Product Development

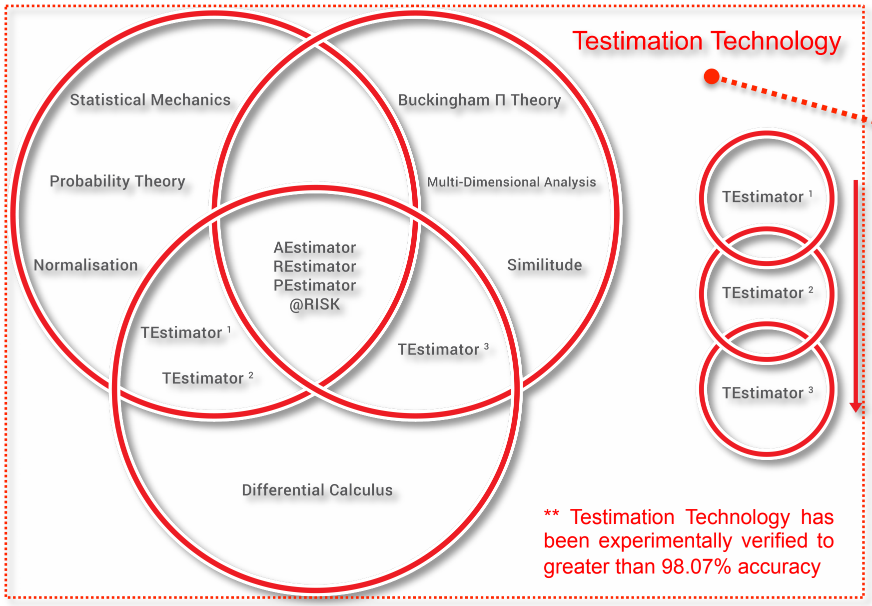
Certification Overview

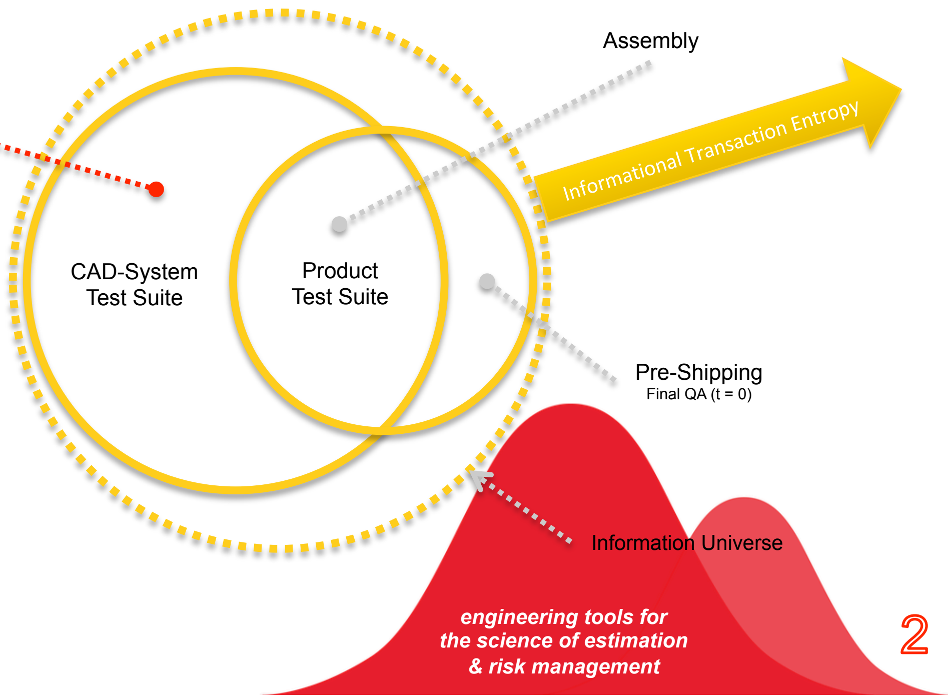
www.testimation.com

engineering tools for
the science of estimation
& risk management

Key Points

1. All physical systems can be modeled virtually; physical tests are a subset of virtual tests in an Information Universe
2. To preserve Dynamic, Kinematic & Geometric Similarity$_{\text{Buckingham } \Pi \text{ Theory}}$ between representations, physical tests also need to be executed in a virtual environment
3. The manner in which Software Quality may be measured for Defect-Free Confidence utilising Testimation Technology, also applies to physical systems at t = 0 on the '**D**esign | **I**nstallation | **P**otential-Failure | **F**ailure' (DIPF) Curve$_{\text{Resistance-2-Failure}}$
4. Testimation Technology$_{\text{Patented}}$ is required to measure DIPF$_{\text{Resistance-2-Failure}}$ at t = 0





Testimation

Table of Contents

1. Testimation Technology predicts & measures Cyber-Risk:
   - i.e. The risk associated with software failures
   - Cyber-Risk = 1 − {Cyber-Confidence}
     - i.e. The Probability of Undiscovered Defects
       - i.e. The Defects missed by the Test Team

2. It achieves this by representing Cyber-Confidence as a Statistical Probability value based upon Factually Executed Tests (FET's):
   - e.g. 120 FET's yields 98.56(%) Cyber-Confidence
     - i.e. FET's are actual results

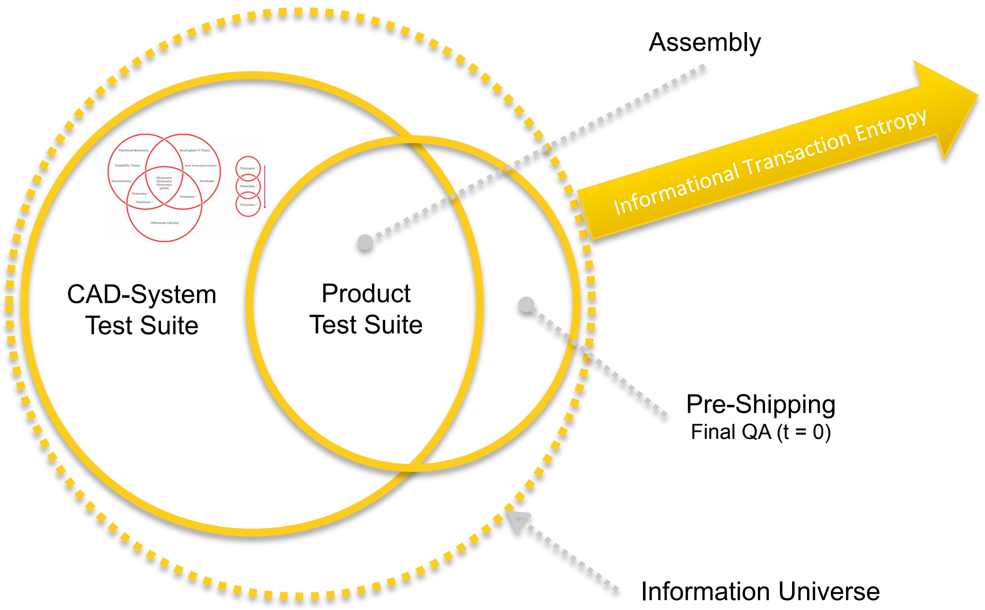
3. All User Interaction with software may be represented by Functional Processes (FP's)
   - An FP is a train of Software Function Points (SFP's) facilitating a User Work Instruction
     - e.g. Create User Account, Delete User Account, Print Annual Sales Report etc.

4. All machines & systems may be designed & virtually tested within any sufficiently advanced CAD-System
   - Each governing physical equation within the programming code represents at least one FP
     - i.e. It requires User Interaction at Input (*the design*) & Output (*design acceptability* | *User Acceptance*)
       - e.g. Reaction Forces, Momentum Transfers, Inductance, Capacitance, Magnetic Flux Density etc.

