T-MODEL
FINGERPRINT CALCULATOR

Sample Case

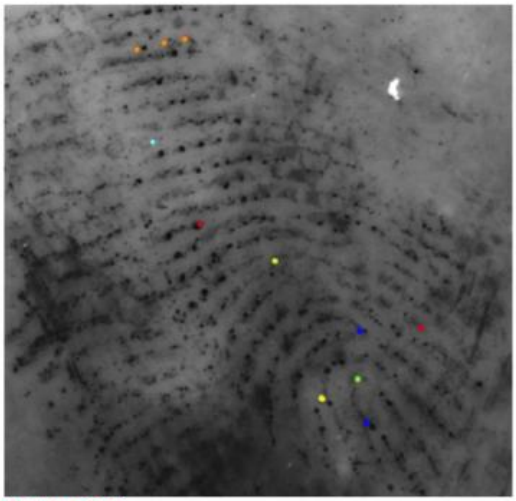
Crime: Sexual Assault

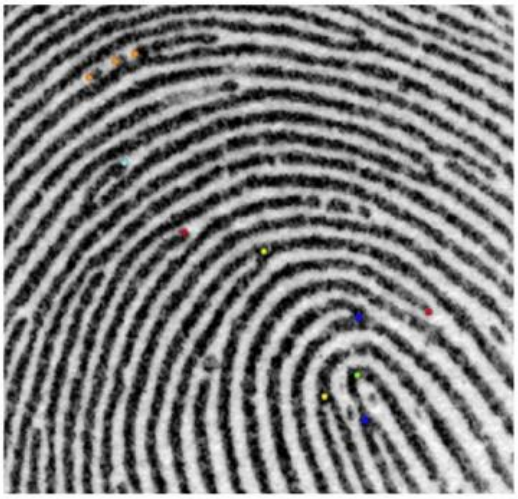
Location: State of Minnesota (population 5.5 million people)

The below Technical Summary shows photographic enlargements of the latent and exemplar fingerprint impressions with colored markings of the corresponding latent and exemplar ridge features relied upon and assessed by a latent print examiner during the analysis and comparison phases of the fingerprint examination. Included are case information and commentary of the analysis and comparison. The evaluation is based on calculations made by the T-Model 9.5 (e.g. values same as v.9.9).

FINGERPRINT ANALYSIS REPORT
TECHNICAL SUMMARY

ABC Police Department
Minnesota Sexual Assault
Case #1234 - Langenburg





ANALYSIS

LATENT: A1

Level I:	**Finger / Right Slant Loop**
Level II:	**Sufficient / In Sequence**
Level III:	**Non-Pertinent**
Quality:	**Average**

EXEMPLAR: John Doe / ID #ABC123 / #1 Finger

Level I:	**Finger / Right Slant Loop**
Level II:	**Sufficient / In Sequence**
Level III:	**Non-Pertinent**
Quality:	**High**

COMPARISON

LATENT VS. EXEMPLAR

LEVEL I: 1: 1 Innermost recurve or core (green).

LEVEL II: 2-3: 2 bifurcations (blue); 4-6: 3 ending ridges (red and light blue); 7-8: 2 ending/bifurcating ridges (yellow); 9-11: 3 cluster-3 dots (orange). Note: Each ridge feature is located in a non-diminishing area (not in a funnel) and conservatively determined to be positioned 0-1 intervening ridges to it's nearest Level II neighbor.

LEVEL III: N/A

EVALUATION

Inference for identification (Professional Judgment)..... Yes
Inference for identification (Mathematical Modeling)..... Yes

NOTE

The relevant fingerprint population for the case was estimated to be 55 million (i.e. the total human population in Minnesota x 10). I performed an independent examination of the above two print impressions, i.e. I did not consult with another examiner. See attached fingerprint analysis report (i.e. Fingerprint Calculator T-Model v. 9.5).

EXAMINER: _____ **DATE: 4/17/2013**
Henry Templeman, CLPE

The following figure shows a sample Fingerprint Calculator Report with case information (blank), examiner assessments for the analysis and comparison phases of the exam, and the T-Model calculations for the conservative (upper bound) number of look-alikes present in the various population groups including the relevant fingerprint population for the case at hand, i.e. 55,000,000, and the subsequent evaluations.

