QUALITY LEADERSHIP FORUM

June 24, 2021

National Aeronautics and Space Administration
Office of Safety and Mission Assurance
NASA Headquarters, Washington, D. C.

QUALITY LEADERSHIP FORUM 2021

Keynote Speaker: Gregory H. Watson, PhD, EUR. Ing.

From Cosmic Quality to Micro-Quality – The Transformation of Quality from Atoms to Digits

Abstract of Presentation:

NASA is a global technology leader. It is a source of American for accomplishing major technological breakthroughs and advancing science and demonstrating innovative leadership in management and engineering. The dedicated people of NASA who have labored diligently to create thoroughly vetted methods and innovative designs that operate in uncertain environments and under the most extreme conditions which are conventional in space exploration. When faced with a technical challenge, the people of NASA have accepted the challenge and prevailed. A new challenge confronts the traditional ways people have learned to work and operate and requires that we discover and develop new capabilities and competence of a different sort. Rather than individual creative genius, the emergence of digitalization in all milieus has spawned Quality 4.0 which disrupts old ways of working and establishes a new approach for "collaborative analytics" where human collaboration in combination with insights from artificial intelligence will challenge our old work ways. The Age of the Smart Machine is coming into maturity through the ubiquitous nature of digital technologies. In this presentation we will probe what this transformation means, how it will impact the traditional practices and methods of quality, and what enlightenments will be required so organizations can adapt their engineering and business practices in a way that is suitable for this emergent digital age. Basic questions will be asked and answered: What is it? What will it mean for us? How do we do it? What are the steps that should be taken to advance toward this direction? What will it look like when we are done? In conclusion, this presentation will show how Quality 4.0 is only be an intermediate step on the quality journey as it opens up "Pandora's box" through its extended implications for society, humanity, and the future of life on Planet Earth. Perhaps, it will even help to codify the future mission of NASA.

About the Presenter:

Dr. Watson is a Past-President and Honorary Member of the International Academy for Quality and the American Society for Quality. He has been designated a Lifetime European Engineer in both Industrial and Systems Engineering, He holds certifications from ASQ as a Quality Engineer, Software Quality Professional, Reliability Engineer, and Master Black Belt. Dr. Watson served in professional quality positions at Hewlett-Packard, Compaq Computer, and Xerox Corporation before founding his consulting practice in 1994. In his practice he has consulted with many leading technology firms: Nokia Mobile Phones, Research in Motion, Microsoft, Toshiba, and Toyota to name a few. Dr. Watson has been an active volunteer in both his quality and industrial engineering communities. He is a co-founder of the American Productivity and Quality Center's International Benchmarking Clearinghouse, the Asian Network for Industrial Engineers, and developed the European-wide training program for industrial engineering students at the Green Belt level of Lean Six Sigma through an on-line learning and certification program for the European Students of Industrial Engineering and Management. Dr. Watson authored the future scenarios for the eight ASQ future studies conducted from 1993 to 2015 and his 1998 articles in *Quality Progress* provided the first visionary conceptualization of what has become called Quality 4.0. In 2016, he first used this term while speaking to the International Academy for Quality in a General Meeting and in 2017 he delivered five public addresses on this subject. His 2018 article in *Quality Progress* described the evolution of the quality movement to the point of Quality 4.0 and his 2019 article in *Quality Progress* described a re-framing of the quality profession that will more closely align with its digitized future. Dr. Watson is widely recognized as a thought leader in technology applications for quality systems and delivers speeches and conducts research on this subject. His forthcoming research project for the IAQ will develop a cornerstone document to define this disruptive transformation of the quality profession will occur and what should be the global call-to-action for remaining relevant in the future.

