The Future of Civil Engineering in a Transforming World

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The Future of Civil Engineering in a Transforming World

1.0 THE TRANSFORMING ENVIRONMENT

2.0 TRENDS AND DEVELOPMENTS

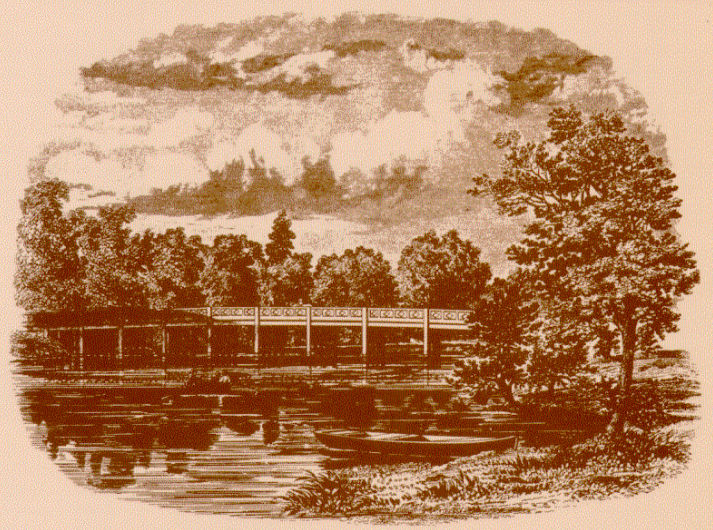
3.0 PREPARING THE CIVIL ENGINEERS OF THE 21ST CENTURY

4.0 SHIFTING PARADIGMS IN THEORY & PRACTICE

5.0 SPECULATING ABOUT THE FUTURE

The Existential Pleasures of Engineering

Samuel C. Florman



THE GATHERING STORM

- **FOUR BILLION MORE PEOPLE ON THE WAY**
- **THE WELLS ARE RUNNING DRY**
- **INFRASTRUCTURE FAILS TO KEEP UP**
- **WASTE JUST KEEPS PILLING UP**
- **TRANSPORTATION DEMANDS TAKE OFF**

Premises of Foresight

1. **Trend is not destiny**

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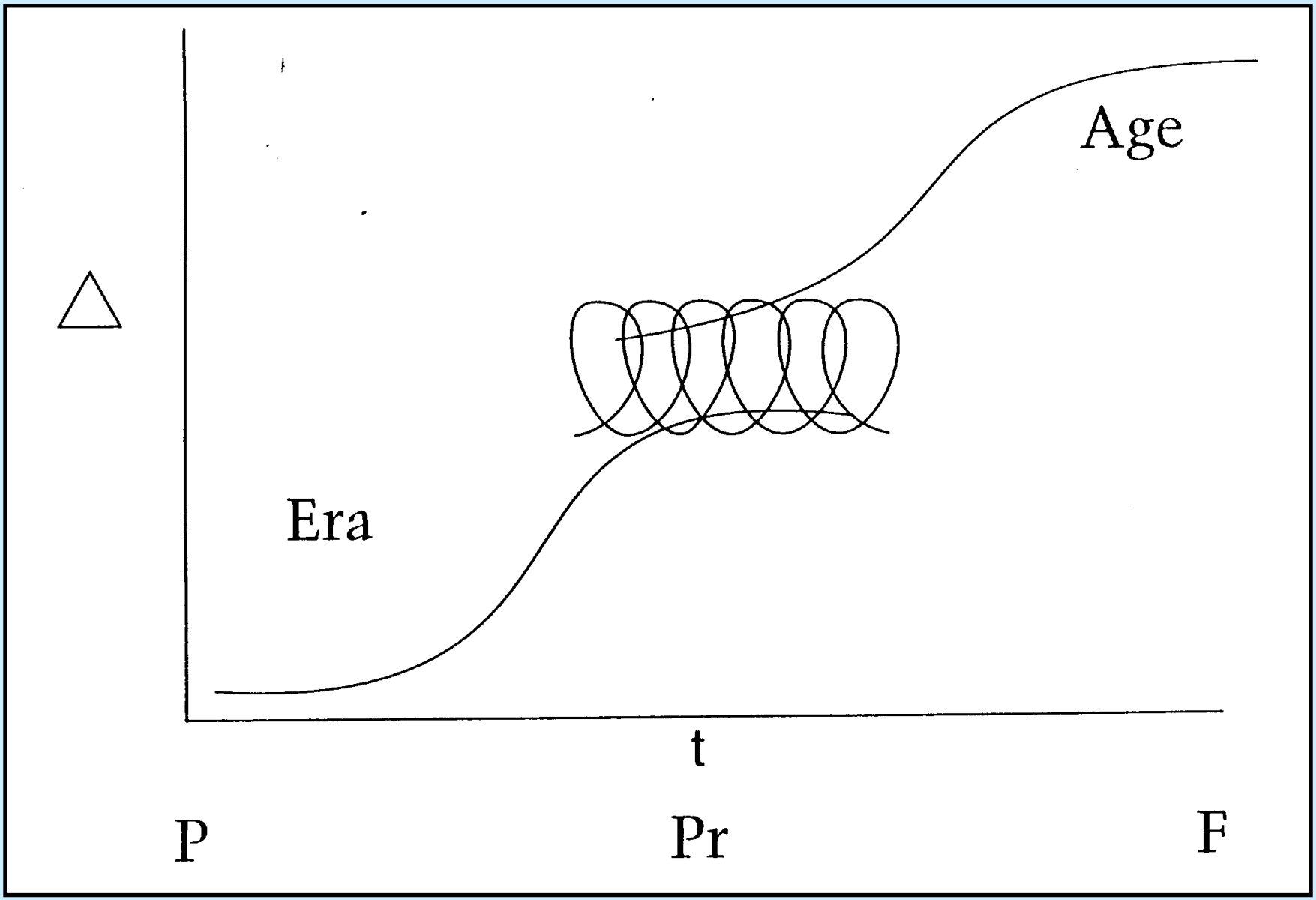
2. **Those who live by the crystal ball are bound to eat groundglass**

Premises of Foresight

1. **Trend is not destiny**

2. **Those who live by the crystal ball are bound to eat groundglass**

3. **It is better to be approximately right rather than precisely wrong**


Age
Era
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P
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F

INTERLOCKING CRISES

- **CLIMATIC SHIFTS**
- **MEGARUPTURES**
- **METABOLISM**
- **SOCIO-POLITICAL CONTEXT**
- **TRANSBOUNDARY DEPENDENCIES**
- **FAST PACE OF TECHNOLOGICAL DEVELOPMENT**

- **Globalization and Interdependence**

  (world economy, sustainable development, global vulnerability, etc.)

- **Environmental and Resource Scarcities**

  (energy and materials, hazards, ecology, spatial imbalances, etc.)