Fingerprint Calculator Report

Agency		Date In	
Case Number		Date Out	
Requestor		Latent	
Telephone		Exemplar	

ANALYSIS | **COMPARISON**

#	Latent Ridge Feature: Shape	Position	Clarity	Value	Exemplar Ridge Feature: Shape	Position	Clarity	Value	Latent v. Exemplar: Lower Value	Quality of Agreement	Value
1	209	1	1	209	209	1	1	209	209	1	209
2	26.75	1	1	26.75	26.75	1	1	26.75	26.75	1	26.75
3	26.75	1	1	26.75	26.75	1	1	26.75	26.75	1	26.75
4	14.25	1	1	14.25	14.25	1	1	14.25	14.25	1	14.25
5	14.25	1	1	14.25	14.25	1	1	14.25	14.25	1	14.25
6	14.25	1	.75	10.6875	14.25	1	1	14.25	10.6875	.50	5.34375
7	20.5	1	.50	10.25	20.5	1	1	20.5	10.25	.50	5.125
8	20.5	1	.50	10.25	20.5	1	1	20.5	10.25	.50	5.125
9	6	1	1	6	6	1	1	6	6	1	6
10	6	1	1	6	6	1	1	6	6	1	6
11	6	1	.75	4.5	14.25	1	1	14.25	4.5	.50	2.25
12	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1

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T-Model Fingerprint Calculator

T-Model Version 9.9

www.facts.mynetworksolutions.com

EVALUATION

T-Value (Total Value)	345256988368.04236
Fingerprint Match Probability (1/T-Value)	2.896393219227194e-12
Fingerprint Parts Per Finger	10.400287587852816
Relevant Fingerprint Population (Local, State, National, etc)	55000000
Estimated Number of Fingerprint Look-alikes (Not Greater Than)	0.0016567827346108
SUFFICIENT TO INFER IDENTIFICATION	

Fingerprint Population	<# Look-alikes	Sufficient To Infer Identification
100	0.00	Yes
1,000	0.00	Yes
10,000	0.00	Yes
100,000	0.00	Yes
1,000,000	0.00	Yes
10,000,000	0.00	Yes
100,000,000	0.00	Yes
1,000,000,000	0.03	Yes
10,000,000,000	0.30	Yes
100,000,000,000	3.01	No
1,000,000,000,000	30.12	No

Signature / Date

Examiner Name (Print)

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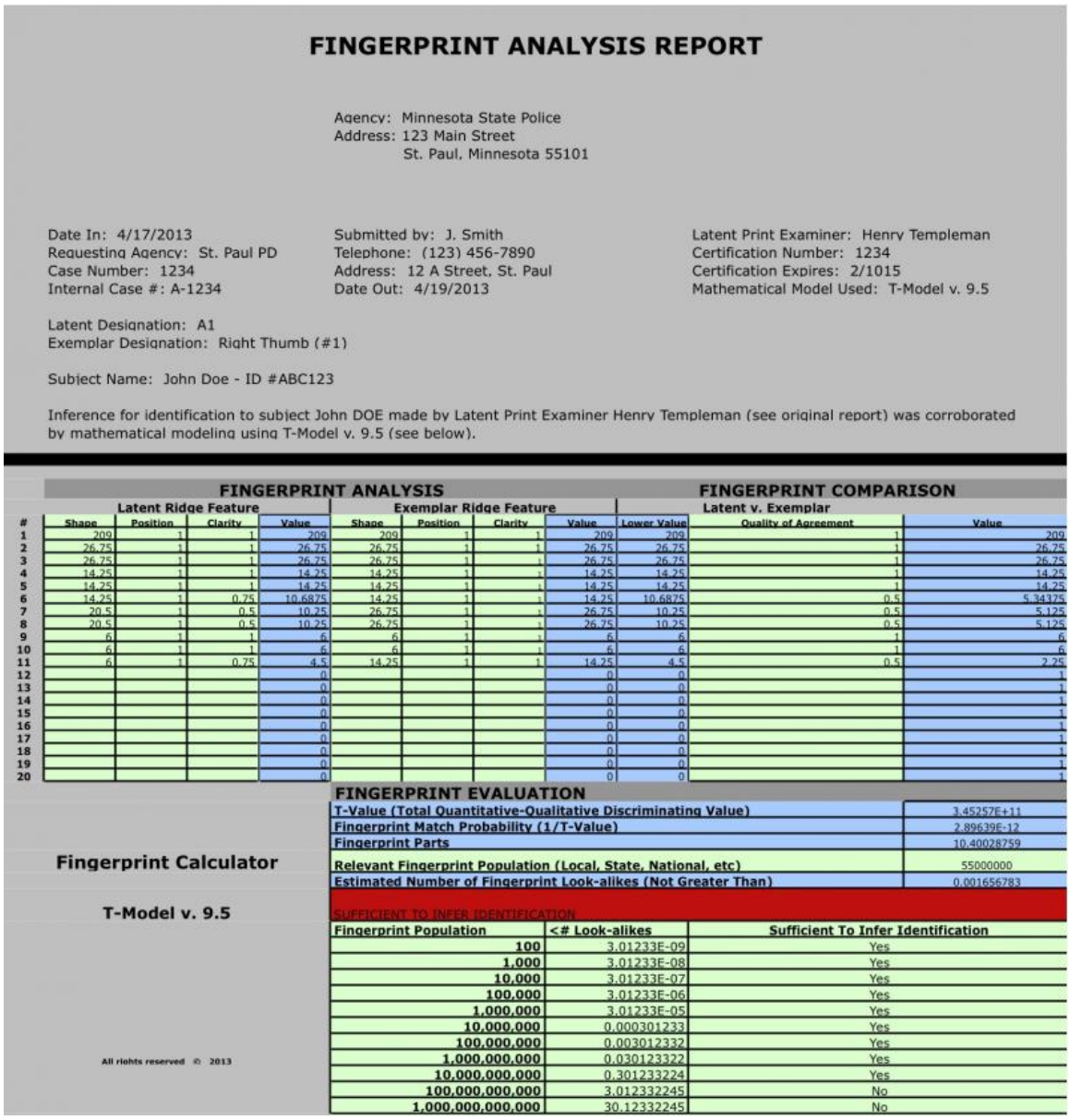
A variety of fingerprint analysis report formats are possible. The following figure illustrates an alternative report style.