5. Apply the principles of Dynamic, Kinematic & Geometric Similarity$_{\text{Buckingham }\Pi\text{ Theory}}$
   - Whatever works in a virtual environment will work in a physical environment
     - i.e. If the governing physical equations & relationships in the virtual environment are Defect-Free

6. The number of physical tests required for component assembly are a sub-set of the total number of software tests required to validate the behaviour of the CAD-System
   - i.e. Everything that would be verified during the component assembly process also requires validation in the virtual environment

7. Suitable CAD-Software is substantially more complex than any physical system
   - e.g. The Functional Processes (FP's) associated with software can adopt a limitless number of integration points (*by design* + *human error*); however, Integration points of physical FP's are dominated by localized influences
     - e.g. an Electron at the periphery of the observable Universe is gravitationally integrated to machinery on Earth, but its influence is negligible; this principle differs substantially compared to software integration points



Key Points

1. All physical systems can be modeled virtually. Hence, physical tests are a subset of virtual tests in an Information Universe
2. To preserve Dynamic, Kinematic & Geometric Similarity$_{\text{Buckingham } \Pi \text{ Theory}}$ between representations, physical tests also need to be executed in a virtual environment
3. The manner in which Software Quality may be measured for Defect-Free Confidence utilising Testimation Technology, also applies to physical systems at t = 0 on the DIPF Curve$_{\text{Resistance-2-Failure}}$

How-2-Count Functional Processes

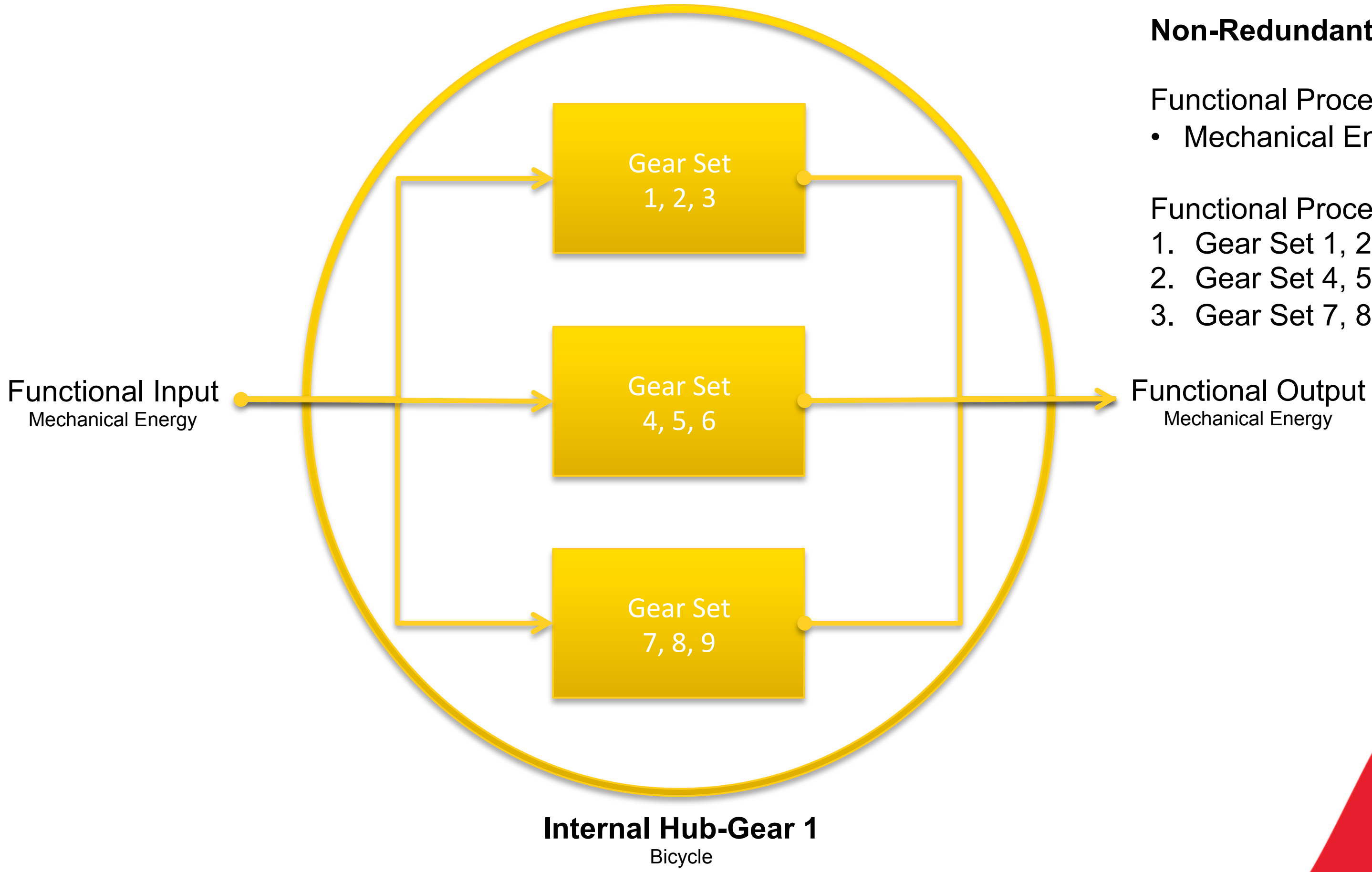
"Counting Functional Processes (FP's)" is a description of the desired outcome; what we're actually seeking to determine, are the number of Functional Process Pathways (FPP's) through a system. An FPP denotes a route capable of carrying information critical to the Primary Operational Function of a product (*multiplicity is possible*); FPP's transgress the system boundary from input to output. Information input & output can take various forms, so we will limit ourselves to generalised concepts herein. For further information, contact Testimation directly, or review the available literature on our web-site.

Considerations

1. Define the system boundary
    - Typically drawn by encircling a product or one major sub-component of a broader system
2. Ask yourself
    1. Where does energy information enter / exit ?
        - This does not include Control System information transgressing the system boundary
            - A Control System should be analyzed separately as it represents an information system in its own right
    2. How many ways can energy information get to the destination ?
        - If any particular internal component fails, can input information still reach the output ?
    3. What are the number of Primary User interactions ?
        - e.g. Mechanical assistance from an electric motor for an E-Bike Rider
        - e.g. The number of User Interface functions on an oscilloscope
    4. What are the number of Primary Design Functions (PDF's) ?
        - e.g. Electrical to Mechanical Energy Conversion (*a fluid pump*)
    5. What are the Energy Transformations ?
        - e.g. Chemical Energy to Thrust (*aircraft engines*)
        - e.g. Electrical Energy to Mechanical Energy Conversion (*an electric motor*)

Functional Processes cont.

