

INFORMATION INTEGRITY SYSTEM - AN OVERVIEW

Vijay V. Mandke

Research Leader,

Center for Information Integrity Research,

Delhi Center: B-64, Gulmohar Park, New Delhi – 110 049,

Pune Center: Flat A-2, Nikash Skies, Someshwar Wadi, Pashan, Pune-411 008

Visit us at: centerforinformationintegrityresearch.org

Information Integrity/Integrity Information System/Management Information System

Course Lecture (s) # 0

2006-2007

Note: “Information Integrity (I*I) Overview” presentation lecture is equivalent of 5 lectures.

INFORMATION INTEGRITY

- An interdisciplinary introduction covering areas of:
 - Design Engineering,
 - Systems Engineering,
 - Software Engineering,
 - Information Systems,
 - Decision Models, and
 - Management and Economic Sciences
 - Information management and economics

THE BEGINNING...

- James Watt patented a singularly ingenious device whereby the shaft speed of his steam engine was maintained regardless of load variations and boiler pressure.
- The fundamental principle was to make the amount of steam admitted to the cylinder proportional, not to the desired speed, but to the difference (error) between the desired and the actual shaft speeds.

...AND TODAY

- The car manufacturer knows more about the car than the purchaser. The clothes retailer is better informed about current fashions and the quality of materials. The supermarket knows the provenance and age of lettuces, and knows that the buyer doesn't.
- In such situation, there is no motive for exchange except differences in information. There are no gains from trade through specialization or differences in capabilities.

- Even when there are net gains from trade, transactions are clouded by differences in information.

TO ILLUSTRATE..

Suppose there are two kinds of products – one emphasizing good design and other lemons. The salesman knows which is which but it is difficult for the customer (buyer) to figure out.

- Quality design expenses incurred and reputation entertained will be discounted to reflect the incidence of lemons in the products population. It will be respective averages of the values of good designs and poor designs.
- But those averages are fine for the producers of lemons, and disappointing for the producers of good products. So the producers of lemons will want to offer products at lower prices, and the good quality product producers won't.
- And as customers discover this, that knowledge will push down the price of the product, and lead to market failure.

Information Errors Are Predominant Errors

- A 1993 research shows that
 - 60 % of systems errors across all systems (automobile, nuclear power plants, transportation systems, etc.) are information errors and
 - only 40% errors are due to material, electrical, and mechanical failures.

PRE AMBLE

- Successes in production automation sharply increased the volume and speed of energy conversion and material processing.
- This precipitated structured and periodic (fixed information decision) control responses for ‘standard’ product in high volume business model.

PRE AMBLE

- With innovations in IT, the volume and speed of information processing and decision-making have undergone sharp increases.
- Accordingly, business enterprises for their competitive survival are looking for bigger business opportunities through customized products.

PRE AMBLE

- This is requiring businesses to pass on the control baton to *controlling Information Integrity* (i.e., *correctness* aspect) of unstructured and aperiodic, i.e., **flexible** information decision, **which is an information origination situation in the presence of uncertainty.**

PRE AMBLE

- Information is an organizing mechanism, which provides an ability to deal with the environment.
- Given the reality of ever changing environment, therefore, the assumption that *data and information are perfect, once validated*, and the practice that *most information processing systems do not anticipate defective data and information* are not acceptable.

LECTURE PRESENTATION

AN EXTRACT FROM BOOK INFORMATION INTEGRITY ISSUES AND APPROACHES

- “In 1964, TIFR bought its first commercial computer. It was the cutting edge technology at that time. In less than six months, the computer was saturated. I wrote up a short note about the functioning of the computer system and its use and sent it to Dr. Bhabha. He wanted to know whether it was possible for someone at the user- end to damage the system. My confident answer was that it was impossible. We have come a long way since then!”
 - Professor R. Narasimhan, June 1995