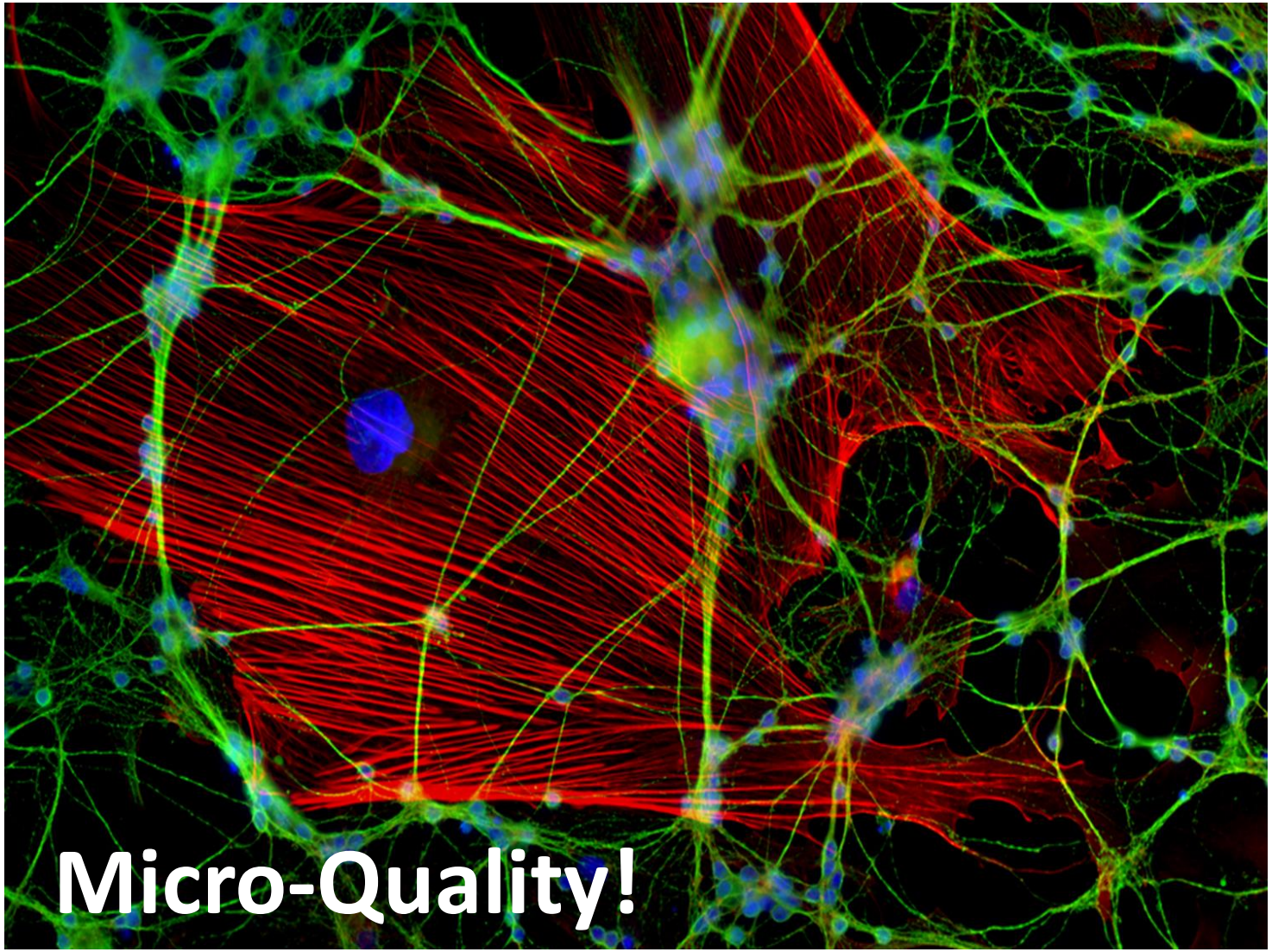
From Cosmic Quality to Micro-Quality:

The Transformation of Quality from Atoms to Digits

There are macroscopic systems:

Here our knowledge is limited by ability to observe, measure, and understand.