FINGERPRINT ANALYSIS REPORT

Agency: Minnesota State Police
Address: 123 Main Street
St. Paul, Minnesota 55101

Date In: 4/17/2013
Requesting Agency: St. Paul PD
Case Number: 1234
Internal Case #: A-1234

Submitted by: J. Smith
Telephone: (123) 456-7890
Address: 12 A Street, St. Paul
Date Out: 4/19/2013

Latent Print Examiner: Henry Templeman
Certification Number: 1234
Certification Expires: 2/1015
Mathematical Model Used: T-Model v. 9.5

Latent Designation: A1
Exemplar Designation: Right Thumb (#1)

Subject Name: John Doe - ID #ABC123

Inference for identification to subject John DOE made by Latent Print Examiner Henry Templeman (see original report) was corroborated by mathematical modeling using T-Model v. 9.5 (see below).

FINGERPRINT ANALYSIS

#	Latent Ridge Feature				Exemplar Ridge Feature				FINGERPRINT COMPARISON Latent v. Exemplar		
	Shape	Position	Clarity	Value	Shape	Position	Clarity	Value	Lower Value	Quality of Agreement	Value
1	209	1	1	209	209	1	1	209	209	1	209
2	26.75	1	1	26.75	26.75	1	1	26.75	26.75	1	26.75
3	26.75	1	1	26.75	26.75	1	1	26.75	26.75	1	26.75
4	14.25	1	1	14.25	14.25	1	1	14.25	14.25	1	14.25
5	14.25	1	1	14.25	14.25	1	1	14.25	14.25	1	14.25
6	14.25	1	0.75	10.6875	14.25	1	1	14.25	10.6875	0.5	5.34375
7	20.5	1	0.5	10.25	26.75	1	1	26.75	10.25	0.5	5.125
8	20.5	1	0.5	10.25	26.75	1	1	26.75	10.25	0.5	5.125
9	6	1	1	6	6	1	1	6	6	1	6
10	6	1	1	6	6	1	1	6	6	1	6
11	6	1	0.75	4.5	14.25	1	1	14.25	4.5	0.5	2.25
12				0				0	0		1
13				0				0	0		1
14				0				0	0		1
15				0				0	0		1
16				0				0	0		1
17				0				0	0		1
18				0				0	0		1
19				0				0	0		1
20				0				0	0		1

FINGERPRINT EVALUATION

T-Value (Total Quantitative-Qualitative Discriminating Value)	3.45257E+11
Fingerprint Match Probability (1/T-Value)	2.89639E-12
Fingerprint Parts	10.40028759
Relevant Fingerprint Population (Local, State, National, etc)	55000000
Estimated Number of Fingerprint Look-alikes (Not Greater Than)	0.001656783

Fingerprint Calculator

T-Model v. 9.5

SUFFICIENT TO INFER IDENTIFICATION

Fingerprint Population	<# Look-alikes	Sufficient To Infer Identification
100	3.01233E-09	Yes
1,000	3.01233E-08	Yes
10,000	3.01233E-07	Yes
100,000	3.01233E-06	Yes
1,000,000	3.01233E-05	Yes
10,000,000	0.000301233	Yes
100,000,000	0.003012332	Yes
1,000,000,000	0.030123322	Yes
10,000,000,000	0.301233224	Yes
100,000,000,000	3.012332245	No
1,000,000,000,000	30.12332245	No

The below figure shows the discriminating value and qualitative assessment guidelines required of the latent print examiner to follow during the analysis and comparison phases of the exam. Included are the formulae used by the T-Model in the evaluation phase.