How-2-Count Functional Process Pathways ***(conceptual only)***



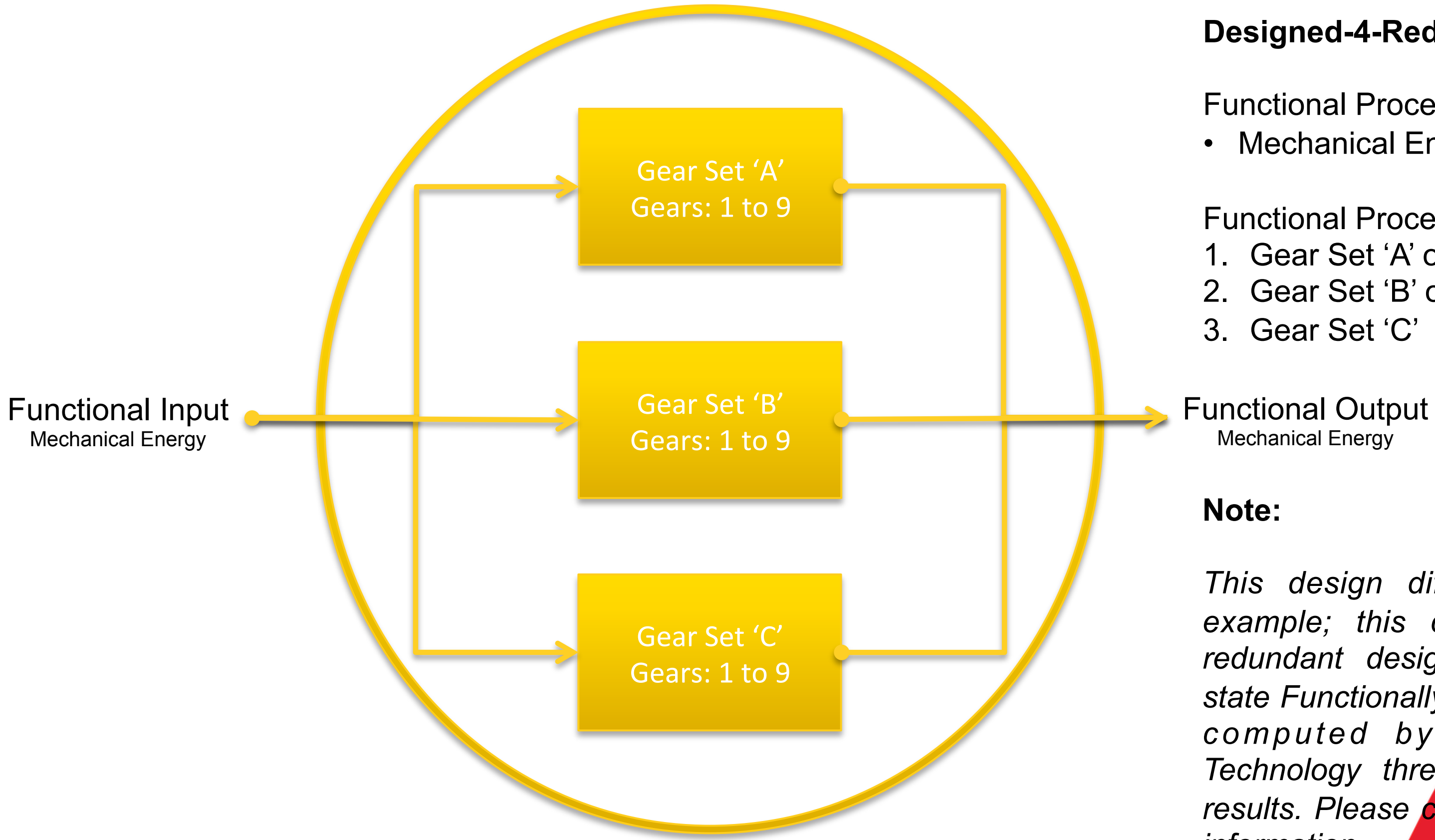
Non-Redundant Design

Functional Processes (1)
- Mechanical Energy → Mechanical Energy

Functional Process Pathways (3)
1. Gear Set 1, 2, 3
2. Gear Set 4, 5, 6
3. Gear Set 7, 8, 9

Functional Processes cont.

How-2-Count Functional Process Pathways ***(conceptual only)***



Internal Hub-Gear 2
Bicycle

Designed-4-Redundancy

Functional Processes (1)

- Mechanical Energy → Mechanical Energy

Functional Process Pathways (3)

1. Gear Set 'A' or,
2. Gear Set 'B' or,
3. Gear Set 'C'

Note:

This design differs from the preceding example; this configuration is a doubly redundant design. Consequently, its final state Functionally Defect-Free Confidence is computed by utilising Testimation Technology three times & combining the results. Please contact Testimation for more information.

Table of Functional Processes *(conceptual only)*

System or Major Sub-Component	Primary Function/s	Primary Functional Processes (FP's)	FPP's
Aircraft Control System	Multiple	Electrical Energy → Mechanical Energy (*multiple*)	TBD
Aircraft Engine	Thrust	Chemical Energy → Thrust	TBD
Aircraft Fuselage	Resist Stress	Mechanical Forces → Stored Stress Energy	TBD
Aircraft Wing	Generate Lift	Chemical Energy → Lift	TBD
Bicycle Frame	Resist Stress	Mechanical Forces → Stored Stress Energy	1
Electric Motor	Rotation	Electrical Energy → Mechanical Energy	1
Heat Exchanger	Thermal Transfer	Thermal Energy → Thermal Displacement	1
Washing Machine	Rotation	Electrical Energy → Mechanical Energy	1
Washing Machine / Dryer Combo.	Rotation, Thermal Transfer	See Above	2

** **IMPORTANT: hereon, we only consider / discuss a single Functional Process system (FP = 1)**

Testimation

Table of Generalised Theoretical Examples *(conceptual only)*

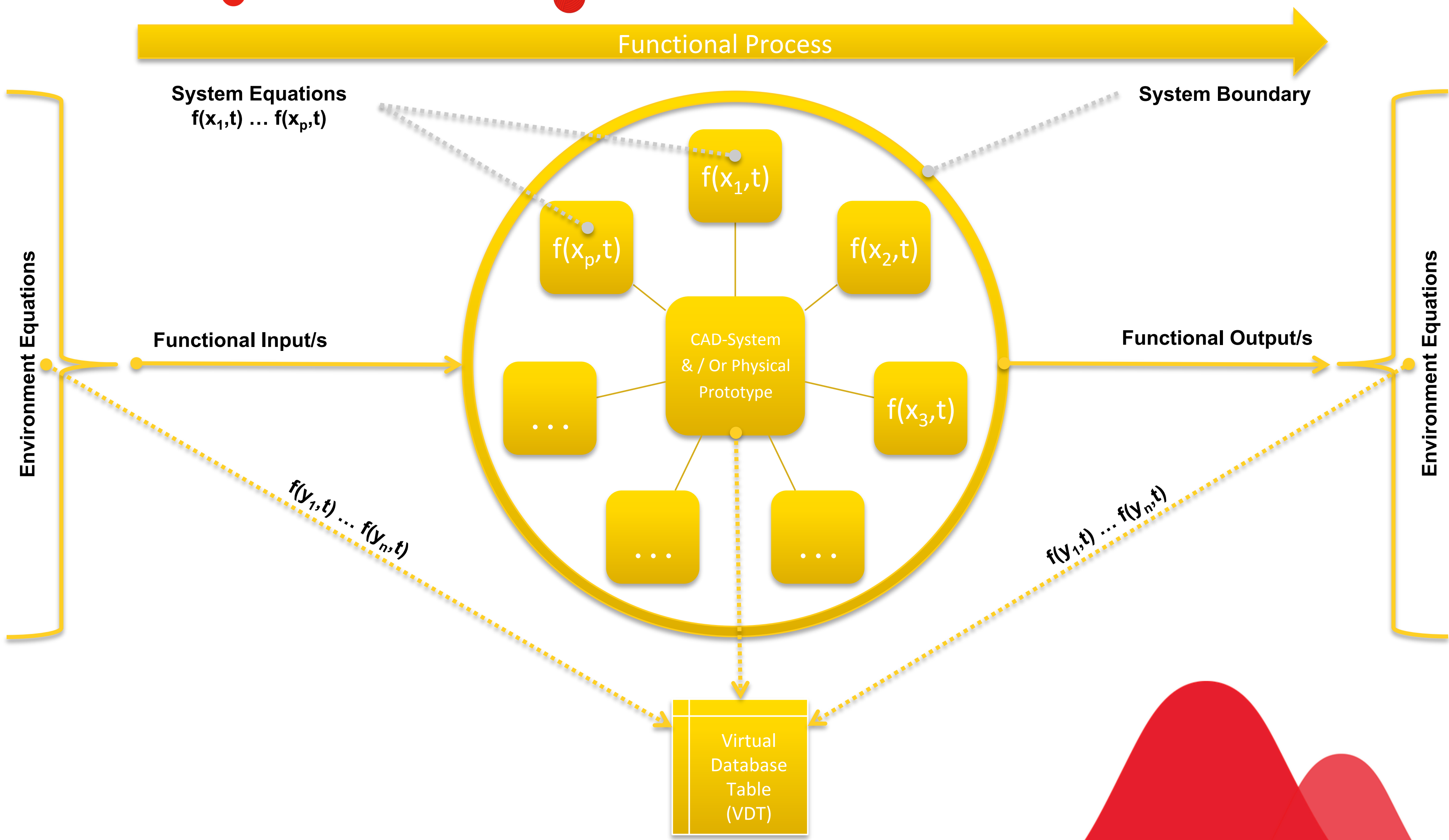
Simple Electric Motor			Internal Hub-Gear (*Bicycle*)			Jet Engine		
FP Pathways	**QA Tests**	**Defect-Free Confidence**	**FP Pathways**	**QA Tests**	**Defect-Free Confidence**	**FP Pathways**	**QA Tests**	**Defect-Free Confidence**
FPP	QA	99.9892488823271 %	3×FPP	QA	97.4652681322532 %	20×FPP	QA	61.3523769228767 %
	2×QA	99.9999956795369 %		2×QA	99.8434597741997 %		2×QA	77.9328638080153 %
	3×QA	99.9999999980297 %		3×QA	99.9892488823271 %		3×QA	86.6385597462284 %
	4×QA	99.9999999999991 %		4×QA	99.9992255783569 %		4×QA	91.6735483336450 %
	5×QA	> 99.9999999999999 %		5×QA	99.9999426696856 %		5×QA	94.7192488583886 %
	6×QA	> 99.9999999999999 %		6×QA	99.9999956795369 %		6×QA	96.6105146475311 %