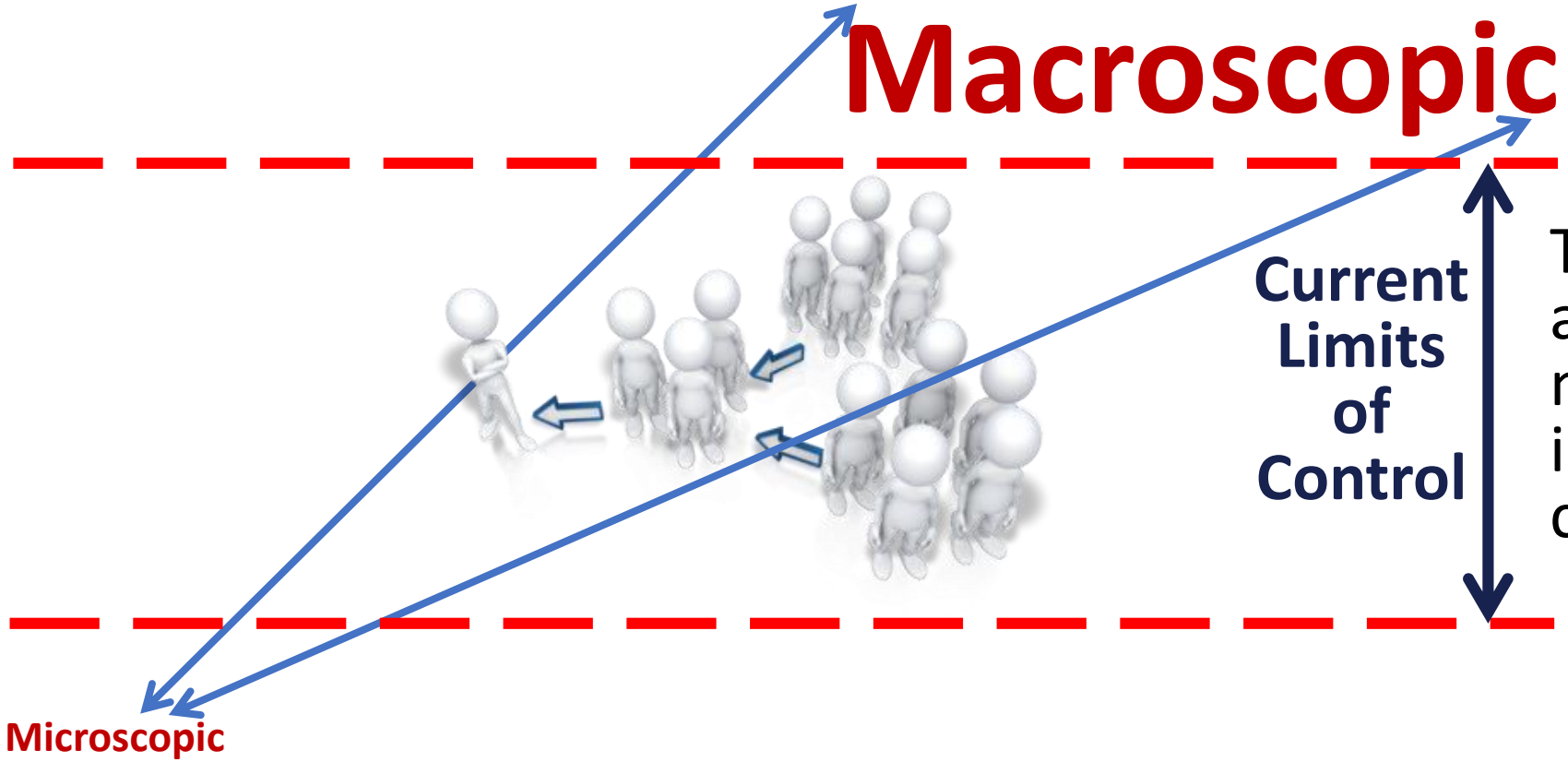
There are microscopic systems:



Here also knowledge is limited by ability to observe, measure, and understand.

Despite the scale the name of the game is data!

We live between two worlds of systems …



The limit is our ability to see and measure which let interpretation and control happen!

… so, is there is a limit to what humans can control?

What is the meaning of "Quality 4.0" in general?

The idea and naming of Quality 4.0 originated as an extension of the Industry 4.0 strategic initiative first adopted as an action plan by the German government in 2010. This term was first used in 2017 and applied to indicate that there is a new epoch of quality thinking that arrived as a result of the disruptive effect of digitalization and Big Data on the practice of quality in industry and society. Before this term was created the concept of quality had not been segmented into epochal periods based on advances in momentous events its own field. Thus, the prior epochs defined for quality were imprinted on the prior periods of Industrial Revolutions.[1] However, quality thinking has been evolving ever since the development of the control chart by Walter A. Shewhart in the 1920s.[2]

1. Gregory H. Watson (2019), "The Ascent of Quality 4.0," *Quality Progress*, 52:3, pp. 24-30.
2. Gregory H. Watson (2020), "Constant Evolution toward Quality 4.0," *Quality Progress*, 58:8, pp. 32-37.