T-Model Fingerprint Calculator

RIDGE FEATURE VALUES

Ridge Feature Shape	Value
Continuous Ridge Unit (.45mm x .45mm)*	1.15
Pore	5
Ending Ridge Unit In Funnel	10
Ending Ridge Unit Not In Funnel	14.25
Ending/Bifurcating Ridge Unit In Funnel	14.375
Bifurcating Ridge Unit In Funnel	18.75
Ending/Bifurcating Ridge Unit Not In Funnel	20.5
Bifurcating Ridge Unit Not In Funnel	26.75
Dot (Nearest Level2 Neighbor in Same Furrow>1mm)	40
2 Dots In Furrow <1mm apart. Value Per Dot:	10
3 Dots In Furrow <1mm apart. Value Per Dot:	6
4 Dots In Furrow <1mm apart. Value Per Dot:	4.5
5 Dots In Furrow <1mm apart. Value Per Dot:	4
6 Dots In Furrow <1mm apart. Value Per Dot:	3.75
Core Area (1mm x 1mm)	209
Delta Area (Y Shape) (1mm x1mm)	190
Delta Area (Non-Y Shape) (1mm x 1mm)	570

Ridge Feature Position	Value
0-2 Intervening Ridges To Nearest Level II Neighbor	1
3 Intervening Ridges To Nearest Level II Neighbor	4
4 Intervening Ridges To Nearest Level II Neighbor	10
5 Intervening Ridges To Nearest Level II Neighbor	62.5
6 Intervening Ridges To Nearest Level II Neighbor	976
7 Intervening Ridges To Nearest Level II Neighbor	38,125
8 Intervening Ridges To Nearest Level II Neighbor	3,723,144
9 Intervening Ridges To Nearest Level II Neighbor	908,970,832
10 Intervening Ridge to Nearest Level II Neighbor	554,791,767,578

RIDGE FEATURE REDUCTION FACTORS

Ridge Feature Clarity and Reliability (Analysis)

Grade	DISTORTION LEVEL None	Low	Moderate	High	Very High	Reduction Factor
A	Yes	No	No	No	No	1
B	No	Yes	No	No	No	0.75
C	No	No	Yes	No	No	0.5
D	No	No	No	Yes	No	0.25
F	No	No	No	No	Yes	No Value

GUIDELINES

No Distortion	Ridge feature appears visually clear and reliable.
Low Distortion	Ridge feature appears visually unclear or unreliable.
Moderate Distortion	Ridge feature appears visually unclear and unreliable.
High Distortion	Ridge feature appears obstructed, however the orientation and relative position are reliably predictable.
Very High Distortion	Ridge feature appears too distorted to analyze.

Note: 1/P denotes neutralization of ridge feature value, e.g. value equals 1.

Ridge Feature Quality of Agreement (Comparison)

Grade	Ridge Type and Path Agrees	Spatial Relationship To Nearest Neighbor Agrees	Reduction Factor
A	Yes	Yes	1
C	No	Yes	0.5
F	Yes/No	No	No Value

A - Excellent
C - Satisfactory
F - Unsatisfactory

GUIDELINES

Ridge Feature Type: Ending Ridge, Bifurcation, etc. Example #1: Ridge feature in latent print is an ending ridge and the ridge feature in the exemplar print is an ending ridge. The ridge feature types agree. Example #2: Ridge feature in the latent print is an ending ridge and the ridge feature in the exemplar print is a bifurcation. The ridge feature types do not agree.

Ridge Path: Ridge path, ie., an ending ridge unit slants to right, left, or not, or the ridge angle of separation, i.e., the angle of separation in a bifurcation, is large or small.

Spatial Relationship To Nearest Neighbor: Difference in distal relationship is less than 20% and difference in angle of rotation relationship is less than 10 degrees.

