The 2010 NIST Fingerprint Compression Study

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Compression Study Team

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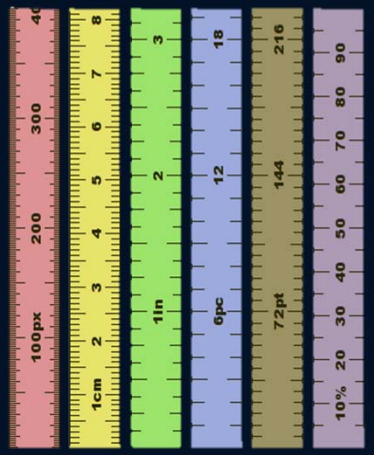


At NIST we specialize in measurement science.

Our most recent effort involved measurement of the impact of compression on 1000ppi fingerprint images. Here is why...

State-of-industry:

Fingerprint capture, transmission and processing at 500ppi.

State-of-art*:

Fingerprint capture, transmission and processing at 1000ppi, and some entities already support this.

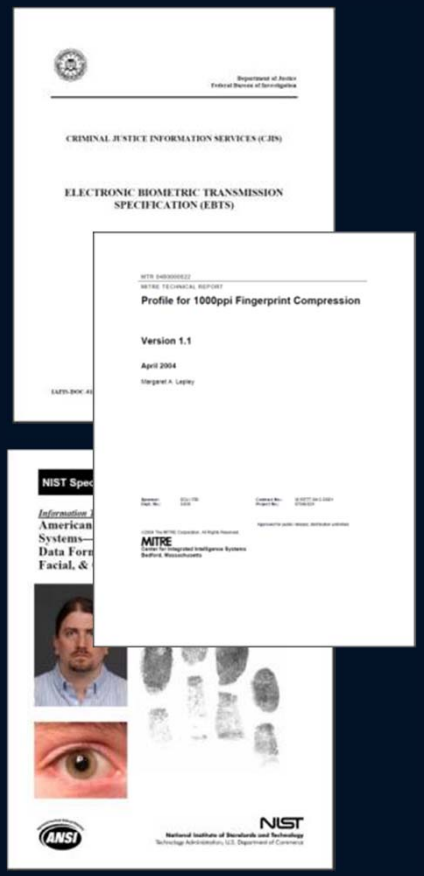
NGI will be a big driver for 1000ppi.

NIST Fingerprint Compression Study

500ppi guidance is really a mosaic of a few things:

- Scanner Certification
  - FBI Appendix F, PIV
- Data Compression
  - WSQ certification
  - Compression guidance from 1994 IAI study (Fitzpatrick et al)
- Data Transmission Standards
  - ANSI/NIST, FBI EBTS, etc.

NIST Fingerprint Compression Study



Current 1000ppi guidance consists of:

- Scanner Certification
  - FBI Appendix F, PIV
- Data Compression
  - CODEC* ***self*** certification
  - MITRE profile for JPEG-2000 (MTR-04B0000022)
- Data Transmission Standards
  - ANSI/NIST, FBI EBTS, etc.

*CODEC: COmpressor / DECompressor

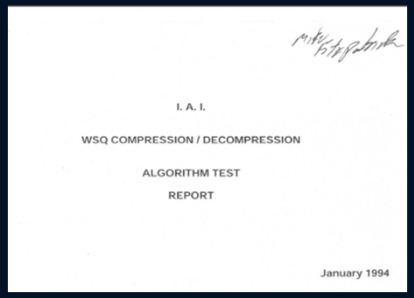
NIST Fingerprint Compression Study

The effort to bring 1000ppi to mainstream has worked, but some gaps remain:

- Gaps in JPEG-2000 guidance that trace back to original WSQ guidance (slaps, livescan, etc.)
- Self-certification: Lessons learned from WSQ support a more formalized certification process
- Need for formal traceability for JPEG-2000 CODECs
- Efforts to modify WSQ for 1000ppi

Back to the 500ppi guidance slide, bullet #2:

- Compression guidance from 1994 IAI study


I. A. I.

WSQ COMPRESSION / DECOMPRESSION

ALGORITHM TEST

REPORT

January 1994

This study was key in establishing the current 15:1 guidance.

Our study builds on the MITRE work and repeats the IAI study, with some expansion in the protocol to provide a more comprehensive basis for 1000ppi fingerprint compression and address some of gaps.

