CAE Model Interrogation & Data Mining

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" A rt without engineering is dreaming;
Engineering without art is calculating."

"The greatest deception men suffer is from their own opinions."

Leonardo da Vinci

Topics

- ✓ **Introduction**
  What is the landscape. Which of the problems this paper addresses?
- ✓ **Current PDP Environment**
  Where is a good way to start?
- ✓ **CAE's influence within PDP**
  Knowledge Elicitation, Quantification Qualification & knowledge utilisation
  - ✓ **CAE model interrogation**
    Several questions for a CAE model
  - ✓ **CAE data mining**
    Make sense out of the CAE Data Output
- ✓ **Conclusions**

Introduction

- Rapid & Turbulent Environment emphasises need for a Rapid & Higher Performing PDP (Product Development Process).
  ∴ Virtual PDP a necessity
- CAE toolset
  - the only virtual means of design valuation and verification
  - the most effective and efficient means to rapidly qualify and quantify product expectations and deliverables

However;

- CAE's functional and domain specific nature.
  ∴ impedes efficient PDP knowledge discovery and flow

Introduction

- PDP's foundation is based on comprehension & availability of product specific knowledge amongst all the stakeholders.
- Comprehension & Availability of Product specific knowledge is via;
  - Acquisition, Processing, Elicitation, Encapsulation, Representation, Validation & Verification
- PDP knowledge is created & established mainly via;
  - Direct engagement & use of every PDP stakeholder specific know-how
  - The acquisition of current and potential future customer needs
  - The direct mapping of all the customer & business needs at all the necessary PDP development layers.

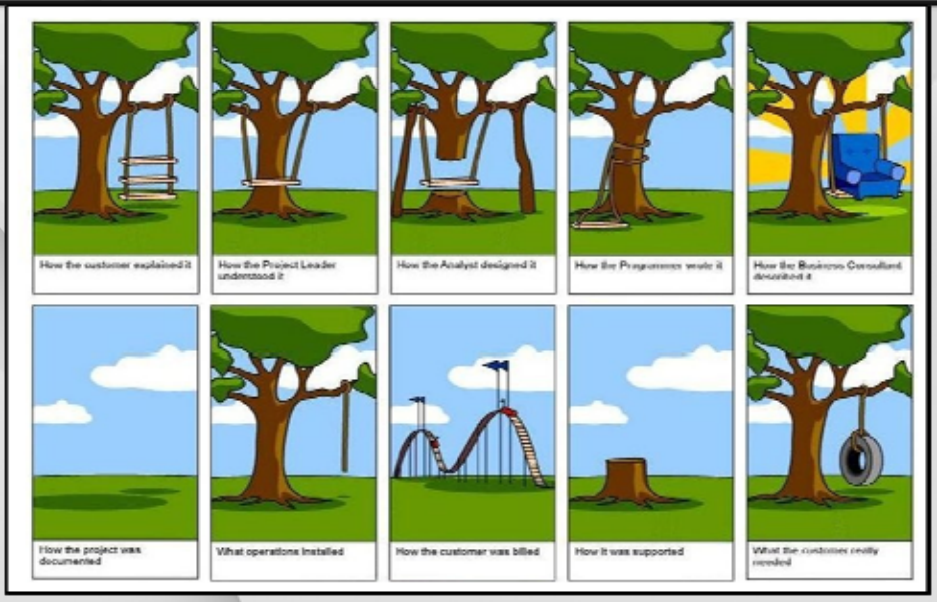
The Problem Focus

What this paper aspires to answer

- **Current CAE toolset perceived shortcomings**;
  - Utilise a small fraction of an enterprises informational asset
  - Specific product requirements can't be addressed explicitly neither described with high fidelity
    However *it has a fundamental impact on CAE assumptions*
  - Are not capable to address the social relational process. *What drives CAE runs? How these get socialised &reported?*
  - Cascaded product requirements have no reliable framework for a traceable decision making process, from which a system, product attribute feature etc. has been derived.

