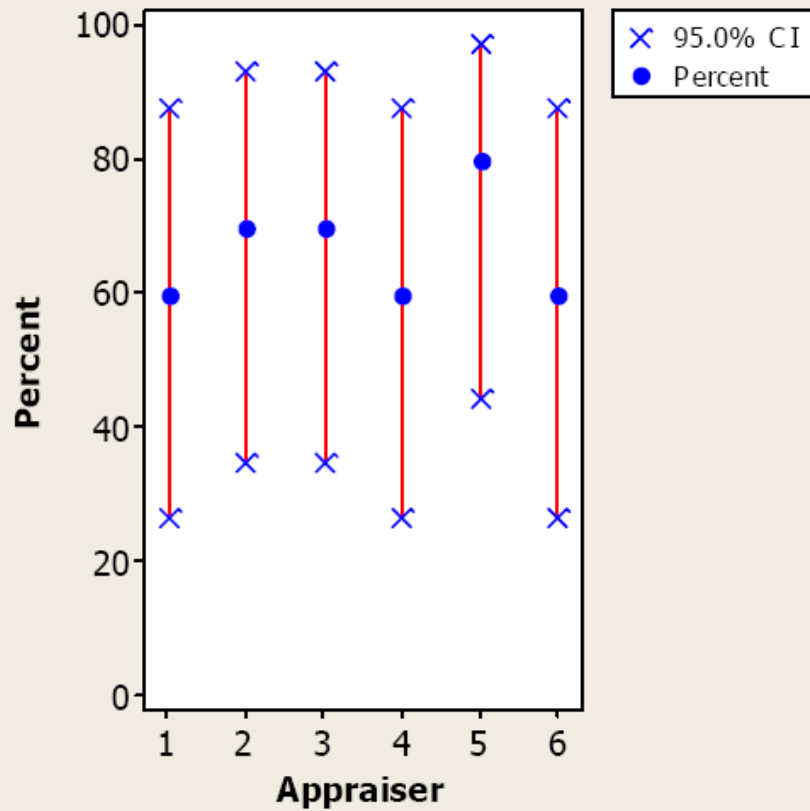
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# Agreement using Old standard

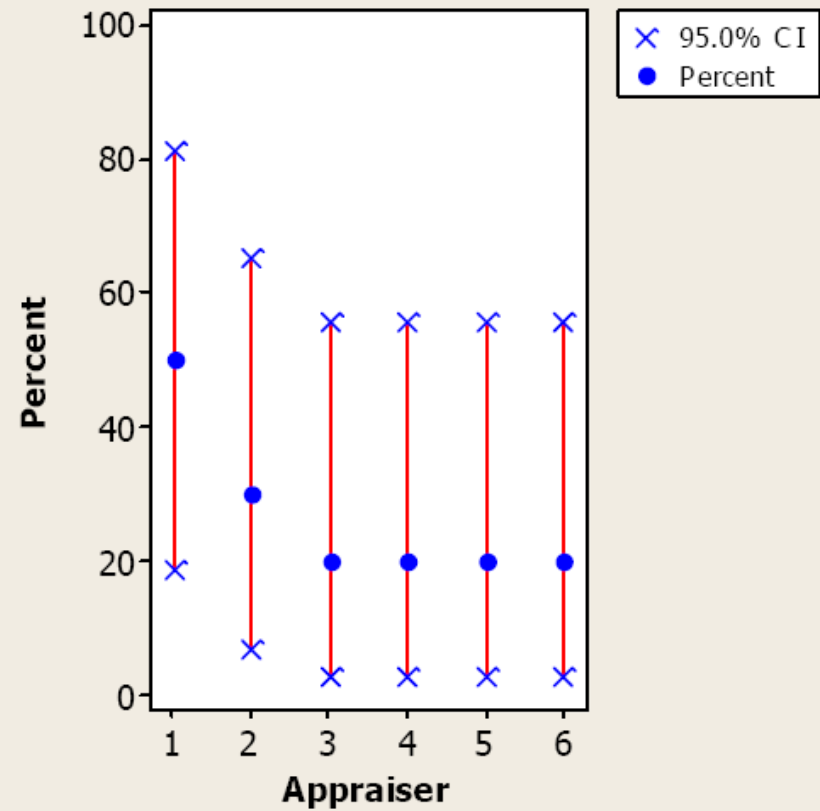
## Assessment Agreement

Date of study: July 2007  
Reported by: Jonathan M. McGuire, Optical Engineer  
Name of product: Laser Systems Scratch Assessment Study  
Misc: Using Old Standard

