Product Development

Certification Overview

engineering tools for
the science of estimation
& risk management

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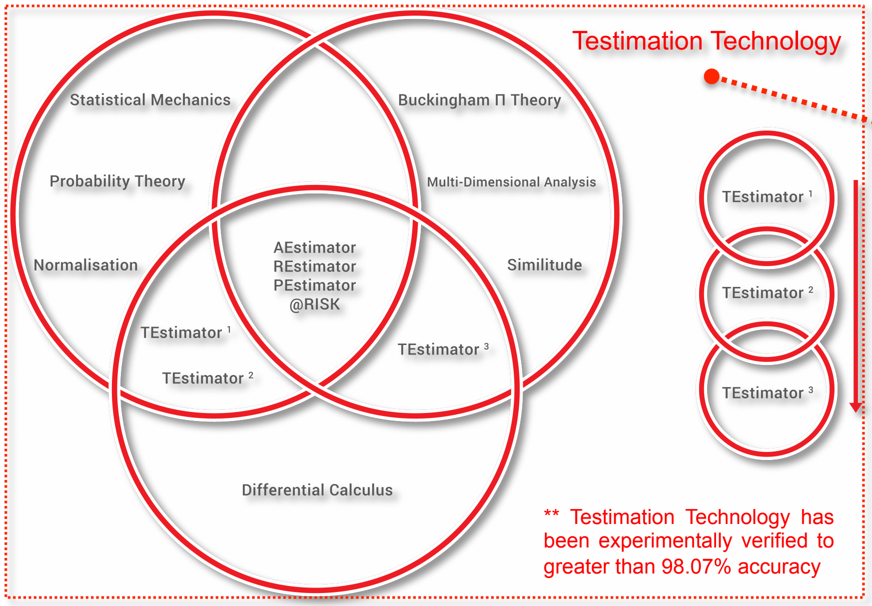
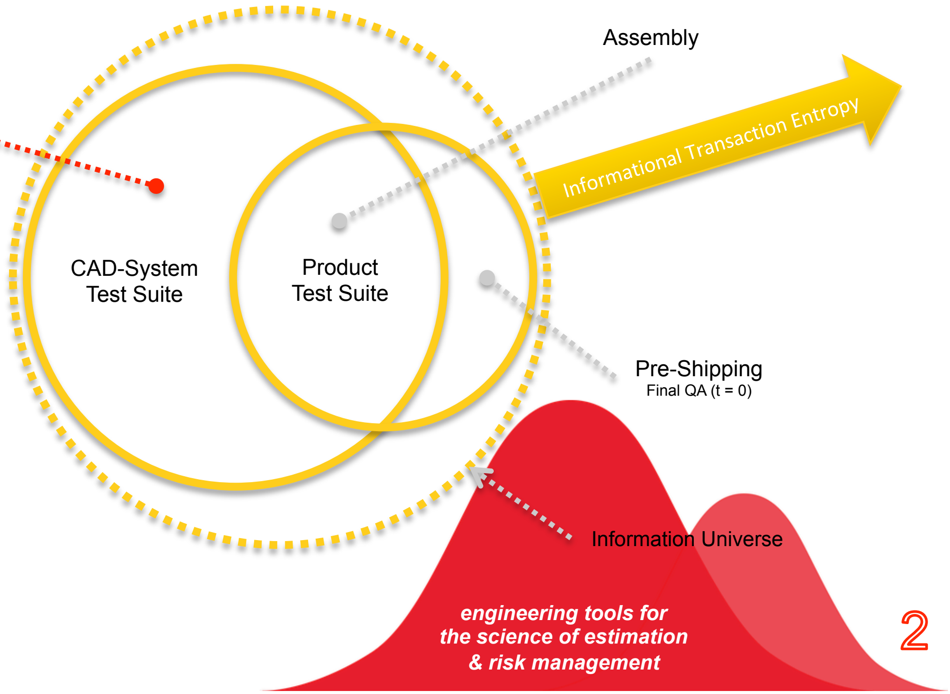
Executive Summary

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





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Principles & Precepts

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

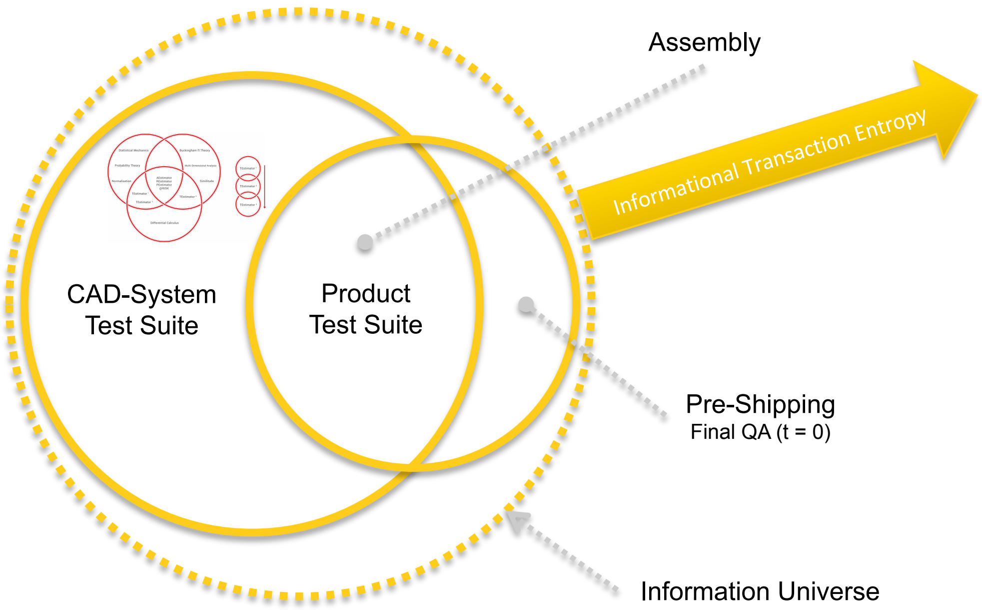
3. All User Interaction with software may be represented by Functional Processes (FP's)
   - An FP is a train of Software Function Points (SFP's) facilitating a User Work Instruction
     - e.g. Create User Account, Delete User Account, Print Annual Sales Report etc.

