

# SUPPORTING ENGINEERING PROFESSIONAL PRACTICE WITH CONTENT AND COMPETENCY

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9 January 2014



# Overview

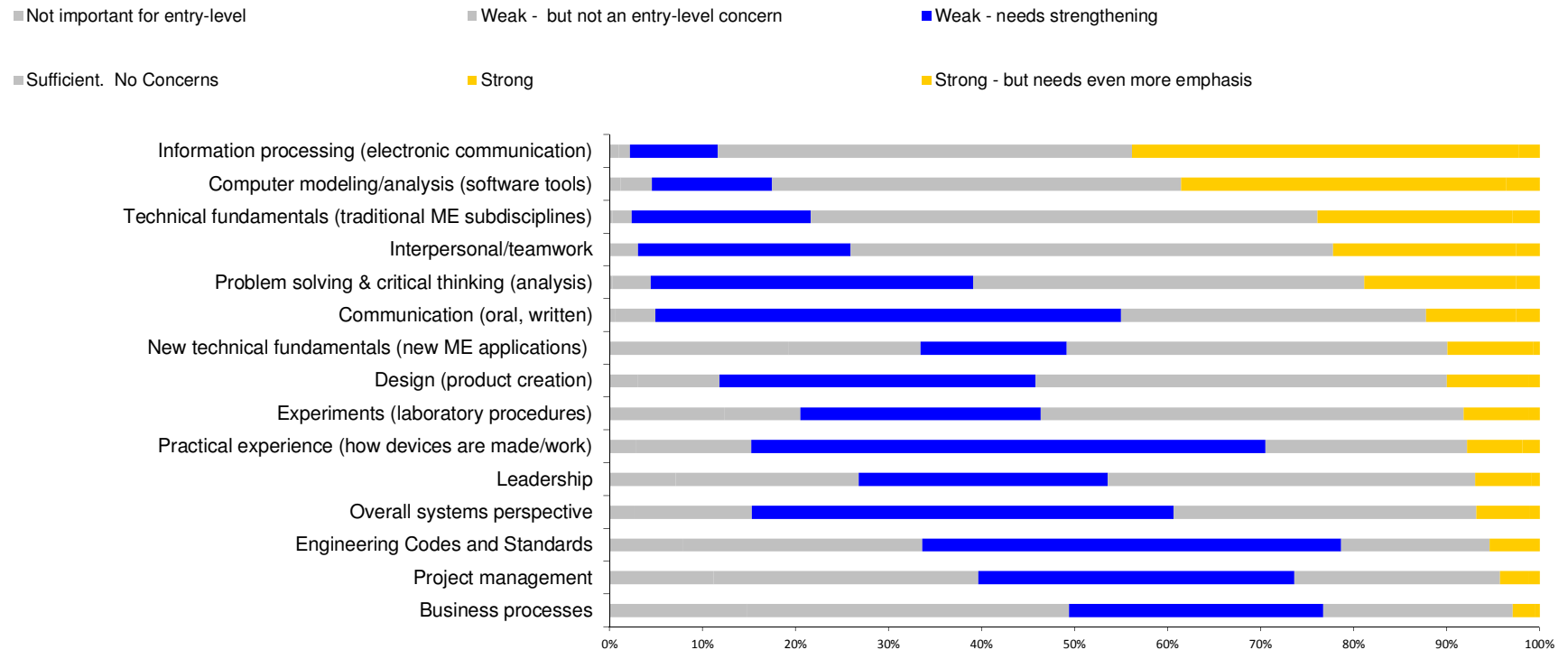
- Why is Engineering Professional Practice a problem worth considering?
- Development of manufacturing strategies and paradigms
- Examples
- The “What” and the “How” – Systems Engineering and Lean Engineering
- Impact on engineering education
- Content and competency mastery
- The dirty word – Holistic
- Summary



# Communication Failures



# ASME Vision 2030 – Early results



# Engineering Professional Practice

Workforce Development

Engineering Education

Life-Long Learning

Problem Solving

Globalization

Safety

Program Development

Faculty Development

Diversity

Systems Thinking

Sustainability

Communication

Ethics

Program Governance

Where are we (ME) teaching (any of) this?



# Complexity, not Integration (Source Functions)

- Engineering sciences – the basics
- Engineering mechanical, electrical, optical components into smaller packages
- Cause-effect chains and networks, unknown and not in plain sight
- Airbus A320 / A333 / Boeing 777 / 787
- DWH, Fukushima, HDD, others
- Supplier qualification



# Project Execution (Environmental Functions)

- Team work
- Different educational backgrounds and disciplines, conflicting values
- Leadership
- Project
- Communication and appreciation of strategies, risks and their mitigation
- Decision-making culture

# Product Development Framework

- Work is carried out in teams
- Team members have various cultural, ethnical, professional backgrounds and specializations
- Different training – different risk awareness / classification
- Teams are not necessarily co-located
- Sequestration (e.g., Google) does not work for all teams
- Non-co-located teams pose huge communication issues





# Career Planning / Career Advancement / Leadership (1)

- Graduating from HS: How to envision a career? Who can guide you? Friends, parents, GC?
- Globalization of markets has globalized the workplace, requirements to compete successfully have increased
- International corporations – global recruitment market
- SMEs – need international staff to support their global customers and suppliers
- New types of jobs, previously unknown
- Product innovation
- Talent Management



# Career Planning / Career Advancement / Leadership (2)

Solid professional foundation (source function) plus competency to navigate professional environment (environmental function) plus decision-making culture (e.g. leadership skills).



# Development of manufacturing strategies and paradigms

	Arts & crafts	Mass Prod.	Lean	Agile
Manual Skills	High (5)	Low (2)	Medium (3)	Medium (3)
Part Quality (interchange)	Low (2)	Medium (4)	High(5)	High (5)
Production Flexibility	High (5)	Low (1)	Medium (4)	High (5)
Required Systems Competencies	Low (1)	Low (1)	High (5)	High (5)
Professional Specialization	Low (0)	Medium (4)		Excessive (?)