NASA Vision, Mission, and Core Values:

- **Mission:** Drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth.
- **Vision:** Discover and expand knowledge for the benefit of humanity.
- **Core Values:** Safety, integrity, teamwork, and excellence.

Problems exiting with data are well-known:

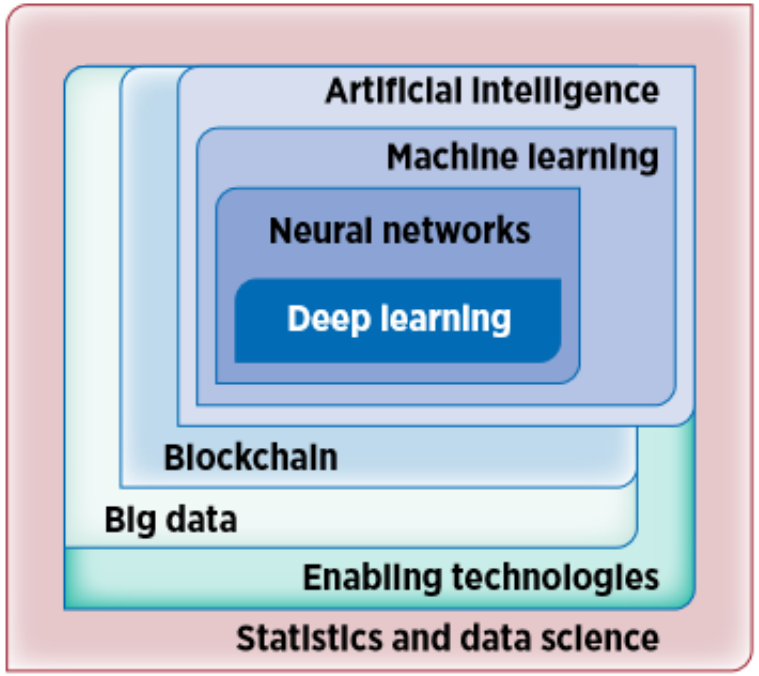
- Voltaire (1748): “In all times, in all countries, and in all genres, the bad abounds, and the good is rare.”
- Charles Babbage (1864): “On two occasions I have been asked: ‘Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?’ ... I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question. Errors using inadequate data are much less than those using no data at all.”
- Mark Twain (~1886): “Data is like garbage. You’d better know what you are going to do with it before you collect it”
- Theodore Sturgeon’s Law (1956): “Not everything is always absolutely so.”
- Theodore Sturgeon’s Revelation (1957): “Ninety percent of everything is crap.”
- William D. Mellin (1957): “Computers cannot think for themselves and sloppily programmed inputs inevitably lead to incorrect outputs.” [Garbage In – Garbage Out (GIGO)]
- Russell L. Ackoff (2004): “We don’t solve problems, we manage messes.”
- Gregory H. Watson (2014): “We are living in a world of dirty data and messy processes.”
- Gregory H. Watson (2016): “Quality is the relentless pursuit of goodness, coupled tightly with the persistent avoidance of badness.”

Evolving technologies create evolving challenges!

How to manage data arriving in such large quantity and diversity in real-time streams?

What is the digital ecosystem of Quality 4.0?

What makes Quality 4.0 so different is how we manage our daily data!



- **Big Data**: searching and sorting through massive data sets to find meaningful relationships to provide insights supporting decisions.
- **Blockchain**: a data management system in which all transactions are traced across several computers in a crypto-linked network.
- **Artificial Intelligence**: the ability of computers to perform tasks that normally require human intelligence.
- **Machine Learning**: an AI discipline of experiential learning where machines to adapt to new situations by self-training.
- **Neural Networks**: a computer architecture that is modeled after the synapse and neural functions of the human brain.
- **Deep Learning**: a ML discipline where NL algorithms learn by analyzing extensive Big Data sets to create adaptive patterns.