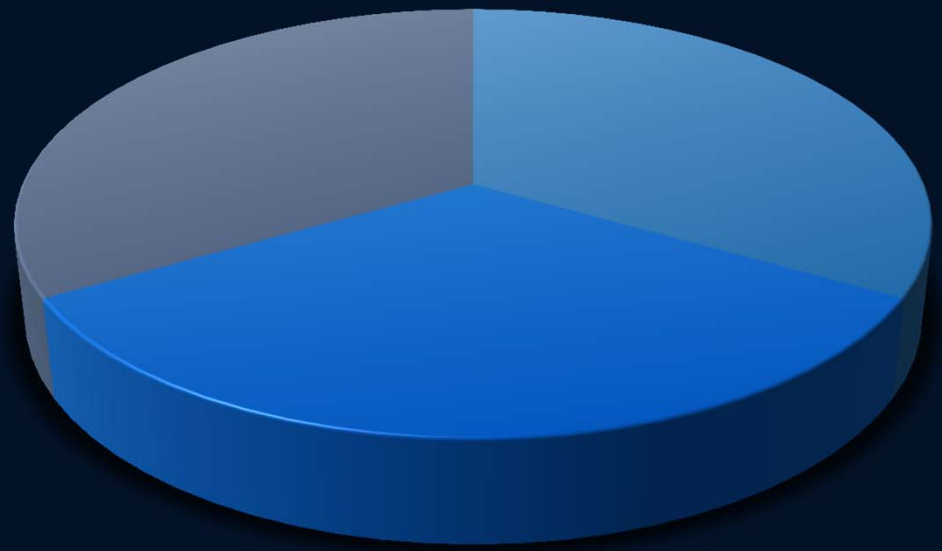
IAI Compression Study:

- Looked at rolled fingerprints
- Examined 100 images at each 5:1, 10:1, 15:1 and 20:1
- Utilized 2 expert examiners to independently judge acceptable compression loss, and a 3rd examiner acted to break the tie/build consensus in case of disagreement*

Results of IAI study:

Provided guidance for compression ratio (15:1)

The 2010 Compression Study has 3 Components to it:



*: Focus of this presentation, modeled after IAI study

NIST Fingerprint Compression Study

The NIST 2010 compression study is modeled after the IAI study and builds on MITRE's work (MTR-04B0000022). Goals included:

- Large scale test of compression guidance in MTR-04B0000022
- Test wider range of compression ratios from 2:1 to 38:1 than the original IAI study.
- Test wider range of impression types: rolled, flat, slaps.
- Test live-scan in addition to card scan (everyone asked for it)
- Recommend to FBI certification path, tools
- Reference CODEC
- Traceability

As a sidebar/component of the compression study, we'll also touch upon the following in the final report:

- PNG, a standard/recommended recipe...
- JPEG-2000 Lossless
- Some guidance on measuring compression loss, tools for this (Son of "SIVV"!!! SIVV2.X)

Details for the above are in the final report.

Highlights of where the 2010 study's expanded on the IAI study:

- Data: More of it. In addition to rolled images, also includes flats & slap-4's
- Capture mode: In addition to card-scan, also now includes live-scan.
- More ratios: In addition to 5:1, 10:1, 15:1 and 20:1 also includes 2:1, 7:1, 12:1, 17:1, 22:1, 26:1, 30:1, 34:1 and 38:1

Highlights of where the 2010 study's diverged from the IAI study:

- 3 Expert examiners used all the way through (rather than 2 plus tie breaker)
- Attempted to identify cases of level 3 detail loss, and level 2+3 detail loss separately.
- Attempted to eliminate bias by not indicating which image was compressed and which was the original.
- Included 1:1 control-case*.
- Created a separate condition of establishing ident/non-ident decision before quantifying compression loss.

2010 Compression Study Test in a Nutshell:

- Utilized 3 examiners at the same time
- Examiners are shown 2 images, one compressed and one original.
- First, examiners asked to make ident decision on the pair of images.
- Next, examiners asked to make subjective evaluation of compression fidelity loss.
- Each examiner sees each unique image pair only once (no dupes). Each unique image pair guaranteed to be seen by 3 different examiners.
- Examiners are not told which image is compressed and which is the uncompressed.
- Examiners are provided only very basic tools.
- Examiner stations are calibrated and equal.