# The “What” and the “How” – Systems Engineering and Lean Engineering

- Systems Engineering - “an interdisciplinary approach and means to enable the realization of successful systems” (INCOSE)
- Defining customer needs, required functionality, documentation
- Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs
- Design synthesis and system validation while considering the complete problem: Operations, Performance, Test, Manufacturing, Cost & Schedule, Training & Support, and Disposal.
- Systemic break-up of project into hierarchical structure
- Unknown cause-effect chains



# Where Content meets Competency

## Systems Engineering

- A system is not 100% deterministic
- System may not follow reductionist approach
- Focused on technology
- Engineering Sciences and Basic Sciences

## Lean Engineering

- Purpose, process, people
- Workforce development
- Continuous evolution
- Teamwork

Source Functions

Environmental Functions

CONTENT

COMPETENCIES

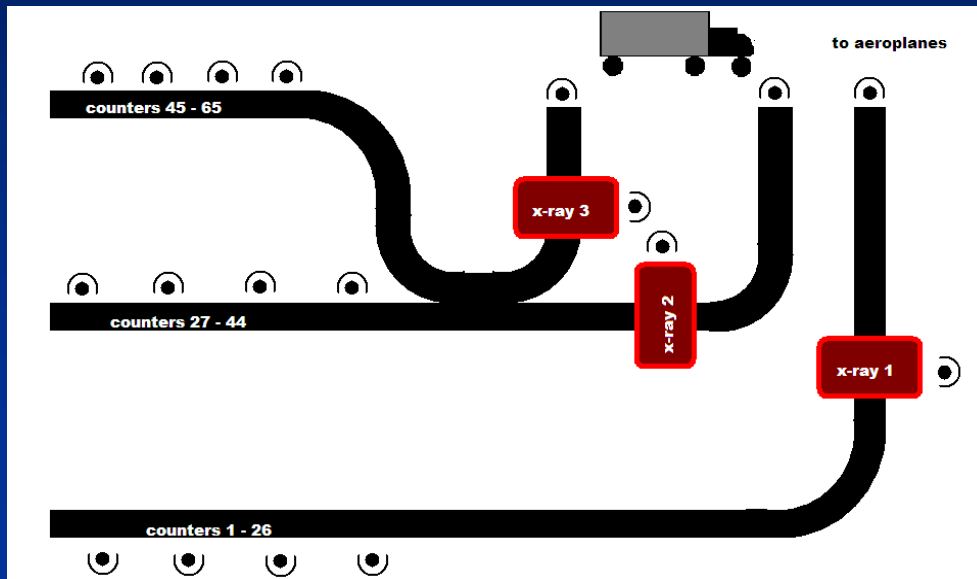


# Case Studies

- CPT airport
  - On-site machining
  - Health care
- 
- Why has it worked?



# Non-contact Measurements – Baggage Sortation at CPT



Old System (until 2009)

## Condition:

- Frequent break-downs
- Low throughput
- Slow
- Safety

Outlook for 2010  
World Cup:

Not suitable

# Baggage Sortation at CPT (2)

- Throughput demands automation of the BSF (length of several km)
- 24 / 7 operation at peak times
- Real-time preventive maintenance and condition monitoring
- Automatic identification and localization of impending malfunctions
- Escalating safety levels





# Baggage Sortation at CPT (3)

	Vibration Analysis	Oil Debris Analysis	Thermal Imaging	Balancing & Alignment	Performance Monitoring
Bearings	•	•	•	•	•
Belts	•			•	•
Electric Motors	•		•	•	•
Frame			•		
Gearboxes	•	•	•	•	•
Rollers	•		•	•	•

- 200 separate conveyor belts, at least one motor each
- Motor damage mostly due to defective bearings and damage to electrical insulation
- Maladjustments during installation or due to shocks during operation
- Breakdown of lubrication
- Limited access to damaged rollers / damage not obvious; proof often indirect (bearing conditions)

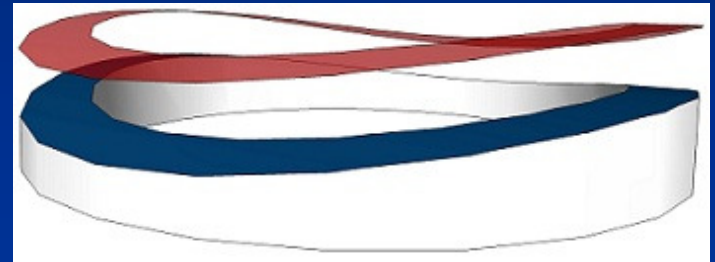
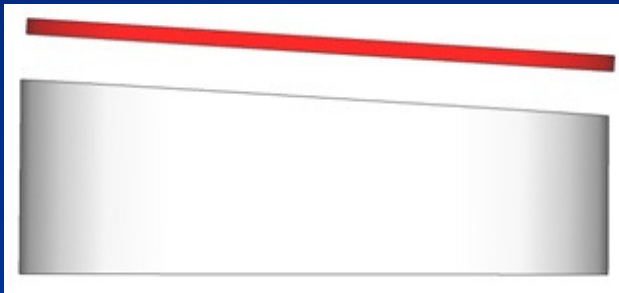
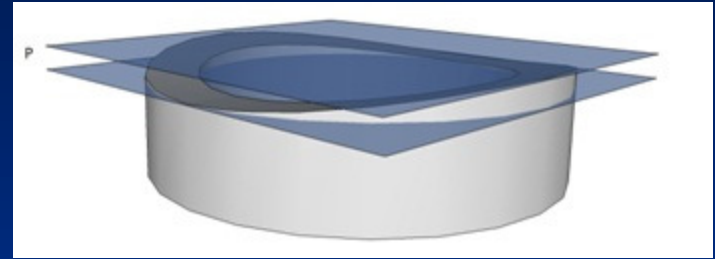
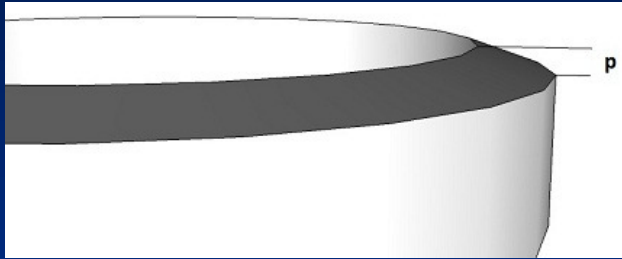
# On-Site Circular Milling

- Portable machine tool
- Assembled on-site, mounts directly to work.