A **digital data eco-system** defines how the data flows across its various platforms, layers, and digital technologies that are the core IoT elements. It identifies how they can operate collaboratively in a system to support decision making and provide information in feedback loops which manage operating systems connected to the network. This technology-centric way to define "Quality 4.0" does not tell how these tools are applied.

1. Nicole Radziwill (2018), "Let's Get Digital," ***Quality Progress***, October, Vol. 51, No. 10, pp. 24-29.

How are these technologies applied to quality?

- **Big Data** consists of large, extensive datasets which are characterized by ***volume*** (amount of data), ***variety*** (multiple types of data and domains for repositories of data), ***velocity*** (data flow rate or rapidity of creating new information), and their ***variability*** (how these three data characteristics will change over time). These characteristics need a digital architecture to efficiently store, manipulate, and analyze data [a*dapted from the NIST working definition of Big Data*]. **But, this does not ensure data quality!**
- **PLUS:** Two data integrity requirements also exist: ***veracity*** and ***value***!
- **Challenge**: how can we possibly cope with using all of this data?
- **Answer**: treat data as indicators of the system state and automate the manner of dealing with it to fit the pace of the four "V's" defining this stream of system-state observations!

Quality 4.0 will create digitalized disruption:

Determining the Current State of Quality Maturity:

It's too easy to get overwhelmed by technology and forget people!

Quality 4.0 Is Not:

- A New Quality Program
- A Quick Fix or Patch to be Added
- Just Technology Transformation
- Just a Cost-Savings Strategy
- Incremental Improvement
- An Excuse for "Rightsizing"
- Another Tool for the Toolkit

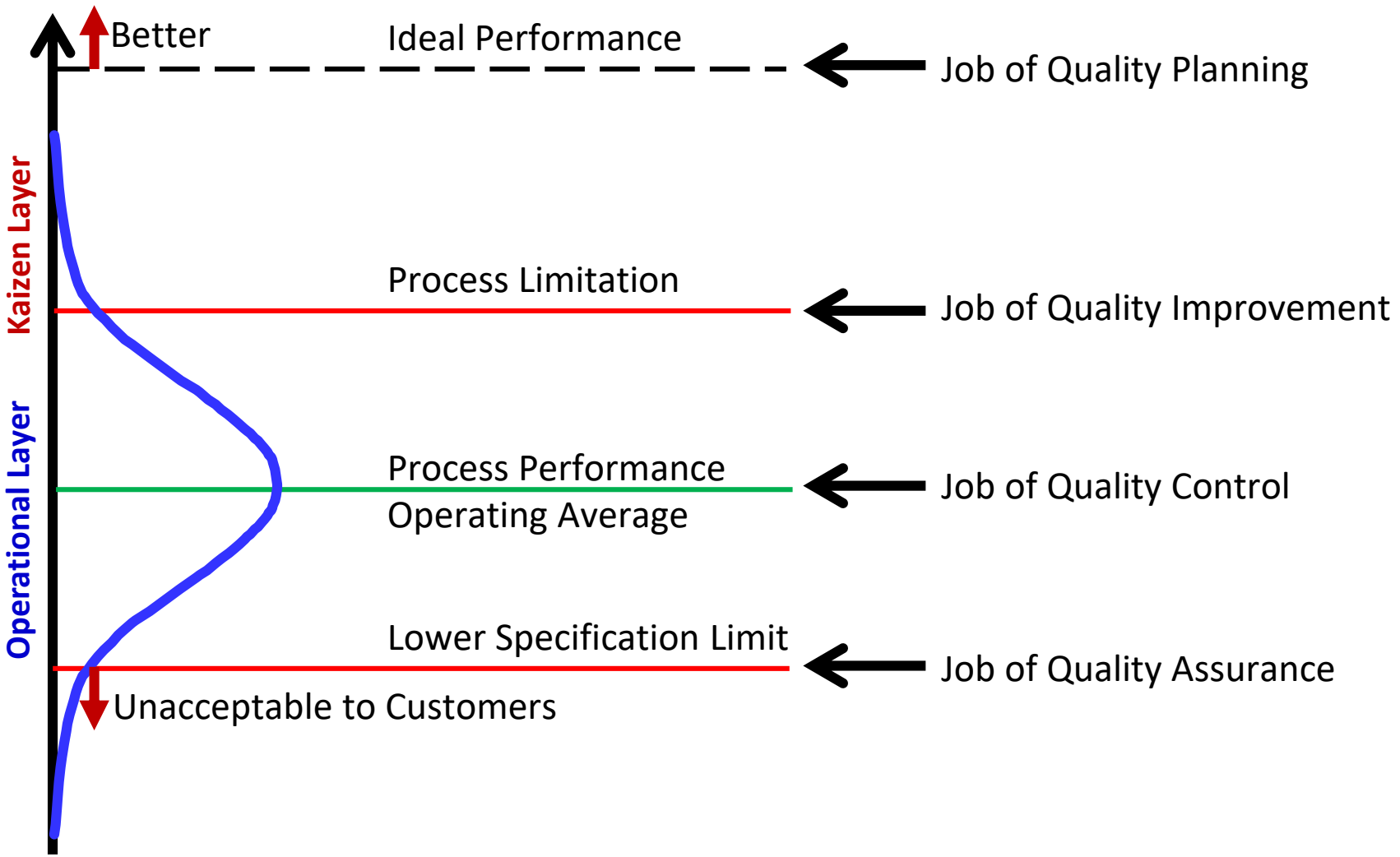
Quality 4.0 Requires:

- Profound Knowledge
- Humanized Technology
- Technology Astuteness
- Process Focus
- Engineering Design
- Distributed Sensors
- Information System Integration

Quality 4.0 is a catalyst that is disrupting industry in a manner that has vast future implications for both industry and quality profession.

Kaoru Ishikawa's model of "managing for quality:"

How to cope with digital disruption in a quality system architecture?



Quality management systems build strength from the bottom up and build its longevity from the top down.

1. An **Operational layer** that performs value-adding work.
2. A **Kaizen layer** that is focused on doing the change management projects.

Elements of Quality Management:

Taking a systems approach to quality management:

Quality Assurance +

Quality Control +

Quality Improvement =

Quality Management

This approach optimizes the investment already made in the system development.

Quality 4.0 in Quality Management:

Some interesting potential applications:

- **Distributed Processing and Predictive Analytics**: Multiple control centers allow a system to perform robustly despite interrupts or overload conditions, controlling all system components as a synchronistic whole to maximize total performance, reduce future risk, and improve real-time control of production systems.
- **Adaptive System Controls:** Process mining using relational pointers enables data to be graphically analyzed for discrepant patterns; data historians provide work traceability where Machine Learning adaptively learn how processes operate and uses patterns of change to identify process issues coupled with rule-based logic to automatically detect minute system changes and define problem states; remote diagnostics observes symptoms in real-time and when failure modes are embedded into the diagnostic logic, anticipatory failure analytics can be used for preventive maintenance.
- **Third-Party Certification**: Digital certificates may be granted by remote monitor using agent technology to monitor digitized quality systems to grant and assure continuing system compliance with certification requirements.

Applications are only limited by imagination!

Elements of Quality Development:

Forging a pathway toward the future of quality:

Quality Planning +

Breakthrough Improvement +

Quality by Design =

Quality Development

This approach creates differential quality through innovative investments.

Quality 4.0 in Quality Development:

Some interesting potential applications:

- **Latent Requirements Analysis**: Application of Big Data searches to define the set of "undiscovered" applications that are latent in customer applications.
- **Customer Preference Inquiry**: Application of preference modeling can determine the set of multi-criteria decision factors that drive preferences and associations in the commercial relationships uncovered by analyzing consumer purchasing data.
- **Improvement Project Management**: Application to mapping, managing, and real-time monitoring of improvement projects to determine schedule bottlenecks.
- **Supplier Management Systems**: Application for monitoring relationships between production demand and supplier fulfillment based on detailed modeling of the supplier production capacity and logistics chains.
- **Simulation Modeling and Analysis**: Application of simulation to all aspects of the development process as a "digital twin" to predict real-world performance.
- **Remote Testing and Beta-site Monitoring**: Application of the Internet of Things (IoT) to monitor and manage remote testing and customer trials.

Applications are only limited by imagination!

Elements of Quality Leadership:

Managerial engineering of business as a system:

Quality Management +

Quality Development +

Quality Culture =

Leadership through Quality

This approach creates a comprehensive engagement of the organization for quality.