'FPP' = Number of Functional Process Pathways | 'QA' = Number of Quality Assurance Tests

Values shown are for demonstration purposes only

Testimation

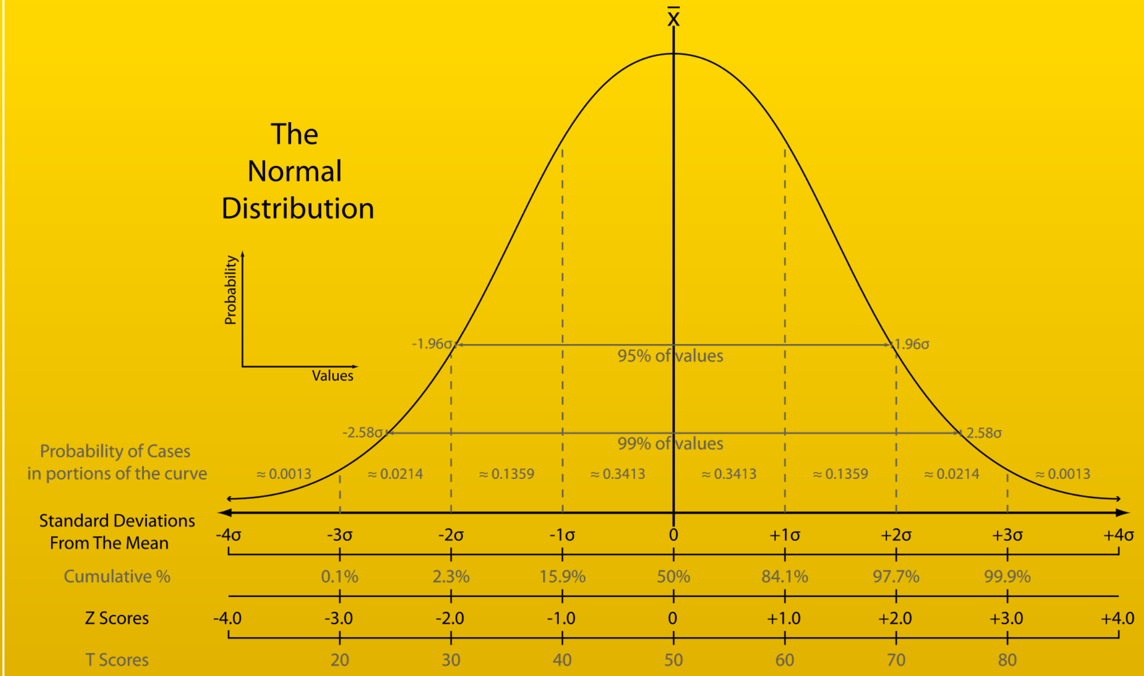
Conceptualisation



Archive, **C**reate, **R**ead, **U**pdate, **D**elete
(A+CRUD)

Testimation

Virtual Database Table (VDT)



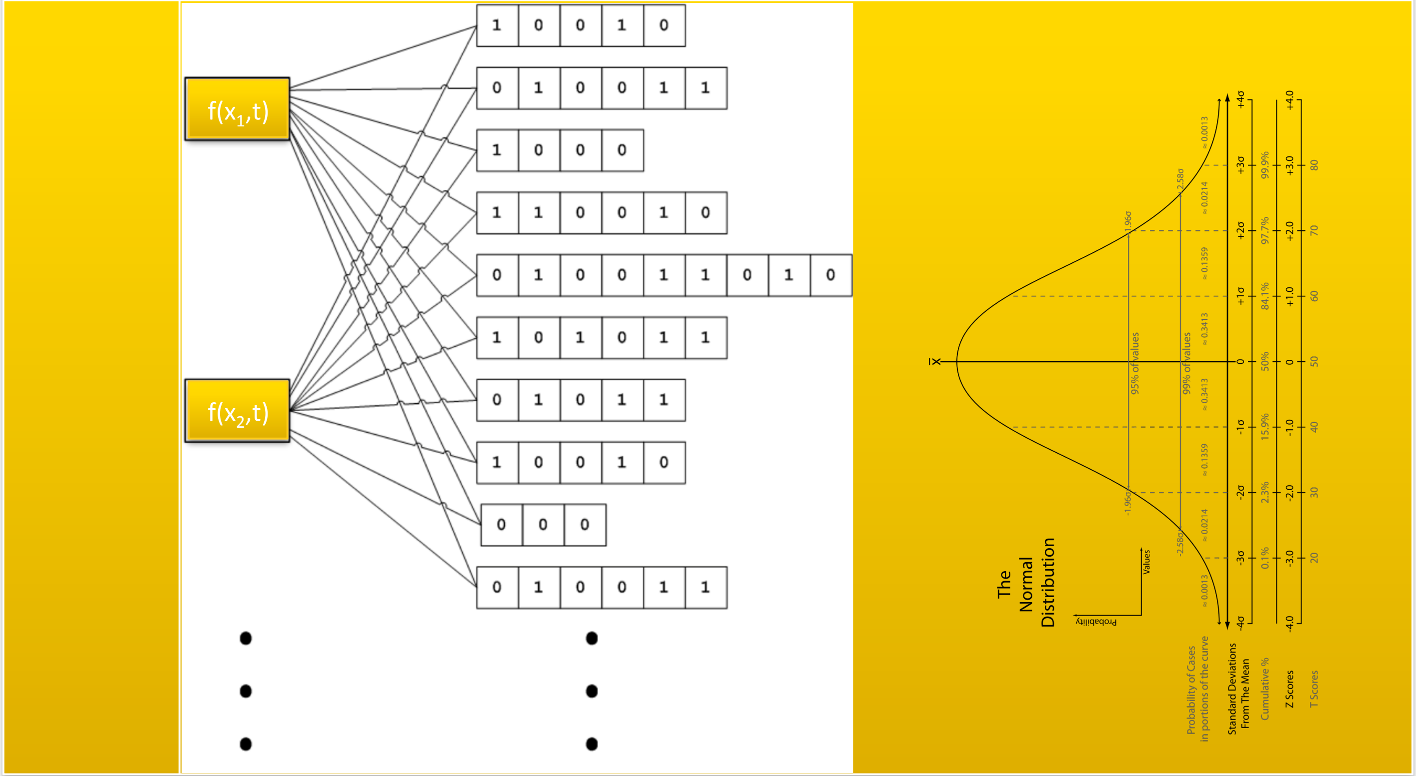
Information from all sources are written to the VDT via five (5) Functional Actions termed **A+CRUD**:

1. **A**rchive
2. **C**reate
3. **R**ead
4. **U**pdate
5. **D**elete

Therefore, as the system boundary around a product expands to infinite radius, all information written to the VDT becomes Normally Distributed.

Big Data cont.

