

Developing a frame work for Effective Collaboration between Academic Research and Industrial Outcome.

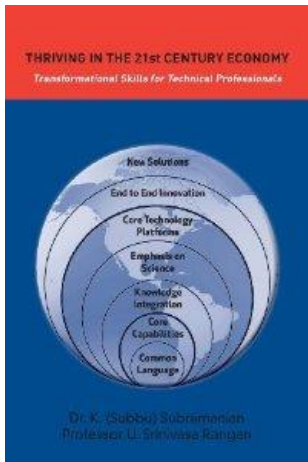
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President, STIMS Institute Inc., USA
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Chinese Conference on Grinding Technology (CCAT)
Harbin Institute of Technology.
Harbin, China.

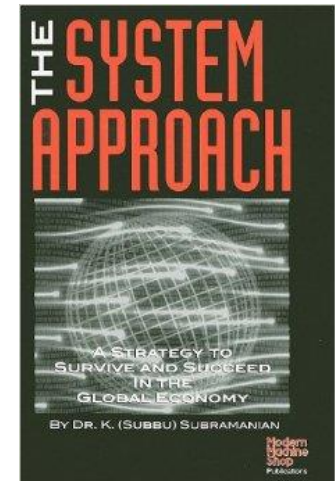
August 5, 2017.

References:

- **The system Approach**
 - *A strategy to survive and succeed in the Global Economy (2000)*



- **Thriving in the 21st century economy: Transformational skills for Technical Professionals (2013)**



<https://stimsinstitute.com/20151207books/>

Tribology as an enabler for innovation in Surface Generation Processes

Proceedings of the ASME 2015 International Mechanical Engineering Congress and Exposition
IMECE2015 November 13-19, 2015, Houston, Texas IMECE2015-52952

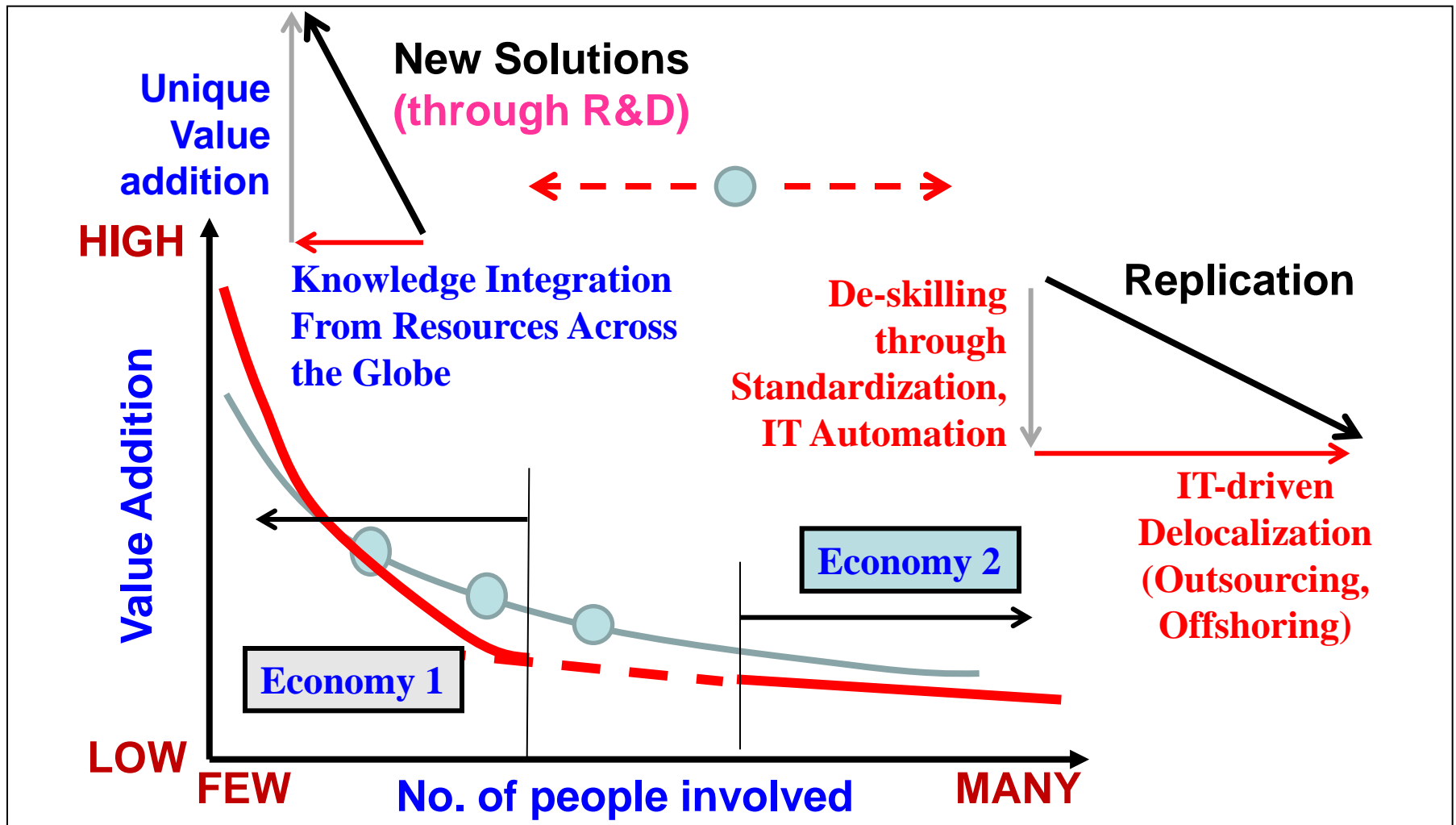
Acknowledgements

- ❖ Thanks to Prof. Zhang, to the organizers of CCAT and Harbin Institute of Technology
- ❖ Thanks to Dr. Jinsheng Wang, GM, Intelligent Grinding Technology (Shenzhen) Co., Ltd., my friend and host for this visit
- ❖ Thanks to many friends and colleagues across the globe in the industry as well as in the academia.
- ❖ This talk is a summary of many years of experience and successful collaboration between Academic researchers and Professionals in the industry across the globe.

OUTLINE:

- ❑ **21st Century economy requires New Solutions with**
 - Deliberate focus on Academic Research
 - That Integrates knowledge from all sources
- ❑ **New Solutions requires three types of Knowledge:**
 - Academic learning
 - Hands on Experience
 - Transformational Skills.
- ❑ **New Solutions in Grinding Processes are the result of collaboration**
 - Between Academic Research and Industrial Applications
 - Enabled by Transformational Skills.
- ❑ **Transformational Skills are necessary for industry / university collaboration**
- ❑ **Examples and Case Studies.**

21st Century Binary Economy



Dr. K. (Subbu) Subramanian

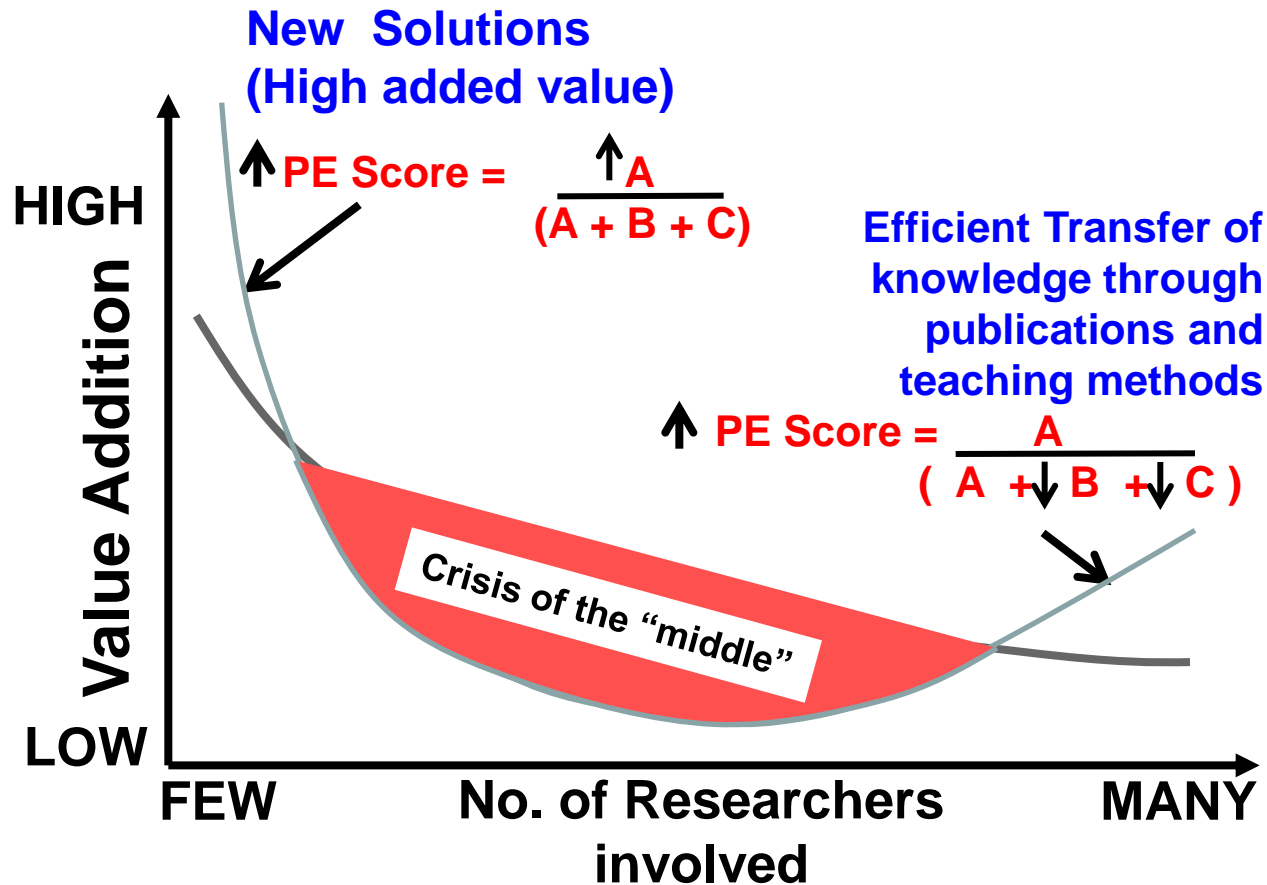
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Today there are two alternatives to add Value through Academic Research



A = Knowledge Work (New Solutions)
B = Information Work (papers; publication)
C = Physical Work (Teaching, travel, etc.)