- **Structural Changes**

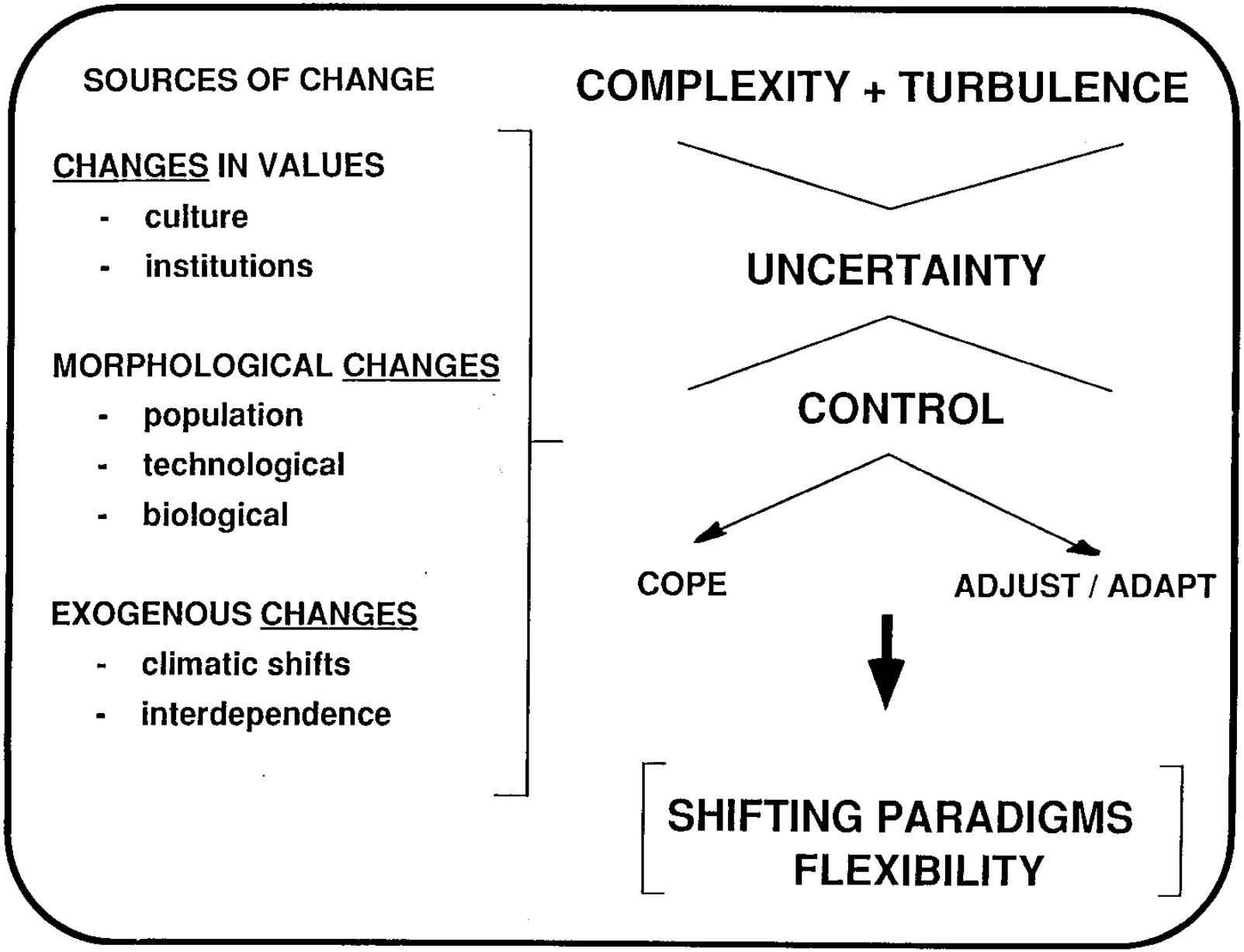
  (population, urbanization, social structure, technological breakthroughs, bioengineering, etc.)

- **Institutional Shifts**

  (economics, politics, inequalities, workforce, health, education, etc.)

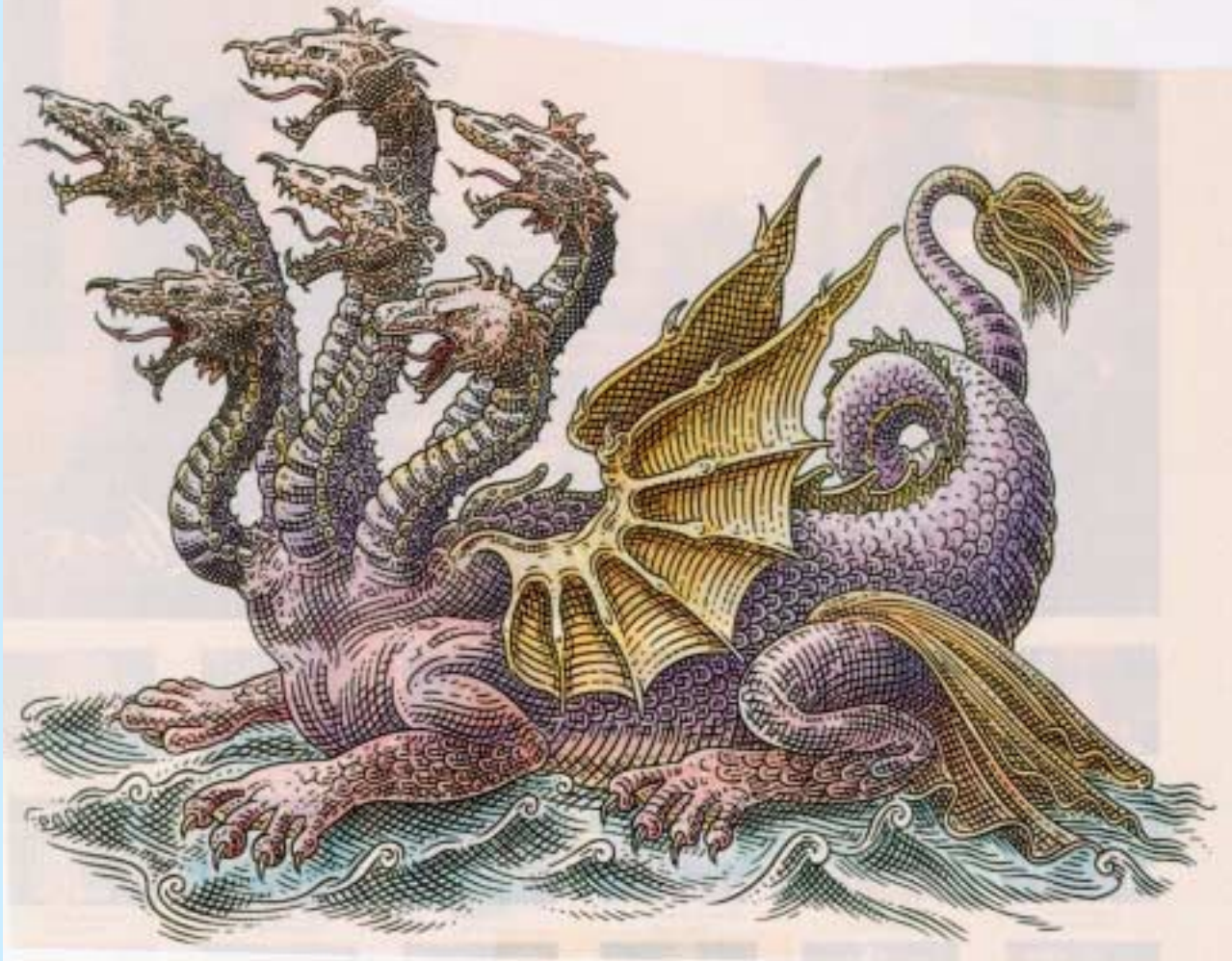
- **Values Transformations**

  (behavioral shifts, cultural changes, social activism, etc.)