VULNERABILITY OF NETWORKED COMPUTRIZED INFORMATION SYSTEMS

- Computerized information systems of today do make mistakes.
- This alarming reality is requiring **research attention to** questions of:
 - **Errors** in information systems that are made but not corrected in spite of application controls,
 - **Poor integrity** of information systems and of information therefrom,
 - Finding **methods, techniques and technologies for** controlling, maintaining and improving **Information Integrity (I*I).**

EXAMPLES OF INCORRECT PRODUCTION OF INFORMATION

EXAMPLE I

Event resulting in loss of competitive advantage (or otherwise)	Event resulting in loss of competitive advantage (or otherwise)
<p>The <i>Mariner IV</i> satellite was to be packaged in a rocket. After launch the satellite was to spin so that the solar panels would unfold by centrifugal force and to be locked in a straight-out position. Because these panels were quite large and very fragile, there was a concern that they would be damaged when they hit the stops that determined their final position.</p> <p>To address this problem, the major aerospace firm that had Mariner contract initiated a design project to develop a retarder (dampener) to gently slow the motion of the panels as they reached their final position.</p> <p>The constraints on the retarders were quite demanding. Millions of dollars and thousands of hours were spent to design these retarders, yet after extensive design work, testing, and simulation, no acceptable devices evolved.</p> <p>With time running out, the design team ran a computer simulation of what would happen if the retarders failed completely; to the team's amazement, the simulation showed that the panels would be safely deployed without any dampening at all. In the end, they realized that there was no need for retarders, and <i>Mariner IV</i> successfully went to mars without</p>	<p>Ballistic processing of product information resulting in loss of Product Integrity</p>

EXAMPLE II

- Change in information structure relationship
- Implication of environmental (i.e., local market (knowledge)) factors

Existing Structural Integrity Standard

Patient with signs of congestive heart failure



is



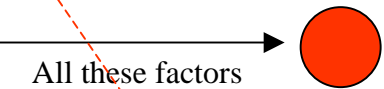
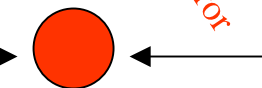
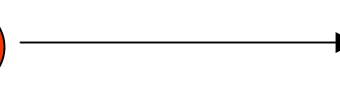
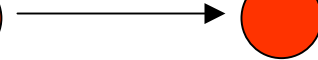
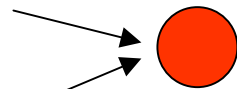
Patient with intravascular volume "high".

Competitive advantage when effective & economic information flow achieved by originating correct information

Information Flow when information originated

Information origination error

Patient with signs of congestive heart failure



All these factors indicate

Patient (having signs of congestive heart failure) with implication of environmental factor of:
 •High urinary output

Patient (having signs of congestive heart failure) with implication of environmental factor of:
 •Depleted intravascular volume

Patient (having signs of congestive heart failure) with implication of environmental factor of:
 •Blood pressure falling much further than intended

Patient (having signs of congestive heart failure) with intravascular volume "Low"

Environmental Factors of:
 •Previous diuretic
 •High serum glucose level

Changed Structural Integrity Standard Required in Given Context and Specific Situation