Virtual Database Table (VDT)



All equations { $f(x_1,t)$, $f(x_2,t)$ … $f(x_n,t)$ } are laced together in the time domain

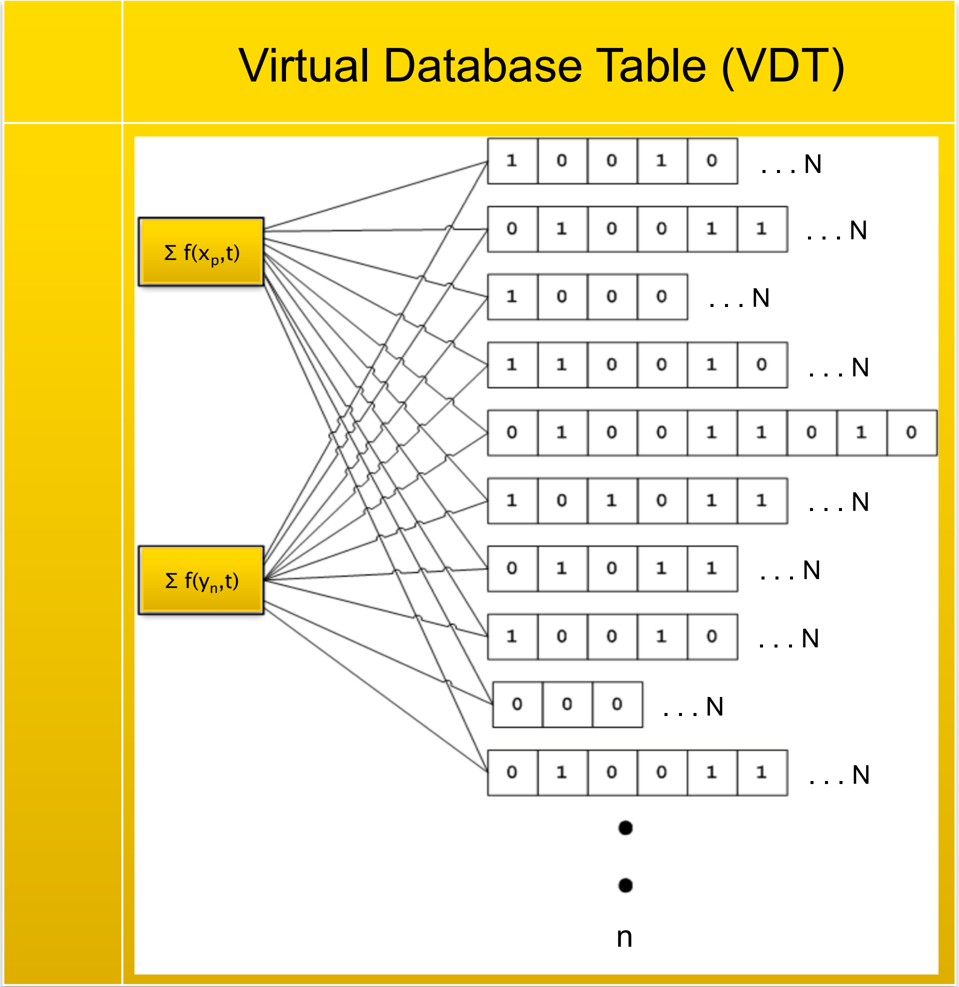
Normally Distributed data refers to the populated fields within each record on the VDT, which has undergone **A+CRUD** Functional Action:

1. **A**rchive
2. **C**reate
3. **R**ead
4. **U**pdate
5. **D**elete

Again: *as the system boundary around a product expands to infinite radius, all of the information written to the VDT becomes Normally Distributed.*

Testimation™

Big Data cont.



The VDT is an 'n × N' Matrix such that:

1. 'n' tends to infinity: 'n' ➔ ∞
   - This is the number of physical equations describing the Information Universe
2. 'N' >> 1
   1. It is an unknown finite value
   2. It denotes the number of measurable physical properties within the Information Universe
      1. e.g. mass, length, charge, inductance, capacitance, reactance, momentum etc.
      2. e.g. N = 3 {mass + length + charge}

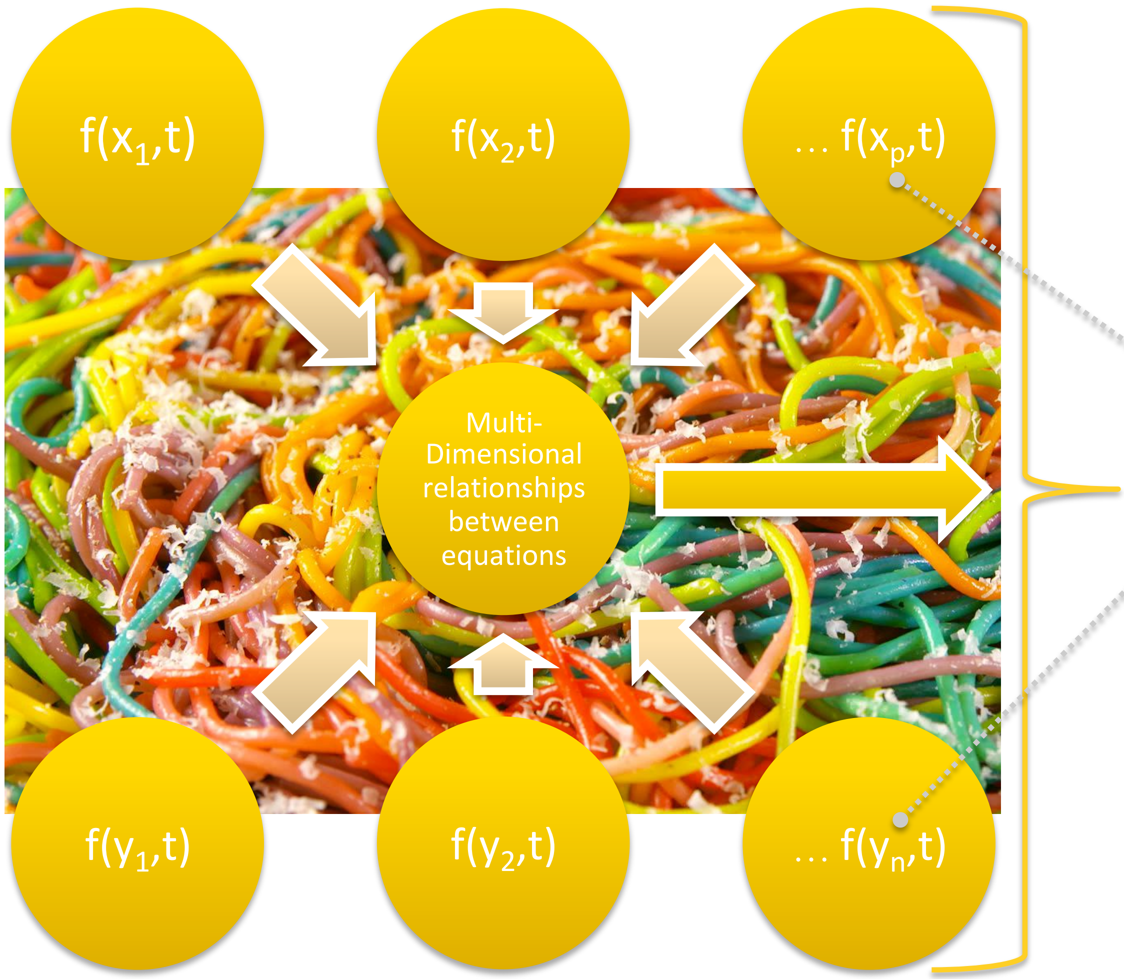
As product system equations interact with the Information Universe, data is being written to the VDT; records &/or fields may (*or may not*) undergo **A+CRUD** Functional Action (FA) continuously over the time domain.