SOURCES OF CHANGE
CHANGES IN VALUES
- culture
- institutions
MORPHOLOGICAL CHANGES
- population
- technological
- biological
EXOGENOUS CHANGES
- climatic shifts
- interdependence
COMPLEXITY + TURBULENCE
UNCERTAINTY
CONTROL
COPE
ADJUST / ADAPT
SHIFTING PARADIGMS
FLEXIBILITY

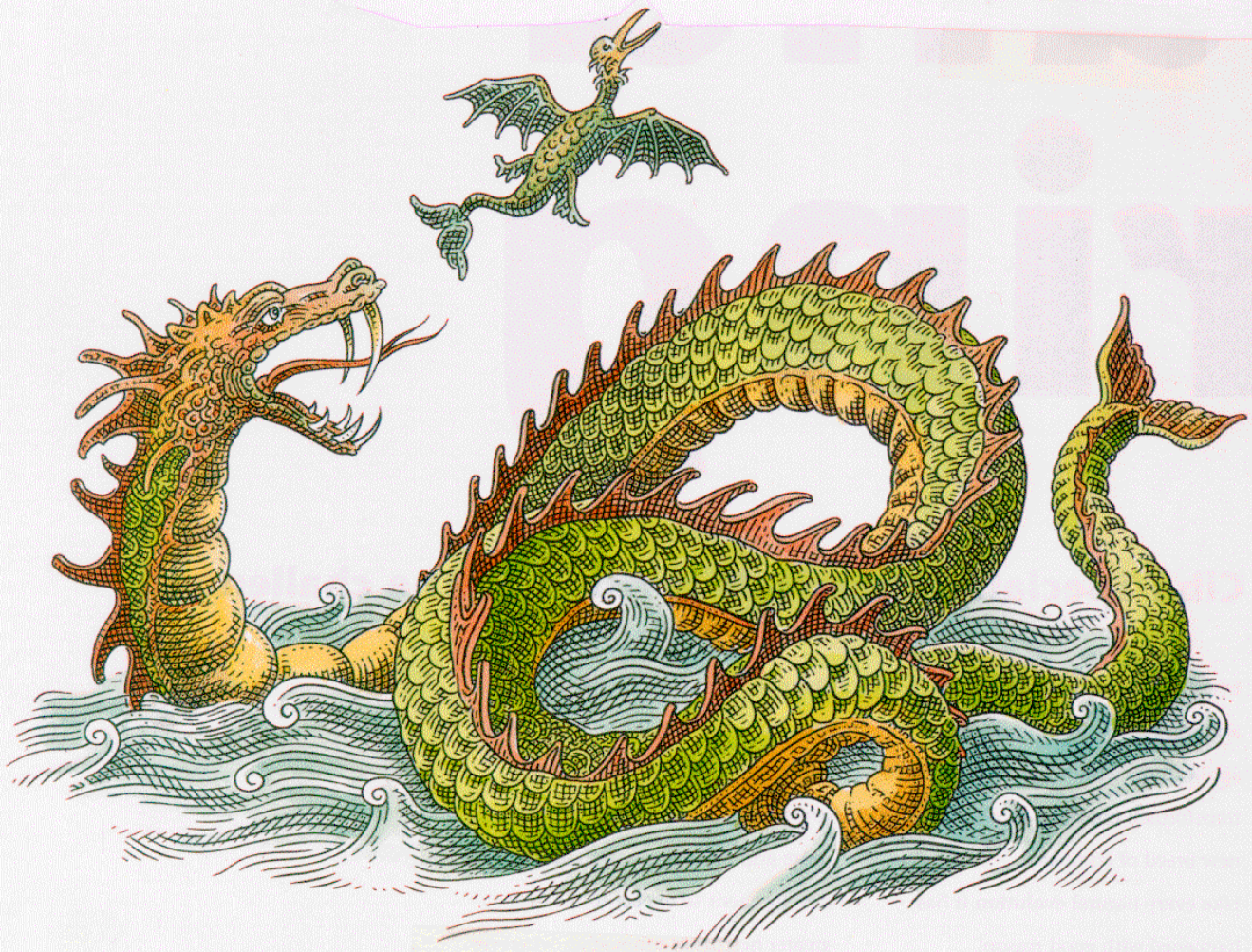
COMPLEXITY

Complexity is a multi-headed monster



UNCERTAINTY

Uncertainty is an implacable beast



MASSACHUSETTS INSTITUTE OF TECHNOLOGY BRUNEL LECTURES 1983–1992

MACRO-ENGINEERING

global infrastructure solutions

editors Frank P. Davidson
and C. Lawrence Meador

THE CHARACTERISTICS OF A POST-INDUSTRIAL SOCIETY

1. From goods to services
   - tertiary economy
2. Emphasis on knowledge
   - education, expertise
3. More social planning
   - new planning techniques
4. Growing Technocracy
   - skills and education

THE TELEMATIC SOCIETY

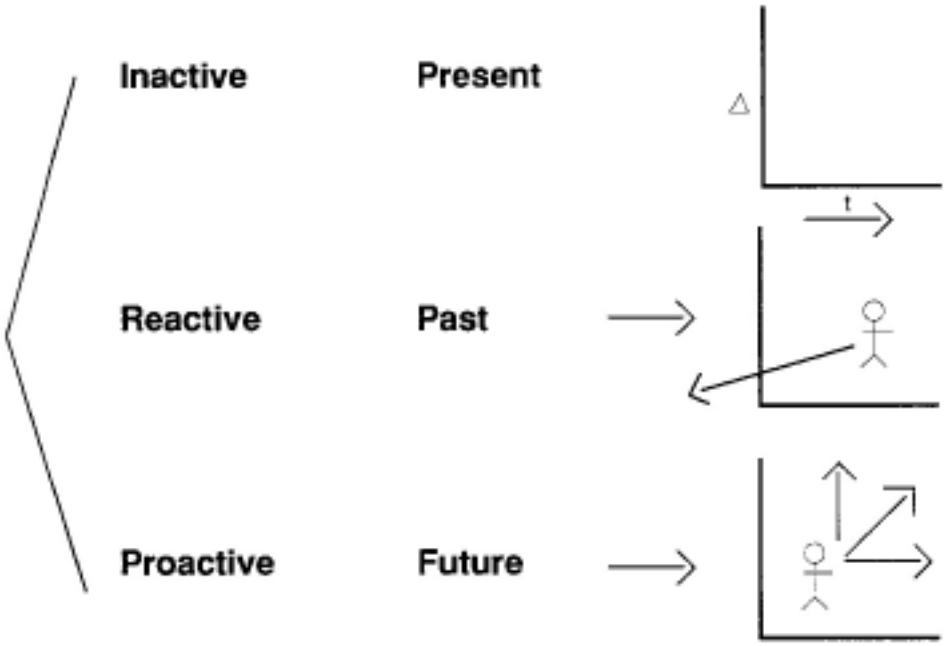
- **DIMINUTION**
- **DIGITALIZATION**
- **COMPUTERIZATION**
- **INSTANTIZATION**
- **GLOBALIZATION**