2010 Compression Study Test Tool (aka “FIXT”) UI:

Judgment Criteria for IAI 1994 Study:

1. No noticeable reduction in image quality
2. Slight reduction in image quality which may interfere with an identification based on poroscopy, ridgeology, or other non-Galton details.
3. Noticeable reduction in image quality which may interfere with an identification based on the Galton details.

Judgment Criteria for 2010 Compression Study:

1. No apparent image quality degradation and the quality of Level II(2) and Level III(3) detail in either image should not cause any difficulty in reaching a conclusive decision of identification or exclusion.
2. A noticeable degradation in the quality of Level II(2) or Level III(3) detail in either image, but not enough to have a negative impact on reaching a conclusive decision of identification or exclusion, though the amount of time to reach a decision may increase.
3. Level III(3) detail quality diminished in either image to the extent that a Level III(3) identification is questionable or not possible, and/or is significantly more difficult.
4. Level II(2) detail quality diminished in either image to the extent that a Level II(2) identification becomes questionable or not possible, and/or is significantly more difficult.

2010 Compression Study Test Data

200 pairs each at 14 ratios x 20 cases (56000 pairs)

Card Roll-Roll Ident Card Roll-Roll Non-Ident Card Slap4-Slap4 Ident Card Slap4-Slap4 Non-Ident Card Flat-Flat Ident	Card Flat-Flat Non-Ident Card Flat-Roll Ident Card Flat-Roll Non-Ident Card Roll-Flat Ident Card Roll-Flat Non-Ident	Done. This presentation is based on preliminary data from these blocks.
Live Roll-Flat Ident Live Roll-Flat Non-Ident	Live Flat-Roll Ident Live Flat-Roll Non-Ident	Pending. Almost done. ETA is by August.
Live Roll-Roll Ident Live Roll-Roll Non-Ident Live Flat-Flat Ident	Live Flat-Flat Non-Ident Live Slap4-Slap4 Ident Live Slap4-Slap4 Non-Ident	Queued. ETA by September..

Preliminary Look at Results*:

- ✓ 15:1 is a viable recipe for rolled-print compression and results on card-scan rolled-prints seem to verify this.

CENSORED / TBD

:1 appears to be a better target for several cases. Need to work on cost function to evaluate benefit/disadvantages of going to

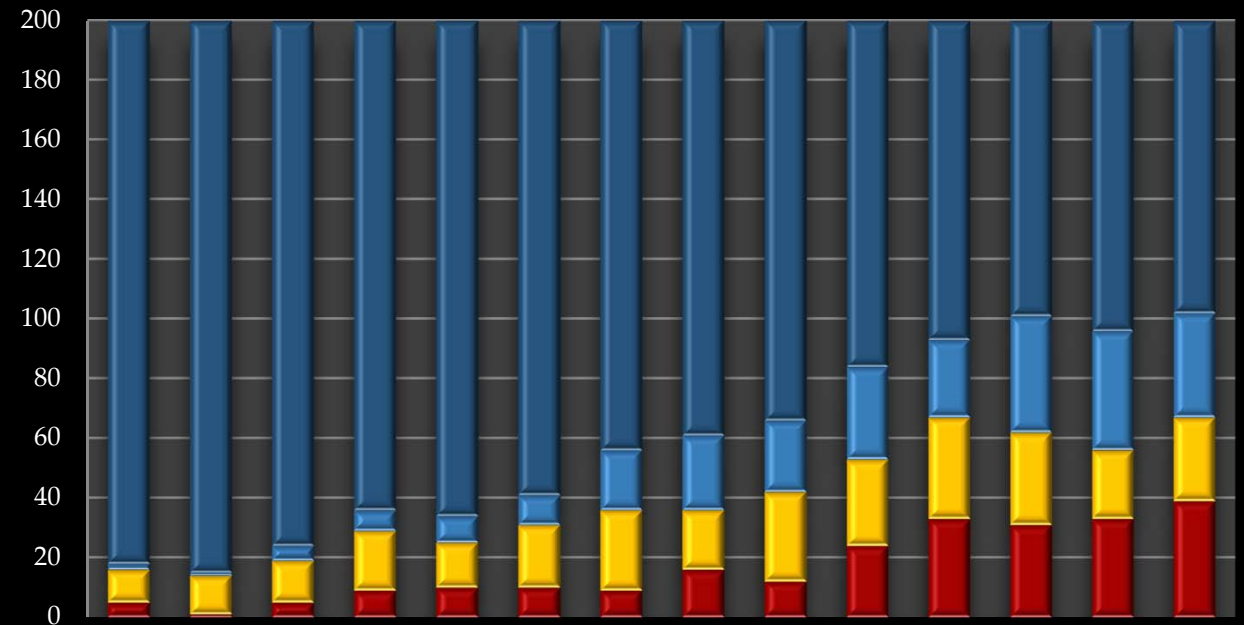
CENSORED / TBD

:1 once live-scan data is complete as well.