Total Effort = (A+B+C)

Professional Efficiency (PE Score) = $\frac{A}{(A + B + C)}$

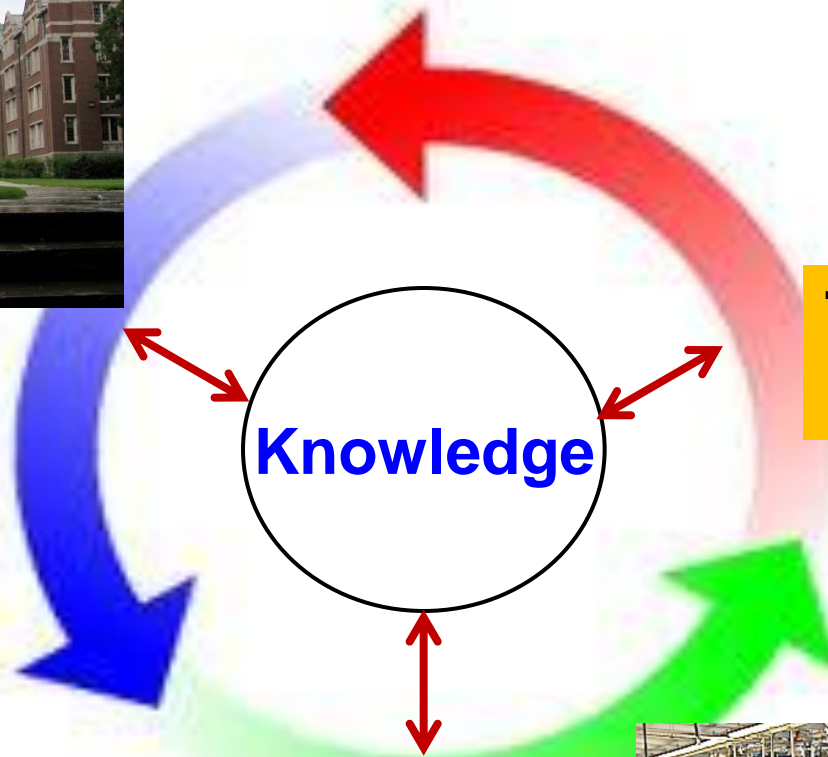
Source of Knowledge



Academic



Transformational Skills



**Hands on/
Industry Specific**



Transformational Skills

- Emotional Intelligence for New Solutions
- End-to-End Innovation

- Build Ecosystem for Core Technology Platforms
- Emphasis on Science and Mobile Diagnostics
- System Thinking and Knowledge Integration

- 3-D View of Core Capabilities
- Develop a Common Language

Deploy

X

Develop

X

Discover
/ Define

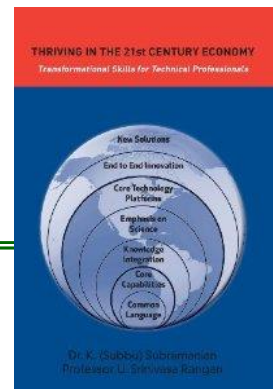
Transformational Skills are a set of skills to Discover, Develop and Deploy / Exploit a stream of New Solutions.

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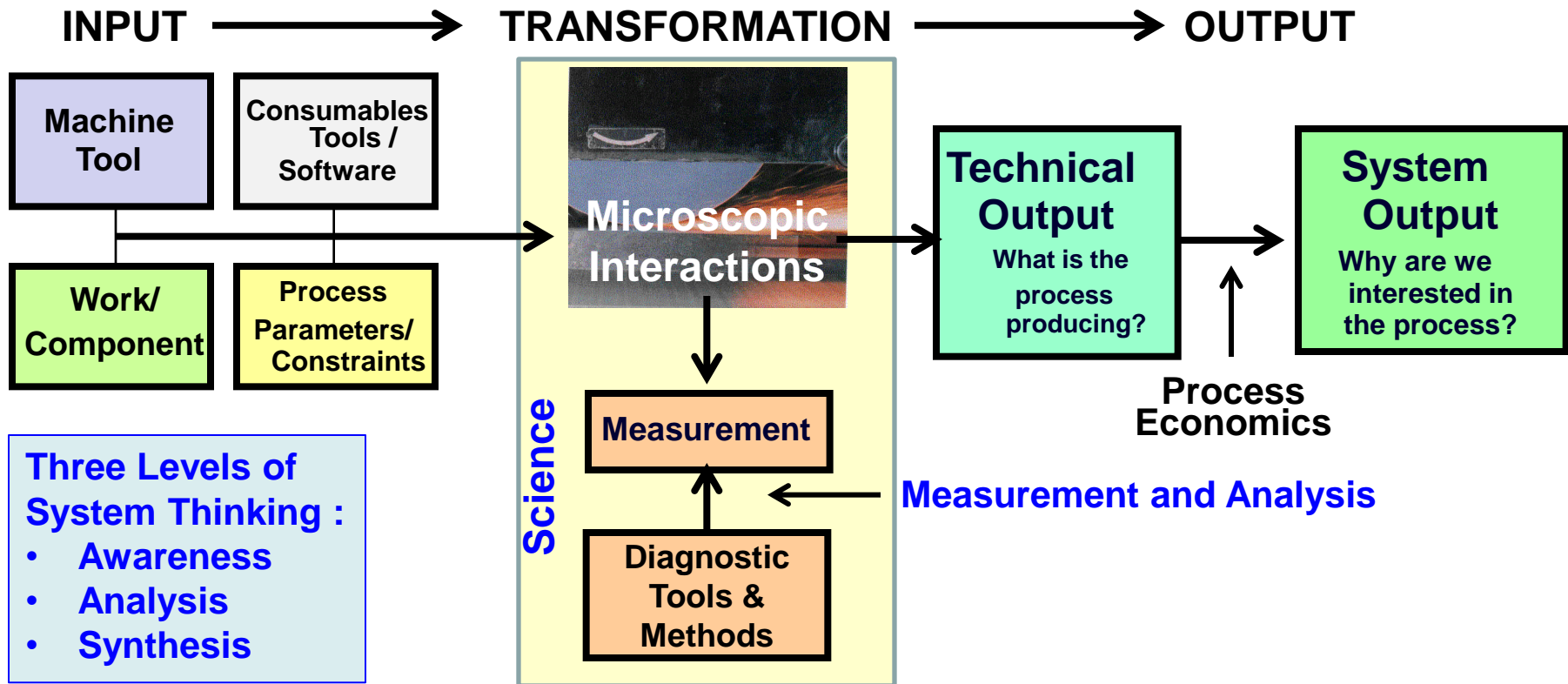
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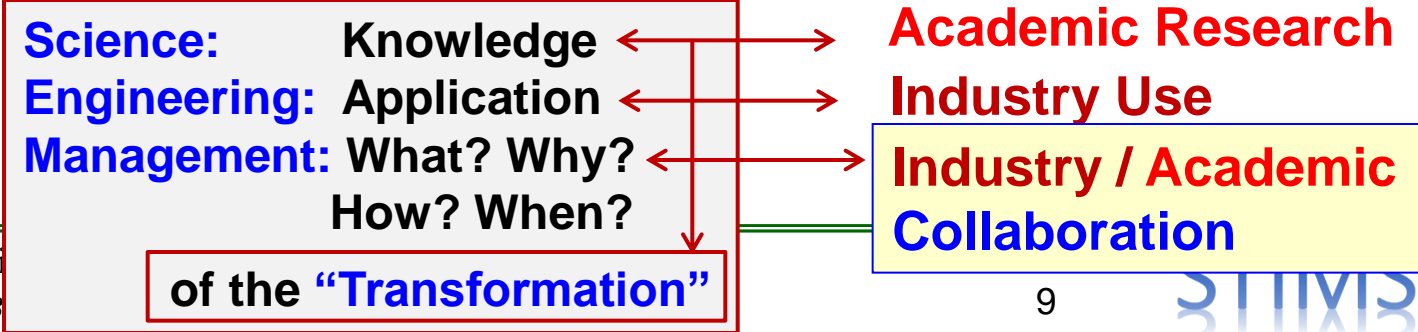
1. Common Language:

Every Grinding Process is a system and an opportunity for Industry / Academic Collaboration



Three Levels of System Thinking :

- Awareness
- Analysis
- Synthesis



Every Grinding Process is a “System”