Example (*only*)

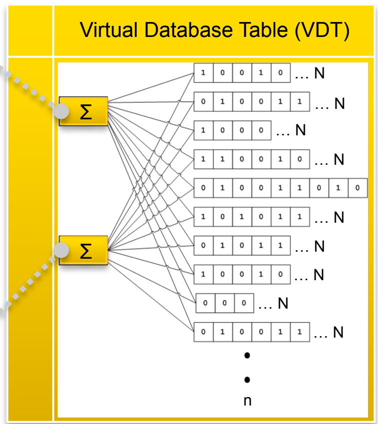
- Possible FA's executed via '$\Sigma f(x_p,t)$' &/or '$\Sigma f(y_n,t)$' upon entries to the VDT are:
  1. **A**rchive = Standby
  2. **C**reate = Commencing Operation
  3. **R**ead = System Feedback
  4. **U**pdate = Increased Current Draw
  5. **D**elete = Ceasing Operation

Testimation

Spaghetti



Equations can be laced together via the time domain (*parametrically*), but we may not understand the lacing between independent variables. For example, the relationship between 'x_1' & 'x_2' may be unknown. We can circumvent this impasse by assuming random lacing & inflating the system boundary to infinity. Hence, the information from a fully integrated Super-System is Normally Distributed due to its record population tending to infinity.

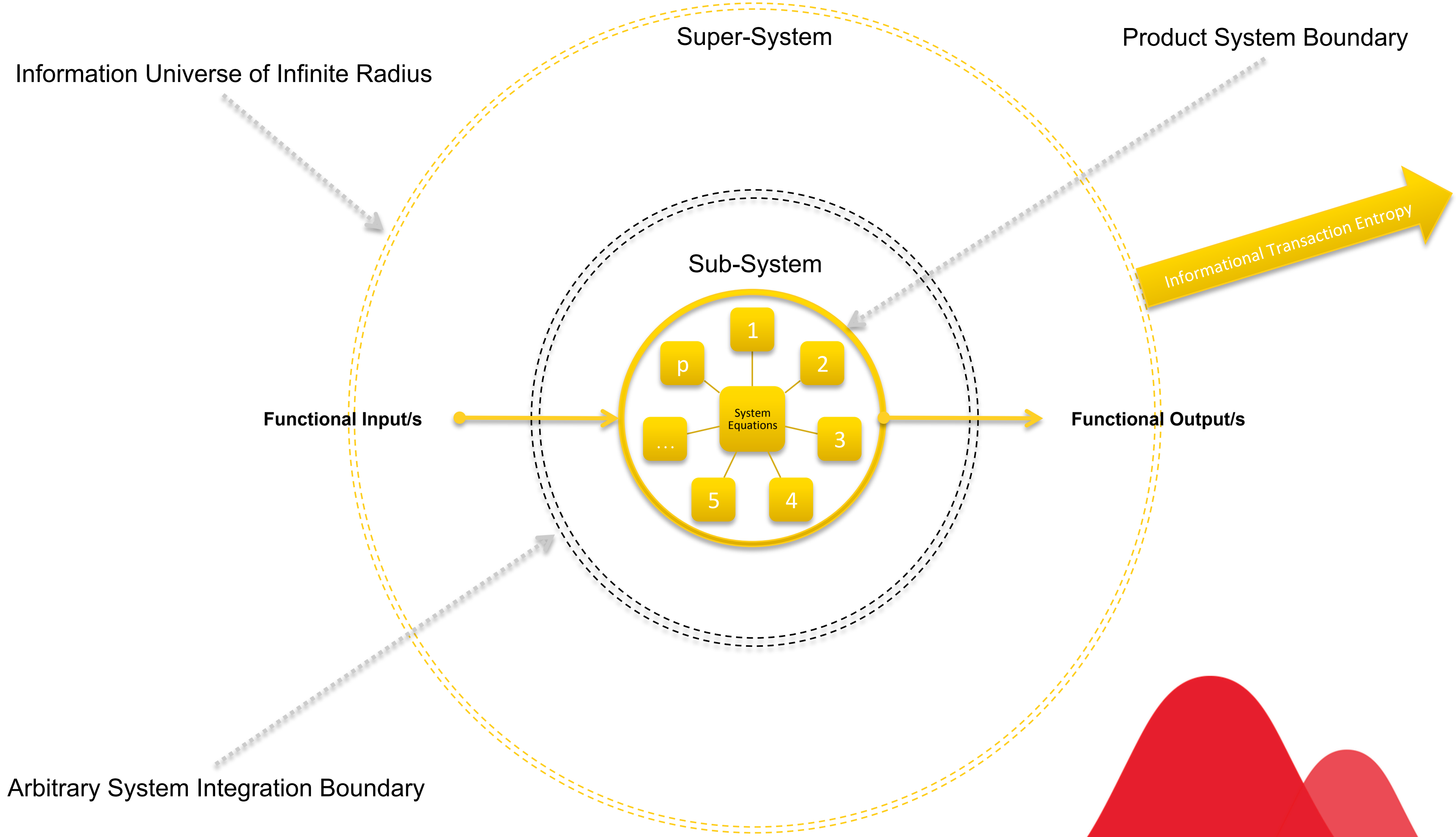


Transactional info. from 'p & n' equations populate destination records &/or fields; via **A + C R U D** Functional Action.

The Functional Processes (FP's) associated with a product, represent a random sample from an infinite population of FP's in a Super-System. Hence, a local product system boundary denotes a random sample taken from within a Super-System boundary of infinite radius.