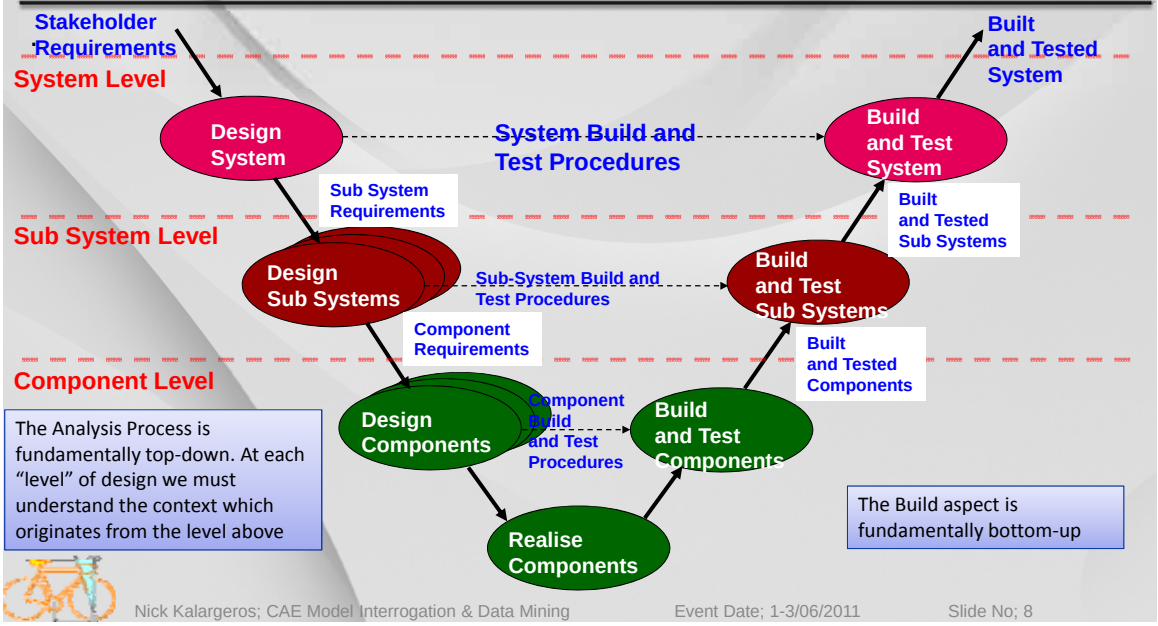
Current PDP Environment

Volatility from Communication failure

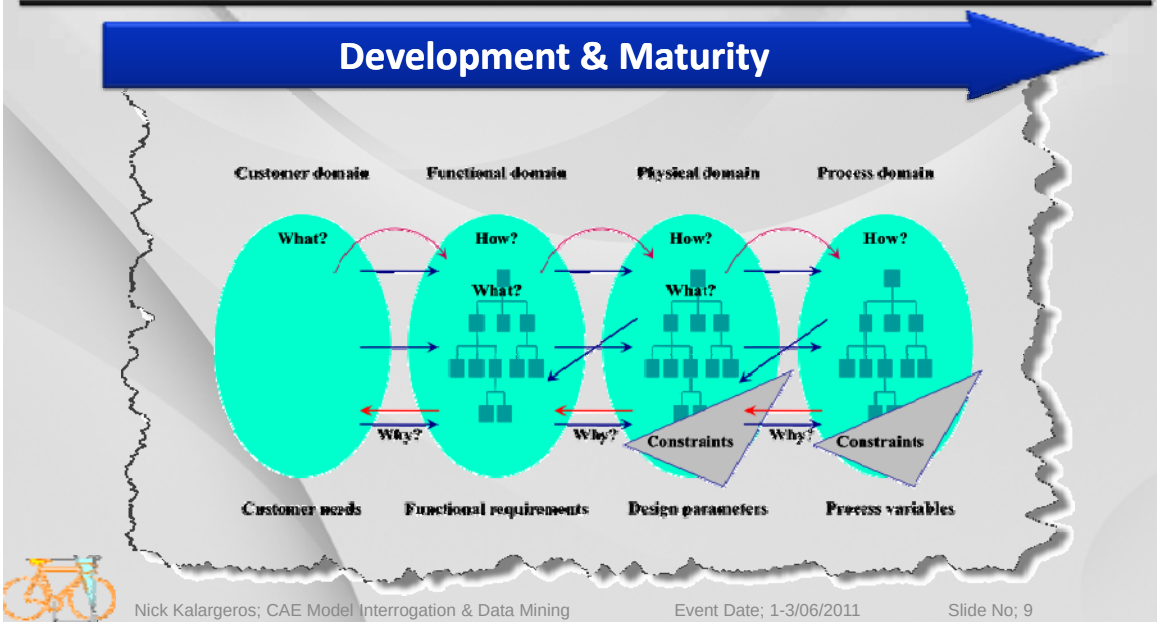


Current PDP Environment

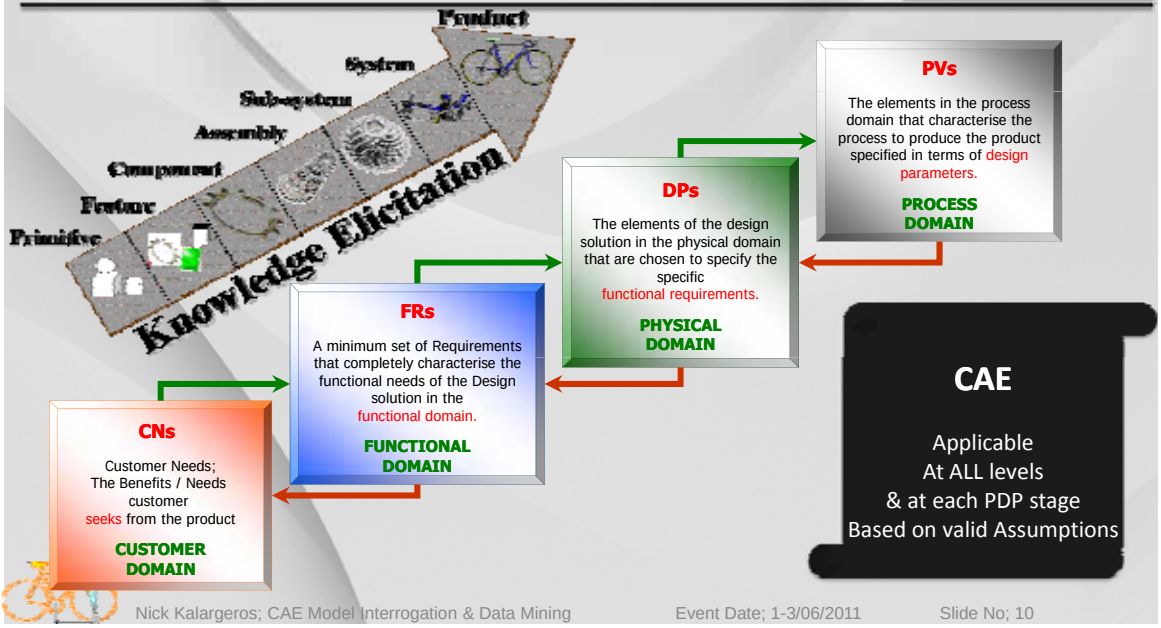
The V Diagram



Current PDP Environment
Cognition

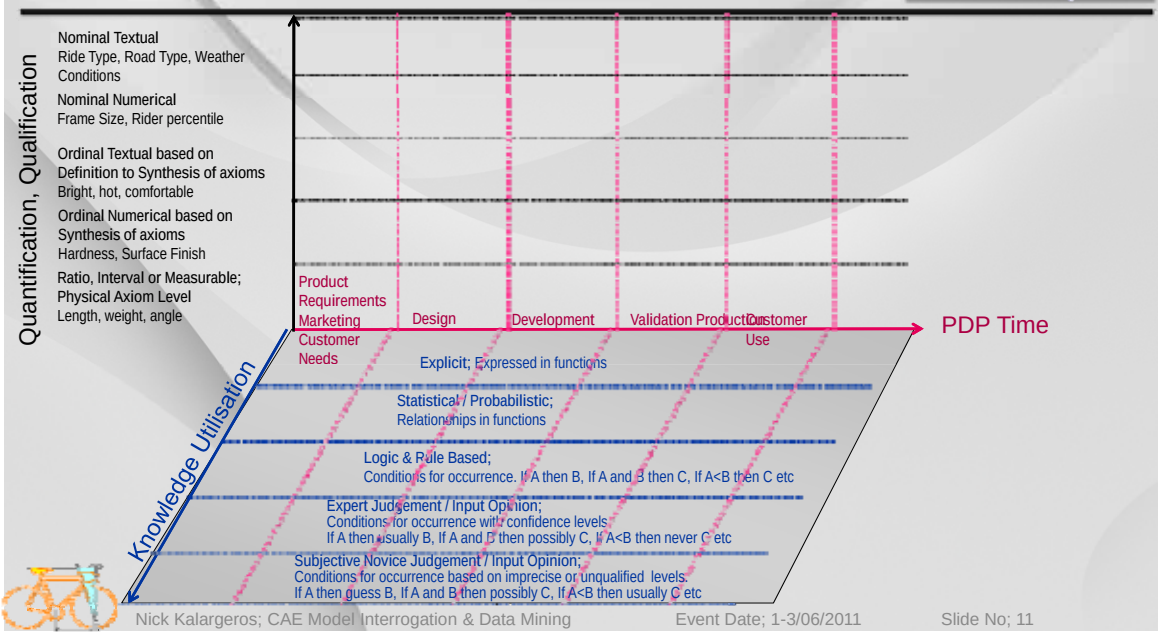


CAE's influence within PDP
Knowledge Elicitation



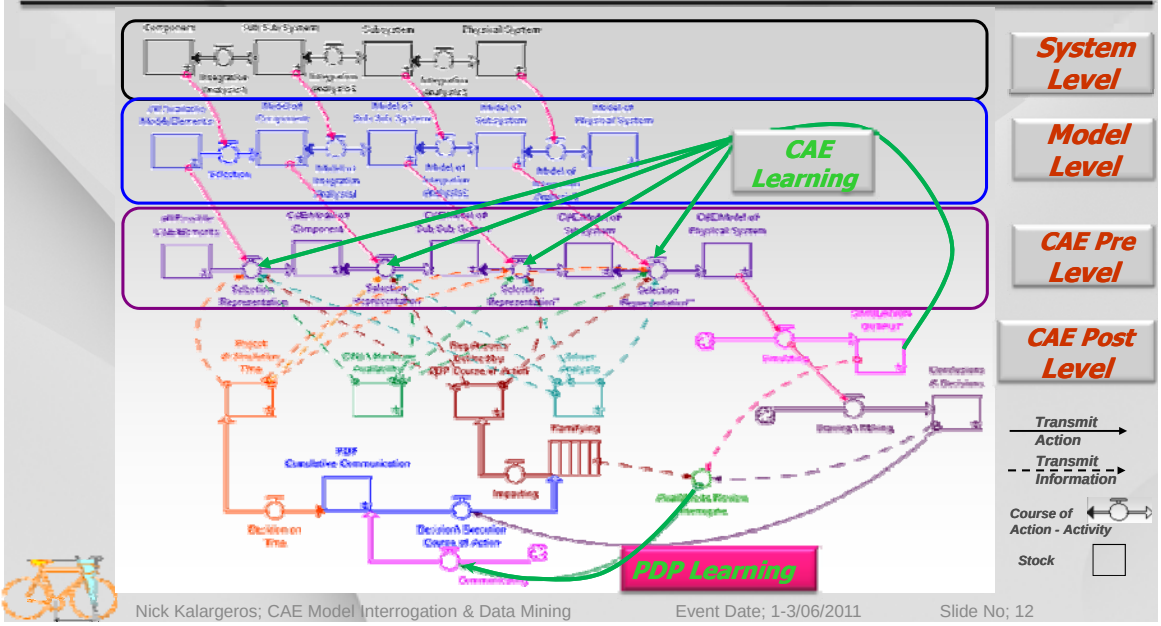
CAE's influence within PDP

Quantification Qualification & Knowledge Utilisation



CAE's Influence within PDP

Communication



CAE Model Interrogation

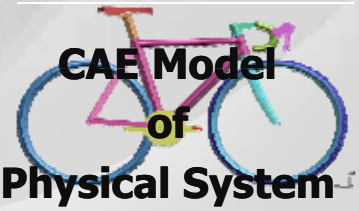
Cognition Comprehension Communication

Preliminary

- ✓ **What** is Known ?
- ✓ **What** is the un-known?
- ✓ **What** is need to be found?
- ✓ **What** is the Understanding !!!

Preparatory

- ✓**How** un-Known is to be found
- ✓**How** un-Known can be modelled
- ✓**How** un-Known can be represented
- ✓**How** Understanding is valid??