Compression loss can at times help (low-pass filtering).

*: Pending further analysis, and incorporation of results from live-scan data.

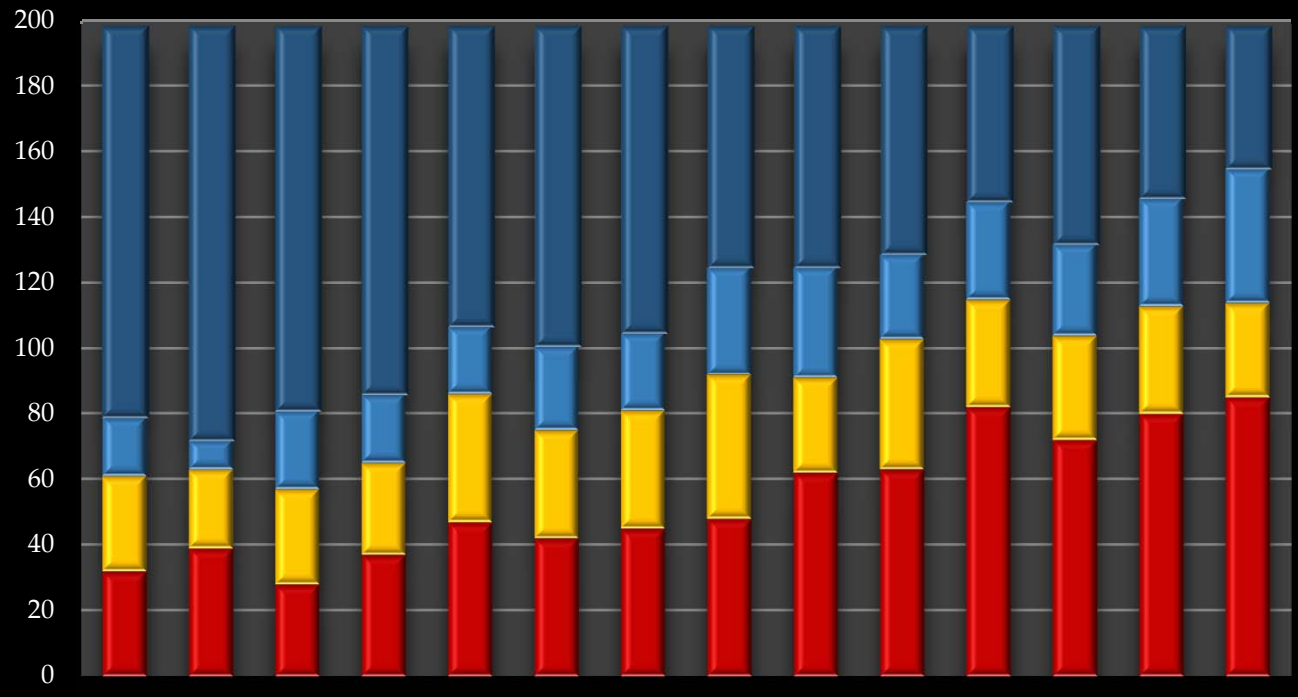
Compression Loss
Card Rolled (No Compression) → Card Rolled (Compressed), Mated (Same Print)



No Significant Loss	182	185	176	164	166	159	144	139	134	116	107	99	104	98
No Significant Loss (Majority 223/224)	2	1	5	7	9	10	20	25	24	31	26	39	40	35
Split/Level 3 Impact (123)	11	13	14	20	15	21	27	20	30	29	34	31	23	28
Signficant Level 2 and/or 3 Impact	5	1	5	9	10	10	9	16	12	24	33	31	33	39