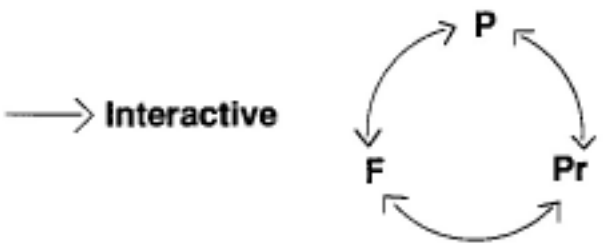
  [OF COMMUNICATION]
- **CUSTOMIZATION**
- **AUTOMATION**
- **ROBOTIZATION**


COMPLEXIFICATION
INTERDEPENDENCE
VULNERABILITY
RISK MANAGEMENT

COMPLEXIFICATION

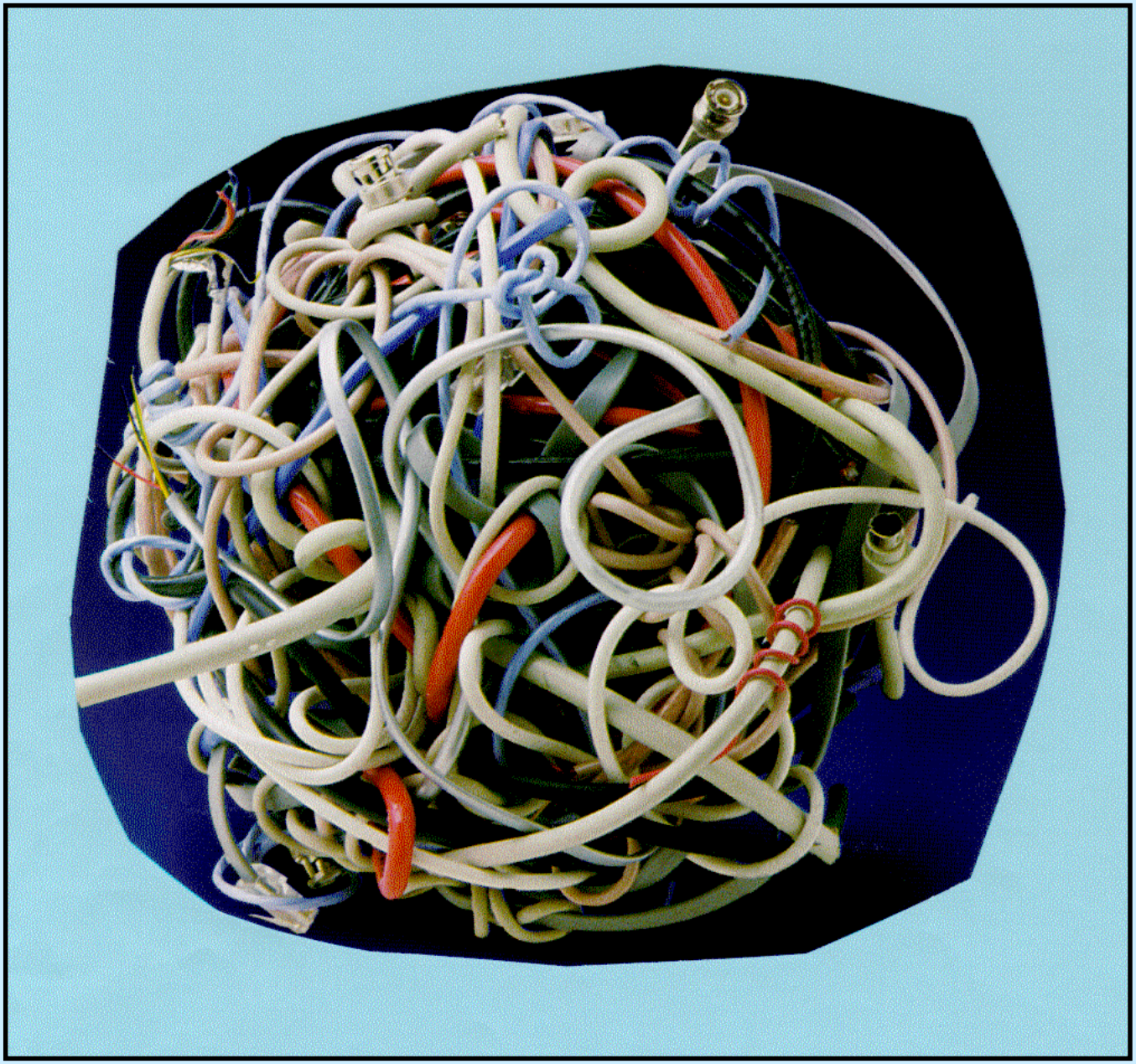
Modes





Make It

This entwining process results in the near inability to cope with any problems at all.



ENGINEERING AS A SOCIAL ENTERPRISE

NATIONAL ACADEMY OF ENGINEERING

TYPES OF ENGINEERS

PAST

- PRACTICING
- ENTEPRENEURIAL

FUTURE

- SYSTEMS ENGINEER
- RISK MANAGER

CHALLENGES IN CIVIL ENGINEERING

A. WHO WOULD BE RECRUITED AND MAINTAINED?

B. WHAT SHOULD BE TAUGHT?

C. WHAT WILL BE THE ENGINEERING PRACTICE?

Factors Influencing Demand for and Supply of Scientists and Engineers

Factors that increase demand

- Increase in basic research
- Increase in mission research
- Economic growth
- Increasing technological sophistication of U.S. manufacturing and services due to scientific progress, international competition, and demand for a higher standard of living
- Increase in science and engineering higher education enrollments (causing an increased demand for faculty)

Factors that decrease demand

- Sending R&D and engineering offshore
- Decrease in basic or mission research
- Economic recession

Factors that shift demand between disciplines

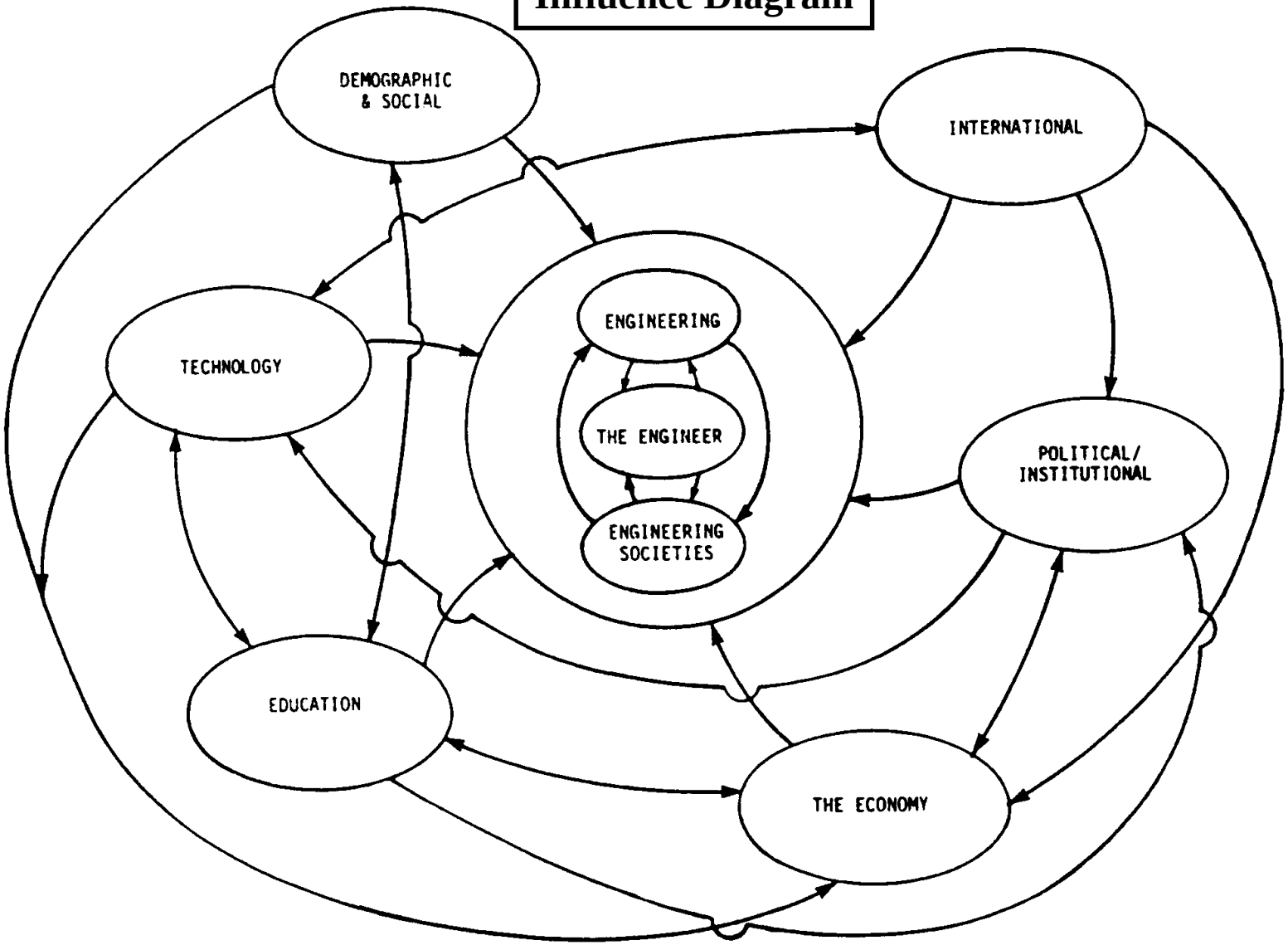
- Technological change and scientific advance of all kinds, which render some disciplines obsolete while creating new ones
- Automation of engineering functions by means of computer-aided design and manufacturing and other communication and information technologies
- Using technicians for some tasks now undertaken by scientists and engineers