Testimation

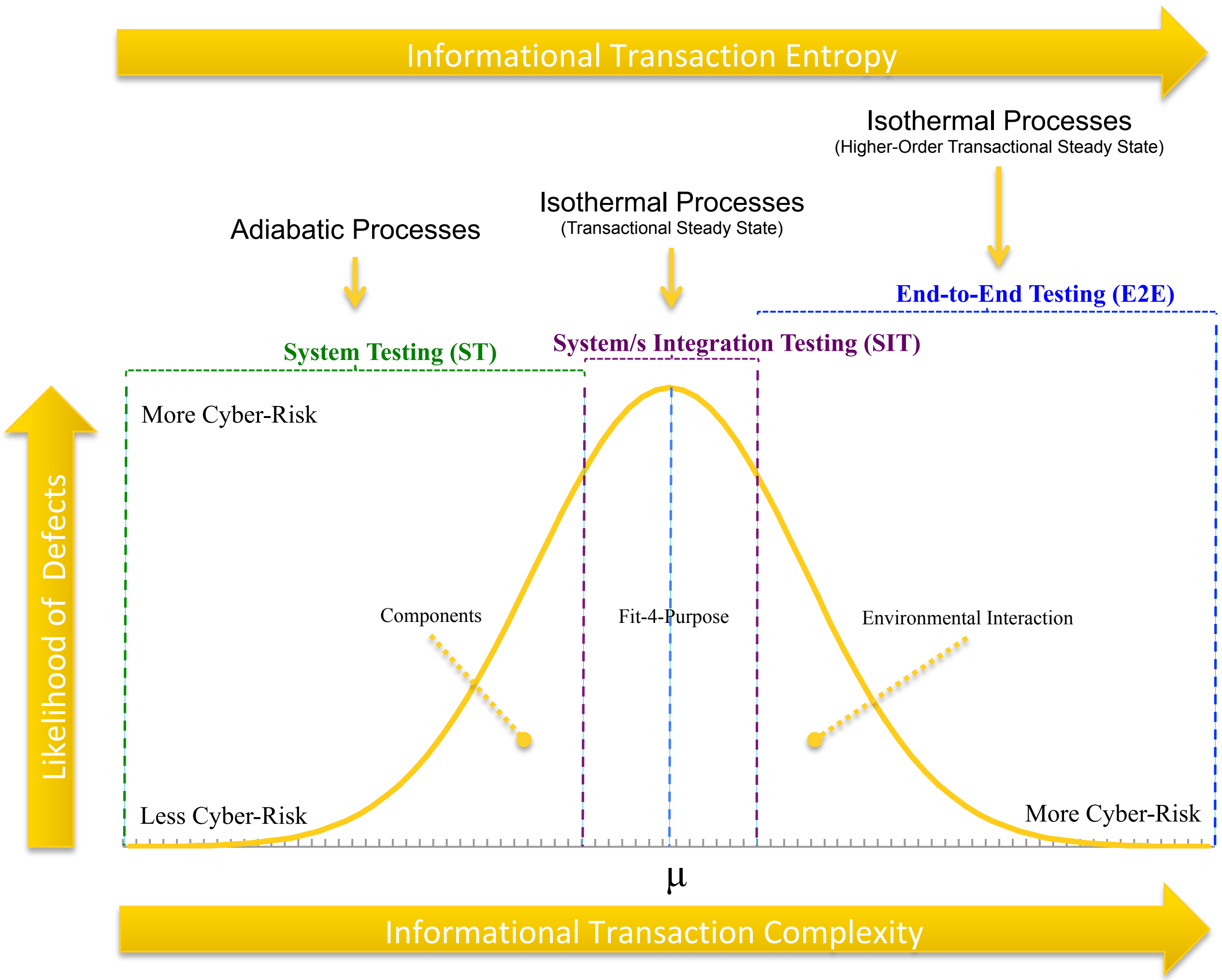
System Boundaries



www.testimation.com

engineering tools for
the science of estimation
& risk management

Informational Transactions

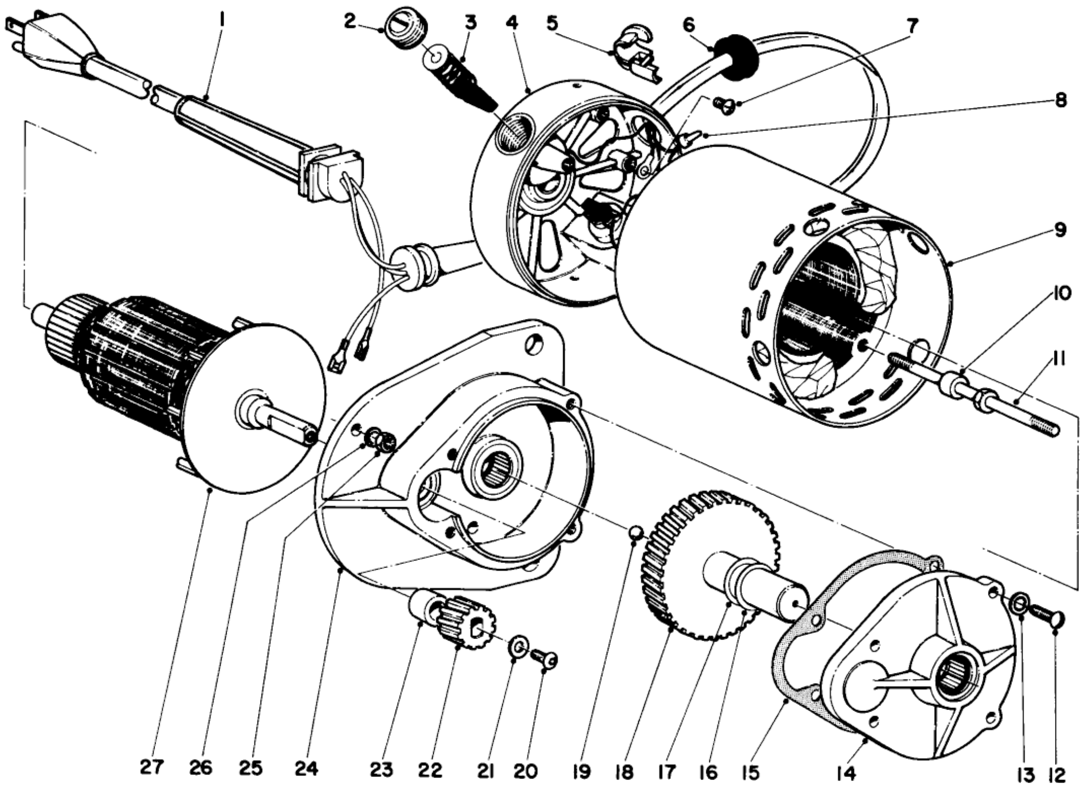


Testing a product (*by definition*) occupies the SIT Phase because information crosses the System Boundary via the Functional Processes designed into the product.

1. μ
   - The mean number of populated fields per record
2. ST
   - The phase where we'll find mostly Component (*fundamental*) defects
3. SIT
   - The phase where we'll find mostly Fit-4-Purpose (*critical*) defects
4. E2E
   - The phase where we'll find mostly Environmental Interaction (*unusual*) defects

engineering tools for the science of estimation & risk management

Sample Calculation



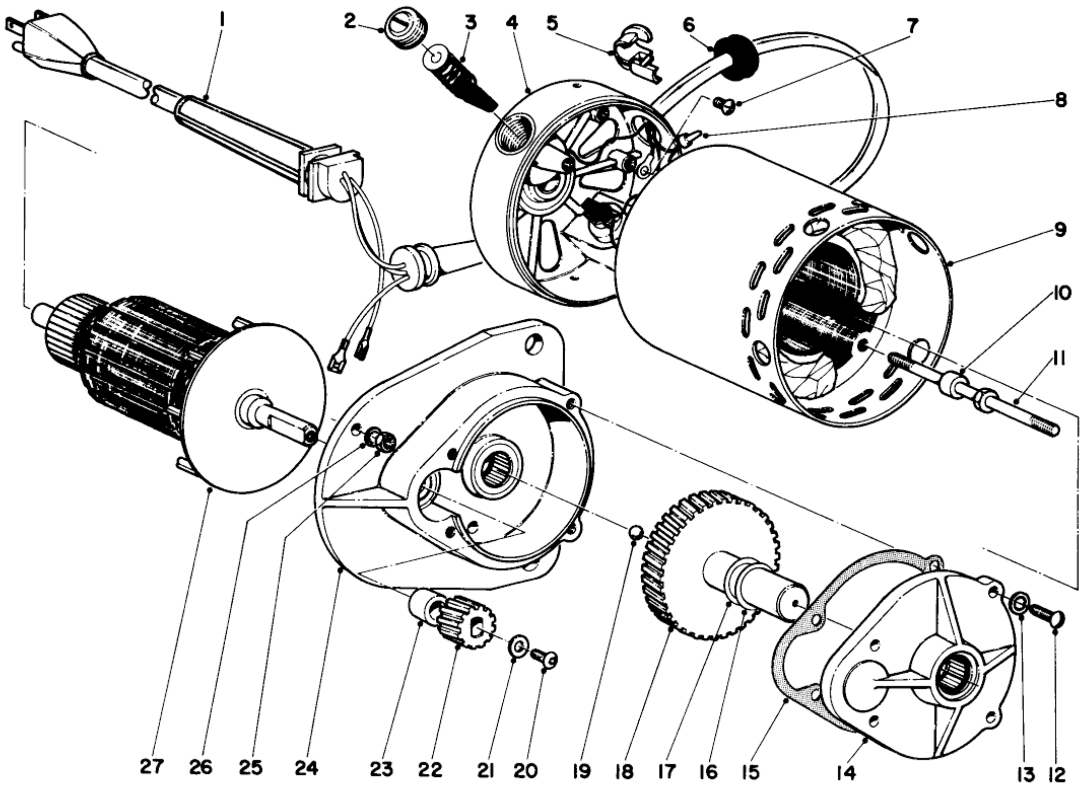
Dilemma 1

- An electric motor is to be assembled according to the drawing (*left*):
  - *What will be its Functionally Defect-Free Confidence* 'F_C' *at completion ?*

Solution

1. Define (*imagine*) a system boundary around the assembled state of the electric motor.
2. Identify the number Functional Processes (FP's) transacting information across the system boundary. In this example, only one FP exists:
   - Electrical Energy ➔ Mechanical Energy
     1. In = Electrical Energy
     2. Out = Mechanical Energy
3. Assume that the operation of each component, is governed by at least one relevant system equation; 27 in this example.
4. Determine (*acquire / obtain*) the total number of Quality Assurance (QA) Tests performed on all components; assume 108 Tests for this example.
5. Compute 'F_C' utilising Testimation Technology:
   - In this example: **F_C = 97.98(%)**

Sample Calculation cont.