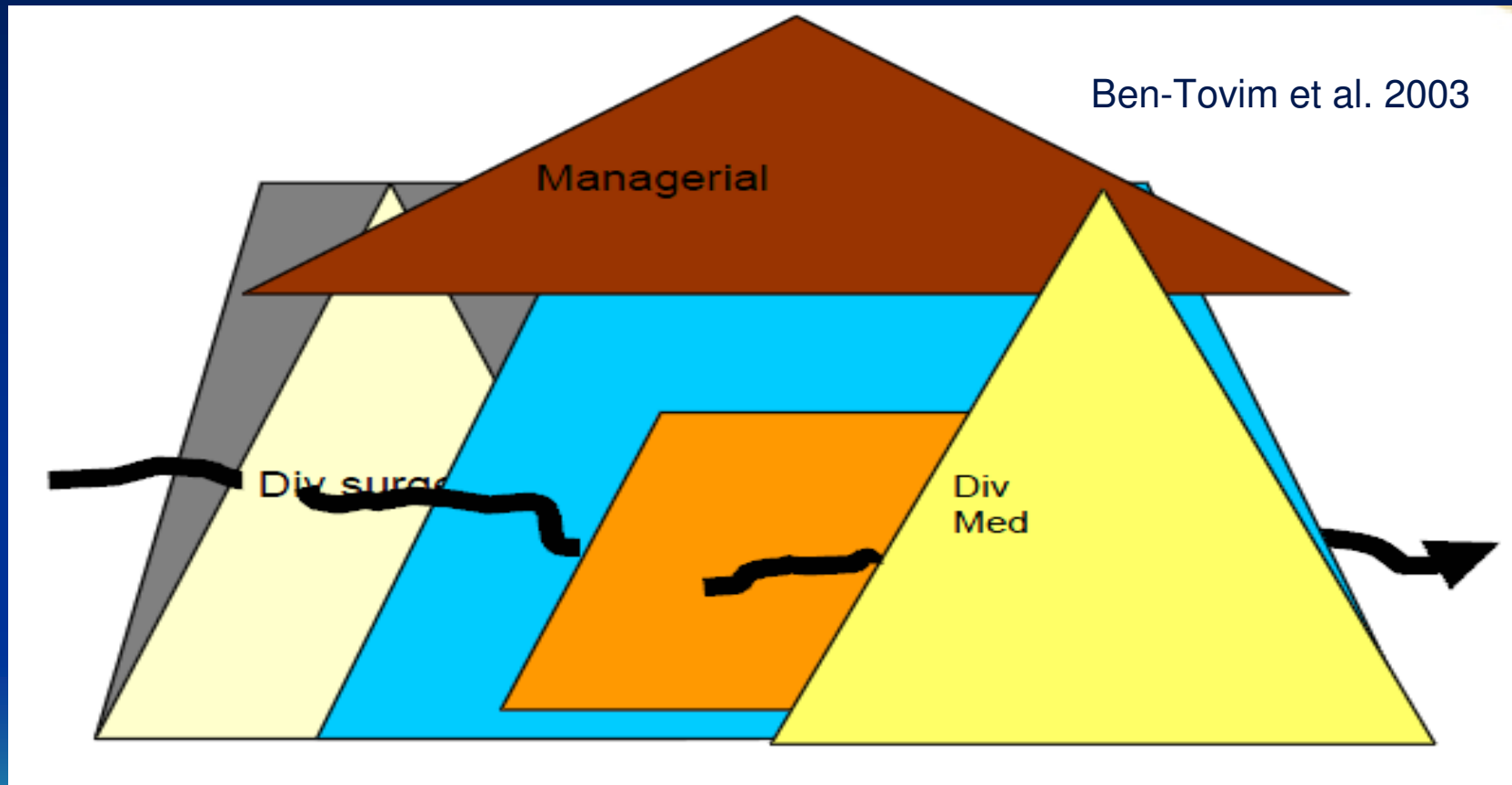
- Re-aligned to work for each job.
- Primary use: finishing slewing bearing seating surfaces to within set un-flatness tolerances.

# Metrology Challenges



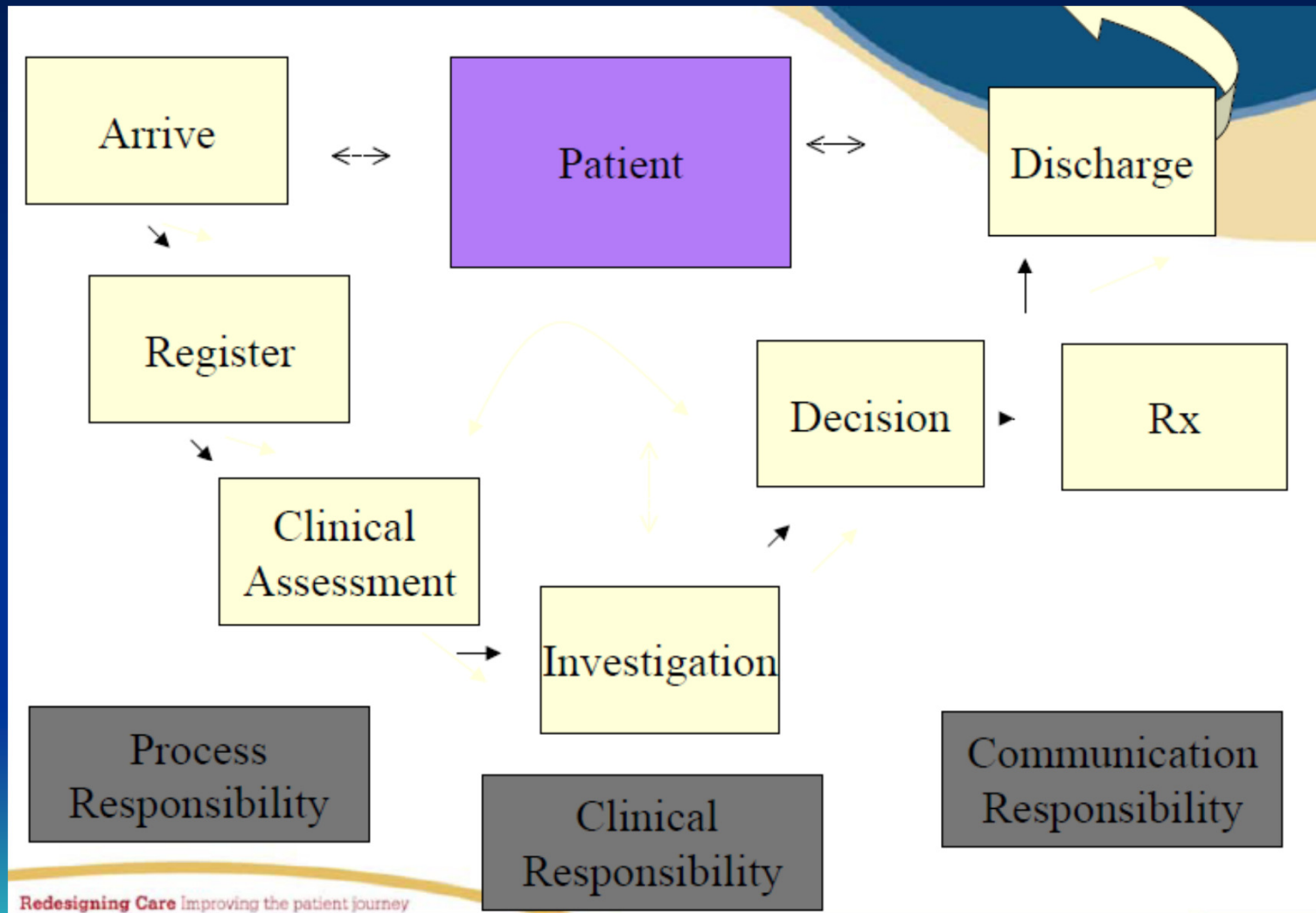
- Aim: To reduce the combined Un-flatness and taper error.
- Reduce localised stresses in slewing bearing raceways.
- Decreased fatigue in bearing.
- Increased in service lifespan.
- Potential for larger load capacity.