CAE Model Interrogation

Cognition Comprehension Communication

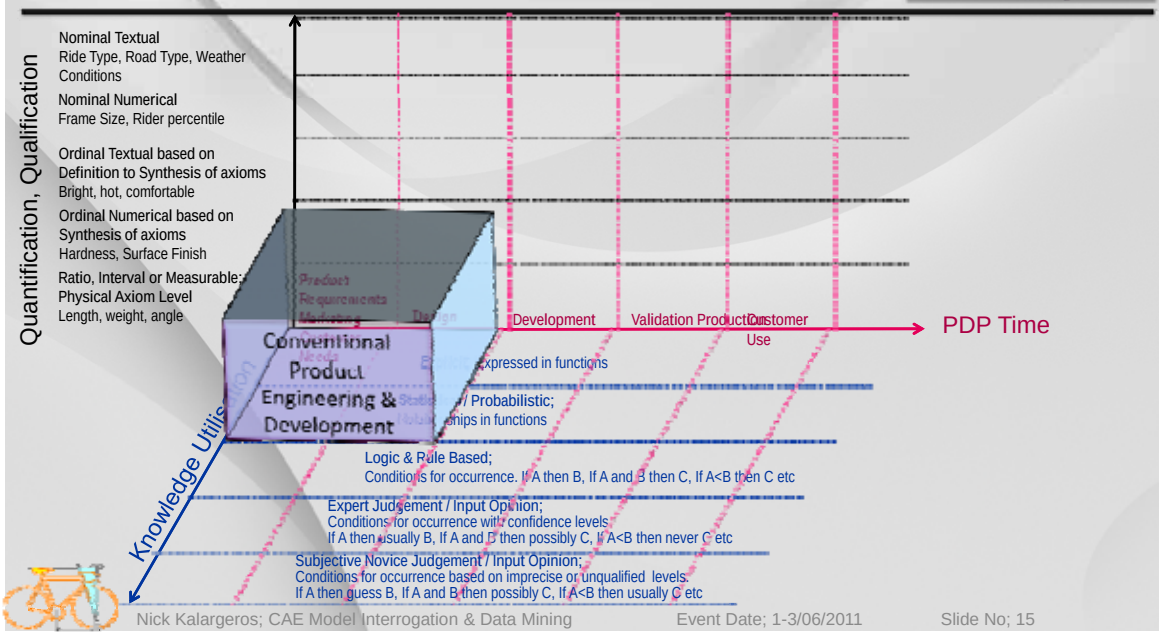
- The challenges faced by CAE Model
  - What one understands
  - What one models
  - How one chooses to represent such understanding
  - What one deduces from the Simulation Output
  - What one wants to communicate
  - What one communicates (*contained message*)
  - How this message is seen in context
  - What one relates to as a conclusion
  - What one elicits as information, knowledge & experience

CAE's
Assumptions

A blessing
&
A curse

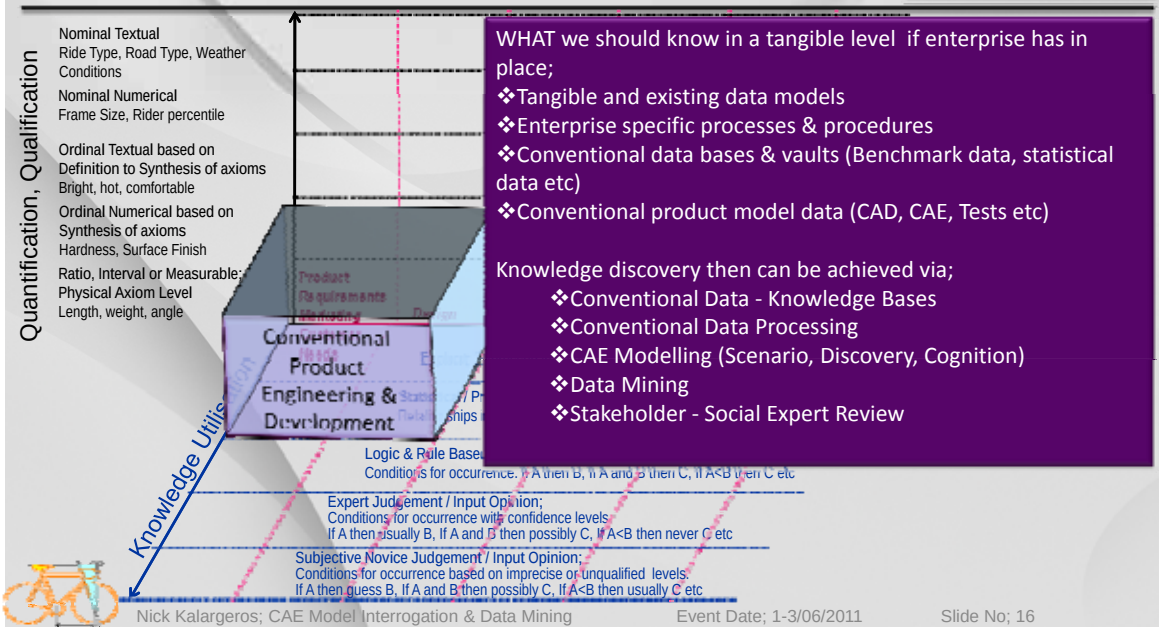
CAE Model Interrogation

Comprehension



CAE Model Interrogation

Comprehension Vs Domain Specific



WHAT we should know in a tangible level if enterprise has in place;