Input \longrightarrow Transformation \longrightarrow Output

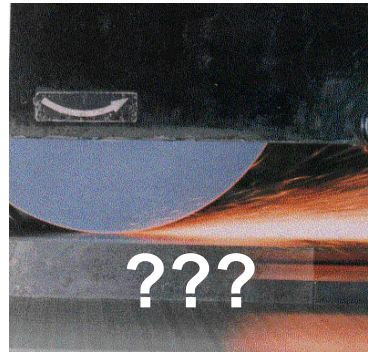
Machine Tool



Work Material



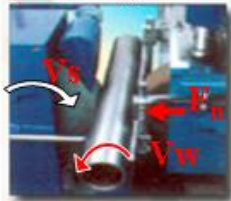
Microscopic Interactions



Abrasive Tool



Operating Factors



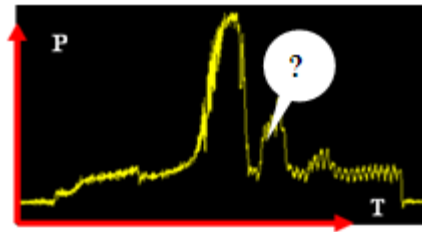
Technical Output



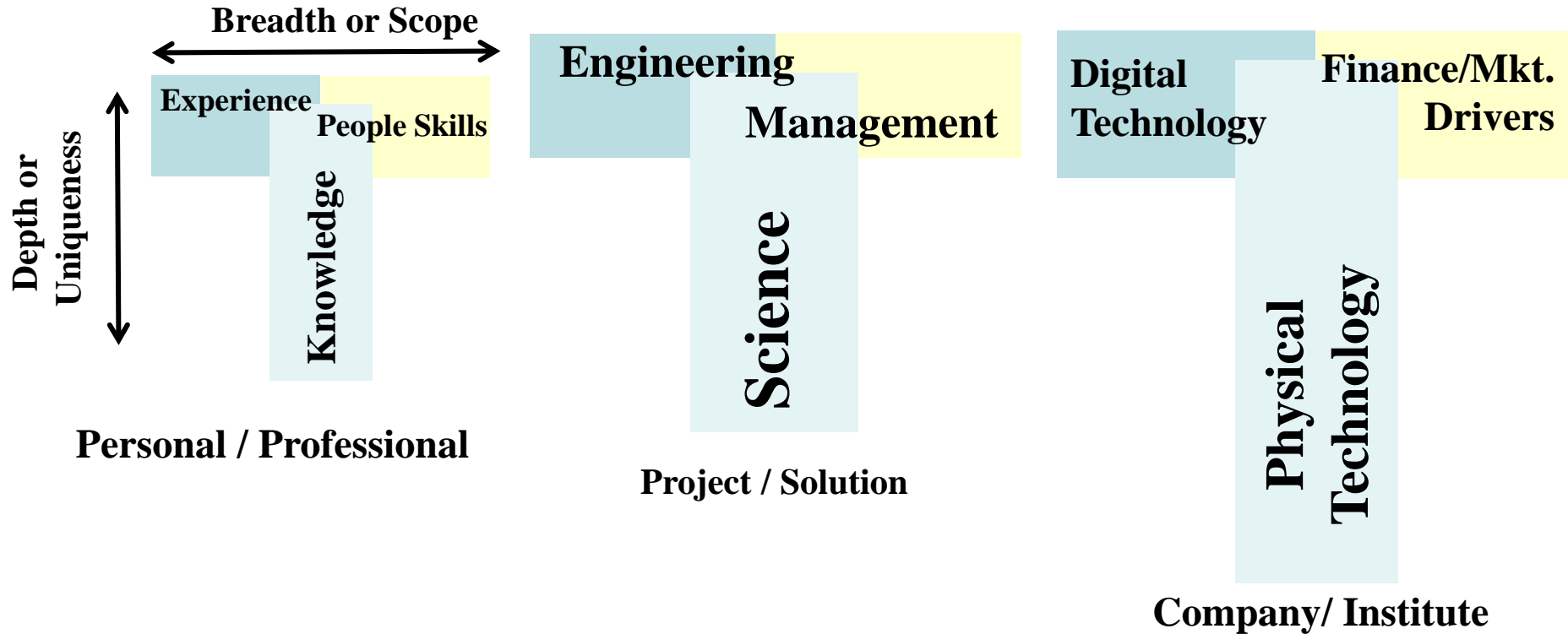
Economic/
System Output



Macroscopic Variables/Measures

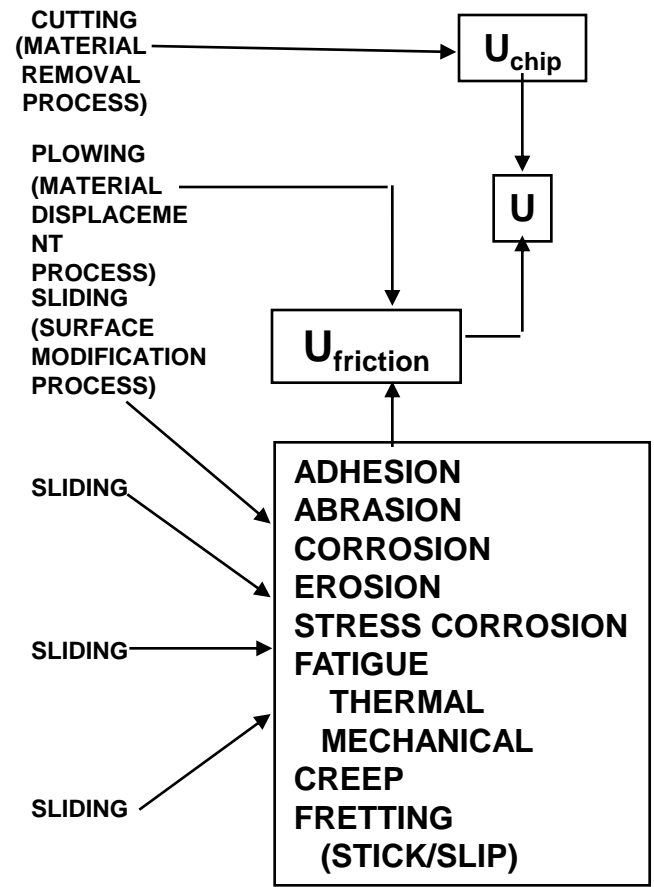
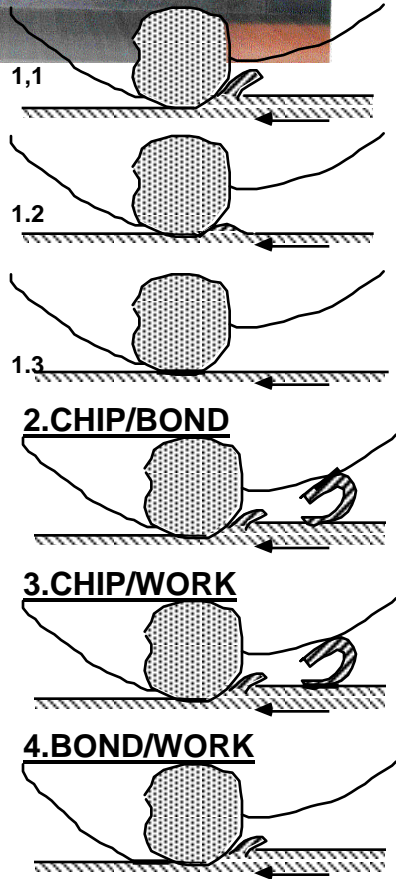


2. Three Dimensions of Core capabilities:



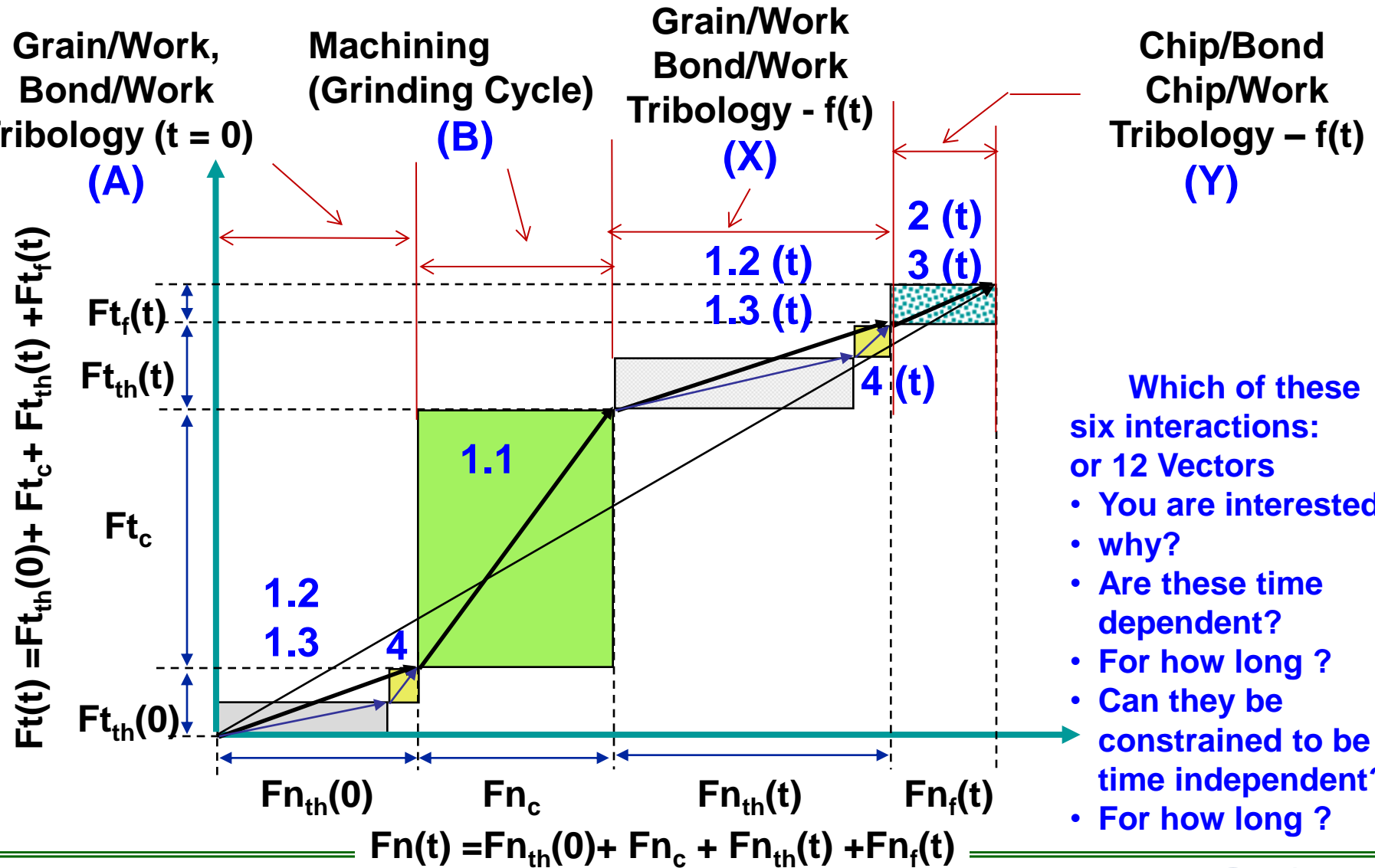
**Technology =
Science X Engineering X Management**