# Self-Organization – Medical Service Delivery



A horizontal journey through a vertical enterprise.

# Flinders Medical Centre



# Case Studies (Pittsburgh)

## Allegheny GH :

# of patients with intravenous infections	37 -> 6
Associated deaths	19 -> 1

## Southside Hospital

time spent searching for meds	- 60 %
stock-outs	- 85 %

## Shadyside Hospital

estimated nurse time spent on patient-controlled anaesthesia pumps	-2900 h p.a.
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# Biological System – TKA – 4th / y



Adverse effects of prosthetic wear debris include:

- Prosthetic structural failure
- Biological incompatibility
  - Toxicity
  - Osteolysis

*Wear debris pseudotumor following total knee arthroplasty: a case report. Mavrogenis, A.F., et al. 9304, s.l. : BioMed Central, November 29, 2009, Journal of medical case reports, Vol. 3.*

# Why has it worked?



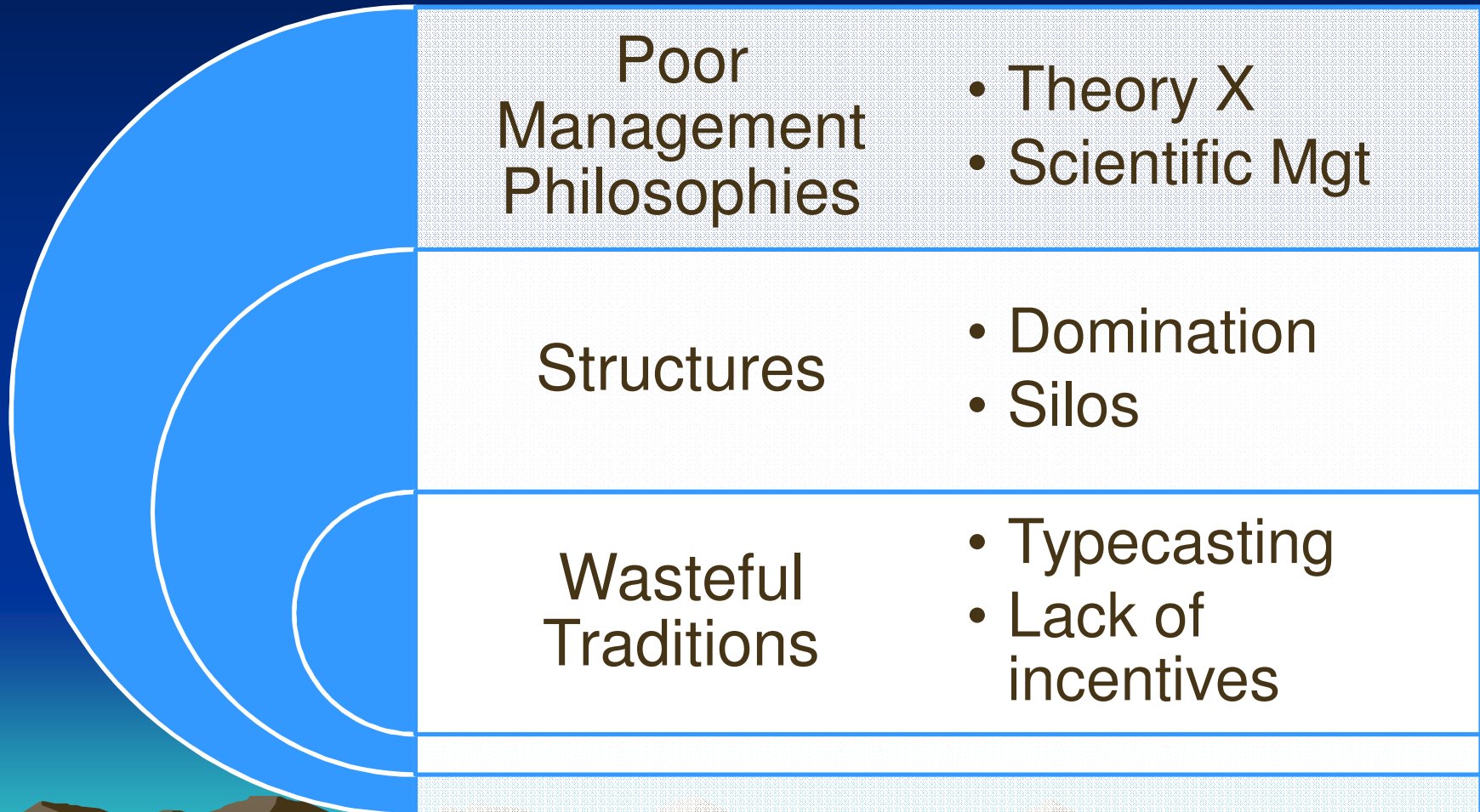


# LEARNING PROCESS

## Holistic Development



# Barriers to Holistic Development



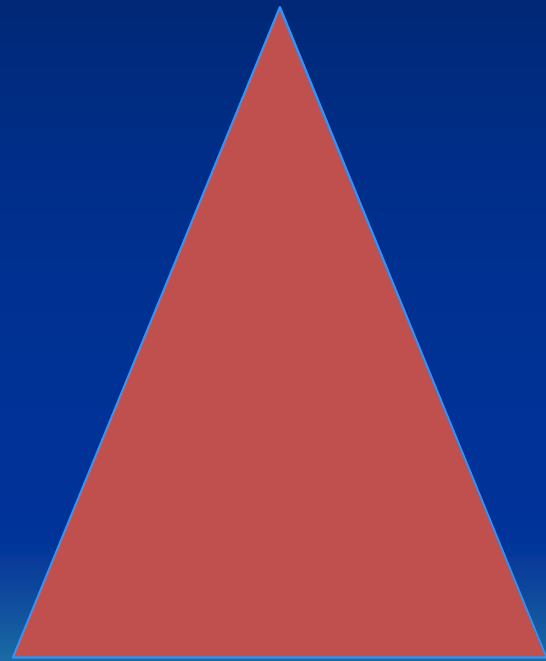
# Mass Production Paradigms

- Allocation of Power, Space, Conditions

- Roles, Duties

- HR Policy, Rules

- HR Philosophy, Culture



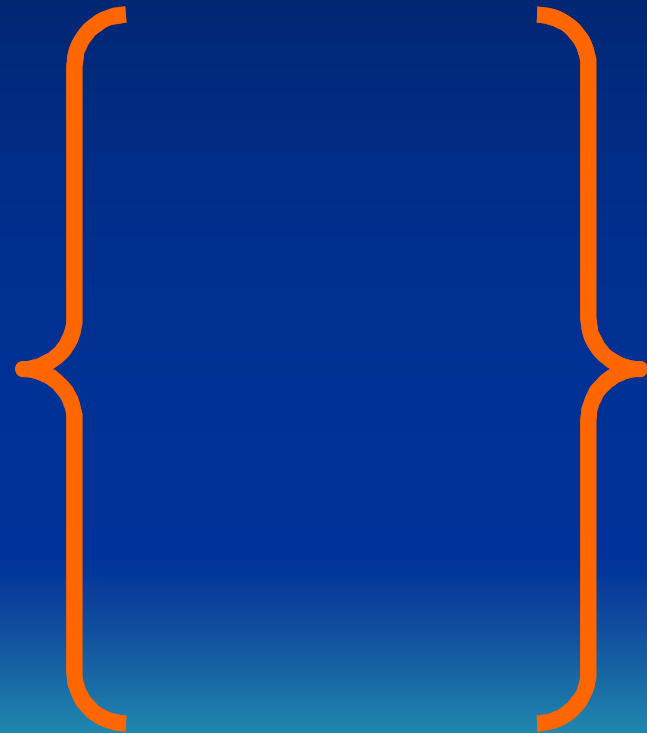
# Lean Production Paradigms

-Allocation of Power, Space, Conditions

-Roles, Duties