Factors influencing supply

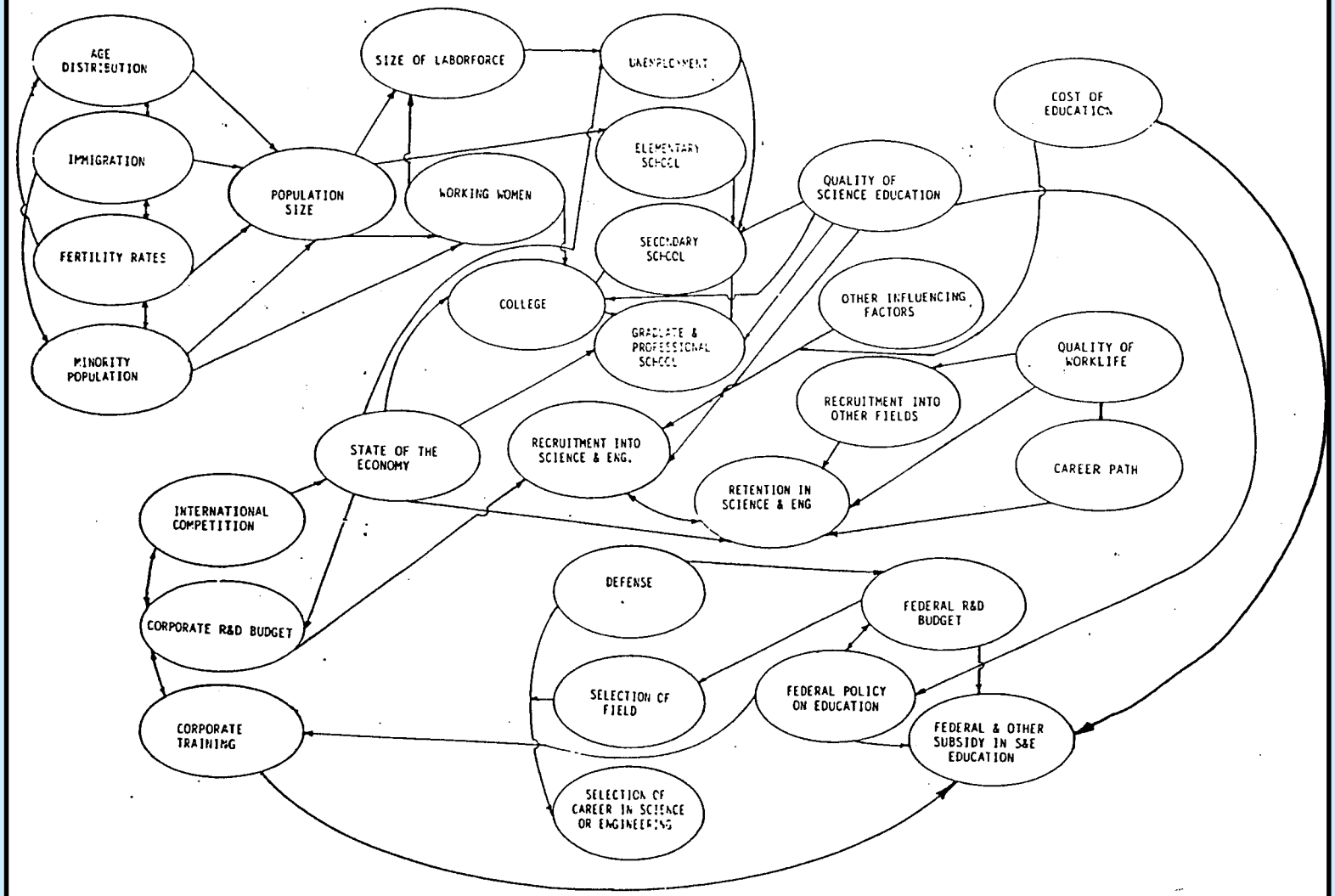
- The size and rate of increase or decrease of demand for scientists and engineers modulated by the salary advantage for scientists and engineers and the national level of R&D expenditure
- The number of births and their racial and ethnic composition
- Education at elementary, secondary, and higher levels
- Permanent and temporary immigration of foreign scientists and engineers
- Federal and State initiatives to encourage different types of institutions to award more science and engineering degrees or award degrees at a higher level
- Legislation and other actions that affect the opportunity to attend and afford college or graduate education

SOURCE: Office of Technology Assessment, 1988.

Influence Diagram



FACTORS INFLUENCING THE RECRUITMENT AND RETENTION OF SCIENTISTS, ENGINEERS, AND OTHER PROFESSIONALS



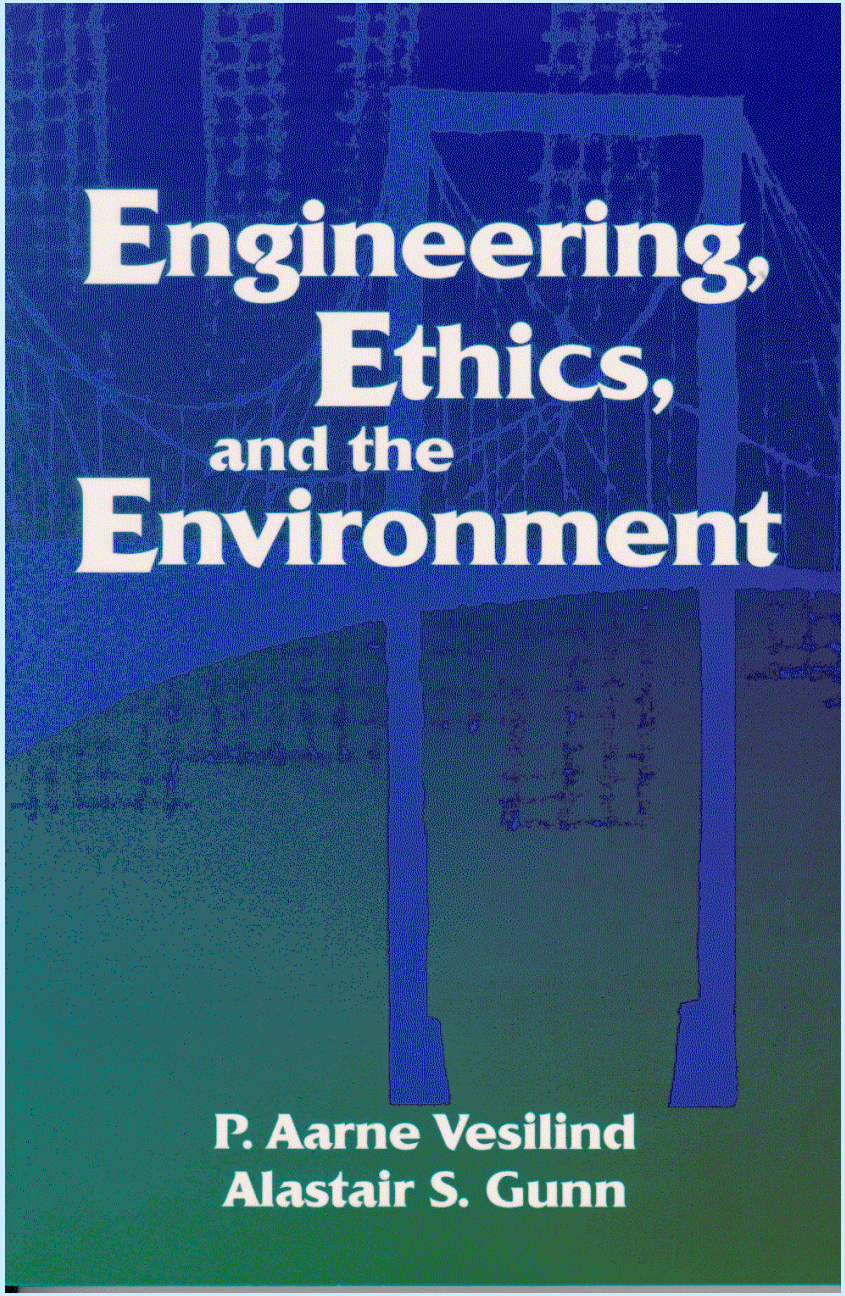
Educational skill level comparison.