3. Emphasis on the “Science” Science of Grinding



Ft/Fn	
1.1	> 1.0
1.2	0.5 to 1.0
1.3	1/6 (= 0.165)
2	0.3 to 0.5
3	0.3 to 0.5
4	0.3 to 0.5

Microscopic interactions – their magnitude and relative impact Determine the Dominant Mechanisms in the design and management of any Grinding Process



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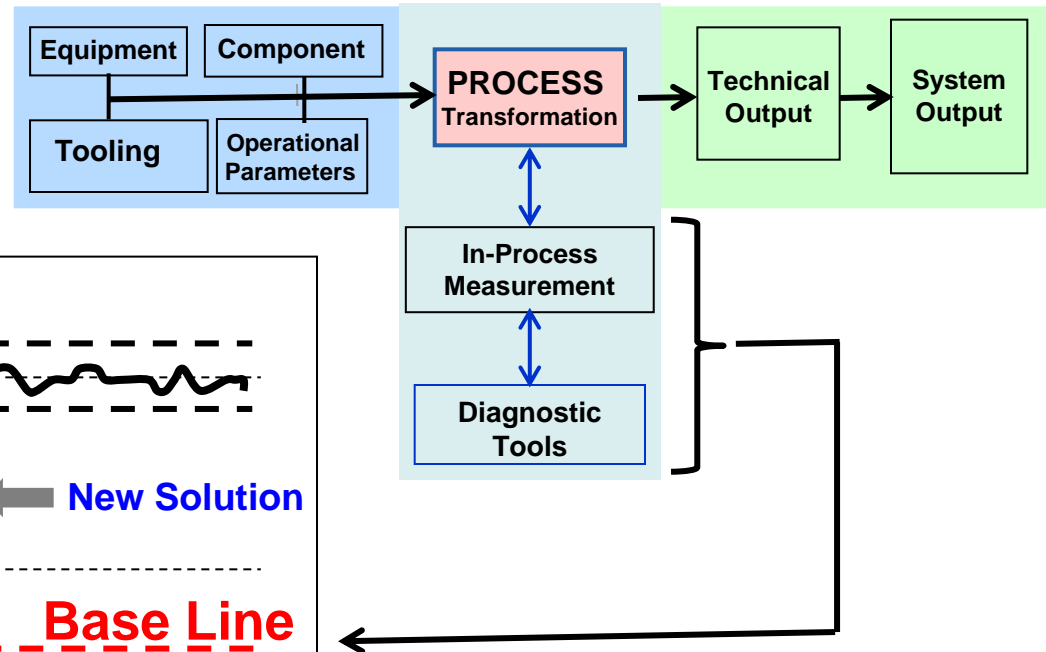
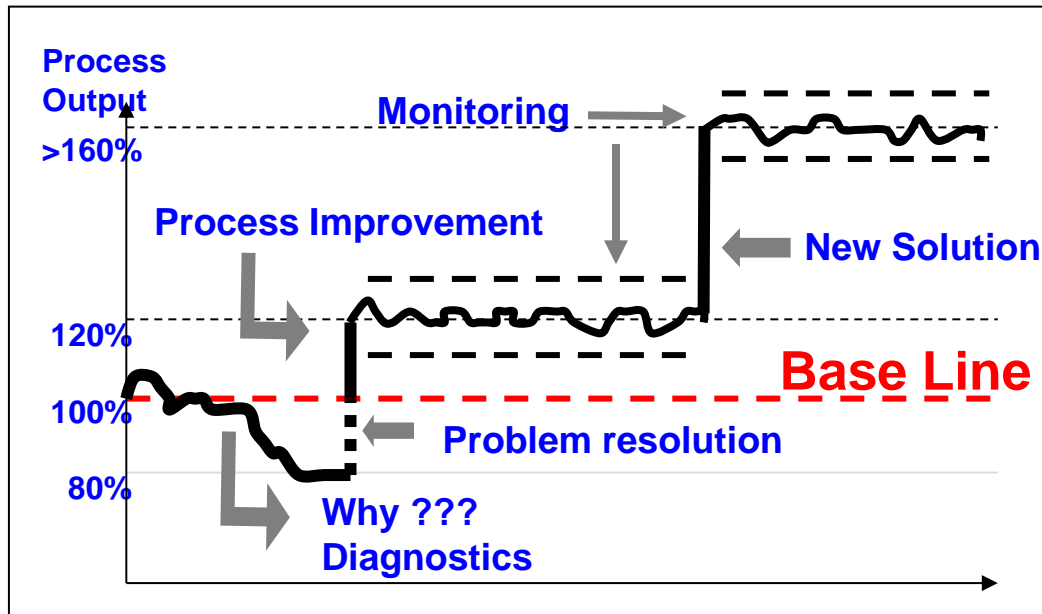
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4. Use of Portable or Mobile Diagnostics

“Science” of grinding has to be backed up by Diagnostic Tools and their active use

Five Steps in the Scientific Approach to Problem Solving:

- ❖ Diagnostics
- ❖ Problem Solving
- ❖ Process Improvement
- ❖ Process Maintenance
- ❖ New Solution or Step Change



4. Use of Portable or Mobile Diagnostics

Bringing the Science to shop floor manufacturing

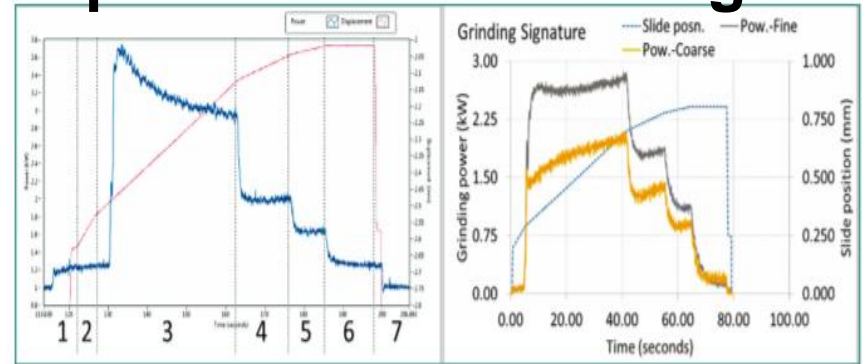
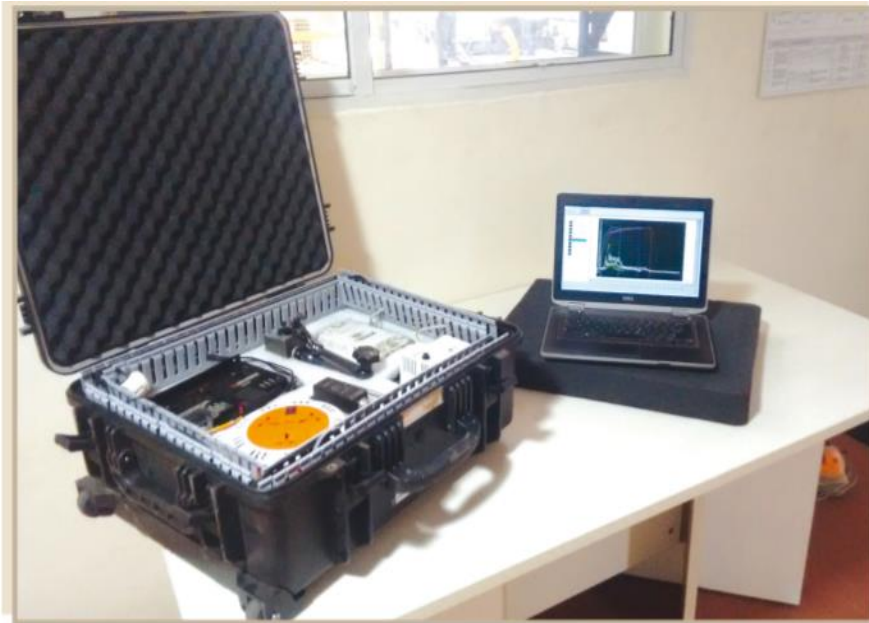
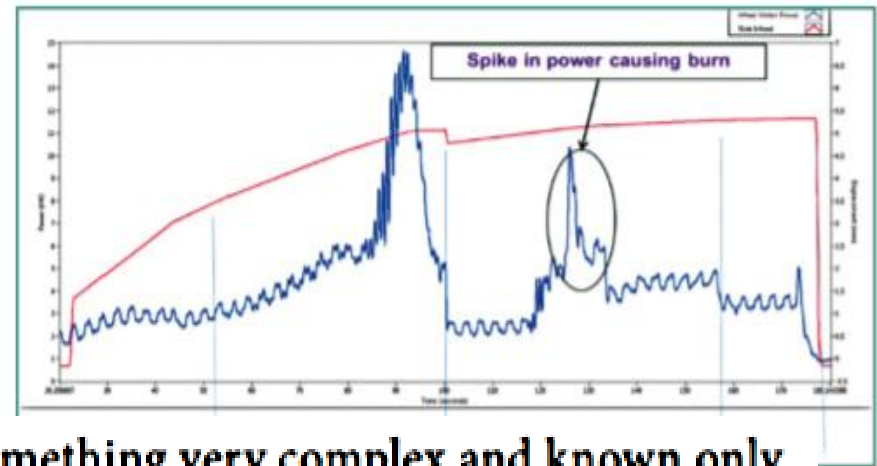