-HR Policy, Rules

-HR Philosophy, Culture



# LEAN LEARNING SYSTEMS

## Transformational

### CANONS

Body of Knowledge  
Contracted  
Transactional

- STANDARDS
- NORMS

*Taught  
Expected  
Didactic  
Outside/In*

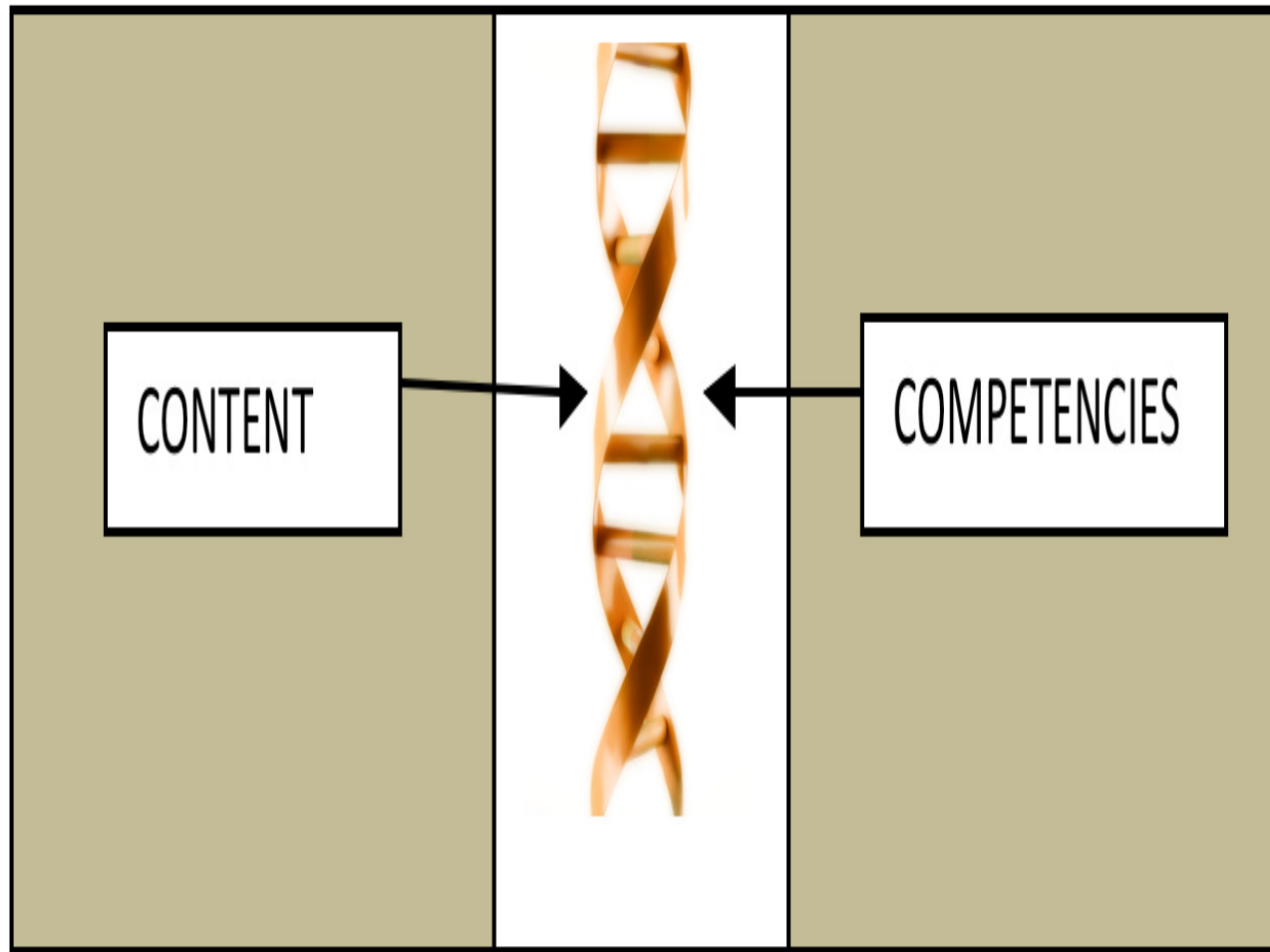
### COMPETENCIES

Body of Practice  
Internalized  
Transformational

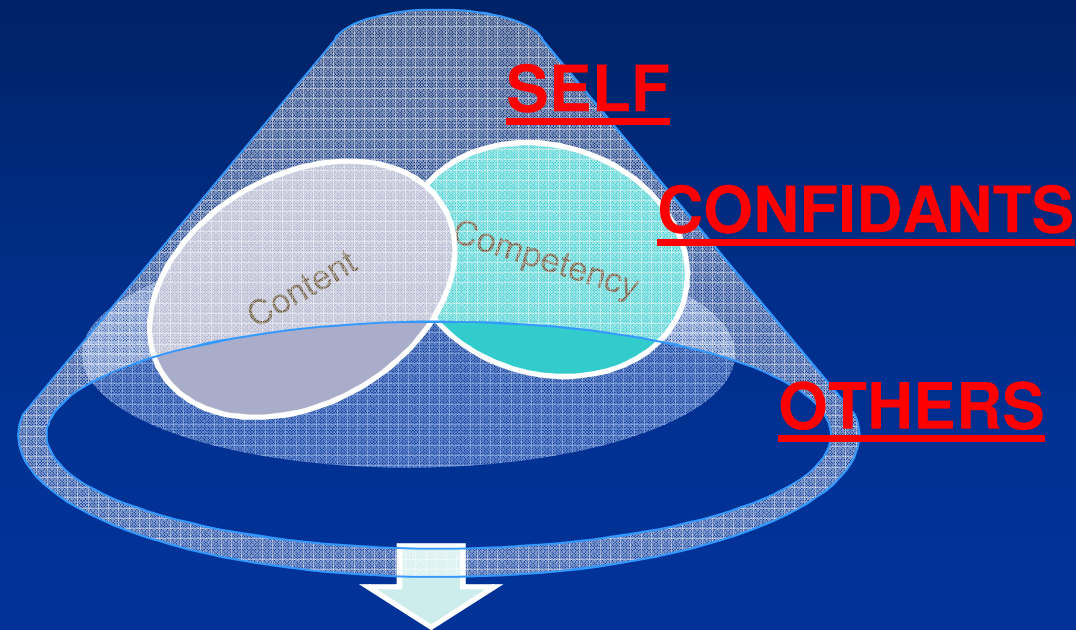
❖ THINKING  
❖ DOING

*Developed  
Hoped For  
Socratic  
Inside/Out*

# PARADIGM SHIFT: HOLISTIC DEVELOPMENT DOUBLE HELIX DNA

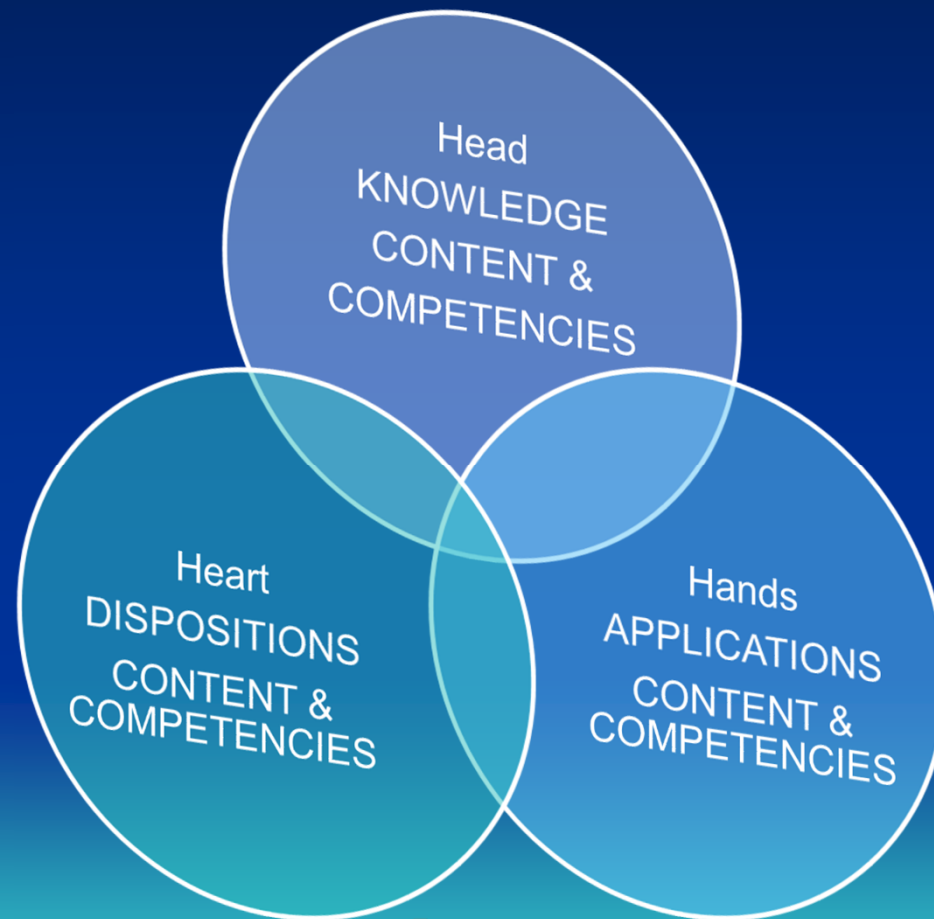


# Content & Competency Development



**Holistic Taxonomy**

# Holistic Taxonomy of Development

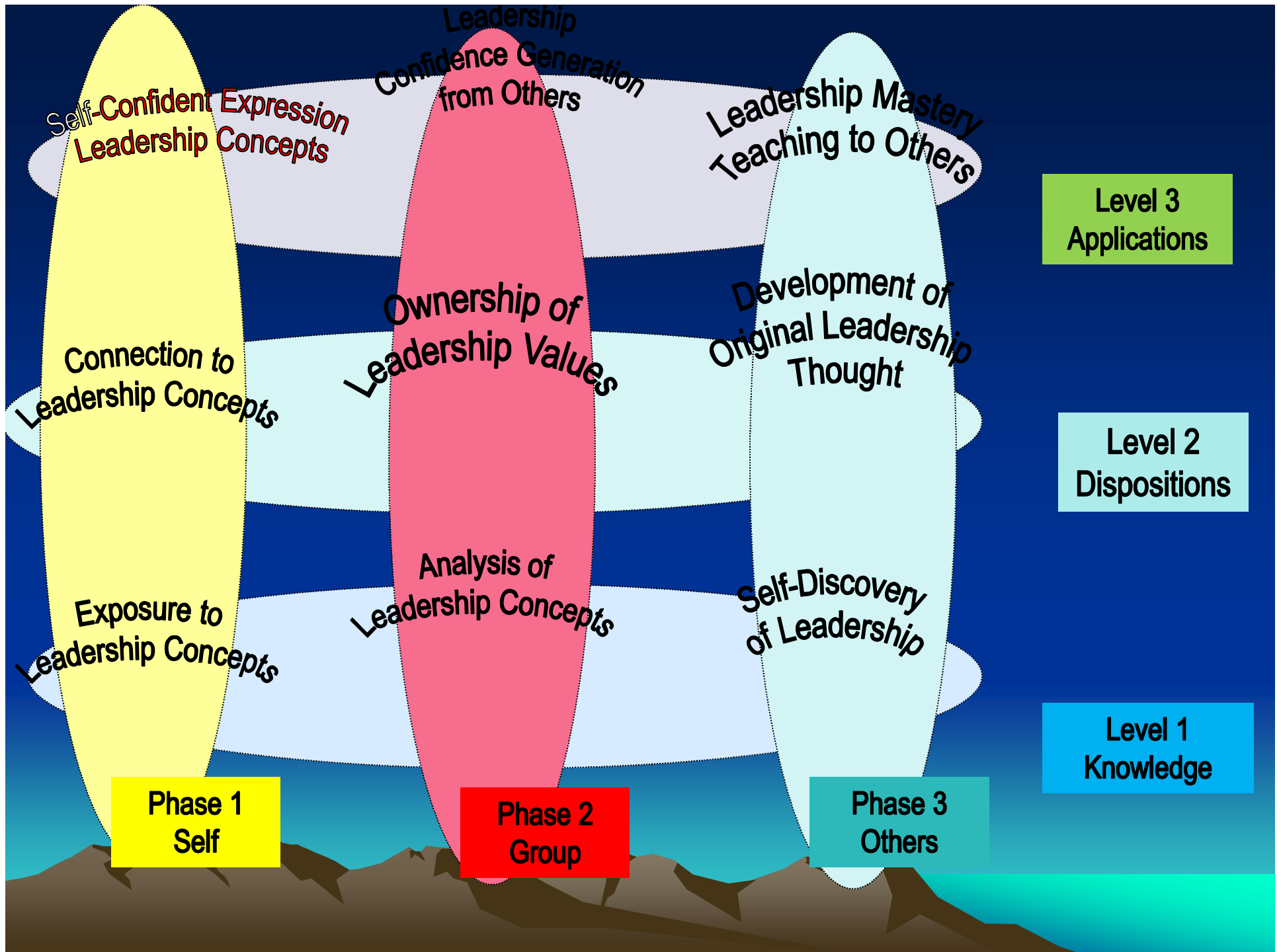


**SELF**

**CONFIDANTS**

**OTHERS**





## LEADERSHIP LEARNING: KNOWLEDGE DEVELOPMENT

Talk with others about leadership ideas and seek support, criticism

Seek to understand what others know about leadership

Examine leadership mistakes and how to improve

Use new language, strategies, ideas to solve, mediate, manage change or connect theory to general settings

Learn from a mentor

Read, research, talk, observe if leadership theories have personal relevance and relate to my prior knowledge

Lead in new ways based on theory, research or documentation

Discuss potential results of new concepts with family, peers, allies, leaders