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

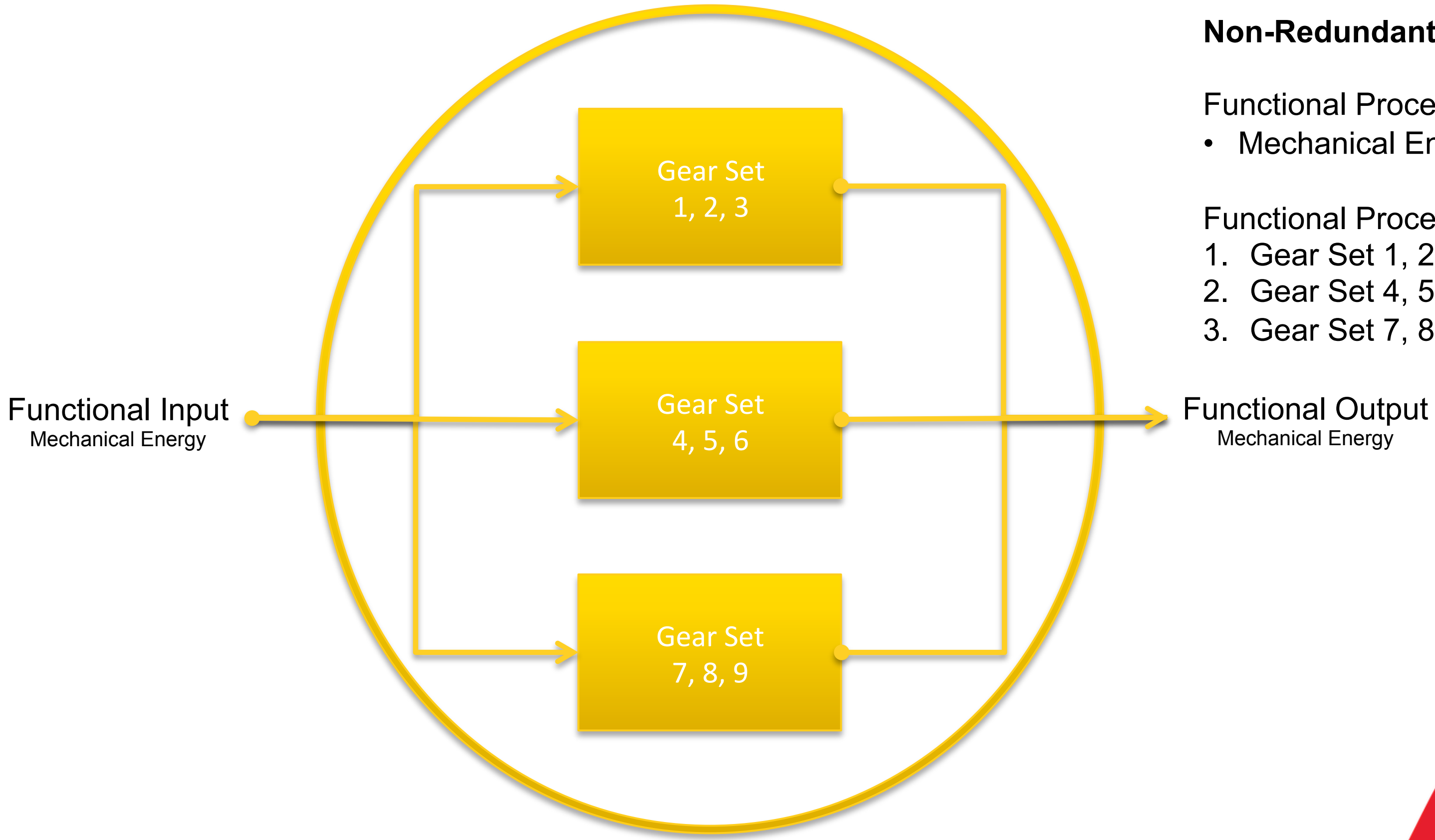
"Counting Functional Processes (FP's)" is a description of the desired outcome; what we're actually seeking to determine, are the number of Functional Process Pathways (FPP's) through a system. An FPP denotes a route capable of carrying information critical to the Primary Operational Function of a product (*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)***



Internal Hub-Gear 1
Bicycle

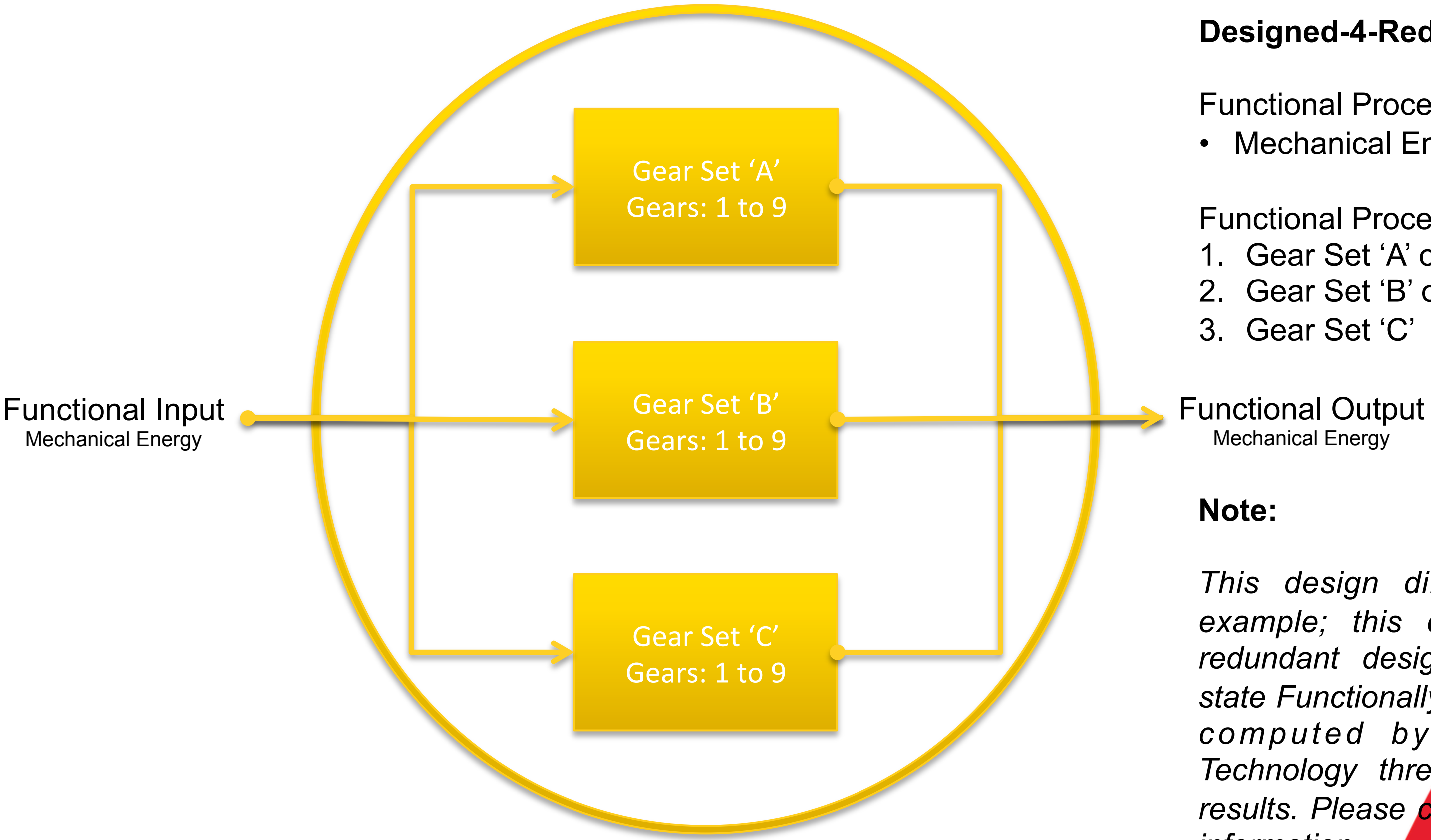
Non-Redundant Design

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)**

Functional Processes cont.