All-University Core Curriculum	*Purpose*	*Additional Engineering Requirements*
Freshman seminar	Provide an integrative experience for first-year students	
Written and oral communication	Establish functional skills in communication, possibly including a second language	
Mathematics	Basic skills in computing	More mathematics
Logic/critical thinking	Foundation for analysis and problem solving	
Biological/physical sciences	Basic knowledge in science areas	More physical sciences
Arts/humanities	At least a basic appreciation of arts and humanities	
Social/behavioral sciences	Foundation knowledge of the social and behavioral sciences	
Historical perspectives	A sense of the past	
Global and cultural awareness	Awareness of current context and events	Contemporary issues relating to engineering practice
US public values and institutions	Knowledge of how US society and government evolved	Civil engineers must understand public involvement
Health and wellness	Appreciation of personal health and wellness	
Integrating competencies: writing, speaking, and problem solving	Demonstrating the ability to apply communication and thinking skills to solve problems	Engineers must communicate and solve problems in a wide span of contextual situations
Building on foundations and perspectives	Demonstrating the ability to apply knowledge to solve problems	
Capstone course	Final integration of knowledge and skills	Complex design experience and function on multidisciplinary teams

Summary of Engineering Role Changes

Current and Past	Emerging
Primarily works in manufacturing sector.	Continues in manufacturing but now also works in service industries.
Male Caucasian.	May be a woman, Asian, or foreign born. With some few blacks or Hispanics.
Sole earner and head of family.	Member of a dual-career or dual-income family with higher income and greater financial independence.
A technical expert who solves a problem, writes a report.	Manages people or a process, must communicate results to others in writing, graphically or orally.
Has a B.S. degree or worked his way into an engineering job from technician.	Has a B.S. or M.S., or may have begun with a two-year technician's degree, earned B.S. on the job. Could have entered workforce with a Ph.D., especially if foreign born.
Has had one or two refresher courses since college.	Participated in at least one retraining program. Takes one or more skill or knowledge acquisition courses annually. Is studying management skills.
Worked for the same employer, a large corporation, for more than 20 years.	Worked for several employers, in small and large companies.
Is an employee.	Is self-employed.
Is invisible to the general public - a Technical expert in the back room, to be brought out and blamed when things go wrong.	Well-known and acknowledged as an expert on technological issues and their societal impacts. Frequently consulted.
Has moved up socially by becoming an engineer.	Has other motives for entering engineering than social position, unless foreign born.
Reaches the top executive spot in his corporation with "hands on" engineering skills as a base.	Is studying management and financial skills to gain an advantage in promotion out of engineering.
Is rapidly becoming obsolescent, may retire early, if company offers.	Expects obsolescence and job change, looks to employer and engineering society for career planning and retraining opportunities.
Does not, or only occasionally uses a computer.	Expects to have the latest electronic equipment available on the job, at home, or on the road.

*Taken from J. F. Coates, *Forces Shaping the Future of the Engineer and the Engineering Profession*, American Society of Mechanical Engineers, Washington, 1987, pp. 7-8


Engineering,
Ethics,
and the
Environment
P. Aarne Vesilind
Alastair S. Gunn

TO ENGINEER IS HUMAN

The Role of Failure in Successful Design

With a new afterword by the author

"Serious, amusing, probing, sometimes frightening and always literate."
—*Los Angeles Times*

HENRY PETROSKI

Author of *THE EVOLUTION OF USEFUL THINGS*

If you don't know your destination,

no wind is favorable.