Dilemma 2

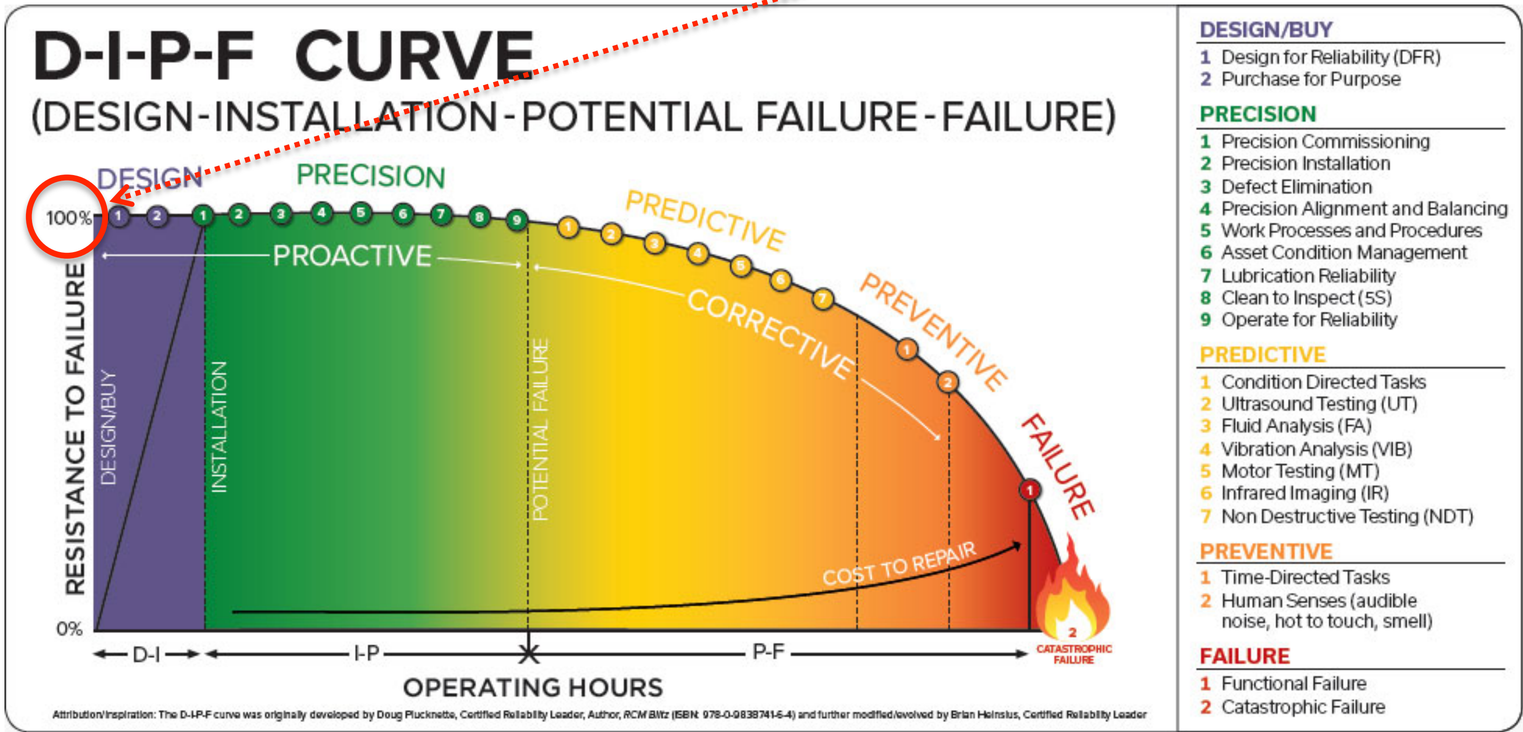
- An electric motor has been assembled according to the drawing (*left*):
  - *What will be its Functionally Defect-Free Confidence 'F_C' when shipped to the customer ?*

Solution

1. Determine (*acquire / obtain*) the number of additional QA Tests which have been executed between assembly & shipping; 12 in this example.
2. Calculate the total number of QA Tests executed by the time of shipping (QA_{TOT}); in this example:
   - QA_{TOT} = 108 + 12 = 120
3. Compute 'F_C' utilising Testimation Technology:
   - In this example: **F_C = 98.56(%)**

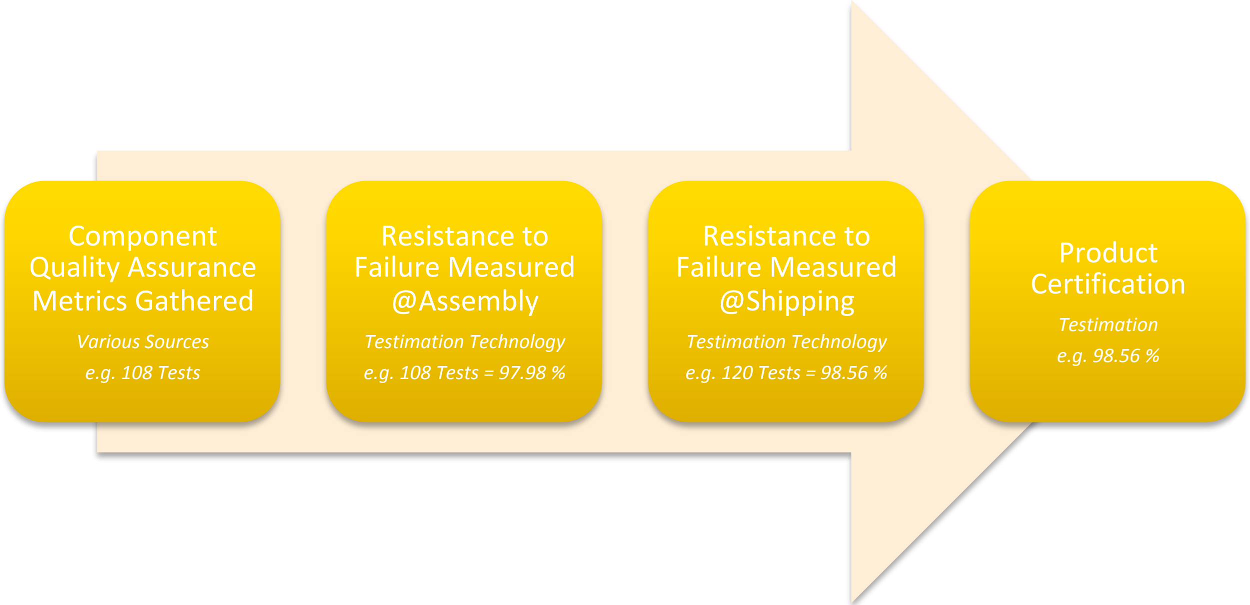
Resistance-2-Failure (R2F)

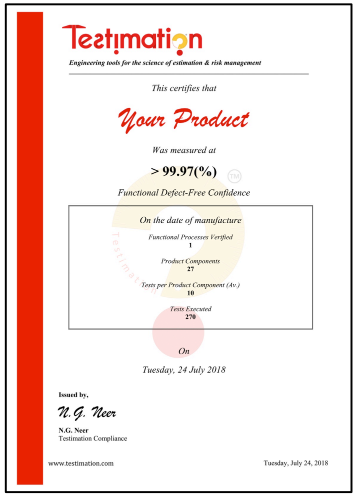
- Testimation Technology expresses a **measured** value at t = 0, not an assumed value (*e.g.* ***98.56%, 99.97%*** *etc., not 100%*)



Testimation

Outcome




Testimation

Engineering tools for the science of estimation & risk management

This certifies that

Your Product

Was measured at

> 99.97(%)

Functional Defect-Free Confidence

On the date of manufacture

Functional Processes Verified
1

Product Components
27

Tests per Product Component (Av.)
10

Tests Executed
270

On

Tuesday, 24 July 2018

Issued by,

N.G. Neer

N.G. Neer
Testimation Compliance

www.testimation.com
Tuesday, July 24, 2018

Sample Format