Quality 4.0 in Quality Leadership:

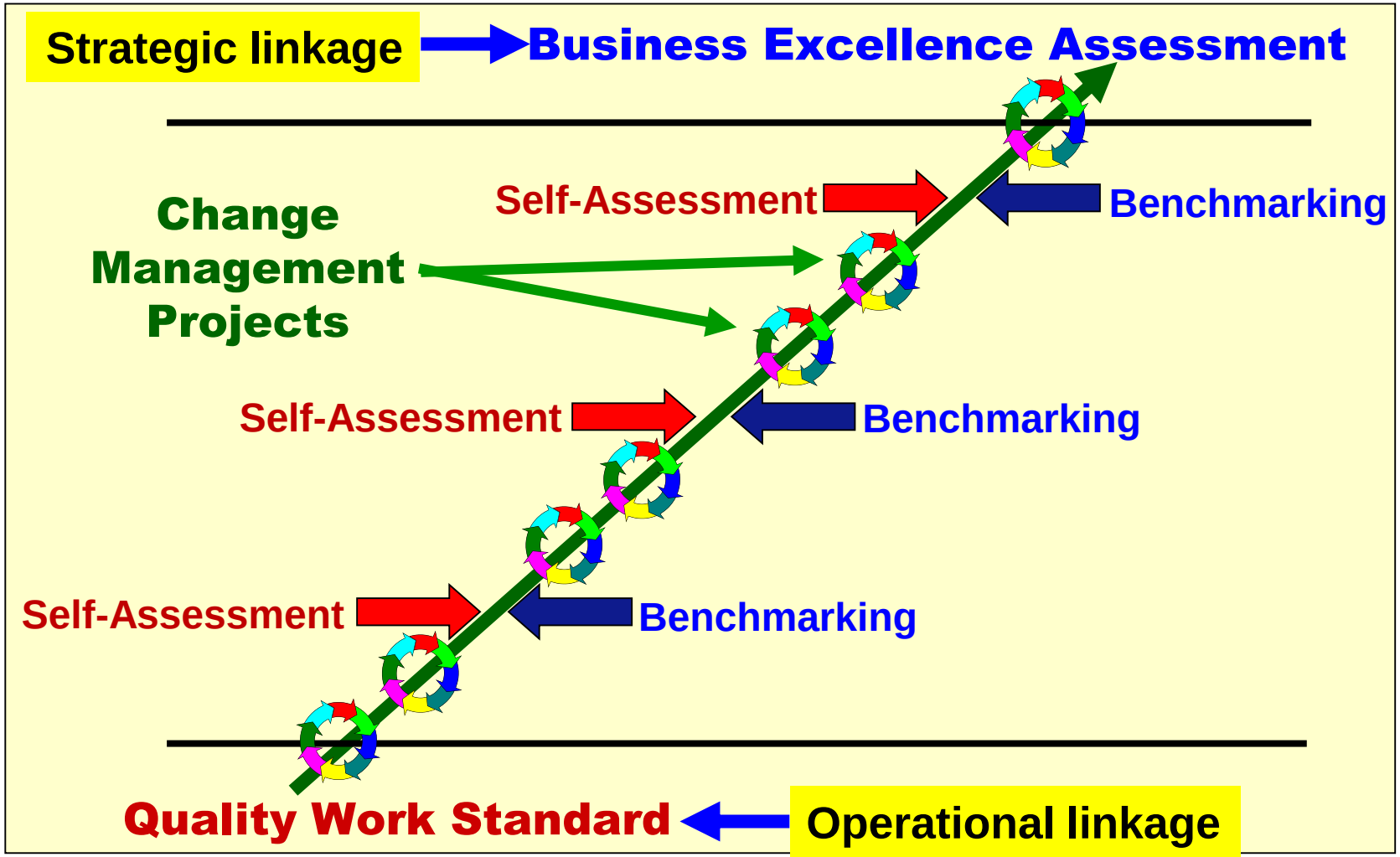
Some interesting potential applications:

- **Daily Management Monitor**: Application conducts a real-time monitor of the key performance indicators of daily management to determine strategic implications.
- **Asset Efficiency Optimization**: Application tracks organization assets to develop a flow-rate metric that enables better management of fixed and variable assets.
- **Program Resource Planning and Analysis**: Application manages the allocation of resources for improvement project assignments to achieve strategic direction.
- **Risk and Security Management Systems**: Application determines business as well as operational risks, including potential cyber and operational security issues.
- **Market Trend Analysis**: Application tracks commercial markets to assess if any of the observed variations create commercial opportunities or are business threats.
- **Partner Vetting Investigation**: Application probes Internet databases to discover any weaknesses or business vulnerabilities that may exist in potential partners for either joint ventures or as preferred suppliers.