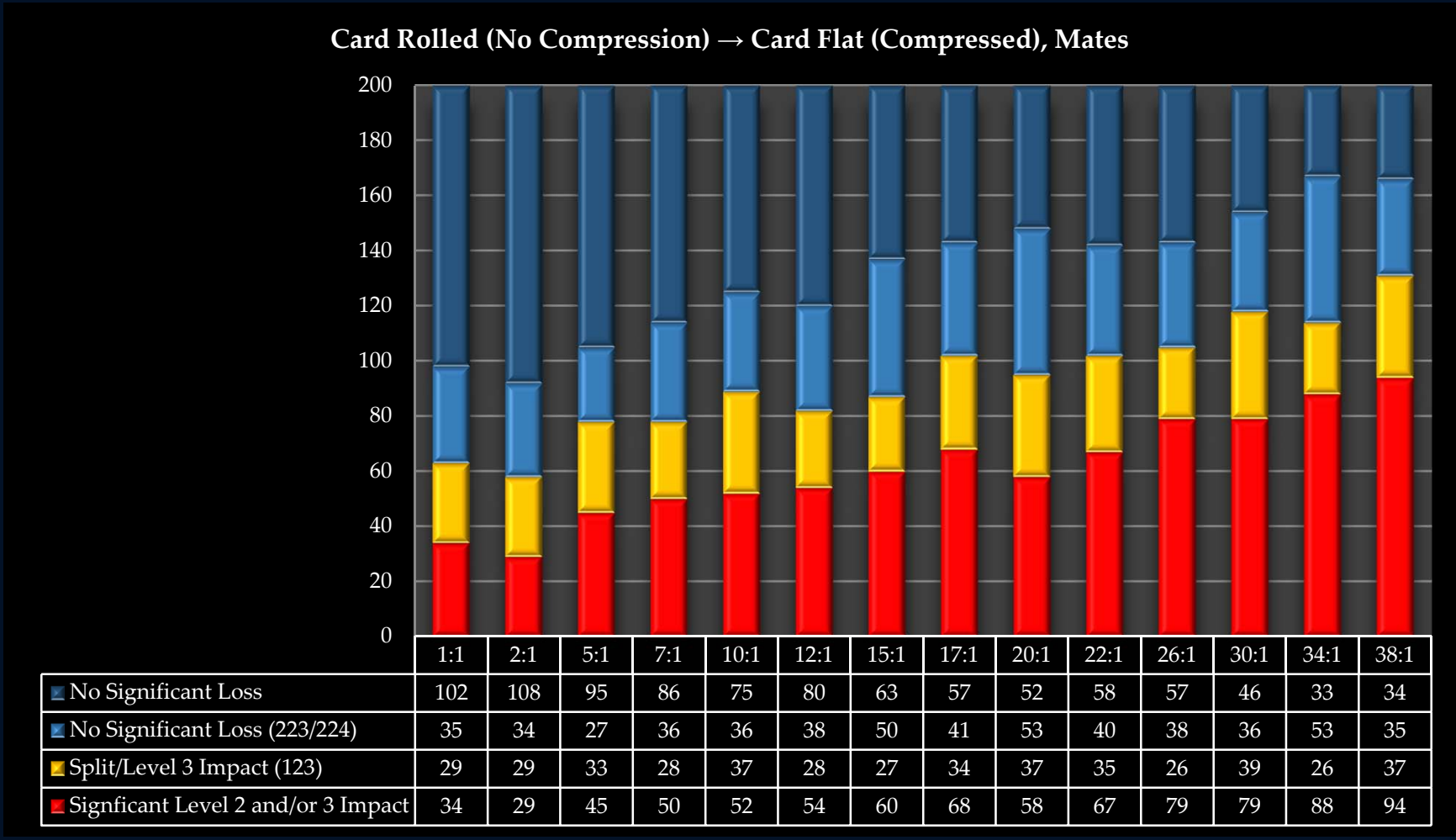
NIST Fingerprint Compression Study

Card Rolled (No Compression) → Card Rolled (Compressed), NON-Mates



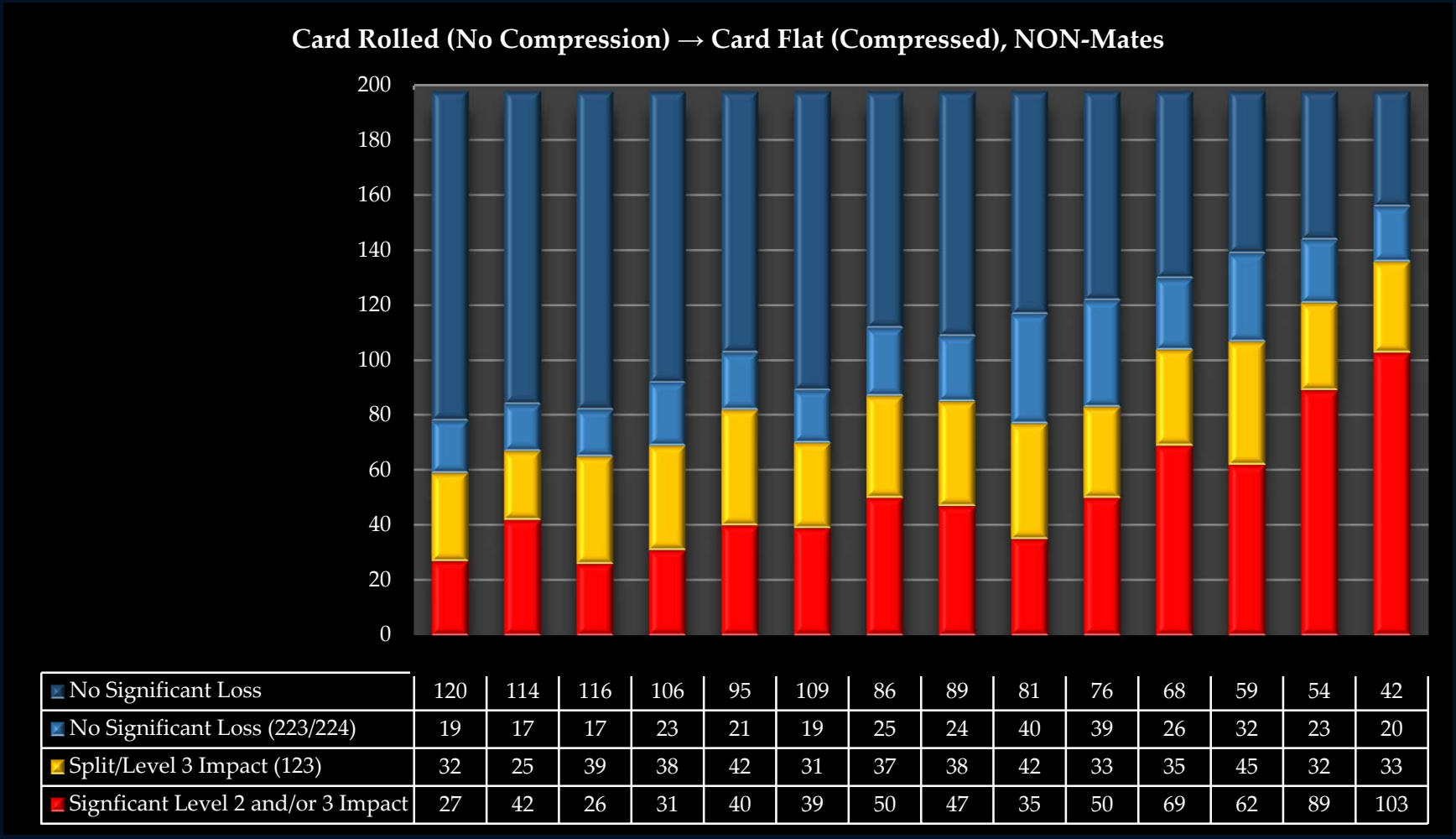
No Significant Loss	119	126	117	112	91	97	93	73	73	69	53	66	52	43
No Significant Loss (223/224)	18	9	24	21	21	26	24	33	34	26	30	28	33	41
Split/Level 3 Impact (123)	29	24	29	28	39	33	36	44	29	40	33	32	33	29
Signficant Level 2 and/or 3 Impact	32	39	28	37	47	42	45	48	62	63	82	72	80	85