Understand leadership constructs to influence others, share information where some are unfamiliar

Contemplate leadership expectations/ plan how to use concepts, strategies, decision making strategies

Talk informally, “hallway talk,” about leadership

Compare personal leadership knowledge with scholarly work, test for validity, evidence, robustness

Take notes, journal, self-talk about leadership

## LEADERSHIP LEARNING: VALUES DEVELOPMENT

Construct personal meaning of values by expression and quoting others

Consider depth of personal relevance, benefits/values, costs/risks of leadership

Self-direct leadership development activities

Develop original ideas and share those with stakeholders

Establish new boundaries in professional, personal relationships by taking risks to advance leadership

Inspire others to lead

Self-reflect on dispositions and aligning actions of leadership

Talk with others noting benefits of sharing about leadership problems

Identify leadership disposition strengths/weaknesses

## LEADERSHIP LEARNING: APPLICATIONS DEVELOPMENT

Have confidence in my ability to lead

Self-analyze, self-develop, self-evaluate how/when to lead, grow/change

Motivate self to pursue more leadership as others rely on me

Admit when wrong, share apologies

Lead from experience

Survey stakeholders assessing my leadership to set goals

Receive compliments, expressions of confidence by others

Discuss leadership with my family

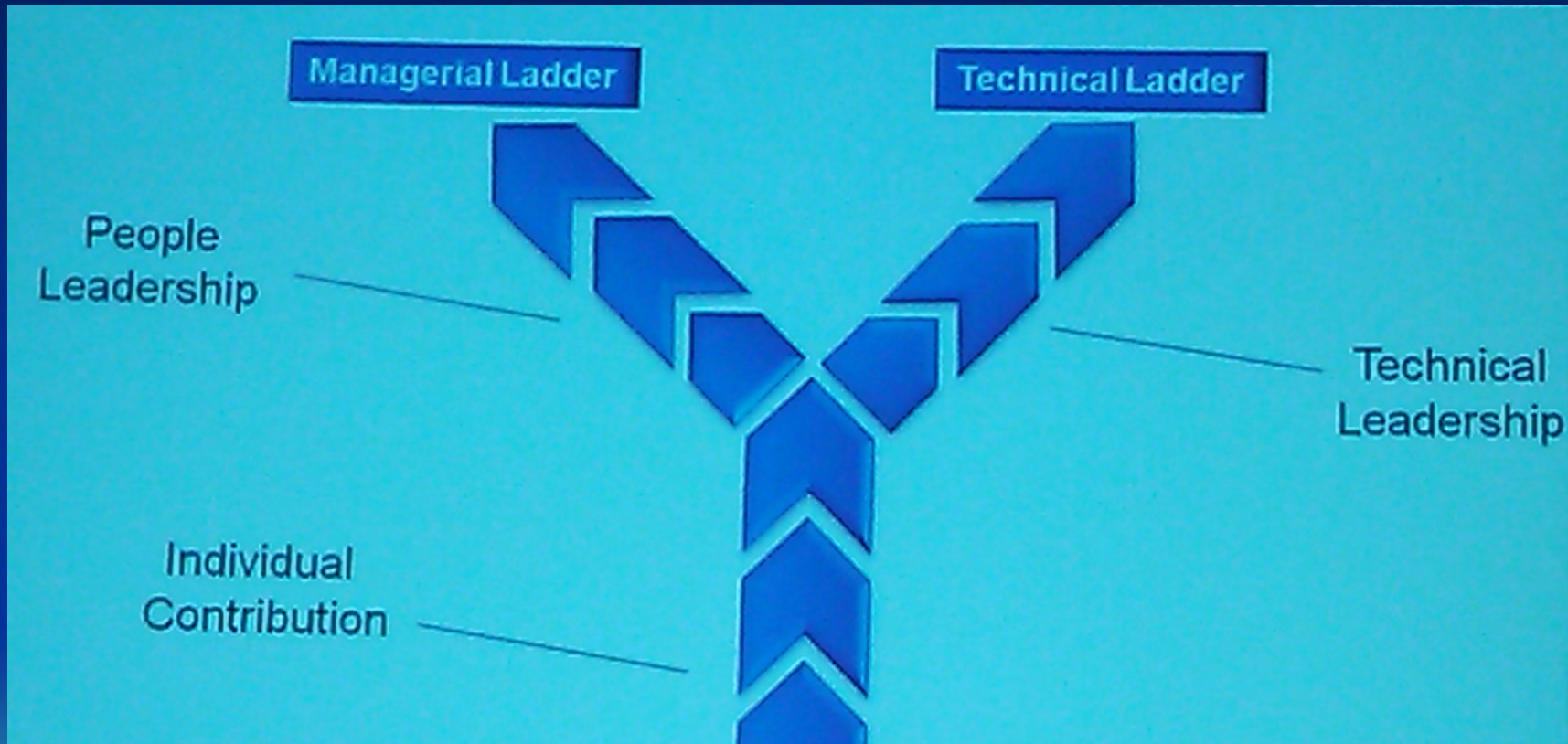


Level	Phase	Leadership Learning Behavior
Knowledge	Self	Contemplating what is expected of a leader by planning how leadership concepts, decision making processes and strategies can be used.
	Confidants	Learning about leadership from a mentor.
	Confidants	Talking with confidants and noting benefits of sharing about personal leadership dispositions, considerations, and common solutions to leadership dilemmas.
	Others	Using new language, new strategies, new ideas to solve problems, mediate conflict, change or connect leadership theory to generalized situations.
Values	Self	Performing self-directed leadership development activities.
	Confidants	Inspiring peers to get involved in leadership.
Application	Self	Having confidence in my ability to lead.
	Self	Self-analyzing, developing self-awareness, self-evaluating how and when to lead, how to grow/change/improve as a leader and impact a system.
	Confidants	Discussing leadership with my family.
	Others	Receiving compliments and expressions of confidence in me as a leader by colleagues, administrators, staff, subordinates.
	Others	Motivating myself to pursue greater endeavors when I realize others rely on me.