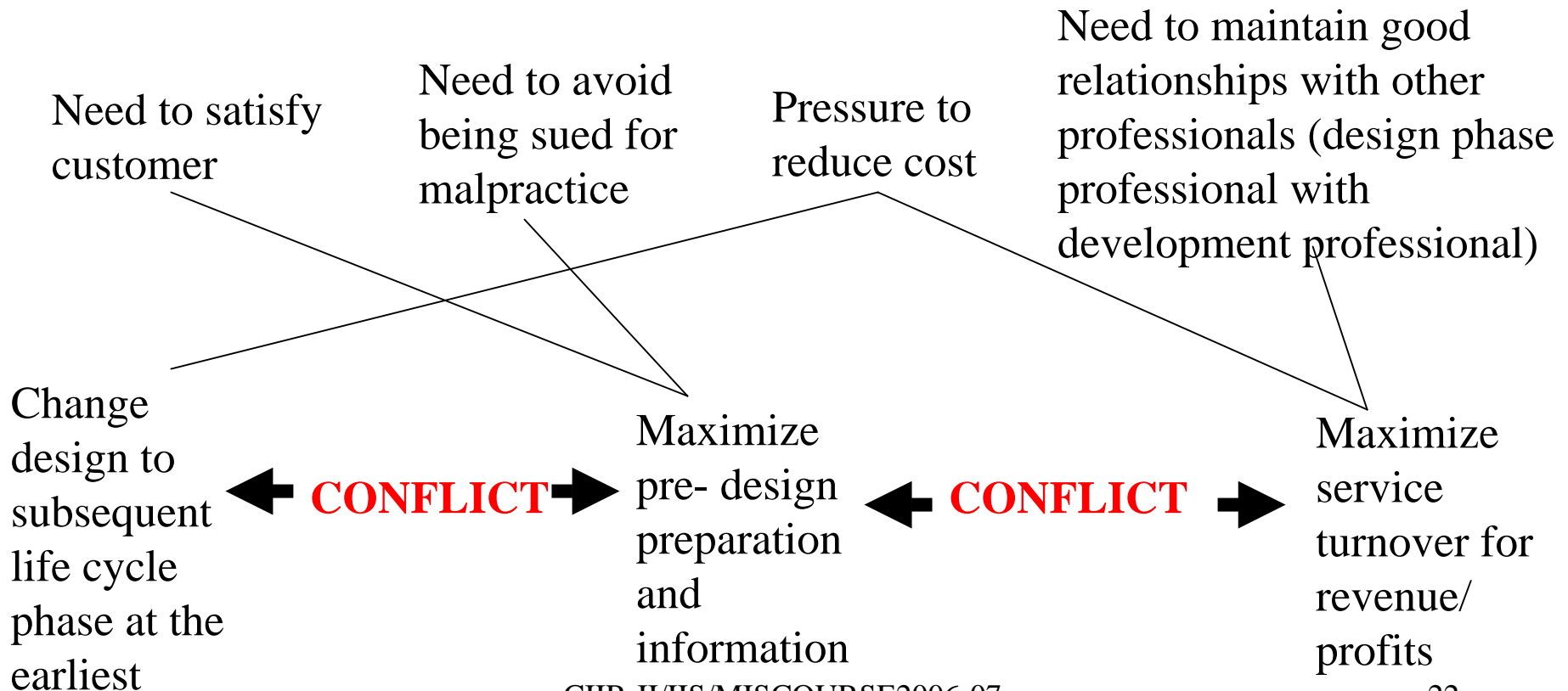
EXAMPLE III: INCORRECT PRODUCTION OF INFORMATION DUE TO EVOLVING SITUATION

- Coronary Artery Bypass Graft Procedure.
- An infusion controller device delivered a large volume of sodium nitroprusside, when no drug was needed. (**Device error**).
- **Hypertension** (systolic blood pressure >160 torr) **gave way to** (i.e., evolved into) **hypotension** (systolic pressure <60 torr).

- **Hypotension** unresponsive to fluid challenge but *fortunately did respond* to repeated boluses of **neosynephrine** and **epinephrine**.
- Patient placed on bypass rapidly.
- Later, the nitroprusside container was found to be empty; a full bag of 50 mg in 250 ml was set up before the case.
- **What is important that information on the device error was not recognized till this point.**

EXAMPLE IV: INCORRECT PRODUCTION OF INFORMATION DUE TO CONFLICTING REAL WORLD GOALS

Conflicting Real World Goals



- For effective and economic product/service delivery, requirement, therefore, is to originate **correct** flexible information decision.
- However incorrect (*distorted*) information is produced (originated) due to:
 - Impact of non-critical, interdependent local environmental factors on system critical variables,
 - Evolving information, i.e., variables (malfunctions) that start small and appear with delay, and
 - Conflicting strategic goals.
- It results in incorrect system operations leading to system failures.