### Within Appraisers



### Appraiser vs Standard

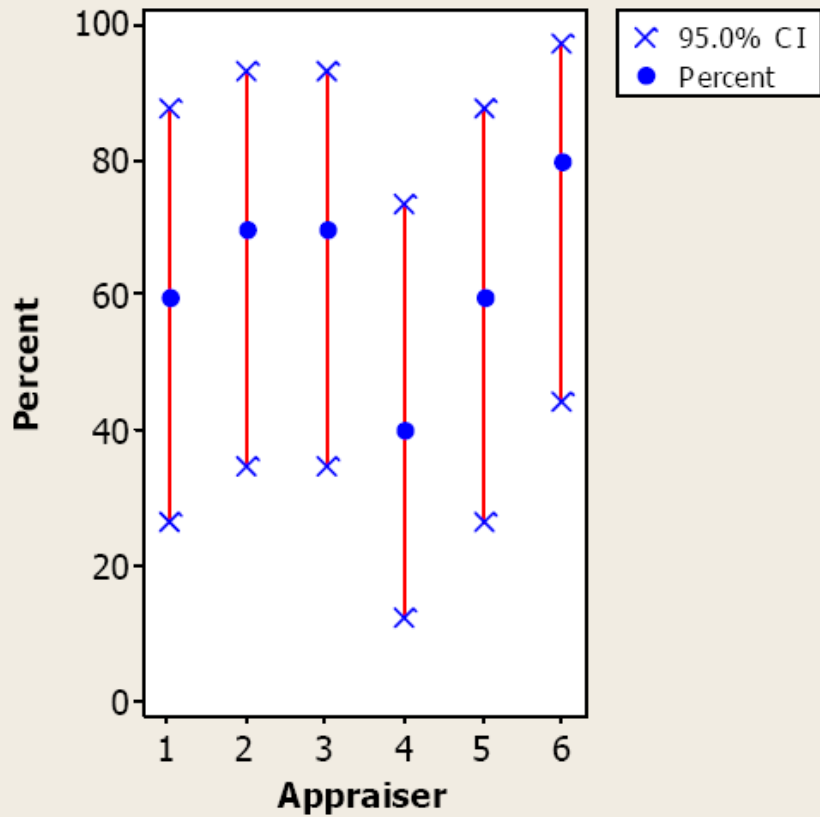


# Agreement using New standard

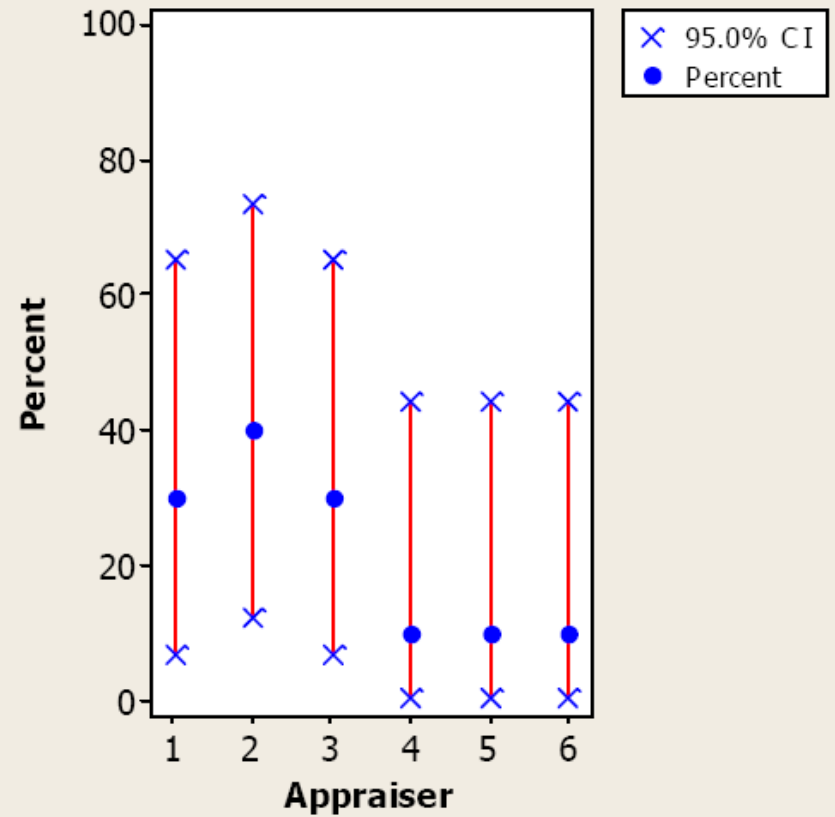
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### Within Appraisers