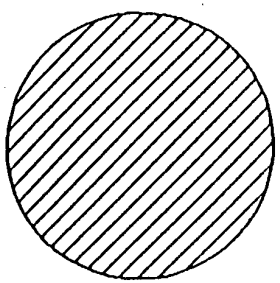
SENECA

Agricultural

HOMOGENEITY

plow

Preindustrial

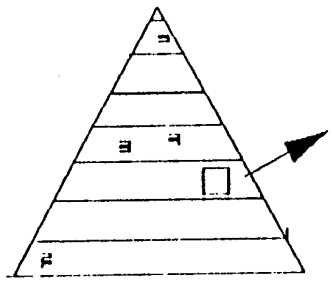


Industrial

HIERARCHY

Energy

internal combustion engine



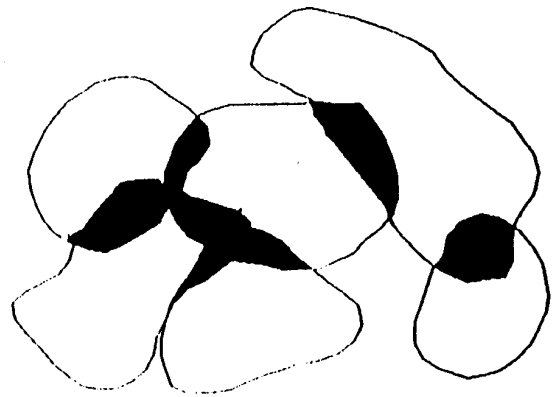
division of labor

Post-industrial

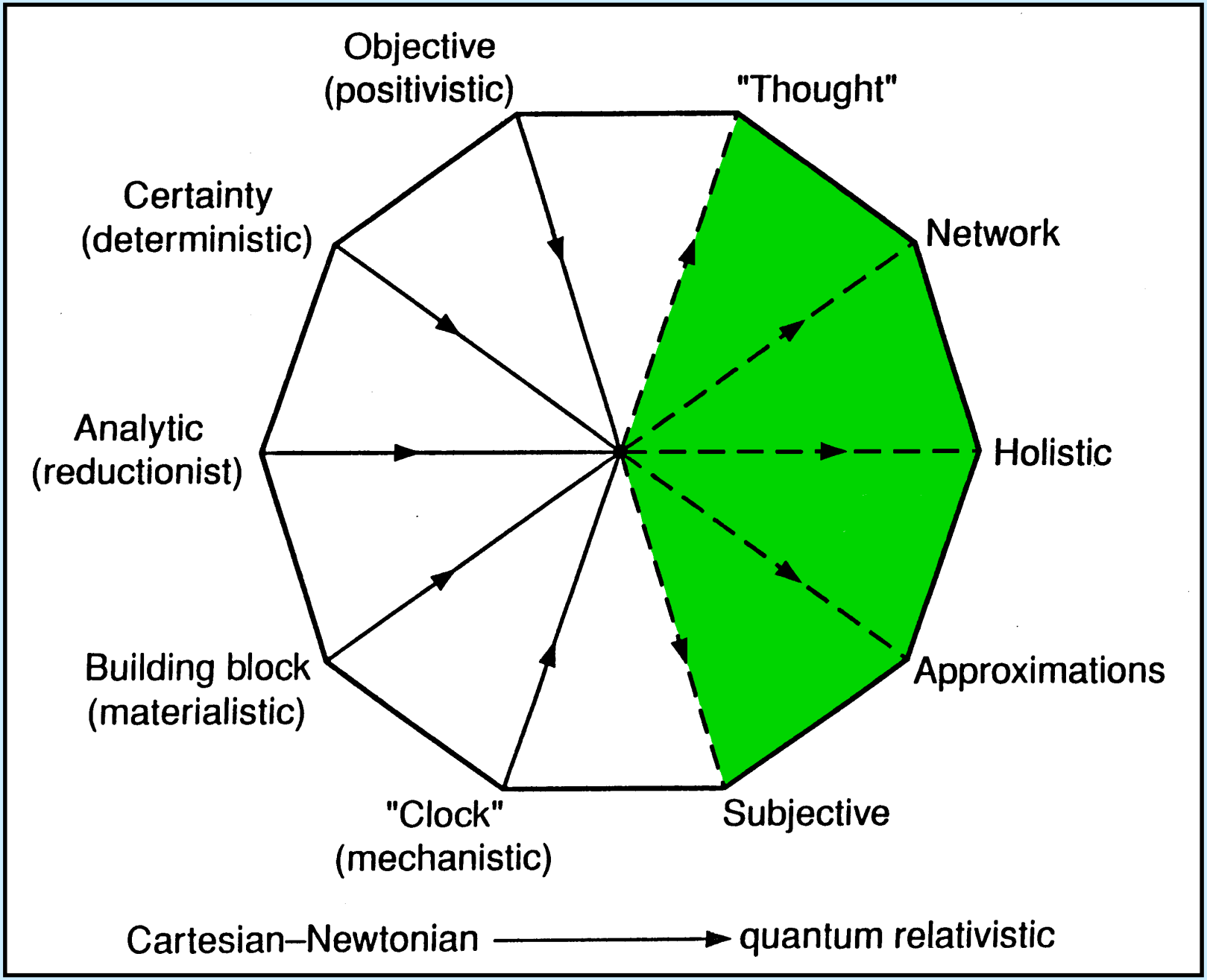
HETERARCHY

Information

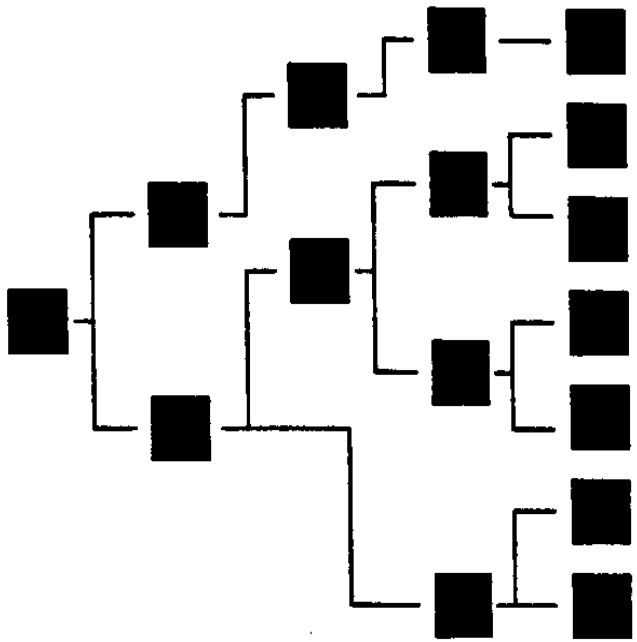
micro-computer



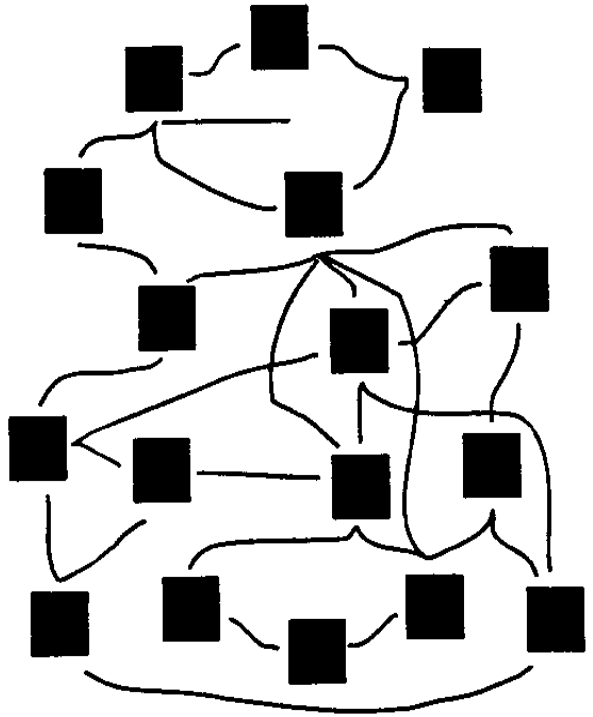
functional coordination


Objective
(positivistic)
"Thought"
Certainty
(deterministic)
Network
Analytic
(reductionist)
Holistic
Building block
(materialistic)
Approximations
"Clock"
(mechanistic)
Subjective
Cartesian–Newtonian
quantum relativistic