**PHISICAL
DEVICE**

Figure: A generic Hierarchical Systems oriented Approach to design and analysis. Upper case terms define levels of description. Lower case terms describe typical variables relevant to each level of description.

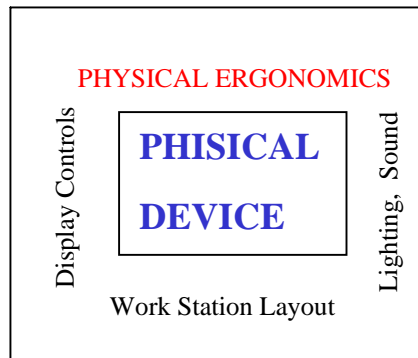


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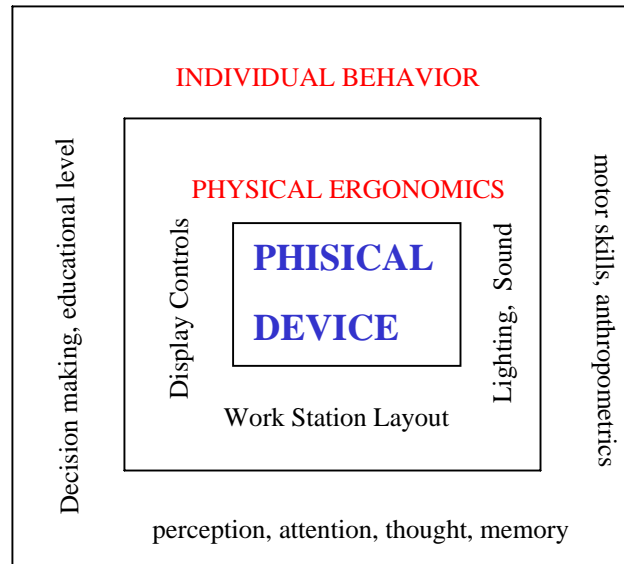


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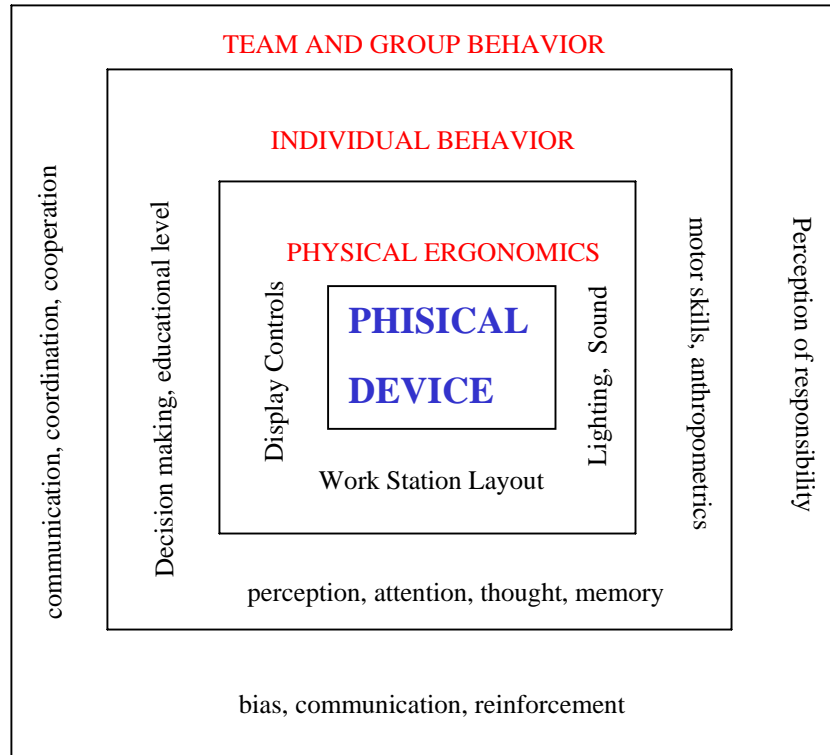