### Appraiser vs Standard



# Assessment Agreements

## Old Standard

### Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95 % CI
10	0	0.00	(0.00, 25.89)

# Matched: All appraisers' assessments agree with each other.

Kendall's Coefficient of Concordance

Coef	Chi - Sq	DF	P
0.788654	85.1746	9	0.0000

### All Appraisers vs Standard

Assessment Agreement

# Inspected	# Matched	Percent	95 % CI
10	0	0.00	(0.00, 25.89)

# Matched: All appraisers' assessments agree with the known standard.

Kendall's Correlation Coefficient

Coef	SE Coef	Z	P
0.436533	0.0717219	6.06065	0.0000

## New Standard

### Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95 % CI
10	1	10.00	(0.25, 44.50)

# Matched: All appraisers' assessments agree with each other.

Kendall's Coefficient of Concordance

Coef	Chi - Sq	DF	P
0.637919	68.8953	9	0.0000

### All Appraisers vs Standard

Assessment Agreement

# Inspected	# Matched	Percent	95 % CI
10	1	10.00	(0.25, 44.50)

# Matched: All appraisers' assessments agree with the known standard.

Kendall's Correlation Coefficient

Coef	SE Coef	Z	P
0.339778	0.0717219	4.71162	0.0000

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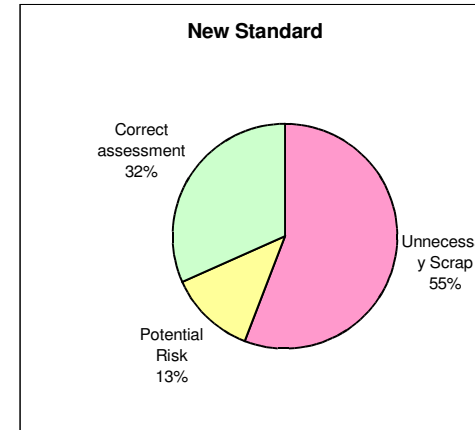
# Results

Assessment using the New Standard

Actual	10	20	40	60	80	Total
10	10	1	7	6	10	24
20	2	3	15	4		24
40	3	1	12	7	1	24
60		1	1	6	16	24
80		1		6	17	24
Total	5	7	35	29	44	120

New Std

	Counts	Percent	
Unnecessary Scrap	67	56%	(false rejections = Producer's risk = Alpha risk)
Potential Risk	15	13%	(false acceptances = Consumer's risk = beta risk)
Correct assessment	38	32%	

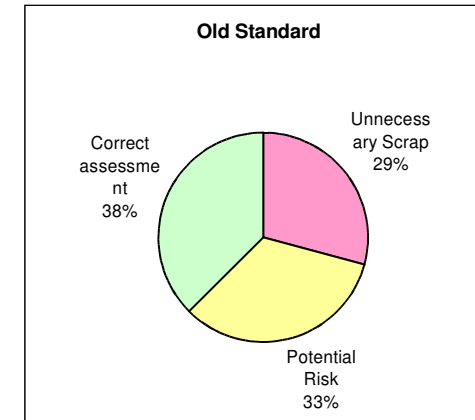


Assessment using the Old Standard

Actual	10	20	40	60	80	Total
10	10	5	9	9	1	24
20	4	16	4			24
40	2	15	7			24
60			11	6	7	24
80			4	4	16	24
Total	6	36	35	19	24	120