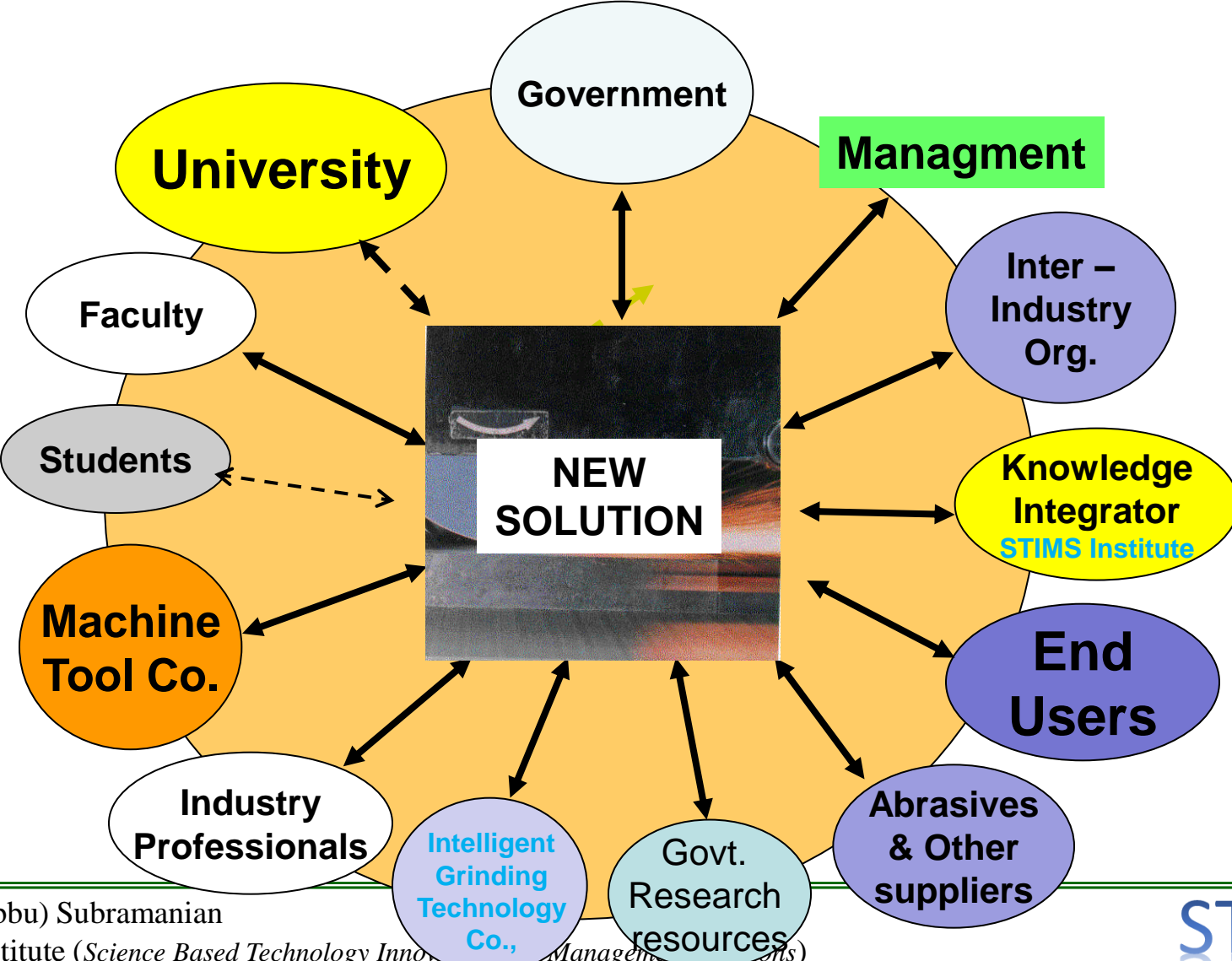
Figure 2: Signature of the grinding process

Figure 3: Effect of coarse vs fine dressing

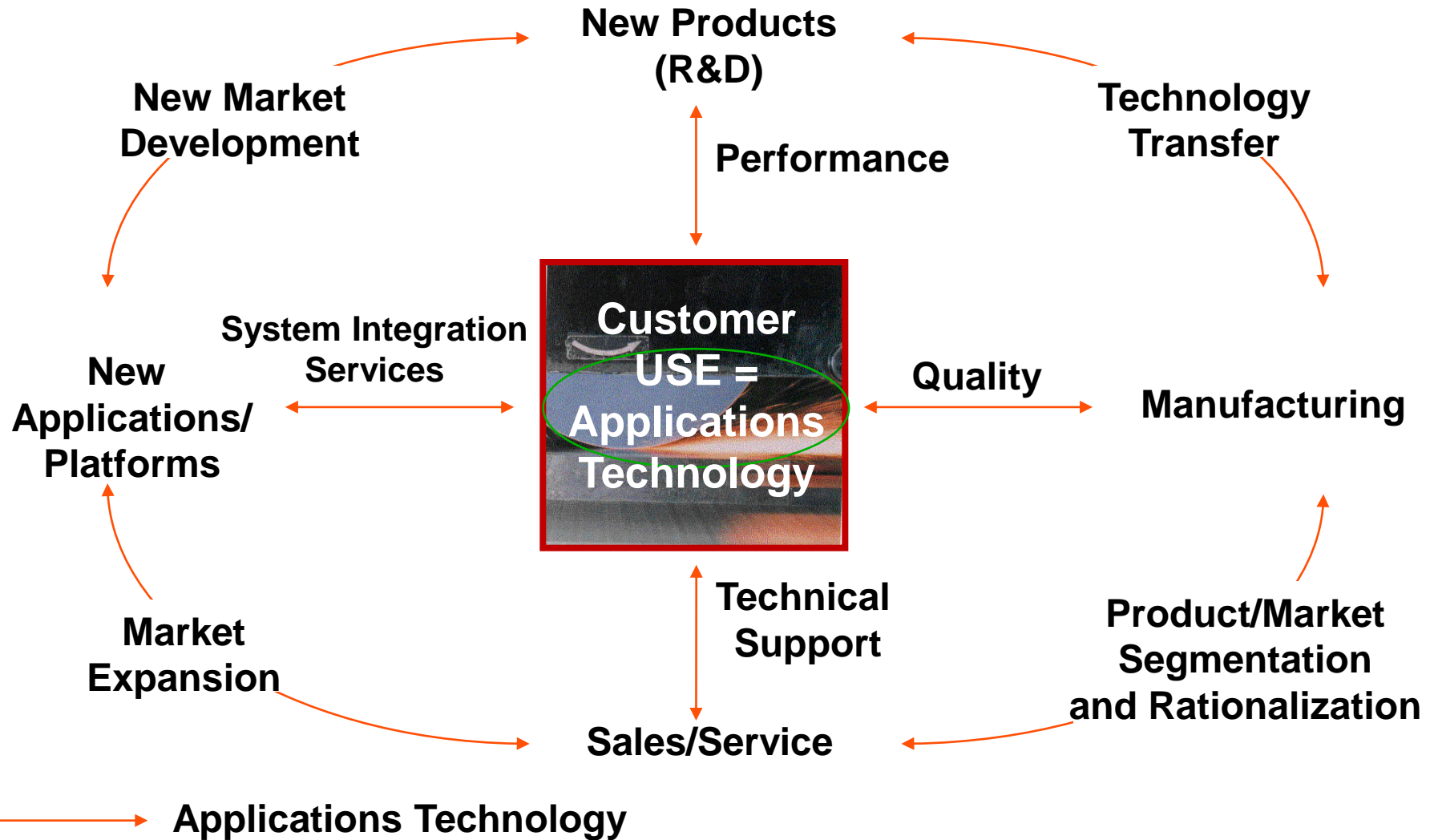


Traditionally grinding process is treated as something very complex and known only to a few with many years of experience and with specialised skills in the shop floor. A portable diagnostic tool and interpreting the process signal is changing the situation and helping to reduce such challenges faced in grinding.