NIST Fingerprint Compression Study



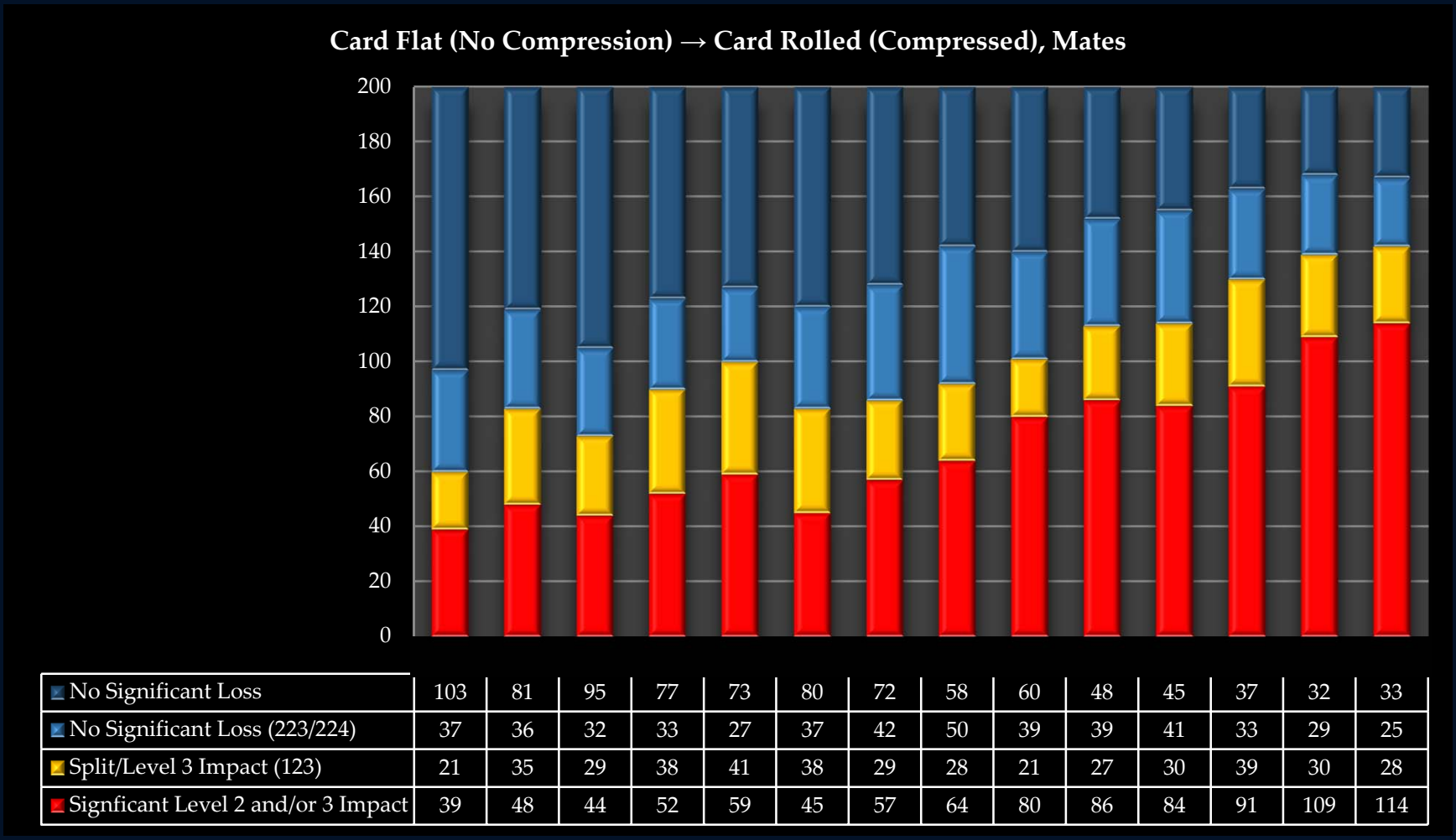
	1:1	2:1	5:1	7:1	10:1	12:1	15:1	17:1	20:1	22:1	26:1	30:1	34:1	38:1
No Significant Loss	102	108	95	86	75	80	63	57	52	58	57	46	33	34
No Significant Loss (223/224)	35	34	27	36	36	38	50	41	53	40	38	36	53	35
Split/Level 3 Impact (123)	29	29	33	28	37	28	27	34	37	35	26	39	26	37
Signficant Level 2 and/or 3 Impact	34	29	45	50	52	54	60	68	58	67	79	79	88	94

NIST Fingerprint Compression Study



No Significant Loss	120	114	116	106	95	109	86	89	81	76	68	59	54	42
No Significant Loss (223/224)	19	17	17	23	21	19	25	24	40	39	26	32	23	20
Split/Level 3 Impact (123)	32	25	39	38	42	31	37	38	42	33	35	45	32	33
Signficant Level 2 and/or 3 Impact	27	42	26	31	40	39	50	47	35	50	69	62	89	103