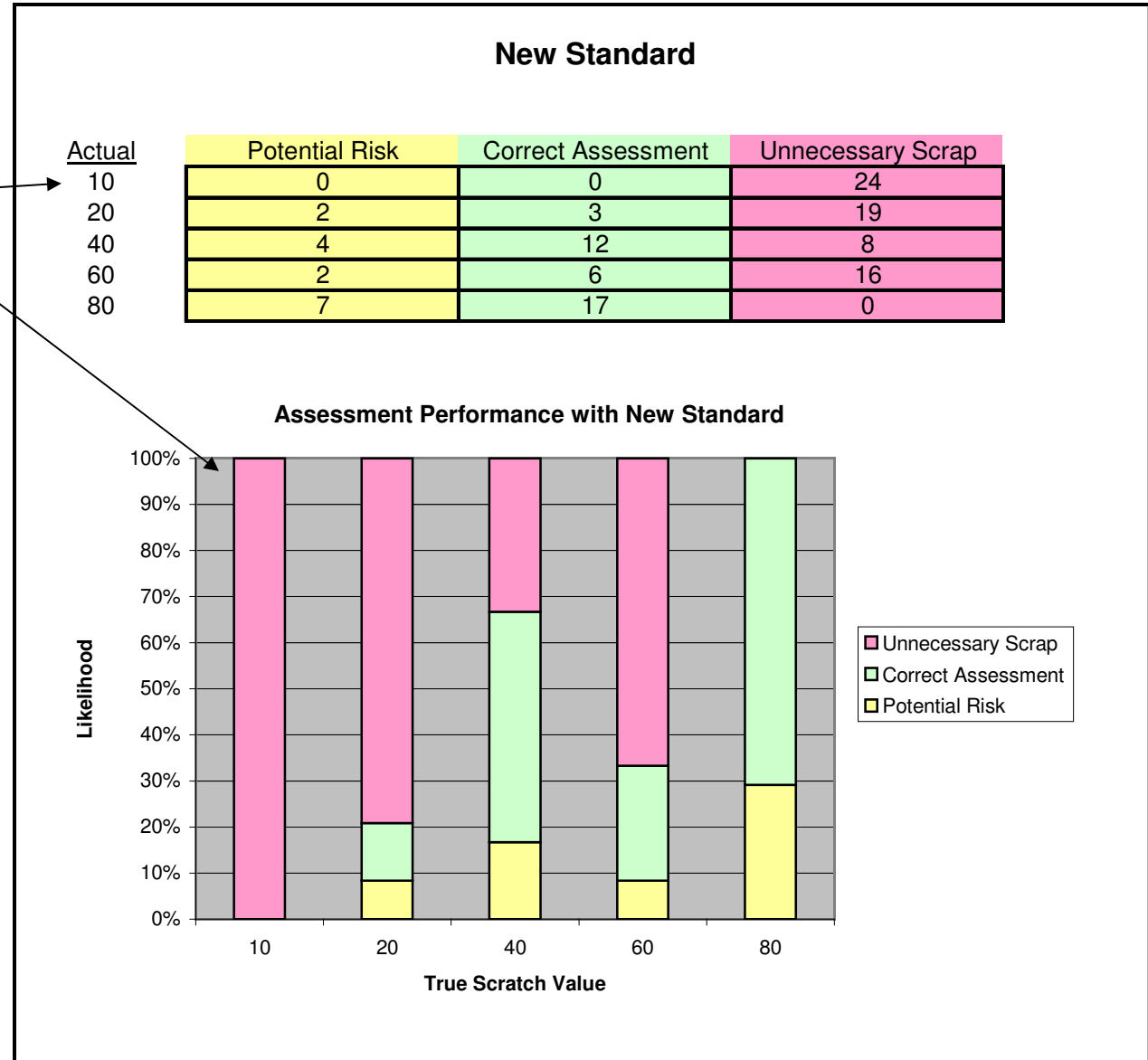
Old

	Counts	Percent	
Unnecessary Scrap	35	29%	(false rejections = Producer's risk = Alpha risk)
Potential Risk	40	33%	(false acceptances = Consumer's risk = beta risk)
Correct assessment	45	38%	



# Results by Category

**Note the 100% rejection rate of #10 scratch; typically denoted as "laser grade" throughout the industry. The implication is that parts are blemish free or will be rejected.**



# Rolling Meadows Data

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# Looking Forward

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- **This problem is potentially industry wide**
  - The scope of the GRR should be expanded
    - More samples (0's and >80's)
    - More operators
- **This begs the question, what can be done?**
  - Ari Siletz has proposed removing much of the human element via the SCR-1
  - Presumably it will be better
    - Can it work with real optics?
    - How good is good enough? >90%? Better?

# Material Sources

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## Data

- Taken at Northrop Grumman

## Analysis

- Steven Kramer; NGRM
- Steven Piazza; NGLS

## Thanks

- John Hamilton; NGRM
- OEOSC