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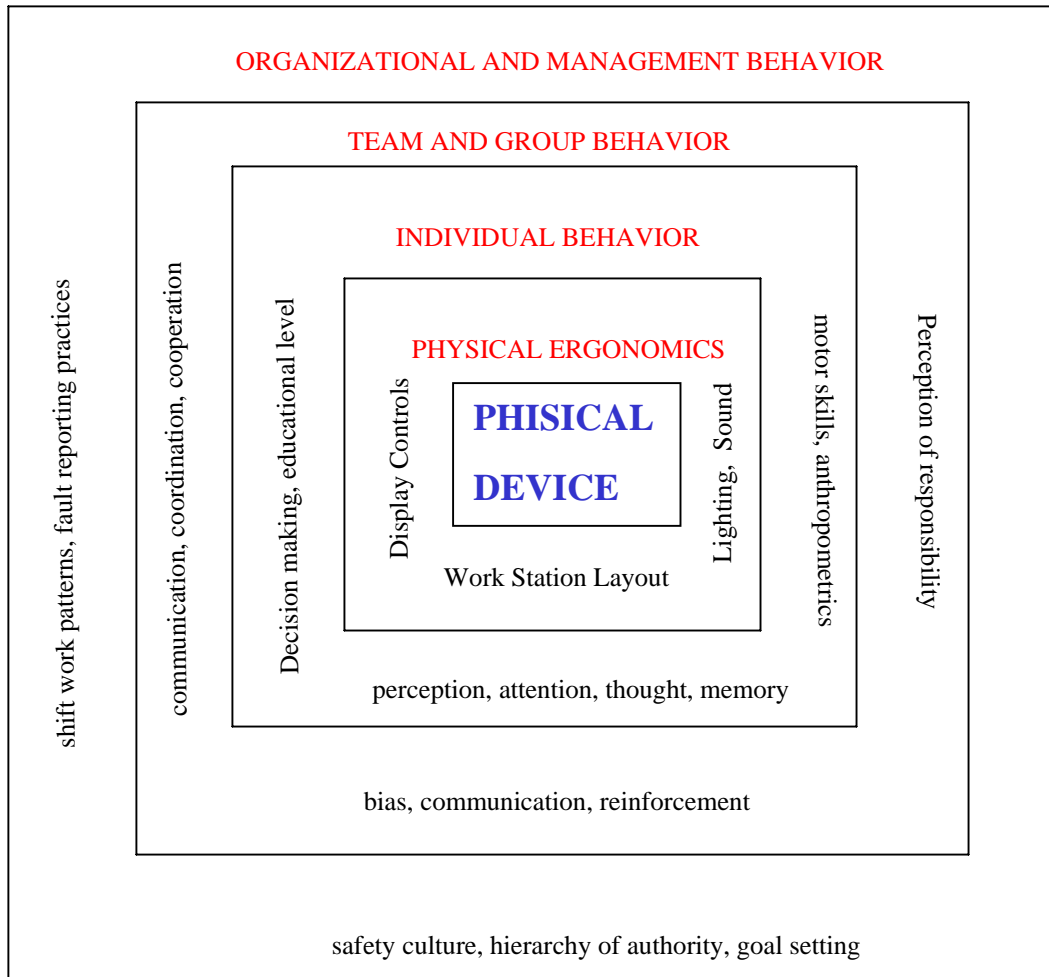