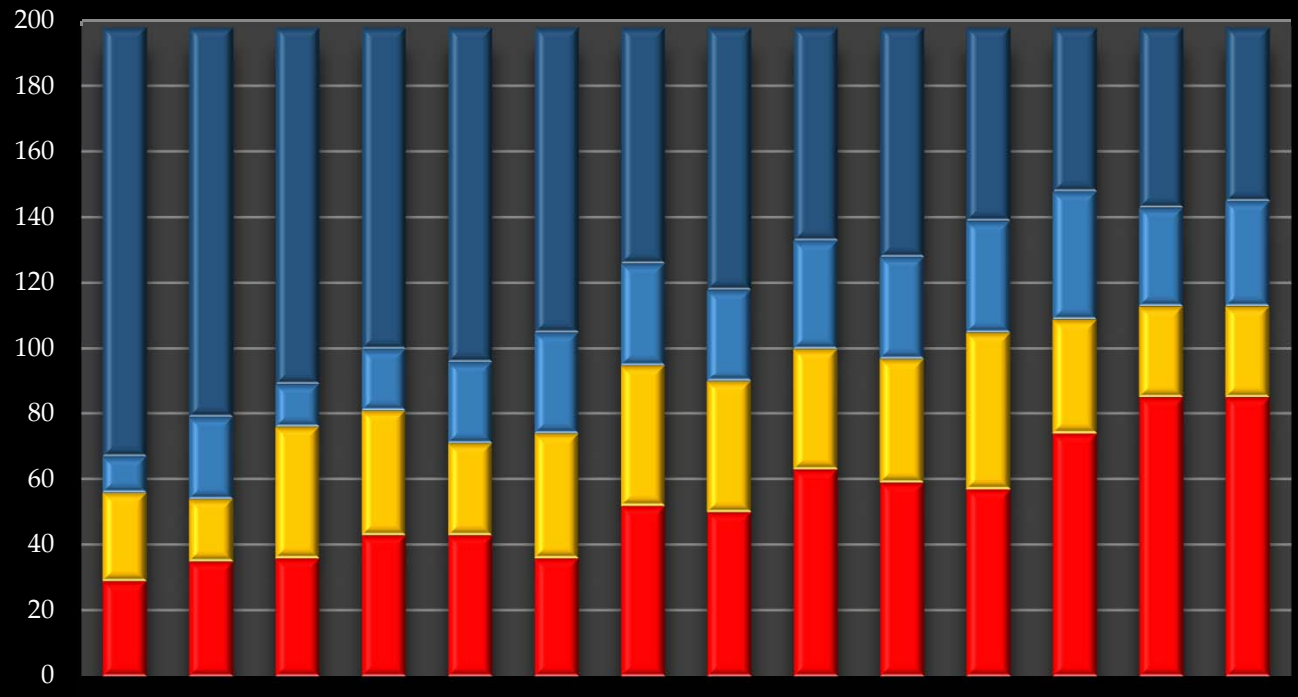
NIST Fingerprint Compression Study



No Significant Loss	103	81	95	77	73	80	72	58	60	48	45	37	32	33
No Significant Loss (223/224)	37	36	32	33	27	37	42	50	39	39	41	33	29	25
Split/Level 3 Impact (123)	21	35	29	38	41	38	29	28	21	27	30	39	30	28
Signficant Level 2 and/or 3 Impact	39	48	44	52	59	45	57	64	80	86	84	91	109	114

NIST Fingerprint Compression Study

Card Flat (No Compression) → Card Rolled (Compressed), NON-Mates



No Significant Loss	131	119	109	98	102	93	72	80	65	70	59	50	55	53
No Significant Loss (223/224)	11	25	13	19	25	31	31	28	33	31	34	39	30	32
Split/Level 3 Impact (123)	27	19	40	38	28	38	43	40	37	38	48	35	28	28
Signficant Level 2 and/or 3 Impact	29	35	36	43	43	36	52	50	63	59	57	74	85	85

NIST Fingerprint Compression Study

In Conclusion:

- Early results from card-scan tests show 15:1 holds, but need to see live-scan before establishing final recommendation.
- 12:1 may be a candidate ratio (pending the rest of the cases)

Next steps:

- Need to finish live-scan test cases
- Need to process matcher data, weigh relevance
- Need your comments

Q & A?

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http://fingerprint.nist.gov/compression