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 %

‘FP’ = Number of Functional Process Pathways | ‘QA’ = Number of Quality Assurance Tests
Values shown are for demonstration purposes only

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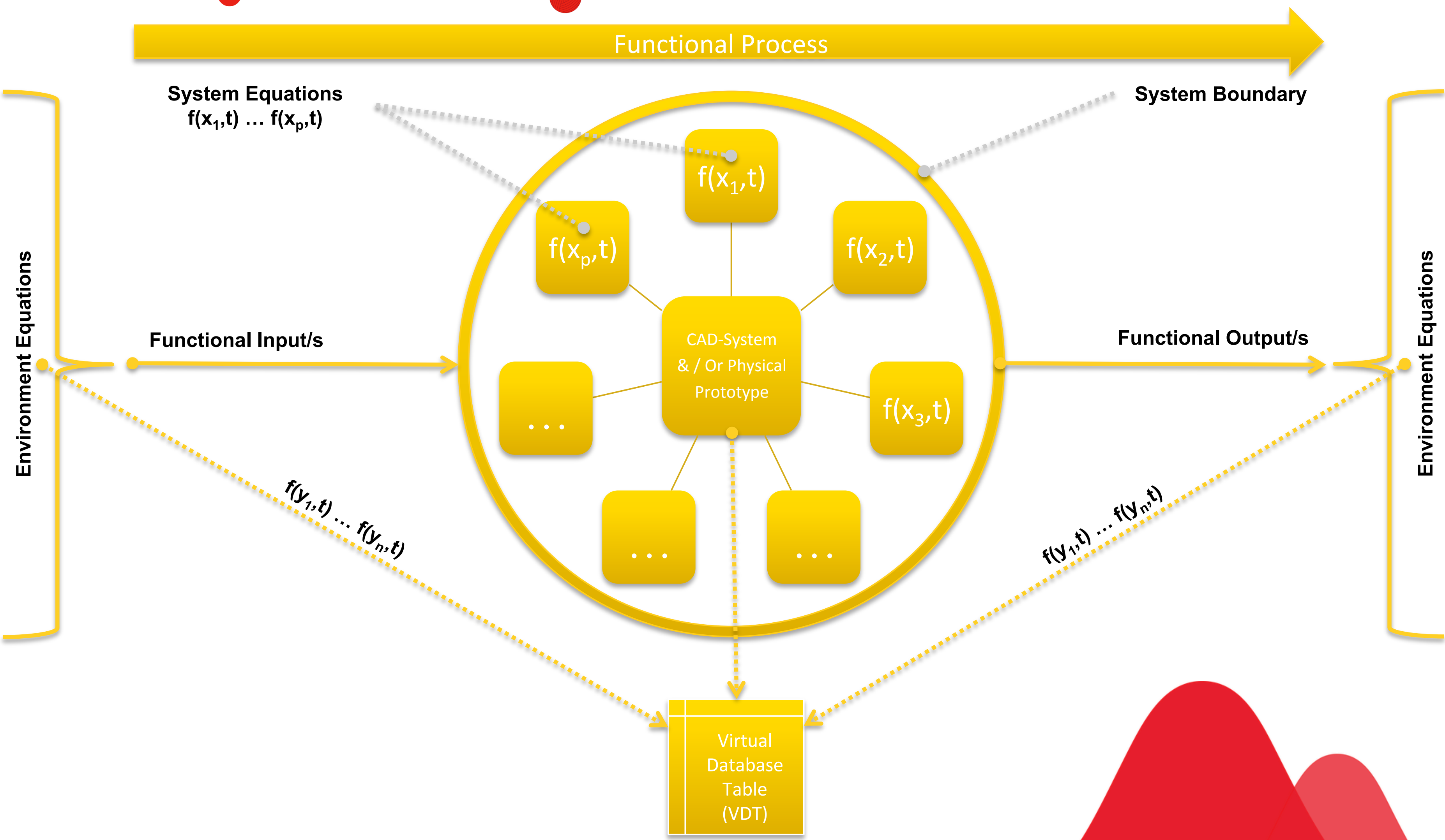
Conceptualisation



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

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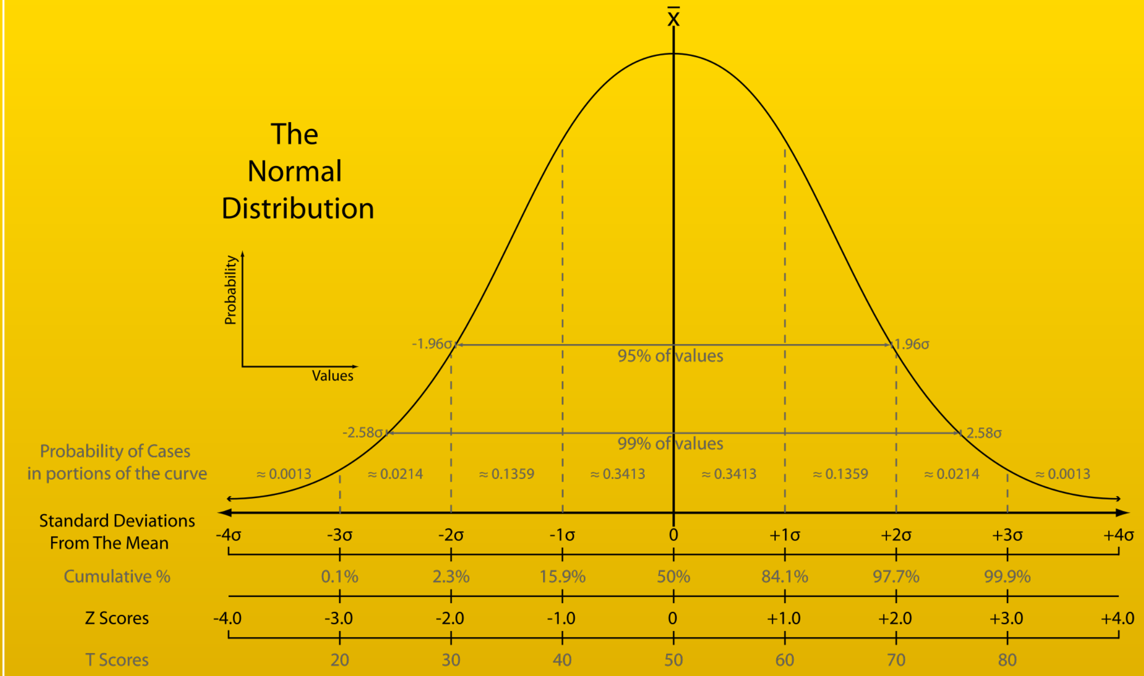
Big Data

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.