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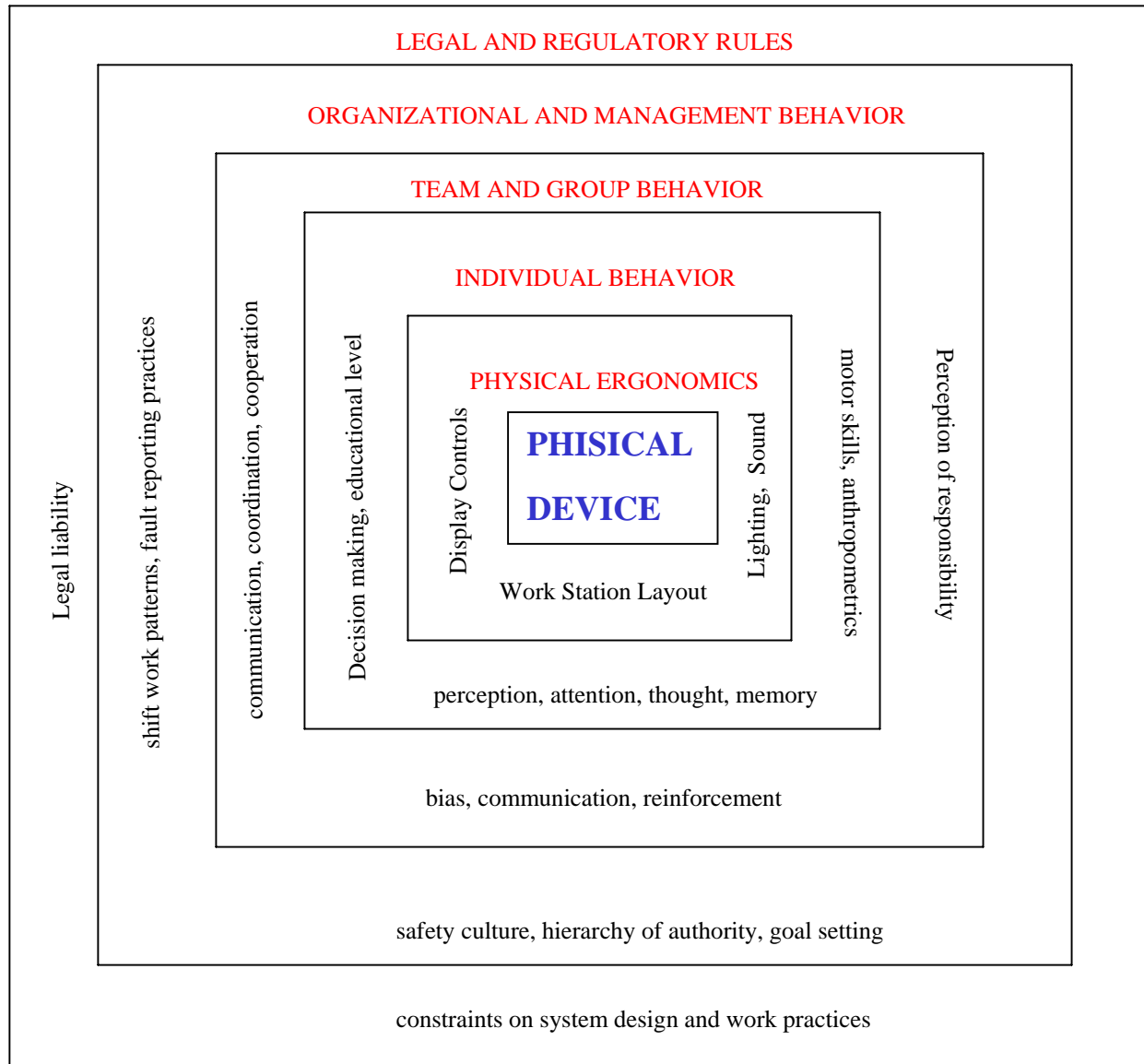