Applications are only limited by imagination!

Moving from Cosmic-Quality to Micro-Quality:

How is data being used throughout your quality management system?



Quality management systems typically will consist of three layers with unique activities:

1. An Operational layer that performs value-adding work.
2. A Kaizen layer that is focused on doing the change management projects.
3. The Strategic layer in which direction is set to manage the future.

What is the challenge of "Quality 4.0" for NASA?

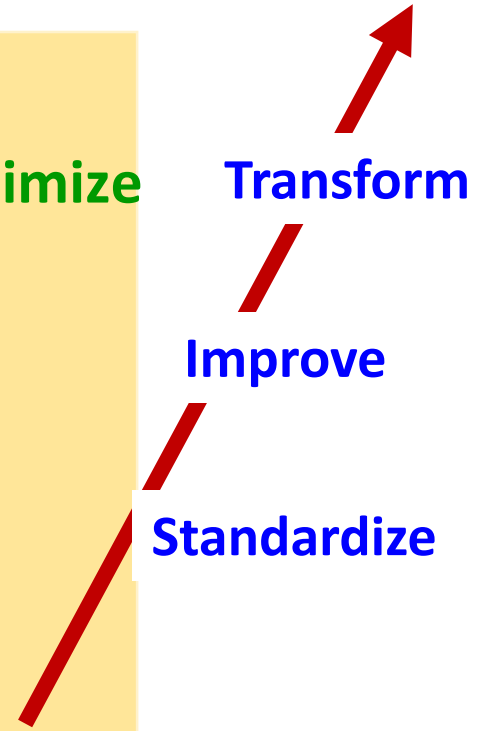
Remember: Digitalization is not a panacea – it does not cure all ills!

- **Choosing Focus Areas for Adopting Digital Technologies**: What are the important priority areas for application of digital technology in NASA's quality management system which can benefit the most from digital technologies?
- **Developing Professional Skills and Competence**: What are most important areas of digital skills were NASA quality professionals need to urgently develop personal competence?
- **Managing the Digital Transformation of Operational Activities**: Which projects in application of digital mechanisms to influence change are the most important for increasing operational capabilities in design and production areas and therefore should become priorities in any digital transformation strategy?
- **Managing the Supplier Base for Appropriate Digital Capability**: How can a digital transformation improve the capability and competence of the NASA supply chain to make it more efficient, effective, and economical?

What are the first steps toward a digital future?

How do we move from “here” to “there?”

Get your processes into control and simplify them before automating.



Quality management systems are designed from the bottom up to assure the delivery of strategic outcomes.

1. **Standard Work is the foundation.**
2. **Strategic Quality will concentrate on transformation.**

1. Gregory H. Watson (1994), *Business Systems Engineering*, (New York: John Wiley).

Advance using repetitive “cycles of learning!”

Charting your strategy toward Quality 4.0:

What will it look like when we are done?

"Step-by-step walk the 1,000 mile road" – but sometimes run!

- **First recommendation**: Take the time to do two preliminary tasks: (1) assess your need for digital capability across your end-to-end system of processes. (2) design a skills matrix that identifies the required technology skills that meet these needs; then conduct a needs assessment of the basic areas where new competence is a requirement; then conduct a skills performance audit to discover what are all of the critical skill shortfalls that need to be developed: and finally, develop a plan to invest in people through skill upgrading or talent acquisition.
- **Summary: Get all of the right people on the bus – one way or another!**
- **Second recommendation**: In parallel with the first recommendation, define a set of implementation priorities that will demonstrate tangible benefits to the NASA quality system and will justify further investment in digitalization and developing the competence of your people. Start with just a few projects and manage them carefully to assure that the probability of success is high. Use these opportunities as a way to bridge to a long-term goal of increased operational effectiveness.

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