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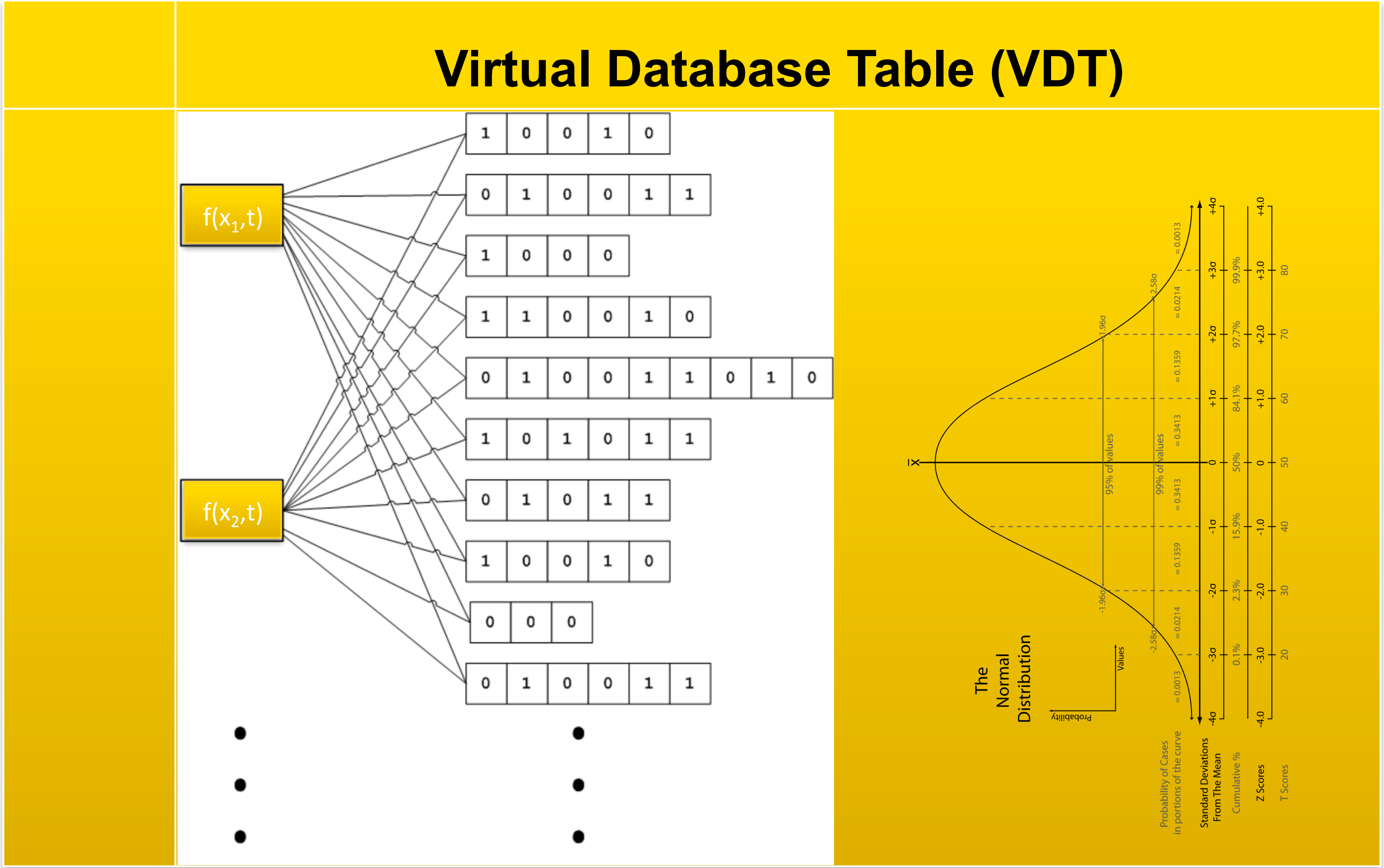
Big Data cont.



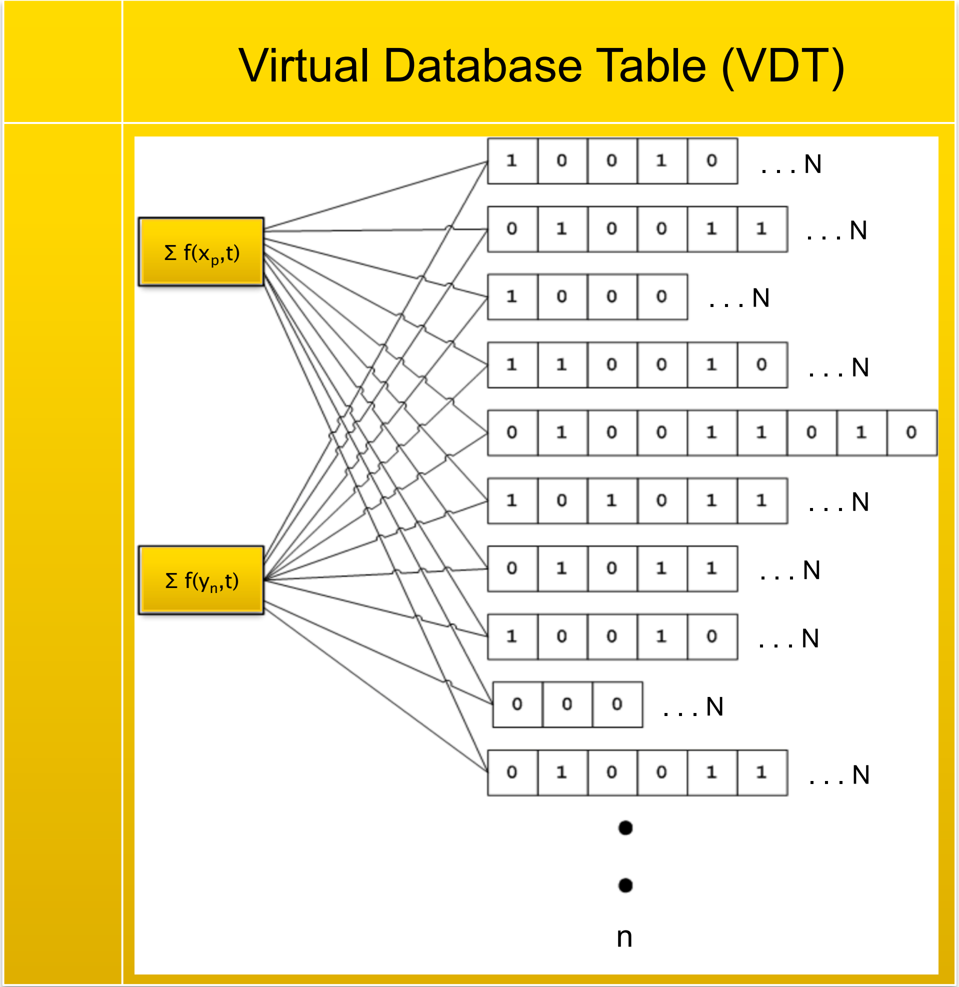
All equations { $f(x_1,t)$, $f(x_2,t)$ … $f(x_n,t)$ } are laced together in the time domain