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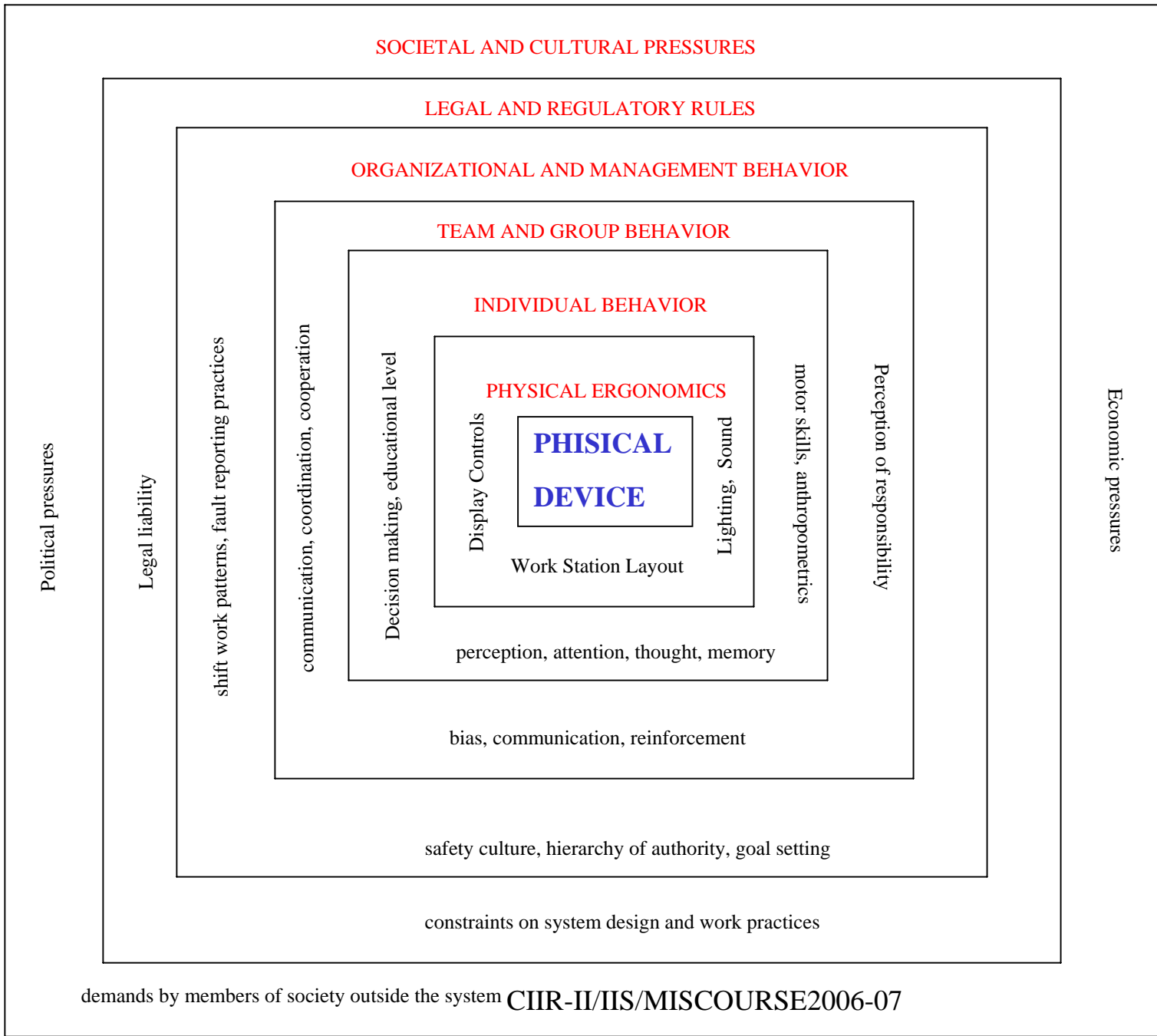


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**PHISICAL
DEVICE**

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SOCIETAL AND CULTURAL PRESSURES