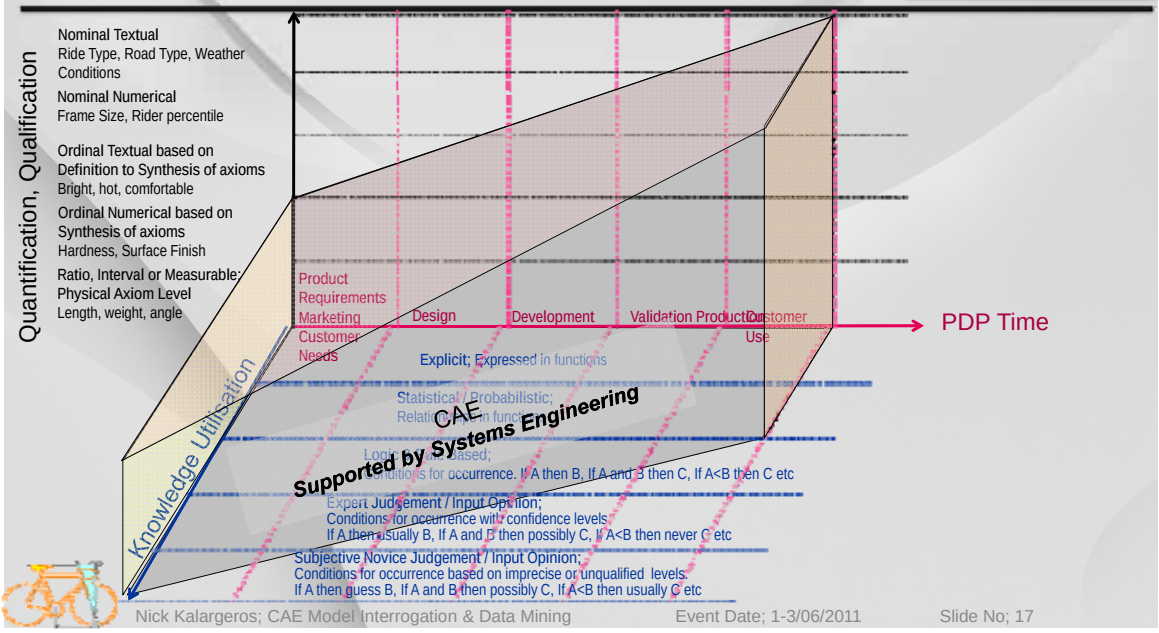
- ❖Tangible and existing data models
- ❖Enterprise specific processes & procedures
- ❖Conventional data bases & vaults (Benchmark data, statistical data etc)
- ❖Conventional product model data (CAD, CAE, Tests etc)

Knowledge discovery then can be achieved via;

- ❖Conventional Data - Knowledge Bases
- ❖Conventional Data Processing
- ❖CAE Modelling (Scenario, Discovery, Cognition)
- ❖Data Mining
- ❖Stakeholder - Social Expert Review