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.*

Big Data cont.



The VDT is an ‘n × N’ Matrix such that:

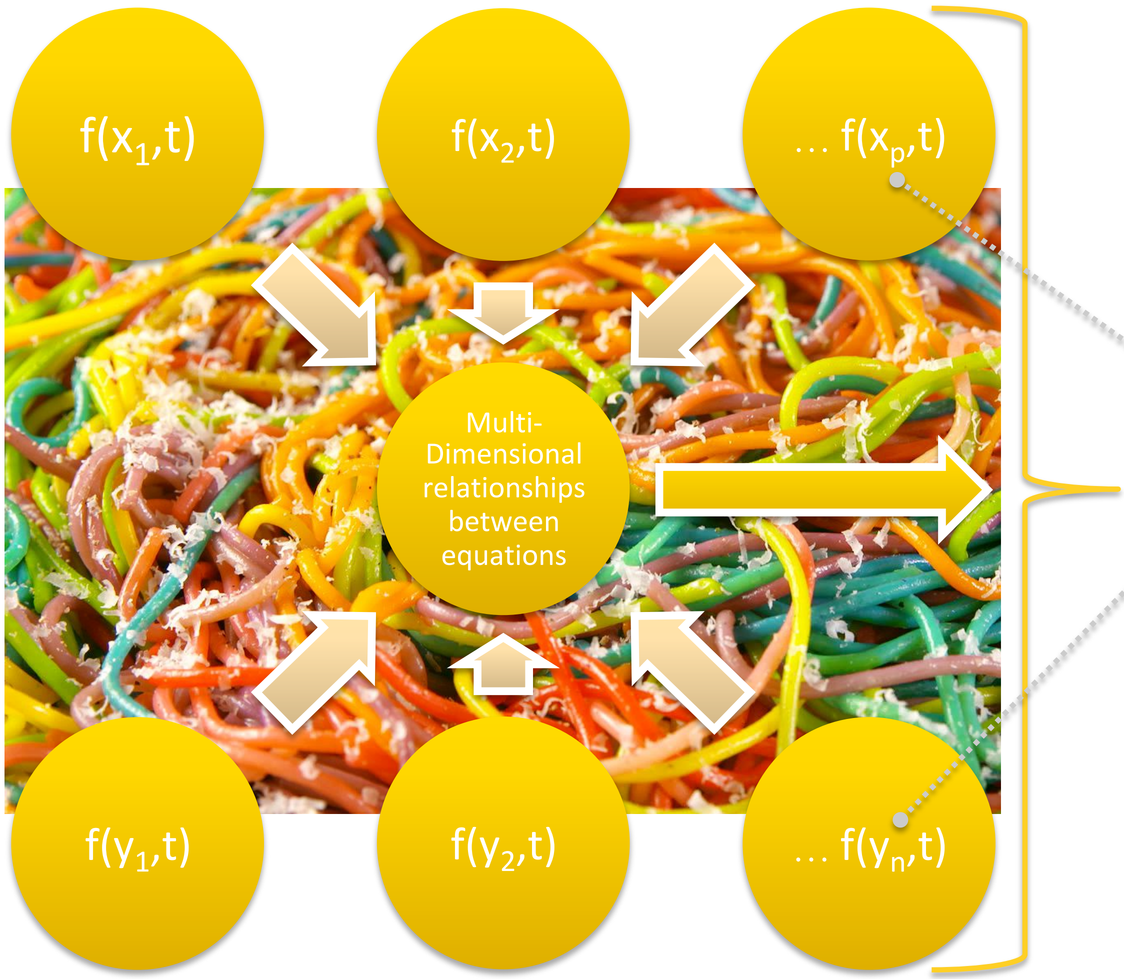
1. ‘n’ tends to infinity: ‘n’ ➔ ∞
   - This is the number of physical equations describing the Information Universe
2. ‘N’ >> 1
   1. It is an unknown finite value
   2. It denotes the number of measurable physical properties within the Information Universe
      1. e.g. mass, length, charge, inductance, 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.

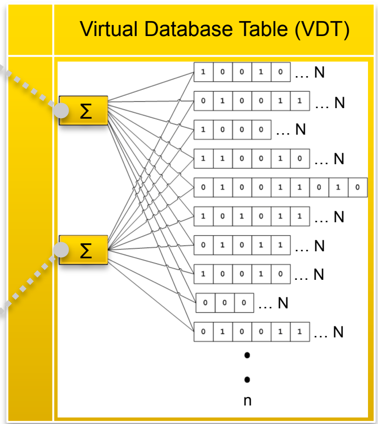
Example (*only*)