# HOLISTIC DEVELOPMENT

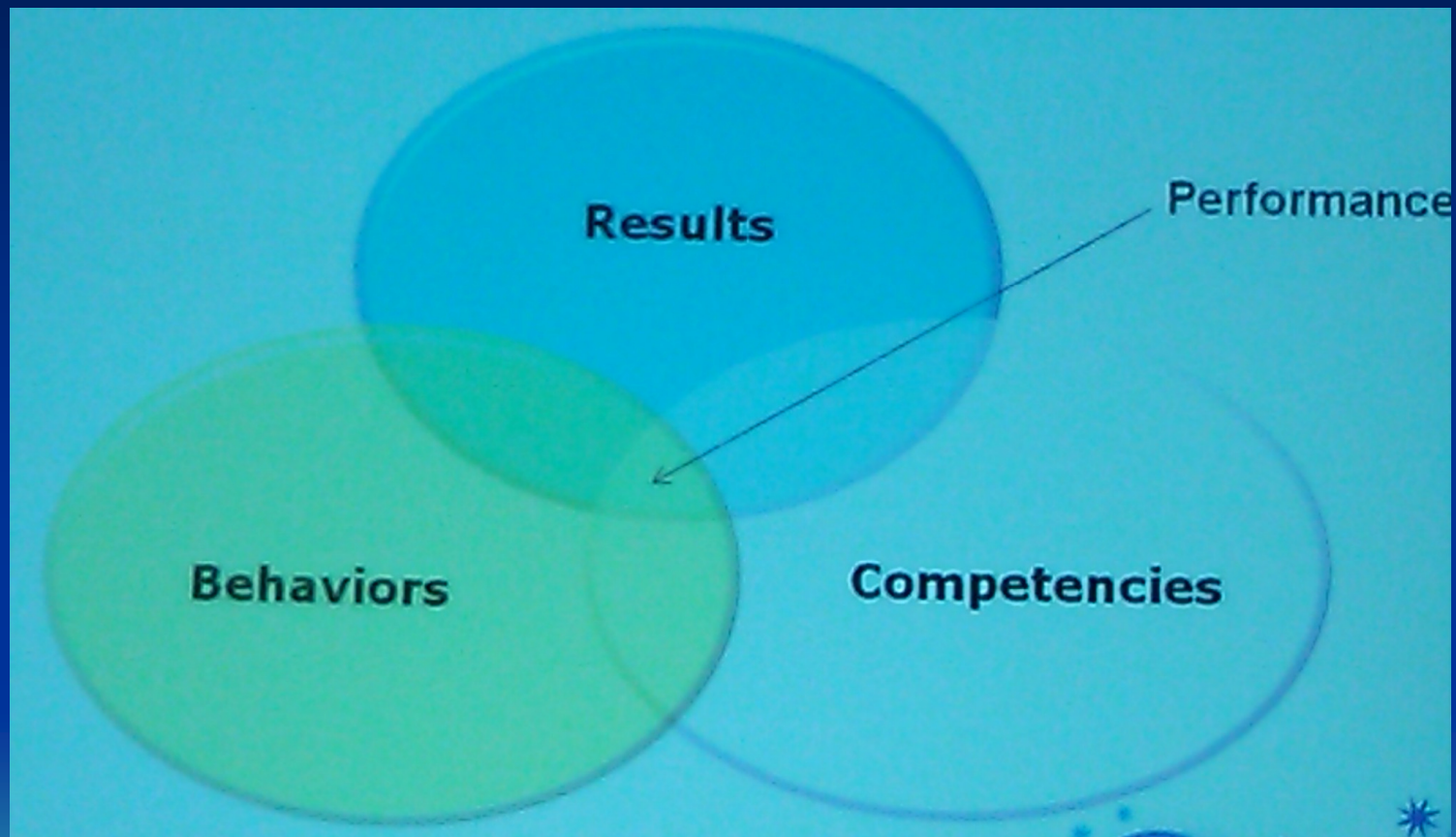
	SPECIFIC COMPETENCY	SPECIFIC CONTENT
SELF		
Knowledge		
Values		
Application		
CONFIDANTS		
Knowledge		
Values		
Application		
OTHERS		
Knowledge		
Values		
Application		

# Competency Development in Industry





# Competency Development in Industry





# Competency Development in Industry

## Competencies

← Competencies identified and maintained by each job family →

Job Function X Job Family X		Competencies identified and maintained by each job family							Results	Behaviors	Competencies
Generic Description		Job Level	Competency 1	Competency 2	Competency 3	Competency 4	Competency 5	Competency 6	Competency 7		
Manages at an enterprise level	M5	●	●	●	●	●	●	●	●		
Manages a regional or global function	M4	●	●	●	●	●	●	●	●		
Manages a job family within a function	M3	●	●	●	●	●	●	●	●		
Manages Mgrs/Individual Contributors	M2	●	●	●	●	●	●	●	●		
Manages Individual Contributors	M1	●	●	●	●	●	●	●	●		
Performs industry-wide technical expert activities	IC6	●	●	●	●	●	●	●	●		
Performs highly-specialized technical expert activities	IC5	●	●	●	●	●	●	●	●		
Performs specialized technical activities	IC4	●	●	●	●	●	●	●	●		
Performs experienced level activities	IC3	●	●	●	●	●	●	●	●		
Performs intermediate-level activities	IC2	●	●	●	●	●	●	●	●		
Performs entry-level activities	IC1	○	●	●	●	●	●	●	●		

Proficiency required for e

Proficiency

Expert
Proficient
Intermediate
Novice
Limited

# Summary

- Competency Development is biggest challenge in workforce development
- Work in non-co-located teams is reality
- Main Challenges: Silos, Communication, Visualization, Leadership, Decision-Making
- Ethnical, cultural, value-related, gender gaps and departmental barriers must be bridged
- Content (Systems Engineering) and competency (Lean Engineering) cannot be regarded as separable