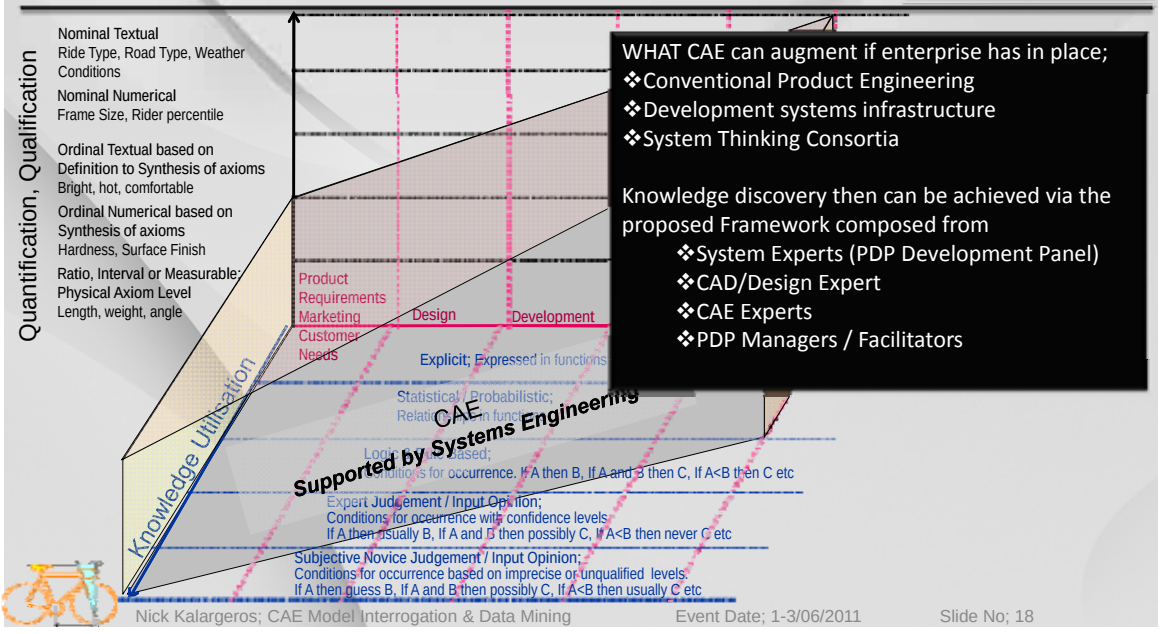
CAE Model Interrogation

Comprehension – CAEs Domain



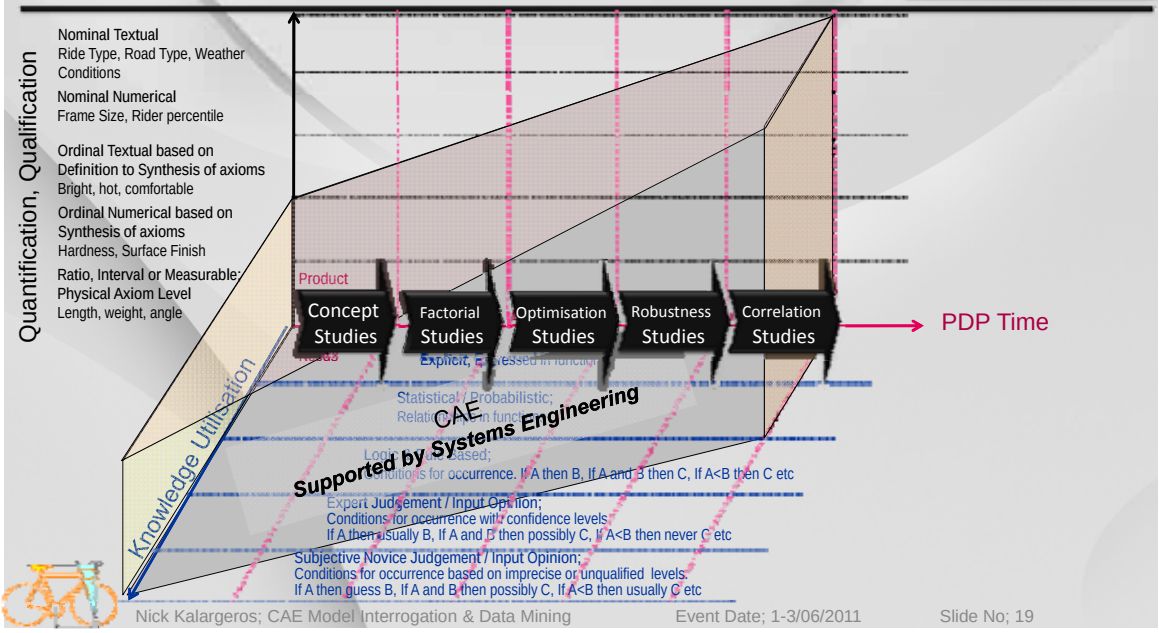
CAE Model Interrogation

Comprehension – CAEs Domain



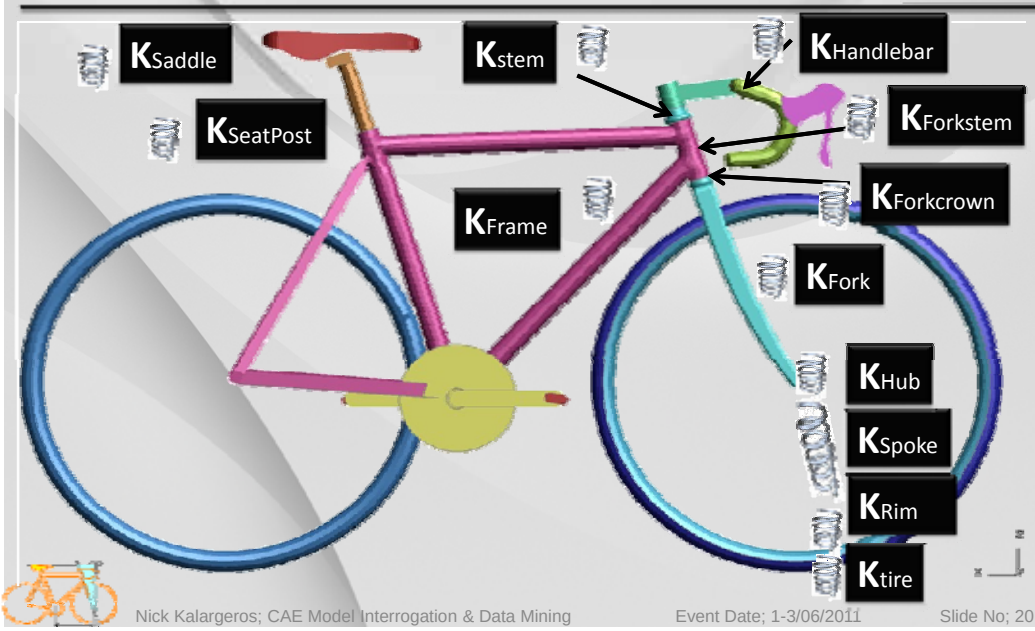
CAE Model Interrogation

Comprehension – Purposeful CAE Model Studies



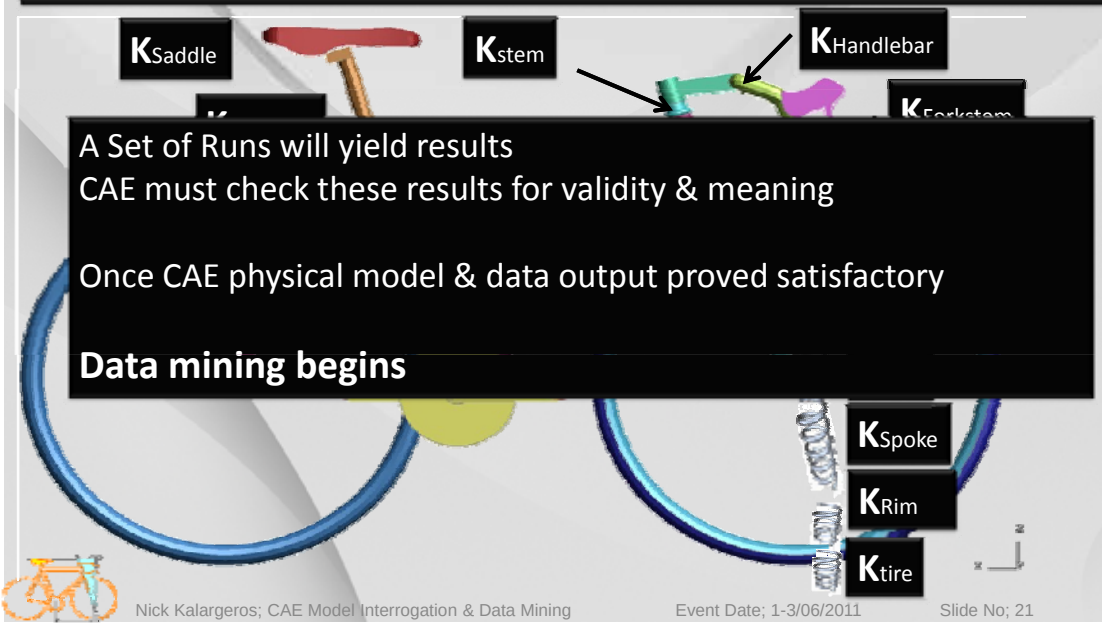
CAE Model Interrogation

Comprehension – Purposeful CAE Model Data Output



CAE Model Interrogation

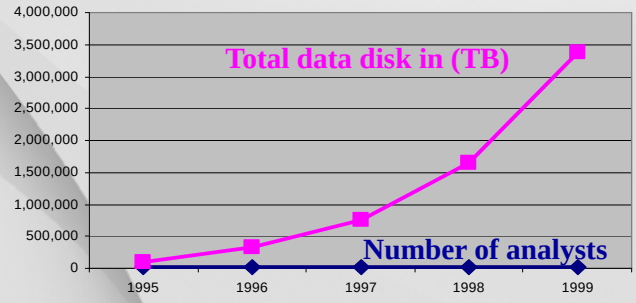
Comprehension – Purposeful CAE Model Data Output



CAE Data Mining

Making Sense out of the CAE Model Output