- 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

Spaghetti



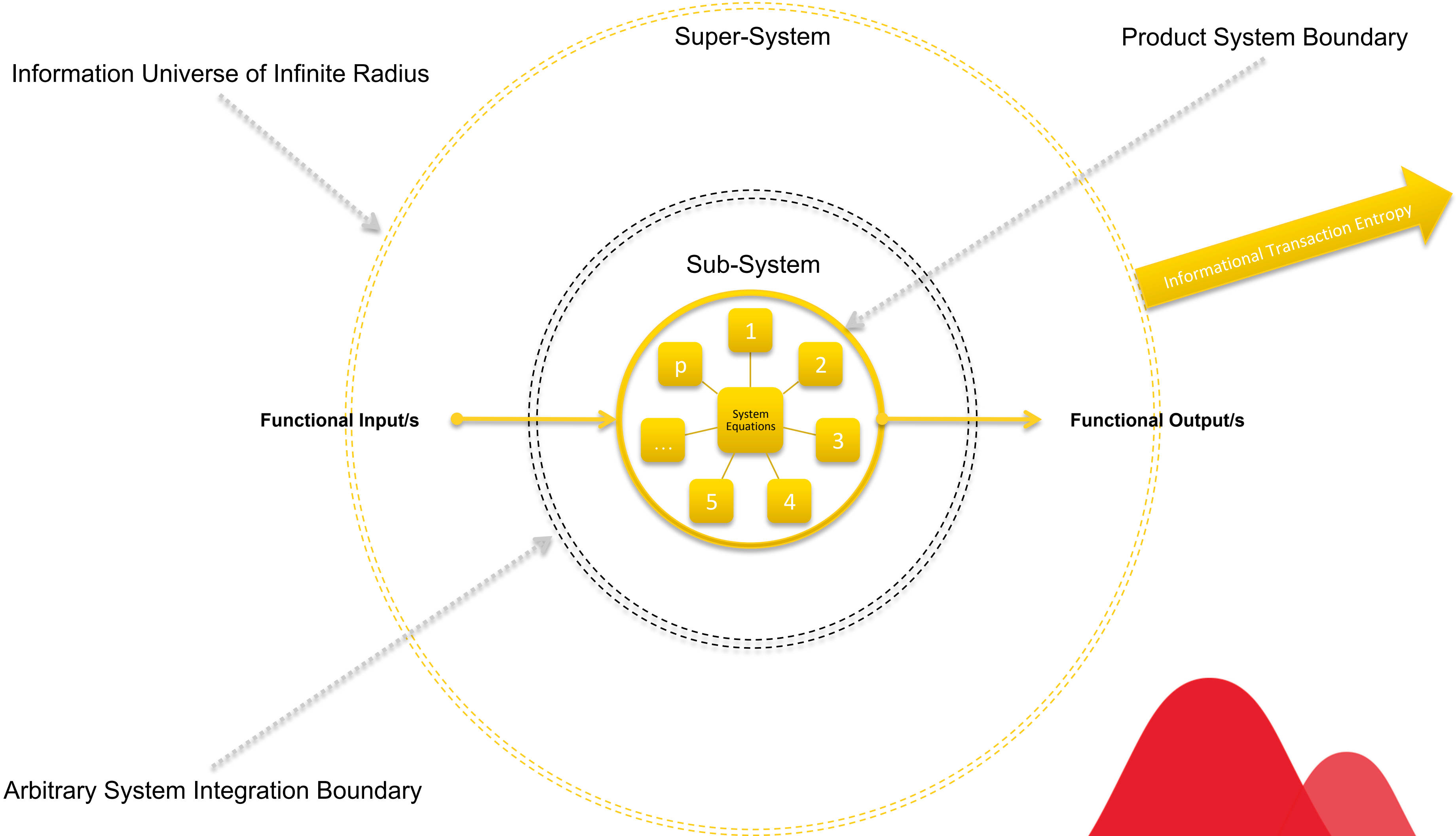
Equations can be laced together via the time domain (*parametrically*), but we may not understand the lacing between independent variables. For example, the relationship between 'x_1' & 'x_2' may be unknown. We can circumvent this impasse by assuming random lacing & inflating the system boundary to infinity. 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.

System Boundaries



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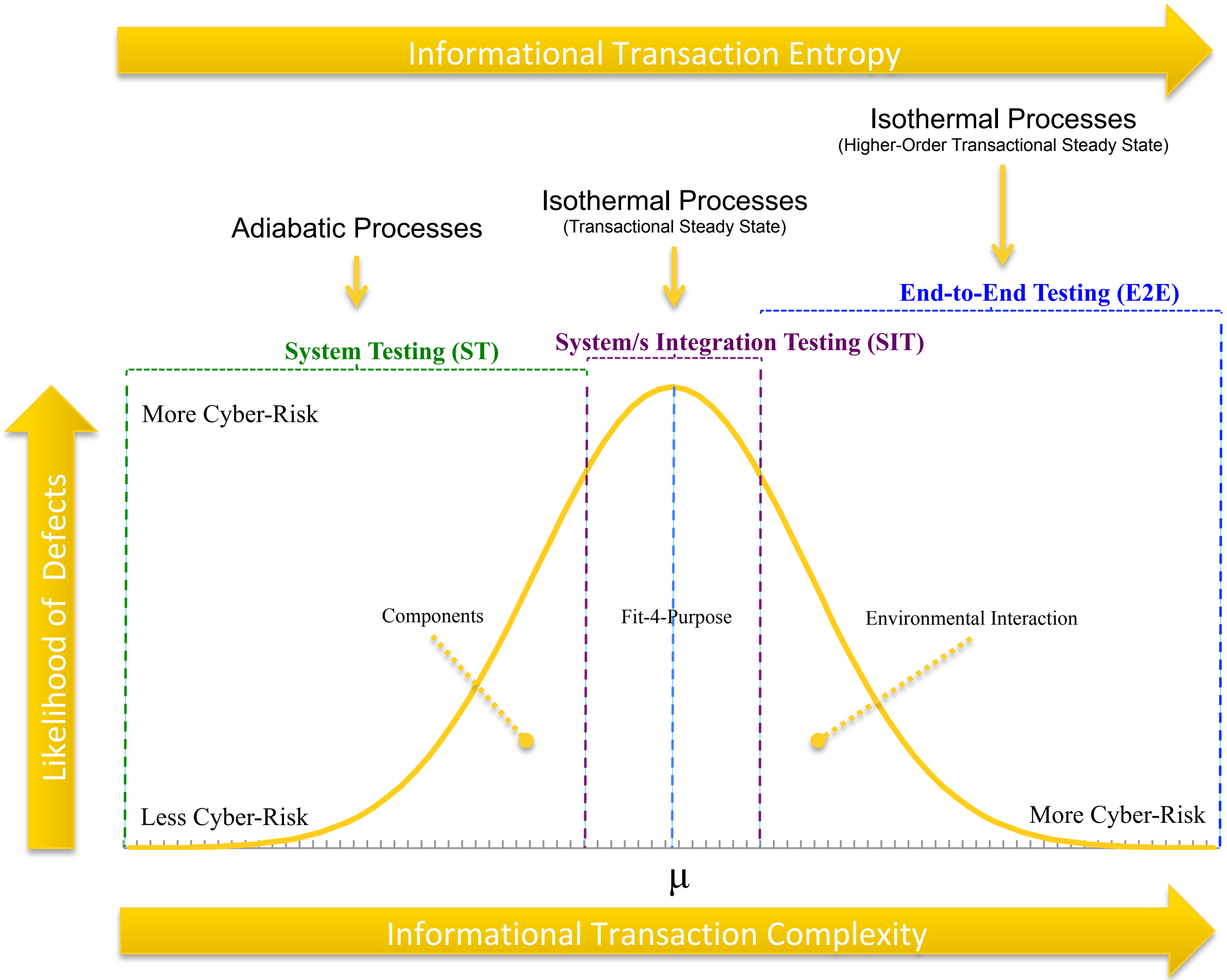
Informational Transactions