5. Eco – system development for New Solutions in Grinding Processes



Grinding Process Knowledge can be used to improve ALL Business Functions



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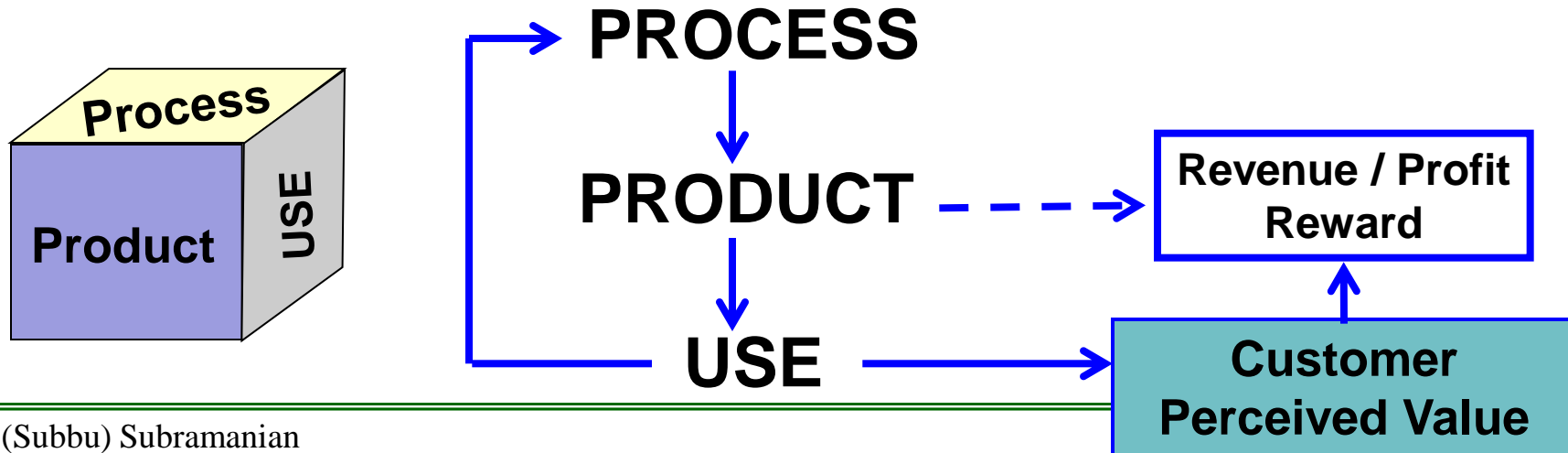
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6. End to End Innovation: Focus on the Customer perceived Value

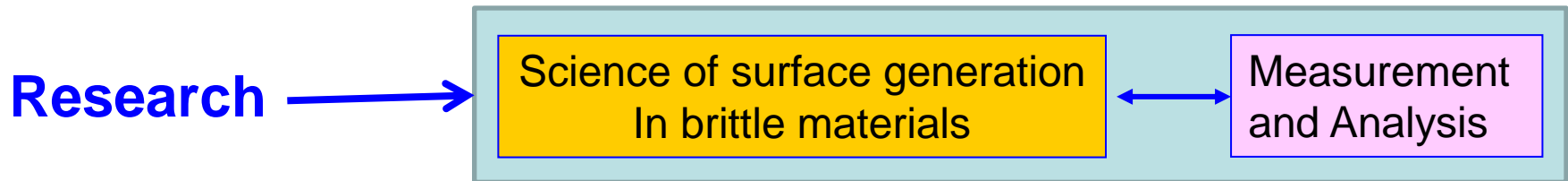
- **“Outputs” of any solution are:**
 - PRODUCT
 - PROCESS
 - Application / USE
- Revenue/reward is a direct result of the Perceived Value by the Customer
- **E 2 E Innovation:** Manage the customer perceived value.



6. End to End Innovation: Focus on the Customer perceived Value

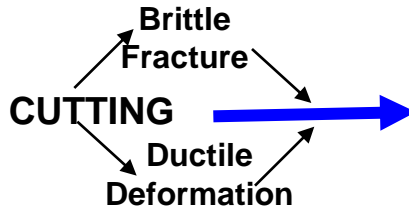
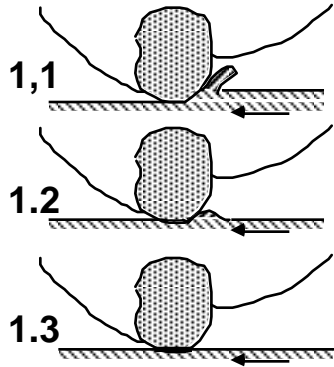
Faster recording speed
and higher density using brittle materials

Floppy to Hard Disk Magnetic Recording Solutions



Science of grinding brittle materials

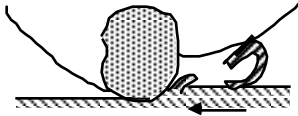
1. ABRASIVE/WORK



PLOWING

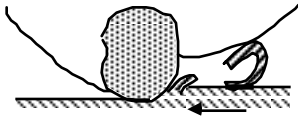
SLIDING

2. CHIP/BOND



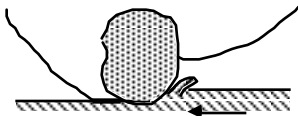
SLIDING

3. CHIP/WORK

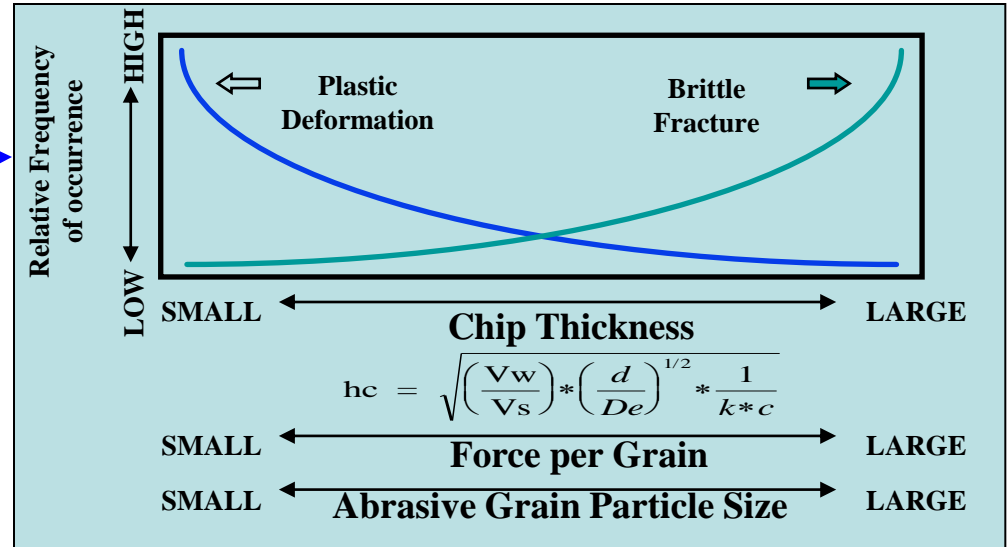


SLIDING

4. BOND/WORK



SLIDING



All Tribological interactions apply for brittle materials grinding just as the case for ductile materials

6. End to End Innovation: Focus on the Customer perceived Value

Industrial Development



Machine Tool



Abrasive Tool

Component:
Multilayer ceramic
TF head substrate

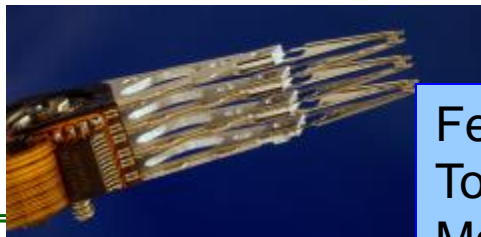
Operational Factors:

- Gang Wheel slicing – process/parameters
- Custom Precision finishing of thin Diamond wheels
- Coolant and fixturing solutions
- Fast response gang wheel assembly
- Unique sales/distribution solutions

Research

Science of surface generation
In brittle materials

Measurement
and Analysis



Ferrite (6X6mm) heads
To Thin Film (1X1mm)
Magnetic Recording heads

Faster recording speed
and density
Floppy to Hard Disk
MR Solutions

6. End to End Innovation: Focus on the Customer perceived Value

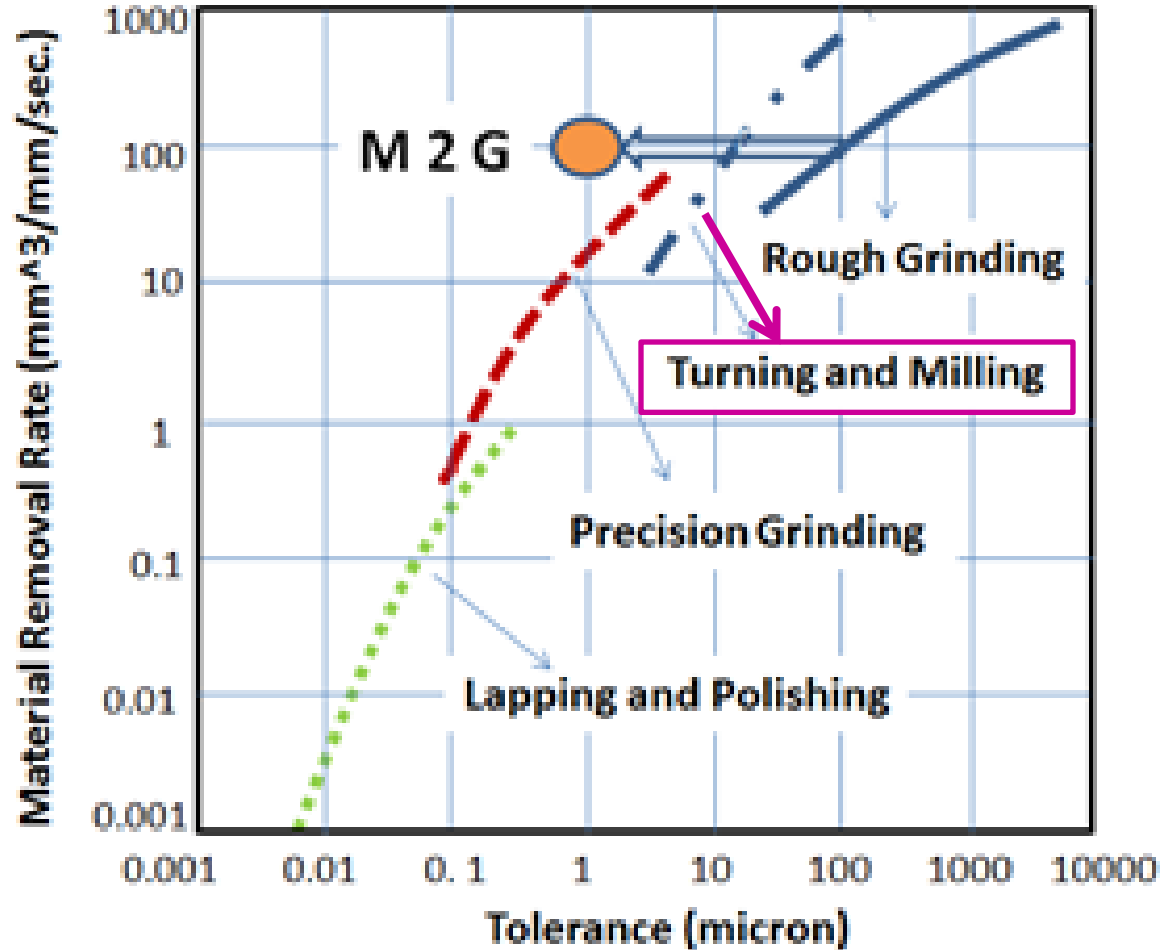
M2G:

Machining to Grinding

- Grinding =
Machining (Interaction 1.1)
+
Tribology
(Interactions 1.2, 1.3, 2, 3, 4).