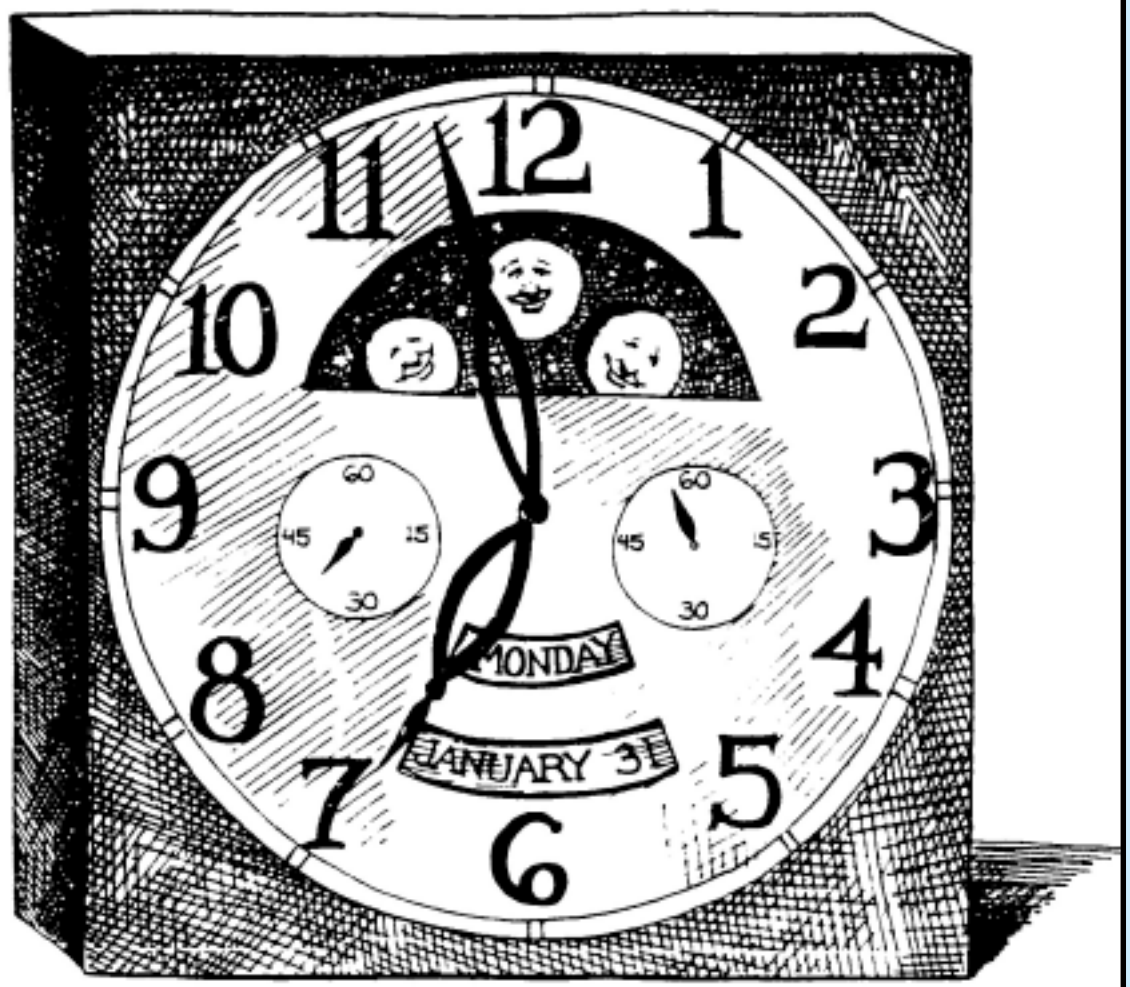
Hierarchical Decision Tree



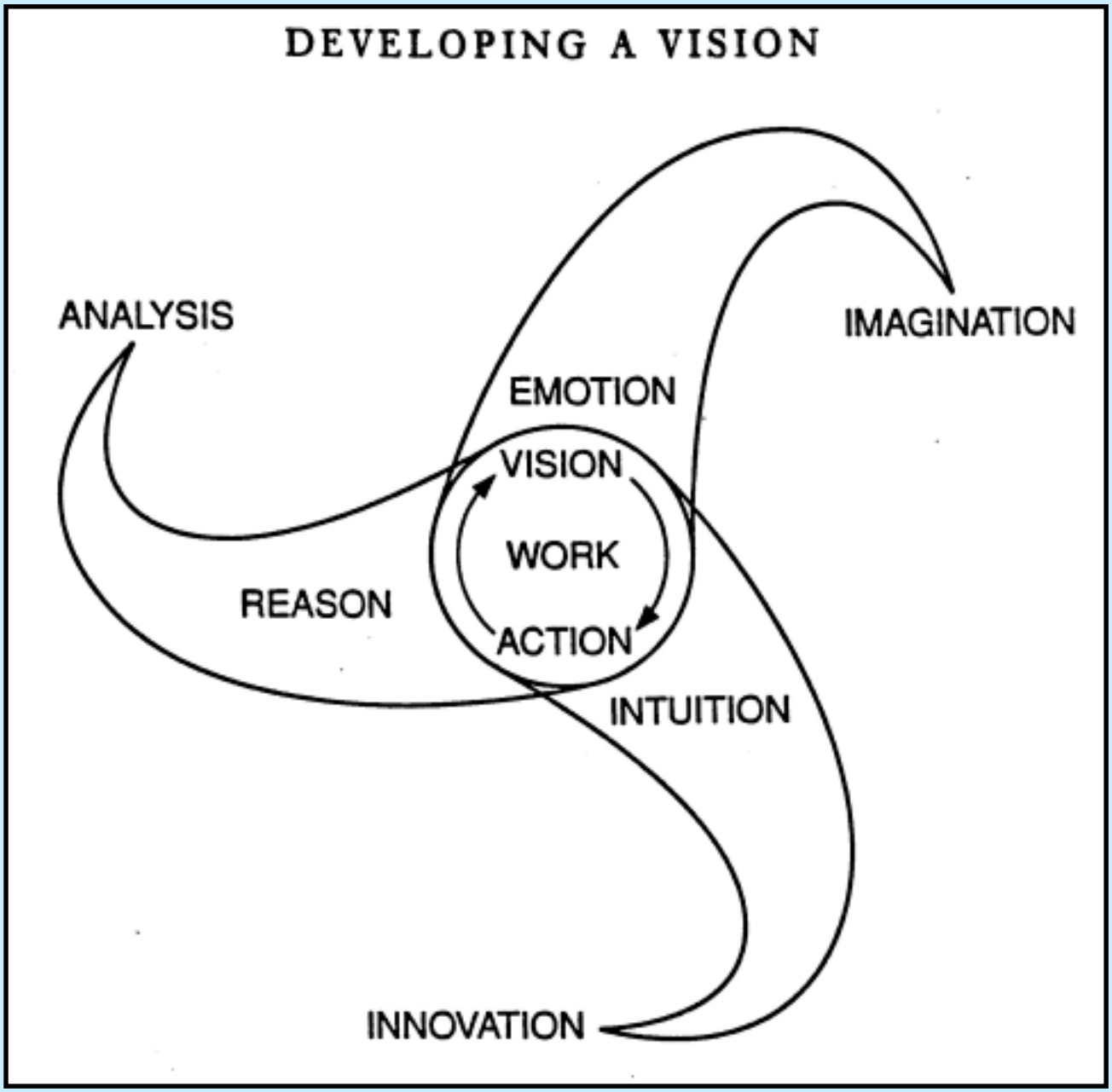
Hyperarchy



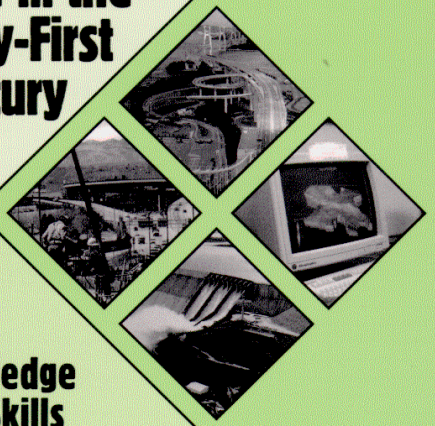
Digital Watch



ANALOG CLOCK


DEVELOPING A VISION
ANALYSIS
IMAGINATION
EMOTION
VISION
WORK
ACTION
REASON
INTUITION
INNOVATION

Civil Engineering Practice in the Twenty-First Century



Knowledge and Skills for Design and Management

Neil S. Grigg
Marvin E. Criswell
Darrell G. Fontane
Thomas J. Siller

ASCE PRESS

"The trouble with our times is that the future is not what it used to be."

P. Valery

Archetypal Worldviews

Worldview	Antecedents	Philosophy	Motto
Conventional Worlds *Market*	Smith	Market optimism; hidden & enlightened hand	Don't worry, be happy
Policy Reform	Keynes Bundtland	Policy stewardship	Growth, environment, equity through better technology & management
Barbarization *Breakdown*	Malthus	Existential gloom; population/resource catastrophe	The end is coming
Fortress World	Hobbes	Social Chaos; nasty nature of man	Order through strong leaders
Great Transitions *Eco-communalism*	Morris & social utopians Ghandhi	Pastoral romance; human goodness; evil of industrialism	Small is beautiful
New Sustainability Paradigm	Mill	Sustainability as progressive global social evolution	Human solidarity, new values, the art of living
Muddling Through	Your brother-in-law (probably	No grand philosophies	Que sera, sera

Source: Great Transition [SEI, 2002]

The Politics of Transformation

- Building Data / DSS
  - Expanding Knowledge / Judgement
    - Creating Institutions / Capacity Building
      - Mobilize Resources
        - Articulate Values

The 3 R's

Rethinking → new paradigms

Reorganizing → organizational mobilization

Retooling → new skills and resources


MANDOD