- The challenges faced by the CAE community
  - There is often information 'hidden' in the data that is not evident
  - CAE Analysts may take sometimes weeks to discover useful information
  - A great proportion of the data is never analyzed at all



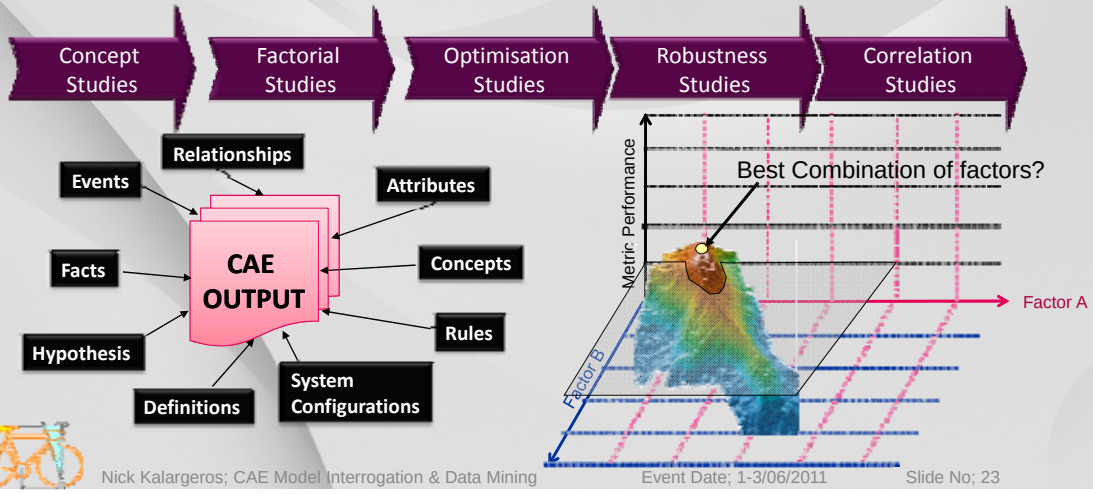
From: R. Grossman, C. Kamath, V. Kumar, "Data Mining for Scientific and Engineering Applications"

CAE Data Mining

Making Sense out of the CAE Model Output

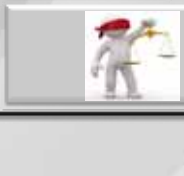
CAE output underpins numerous informational augmentations & inferences