T-MODEL FORMULAE

T-Value (Total Discriminating Value)

T-Value = value 1 x value 2 x value 3 x value n...

where,

value 1 = value for ridge feature no. 1 (shape x position x clarity x agreement)
value 2 = value for ridge feature no. 2 (shape x position x clarity x agreement)
value 3 = value for ridge feature no. 3 (shape x position x clarity x agreement)
value n = value for ridge feature no. n (shape x position x clarity x agreement)

FINGERPRINT MATCH PROBABILITY

Fingerprint Match Probability (FMP) = 1/T-Value

If FMP < 1/Relevant Population (e.g., Number of People x 10 Fingers x Fingerprint Parts), then "Match"

Same as,

If T-Value > Relevant Population, then "Match"

FINGERPRINT PARTS

(T) ^ (P) = 10 ^ 120

P = Fingerprint Parts
T = T-Value

Note: 10 ^ 120 = T-Value for Average Latent (Flat) Fingerprint

ESTIMATED NUMBER OF FINGERPRINT LOOK-ALIKES

L = RP / T

where,

L = Estimated Number of Look-alikes (conservative, upper-bound number)
RP = Relevant Population (e.g., Number of People x 10 Fingers x Fingerprint Parts)
T = T-Value

T-Model Fingerprint Calculator v. 9.9

Scientific Knowledge

The numbers used in T-Model Fingerprint Calculator are fixed, uncertain, and based on data gathered as a result of thirty-eight (38) well-controlled, reproducible, honest close match or "look-alike" experiments performed by Henry Templeman, CLPE (i.e. See Validation Study under snapshot version 9.2 published by the Internet Archive Wayback Machine on August 18, 2012, i.e. See below under Published).

Testable

The ability of the T-Model v. 9.9 to make correct decisions (i.e. to establish sufficiency to infer fingerprint identification) is falsifiable, refutable and testable.

Error Rate

The T-Model has been subjected to the most difficult proficiency tests possible. It has been empirically tested on the most notable erroneous fingerprint identifications ever made and pitted against the largest and best amounts of fingerprint "look-alikes" ever revealed by an automated search, seen in publication, or found during the course of routine casework. So far the T-Model has not been fooled into making an erroneous decision.

Published

The T-Model was published online August 2008 at www.henrytempleman.com when it first became freely available to the fingerprint and scientific community for testing and critical scrutiny. Snapshots of versions of the T-Model are archived at the Internet Archive Wayback Machine at **archive.org/web/web.php**.

Peer Review

The T-Model has been submitted for review to the International Association for Identification (**IAI**), presented to members of **SWGFAST**, and requested for review by numerous members of the law enforcement community including the **FBI Latent Print Support Unit**. As of today (August 7, 2013) to the knowledge of the author, the T-Model has not been refuted or falsified by any member(s) of any of these organizations, or by any other person(s) or organization(s).

Commentary

"Your model can certainly assist in generating good outcomes and underpinning results...Your model has the advantage over other models that it establishes the weight/value of a mark on itself by calculating the chance of existence of a look alike."

Arie Zeelenberg, Senior Fingerprint Advisor National Police Force of the Netherlands 3/7/2010

"You have a lot of information of which I would like my own staff to be aware. I am impressed with your use of the T-Model. This is an example that I believe in and would very much like to see developed and embraced by the Latent Community."

Roy Marzioli, Manager, Central Identification Services, Forensic Services Division, Contra Costa County Office of the Sheriff - 5/19/2009

"Great work on a needed sufficiency research and robust probabilistic model."

John Clark, Western Identification Network, SWGFAST Member - 3/18/2008

"I have read through several of your later revisions and thought it was really well written and based on sound science and statistical computation/theory."

Karen Salamy, Software Engineering Tech Monterey Bay Aquarium Research Institute - 3/11/2008

"There are some really strong ideas here. I also think that you are joining a growing group of examiners that are thinking outside the box and recognizing the need to appropriately weight the corresponding features. I like the initiative of this."

"You are approaching this from a frequentist point of view, rather that Bayesian—which is fine—but changes the framework of the propositions and can lead to a few problems, but these can be avoided."

Glenn Langenburg, CLPE, PhD, SWGFAST Member, Minnesota Bureau of Criminal Apprehension, 12/24/2007 and 1/1/2008

"I would like to request a copy of your T-Model Fingerprint Calculator for review. I appreciate your efforts in advancing the friction ridge analysis discipline through innovative research that seeks to allow scientists to communicate their results more effectively."

Aaron J. Uhle, Major Incident Program Manager, Latent Print Support Unit, FBI Laboratory-August 2012