- Grinding — Tribology
= Machining
(using abrasive
tools and processes)?

= M 2 G



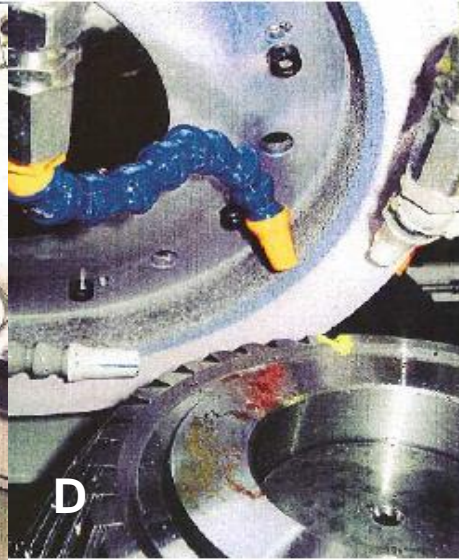
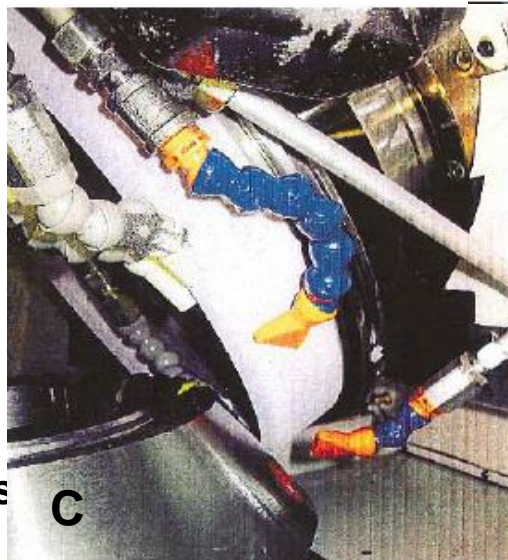
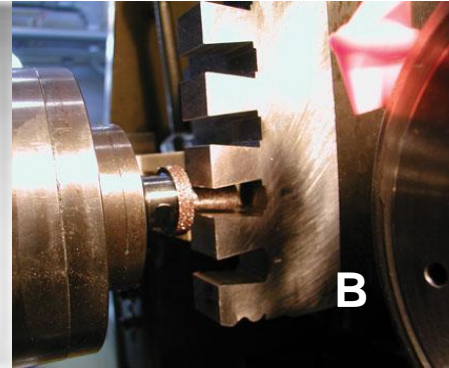
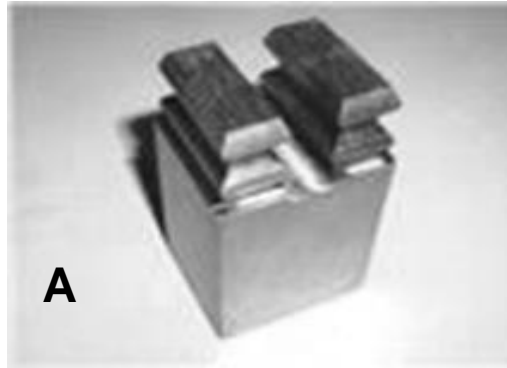
M 2 G of complex shapes from simple solid blanks

A, B: Aerospace Components

C,D: Hypoid gears from solid blank

E,F: Large Wind Mill gears from solid blank

- Higher Productivity
- Better Quality
- High Material removal rates
- Reduce secondary operations



<http://www.mmsonline.com/articles/grinding-turbine-rotors-has-advantages>

<http://www.gearsolutions.com/article/detail/6368/advances-in-abrasive-technology-for-grinding-gears-from-solid>

<http://www.mmsonline.com/articles/grinding-big-gears-from-blanks>

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Effective Collaboration between Academic Research and Industrial Outcome

CASE STUDY.

- **Machine Tool for higher precision grinding was required (NGPG).**
- **Machine could be imported; But Technology could not be purchased.**
- **A team of industry/university worked on this,**
 - **mentored by STIMS Institute**
- **A higher Precision Machine Tool was developed**
 - **through University R&D (IIT – Madras)**
 - **designed and improved by industry (Micromatic Grinding Technology)**
 - **Concept to commercial results in less than 5 years.**

NGPG Project

**Develop a
Common
Language**

NGPG:

**Develop and Demonstrate “Make in India” Capability (GOI)
Through a project that fosters industry – University
Collaboration (IIT - M)**

**To achieve a machine tool of higher precision capabilities
inside of India that is commercially viable (IMTMA)**

**Leading to new resources and business opportunities for
Indian manufacturers (MGTL and user industries)**

**Fostering an education that is academic and yet hands-on
(Mfg. Research / Faculty)**

**Leading to skills that is sustainable through the career of the
students. (Students)**

**Demonstrate the value and efficacy of System Thinking and
Transformational Skills (STIMS Institute).**

Common Language: Defines the Why?

Every one of the stake holders and their interest MUST be addressed

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NGPG Project

Promote development and Use of core capabilities at all levels:	<ul style="list-style-type: none">● Students, Faculty and review Committee:<ul style="list-style-type: none">○ Knowledge, Experience and Inter-personal Skills● Projects, Thesis and Industry – University Collaboration<ul style="list-style-type: none">○ Science, Engineering and Management● Industry, University, Government<ul style="list-style-type: none">○ Precision Machine Tool Technology(Physical Technology), IT driven data and communications (Digital Technology) AND○ GOI / Industry investments (Finance) and Precision Parts Manufacturing (Market Driver).
System Approach and Knowledge Integration	<p>= Science: Precision Machine tool is a synergistic outcome of several pathways</p> <p>+ Engineering: Outcome of active collaboration between IIT Researchers and Industry Professionals</p> <p>+ Management: Strategy (Why?) is clear in terms of Science and end result AND Operations are well managed through reviews and steering committee.</p>

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Thermal behaviour of wheel spindle system

- ⇒ Design of thermal models
- ⇒ Prediction of thermal drifts
- ⇒ Measurement of thermal drifts with and without coolant jackets
- ⇒ Establishment of the effect of spindle thermal drift on ground component

Thermal stability of spindles

Siddharam Mane and Ravikiran B

Control of thermal spindle

- ⇒ Analysis of different designs for wheel spindle
- ⇒ Development of heat transfer analysis of thermal spindle
- ⇒ Inputs for the design of spindle

Manoj B

behaviour of wheel assembly

- ⇒ designs of coolant jacket
- ⇒ assembly transfer model for the behaviour of coolant jacket
- ⇒ of coolant jacket

Thermal behaviour of axes

- ⇒ Generation of heat map of axes
- ⇒ Measurement of thermal drifts
- ⇒ Measurement of thermal drifts on ground component

Slides - Thermal stability

Ravikiran B

Tolerance analysis and synthesis

- ⇒ Development of methods to analyze distribution of tolerances in sub-assemblies

Components

- Error Budgeting
- Assembly methods
- Interface errors

NGPG:

- Synergistic outcome of several research projects at the University
- Simultaneously validated by collaborating industry partner

Geometric and kinematic accuracy of machine tool

- ⇒ Development of HTM based model for determining volumetric error
- ⇒ Measurement of geometric and kinematic errors

Assembly

- Static stiffness
- Kinematic accuracy

Vijayaraghavendra B and R Vairamuthu

Dynamic behaviour of machine tool structure

- ⇒ Development of FE model for structural analysis of machine structure, sub-assemblies and their interface

Assembly

- Vibration
- Dynamic stiffness

various sub-assemblies

Ravithej PV and Amit Patil

Stiffness of wheel spindle

- ⇒ Development of analytical stiffness of wheel spindle
- ⇒ Measurement of spindle stiffness through experimental methods
- ⇒ Determination of optimum nose overhang

spindle

- ⇒ model for wheel spindle stiffness
- ⇒ experimental spindle and bearing

Grinding System:

- Machine
- Tools (Wheel, dresser, ...)
- Component
- Parameters

Analysis of grinding chatter and prediction of stability lobe diagram

- ⇒ Development of FE model for dynamic analysis of grinding assembly
- ⇒ Prediction of stability lobe diagram and mode
- ⇒ Model of cylindrical grinding chatter behaviour and stability lobe diagram and grinding

Sourabh Dike and Arjun Ajay

NGPG Project

Emphasis on Science and Mobile Diagnostics	<ul style="list-style-type: none">• Design Methodology and the modules in it --- Please see the slides above for details.• Mobile Diagnostic tools: feasibility demonstrated at IIT – M has resulted in Grind Trak™ developed and in commercial use.• Measurement and analysis tools and methods at IIT, IMTTF and MGTL used on locations and as needed (Bringing Science to the shop floor) resulting in new protocols used for machine tool testing
Develop an eco – system based on common core technology platforms	IIT – M / Indian Machine Tool Manufacturers' Association / MGTL (Machine Tool builder) / Advanced Machine Tool Testing Facility (AMTTF) / Users / Component fabricators / STIMS Institute --- Collaborative team development leading to the new Center of Excellence focused on Precision Machine Tools and Advanced Manufacturing Solutions.