∴Good CAE practice a well thought combination of factors

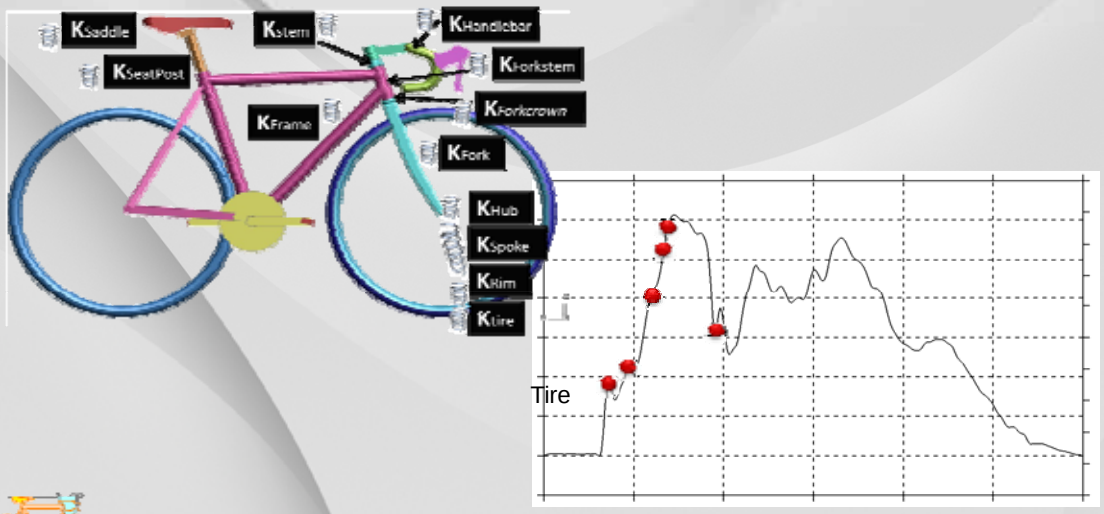


CAE Data Mining

Making Sense out of the CAE Model Output

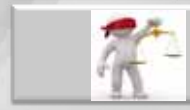


The Journey of deceleration pulse/s



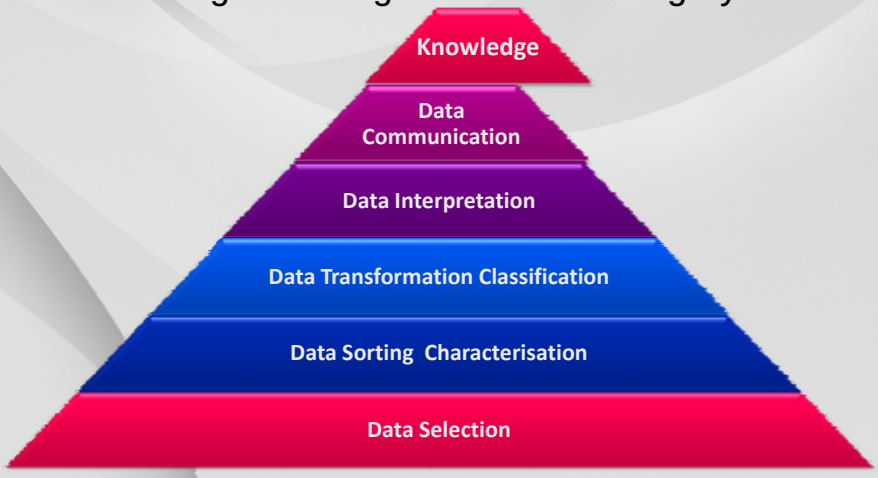
CAE Data Mining

Making Sense out of the CAE Model Output



Post Processing ???

A NEW Pre-Processing > Solving > Post Processing Cycle



CAE Data Mining

Making Sense out of the CAE Model Output

From measurable data we **deduce**

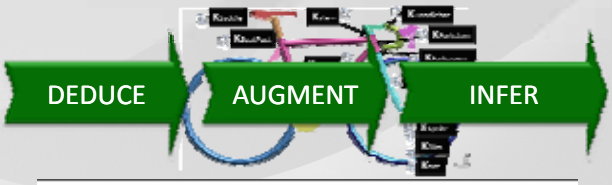
- Energy dissipation at tire
- Energy dissipation at spoke
- etc

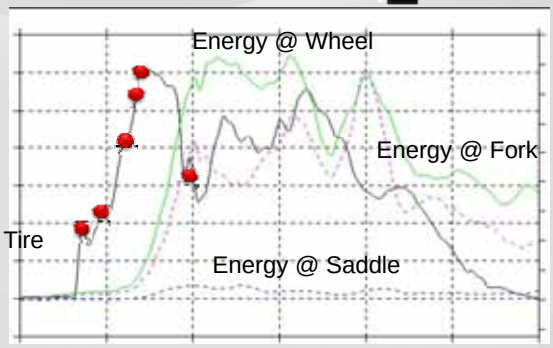
From these data we **augment**

- Energy intensity at a specific $\Delta\tau$
- Inertia effects Vs stiffness
- etc

Which leads to **infer** knowledge

- Energy intensity at X value corridor; ∴Comfortable, Stiff, Unpleasant
- Energy dissipation levels at Y value corridor when Z stiffness; ∴Tire works harder, Fork Durability compromised....
- etc





CAE Data Mining

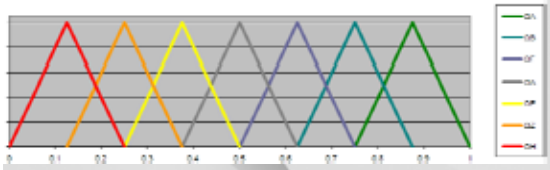
Making Sense out of the CAE Model Output

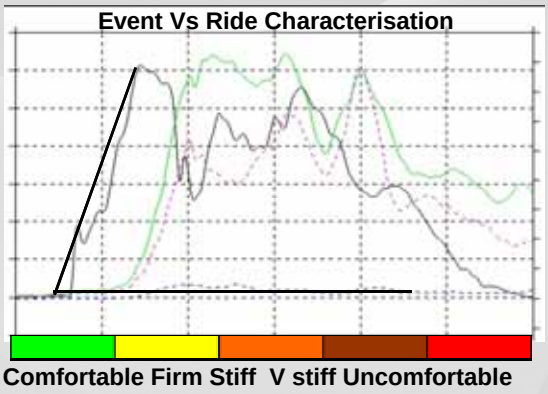
Armed with this information / knowledge

Scripts are written to elicit knowledge - From CAE to PDP stakeholder specific

Simple Graph Representations then are defined

- Colour coding
- Graph clustering & segmentation
- CAE Graph / Vector customisation
- etc





Conclusions

- **CAE is underutilised & not well integrated within PDP**
- **Full CAE toolset potential is unlocked if holistic and conceptual thinking precede them**
  - CAE Assumptions , Tangibles, Metrics & Expectations are all defined at those early stages
- **CAE is underutilising it's own data (Analyst Vs Data Ratio)**
- **CAE has the capacity to become the PDP centre regarding the social relational process by changing CAE output semantics**
- **CAE has the capacity and the ability to provide a reliable framework for traceable decision making utilising the potential from its immense full mathematical formalism / logic**

Questions ?