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

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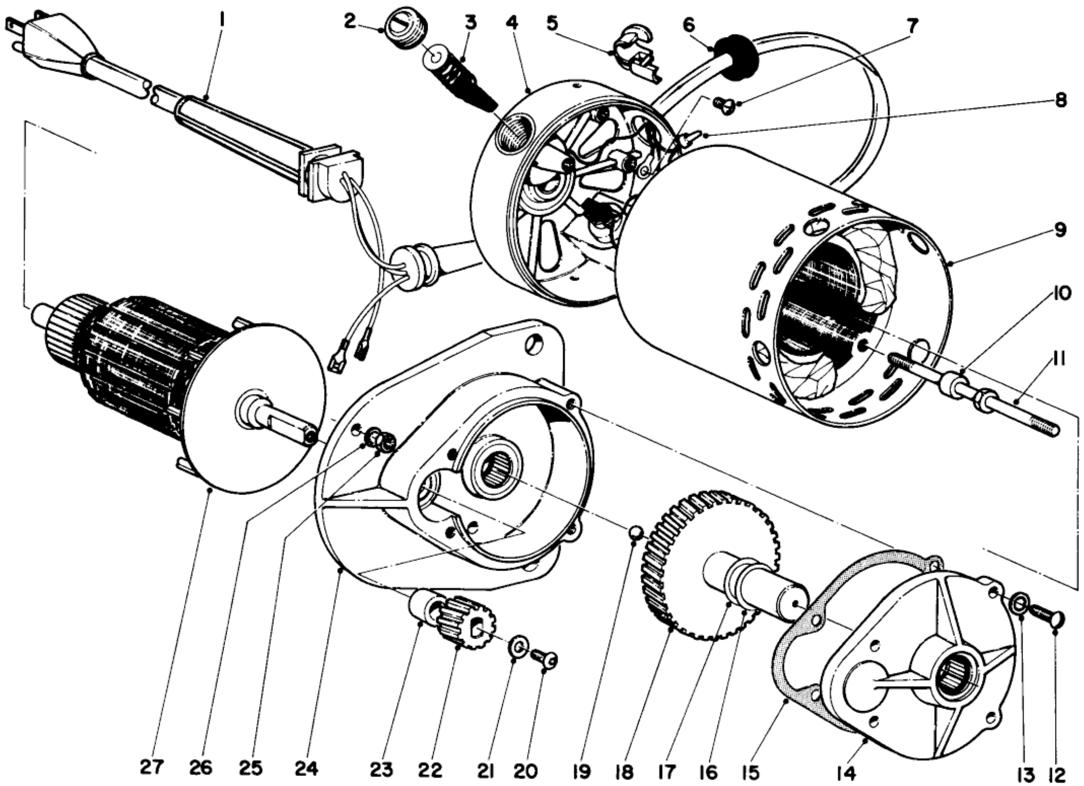
Sample Calculation