NGPG: Outcome of successful collaboration across University, Industry, Government and International experts.

Mentoring and Guidance

Dr K (Subbu) Subramanian
President
STIMS Inc. USA



Project Review and Monitoring Committee



Prof N K Mehta
Chairman
IIT Roorkee

Mr Neeraj Sinha
Member Secretary
OPSA to Gol



Mr Tadimalla Parabrahman
Member
Ex - MD, Toyoda Kirloskar

Mr P J Mohanram
Member
IMTMA



Dr R Balasubramaniam
Member
BARC

Prof P V M Rao
Member
IIT Delhi



Mr B Mohanraj
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CMTI

Project Team IIT Madras



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Dr Amitava Ghosh
Co-Principal Investigator



Mr R Srikanth
Project officer

Mr R Vairamuthu
Ph. D. Scholar



Mr A Dayanithi
Senior Project Technician



An academia industry collaboration



Project Team MGT

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Chairman



Mr Mahesh Samaria
General Manager



Mr Praveen Ganachari
*Senior Manager,
Design & Development.*



Mr M Brij Bhushan
*Former Manager R&D
Currently Graduate student
@ MIT, USA*



Machine Tool Testing



Mr Y Balaramaiah
Director
AMTTF

NGPG Project

End to End Innovation	<ul style="list-style-type: none">• NGPG machine concept reduced to practice with commercial validation in progress.• Every stake holder has realized identifiable benefits as described above under “Develop a Common Language”.
Emotional Intelligence for Innovation	Each stake holder was committed to the NGPG with a belief that the end result will be of use to them, even though such pathways were not clear and obvious up front (Help others, which in the end is also helpful to you) .



1. Knowledge Integration

and resources are available in India. Each resource looks at the problem through a peep hole – their vantage point only. The challenge is to

1. integrate knowledge – Sci., Engg. & Mgt. - from all sources
2. Goal oriented research and system integration is critical
3. Active hands-on collaboration between students and industry engineers is essential.
4. Industry – University Collaboration requires a frame work dedicated to industrially relevant research.



2. Professor

to the academic researchers, pulling them all together as a system for a well-defined goal and commercial outcome is not a traditional



3. CEO

"Active hands on collaboration between IIT-M students and our engineers were a key element for the success of this project."

NK Dhand,
Chairman, Micromatic Grinding Technologies Ltd



4. Industry Coordination

ones in countries like Germany. NGPG has been an excellent example of developing such collaboration using resources available entirely within India."

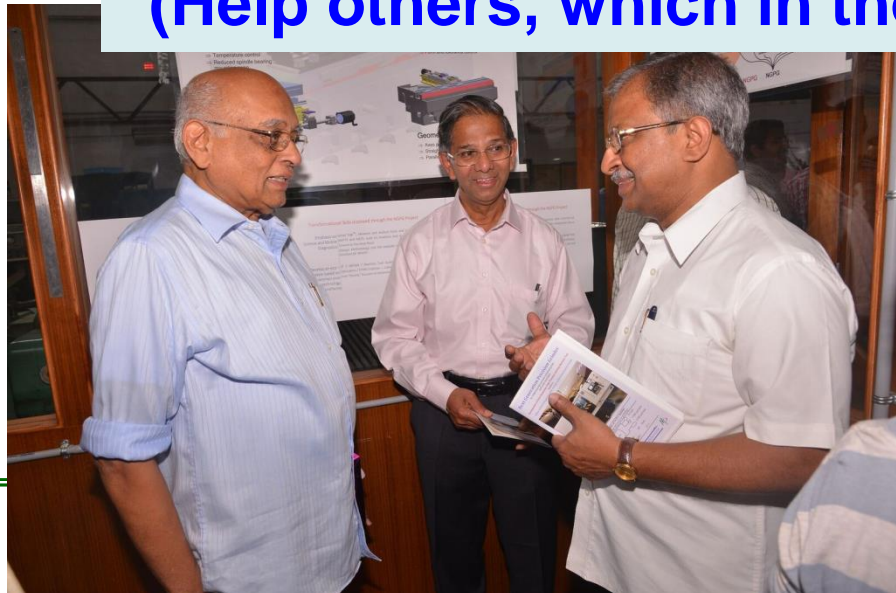
PJ Mohanram,
Senior Scientific Advisor, IMTMA



7. Emotional Intelligence for Innovation

Each stake holder was committed to the NGPG with a belief that the end result will be of use to them, even though such pathways were not clear and obvious up front

(Help others, which in the end is also helpful to you).

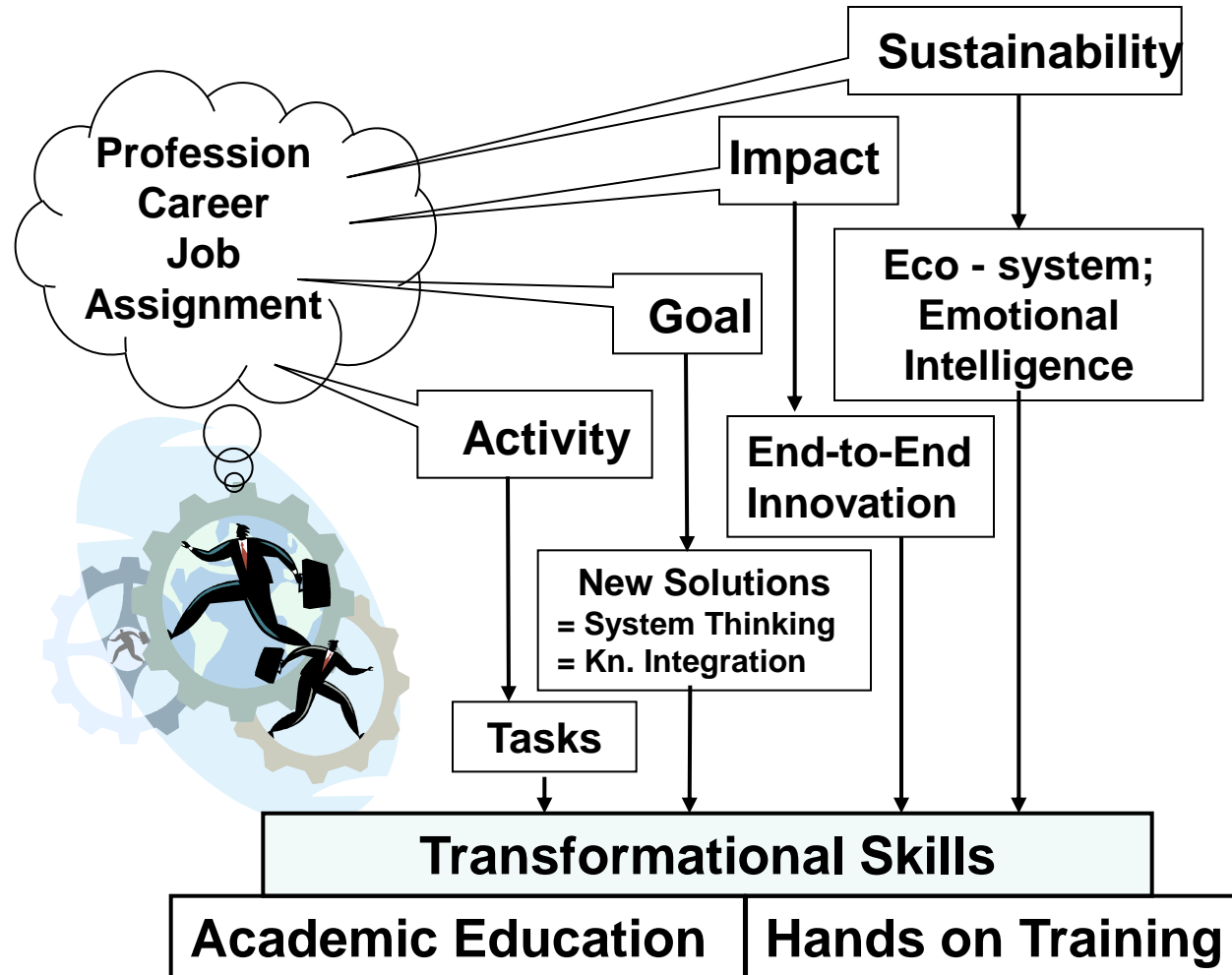


Developing a frame work for Effective Collaboration between Academic Research and Industrial Outcome.

SUMMARY

- **21st Century Research has to be targeted to deliver New Solutions**
- **This requires integrating knowledge from all sources.**
- **Knowledge Integration is enabled by System Thinking:**
 - **Every solution is integration of Science, Engg. And Mgt.**
 - **Focus on the big picture, not merely the dots.**
- **Three sources of Knowledge are simultaneously required today:**
 - **Academic Education**
 - **Hands on Training**
 - **Transformational Skills.**
- **During this talk we have described the “System Thinking” and “TS”.**
- **We have also shown examples of how these are useful for promoting Effective industry/university collaboration.**

Transformational Skills – Life long learning.



Thank You!