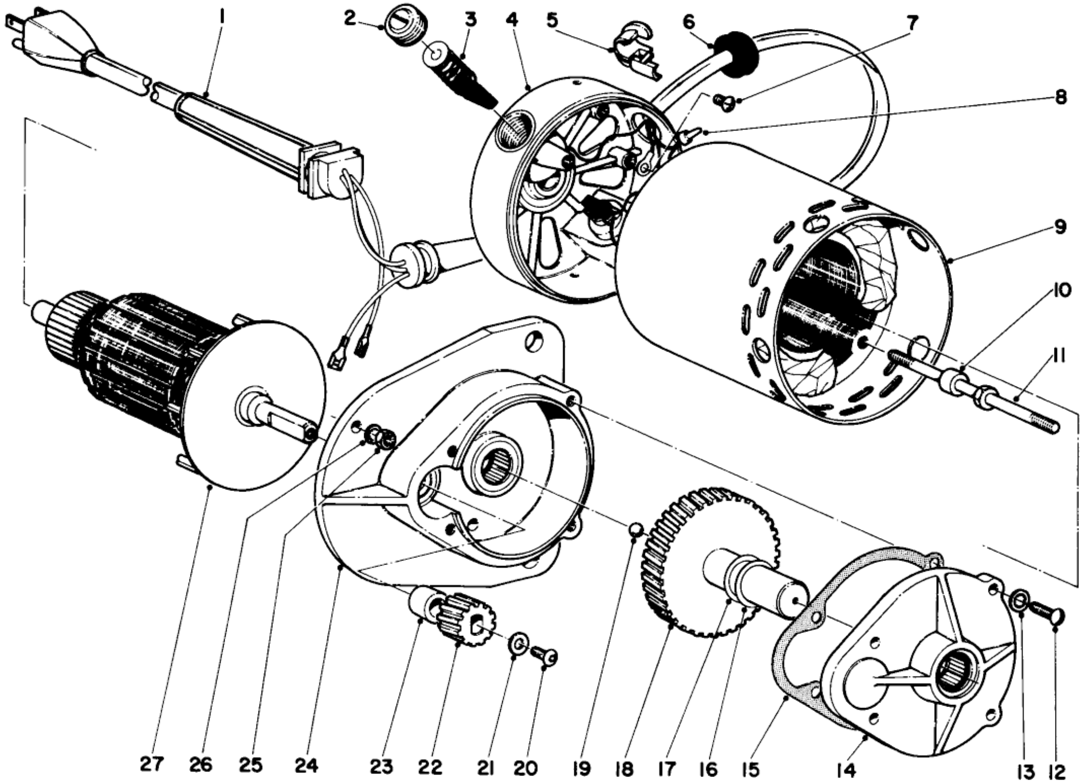
Dilemma 1

- 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

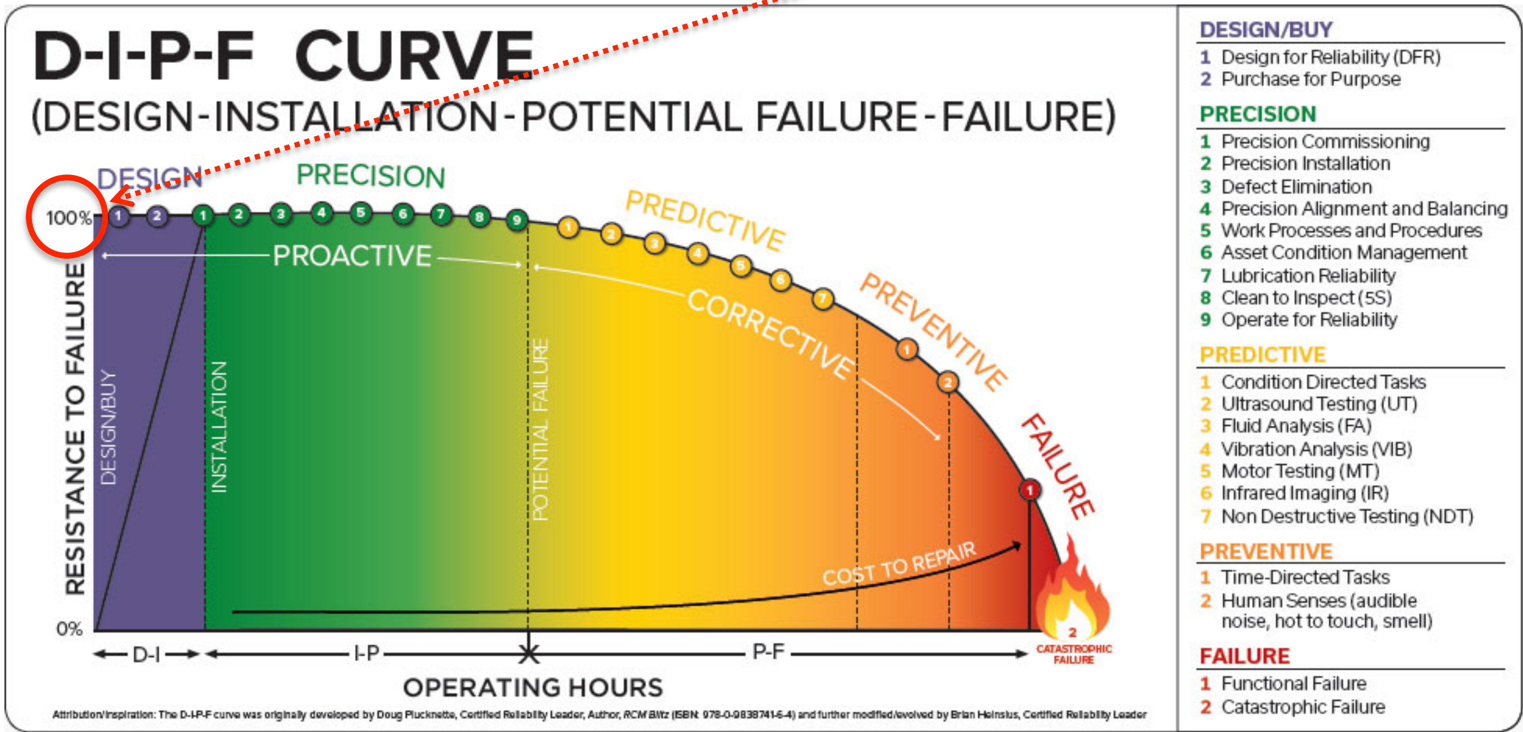
- An electric motor has been assembled according to the drawing (*left*):
  - *What will be its Functionally Defect-Free Confidence 'F_C' when shipped to the customer ?*

Solution

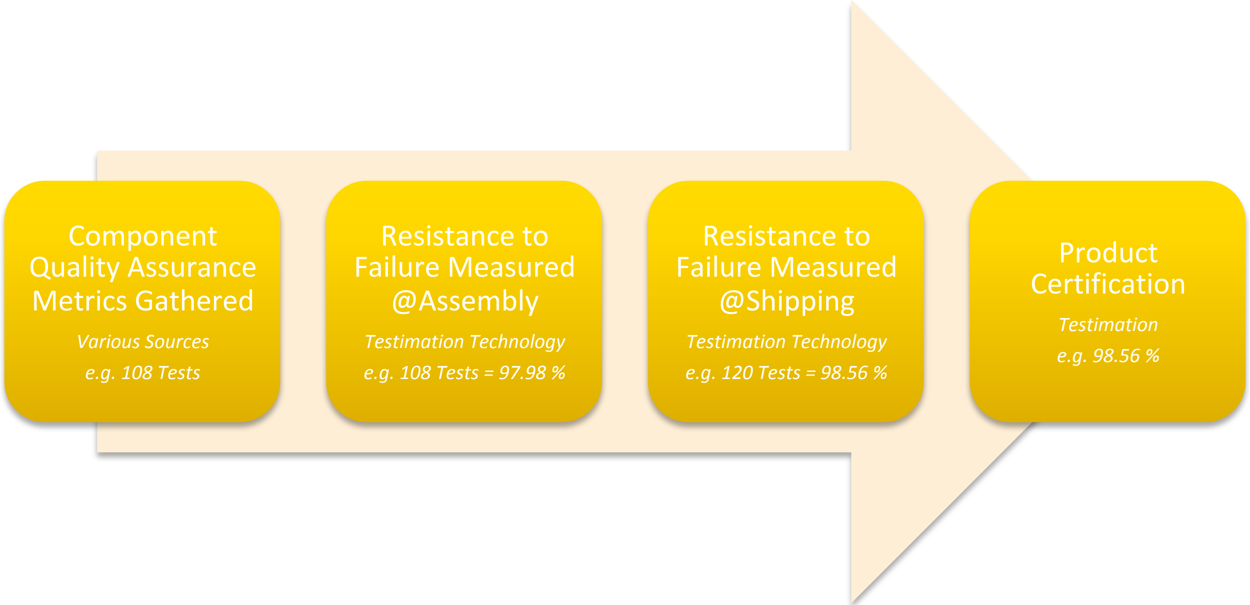
1. Determine (*acquire / obtain*) the number of additional QA Tests which have been executed between assembly & shipping; 12 in this example.
2. Calculate the total number of QA Tests executed by the time of shipping (QA_{TOT}); in this example:
   - QA_{TOT} = 108 + 12 = 120
3. Compute 'F_C' utilising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

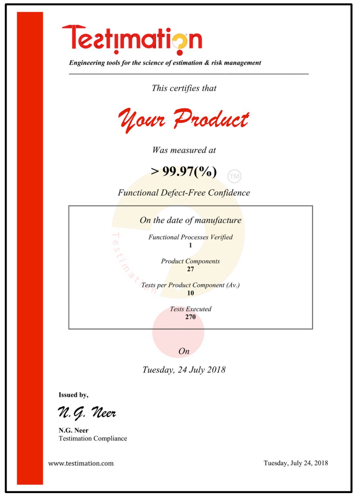
Resistance-2-Failure (R2F)

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



Outcome





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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

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Sample Format