LEGAL AND REGULATORY RULES

ORGANIZATIONAL AND MANAGEMENT BEHAVIOR

TEAM AND GROUP BEHAVIOR

INDIVIDUAL BEHAVIOR

PHYSICAL ERGONOMICS

PHISICAL
DEVICE

Display Controls

Lighting, Sound

Work Station Layout

perception, attention, thought, memory

bias, communication, reinforcement

Decision making, educational level

motor skills, anthropometrics

Perception of responsibility

communication, coordination, cooperation

shift work patterns, fault reporting practices

safety culture, hierarchy of authority, goal setting

constraints on system design and work practices

Political pressures

Legal liability

Economic pressures

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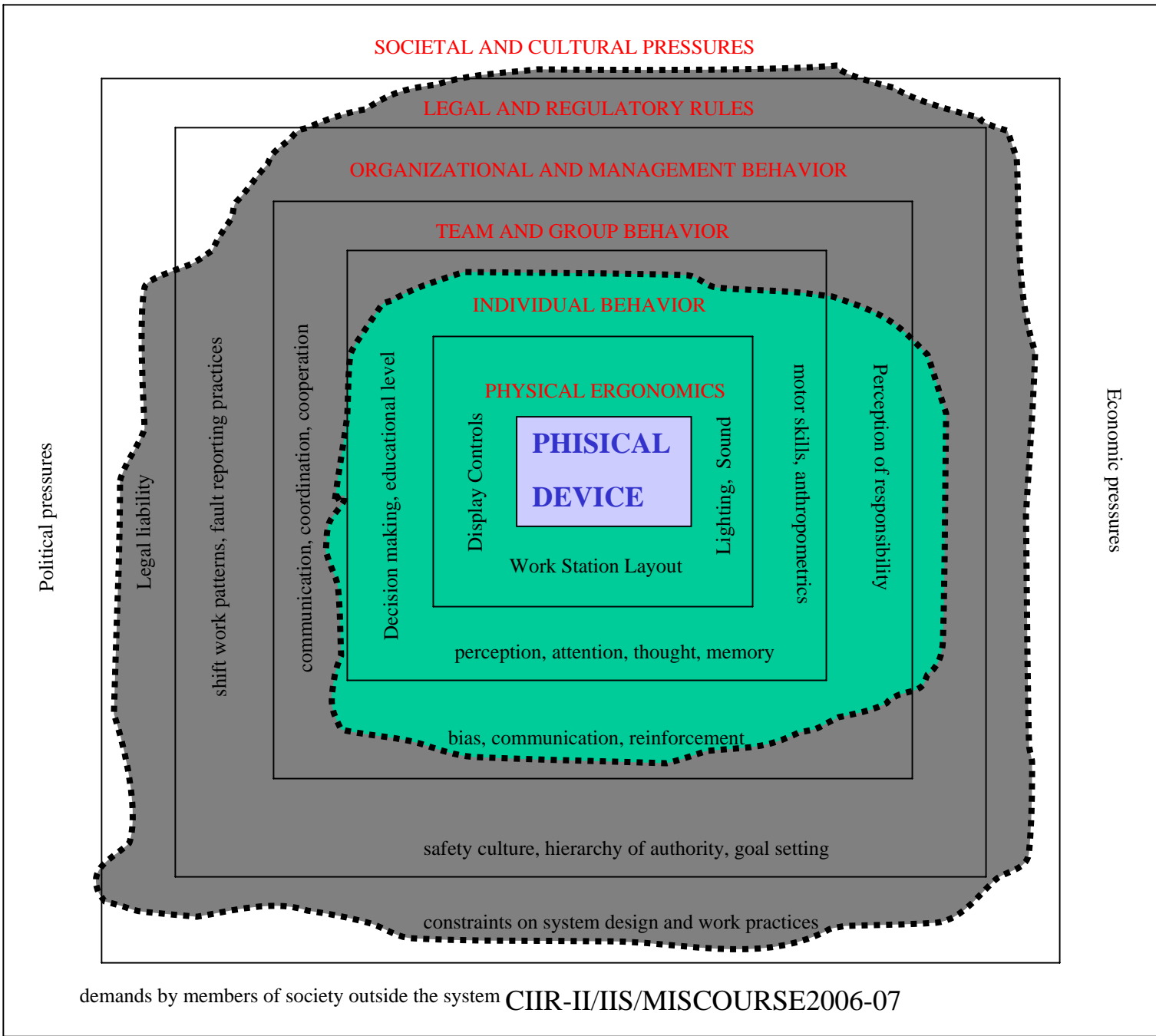


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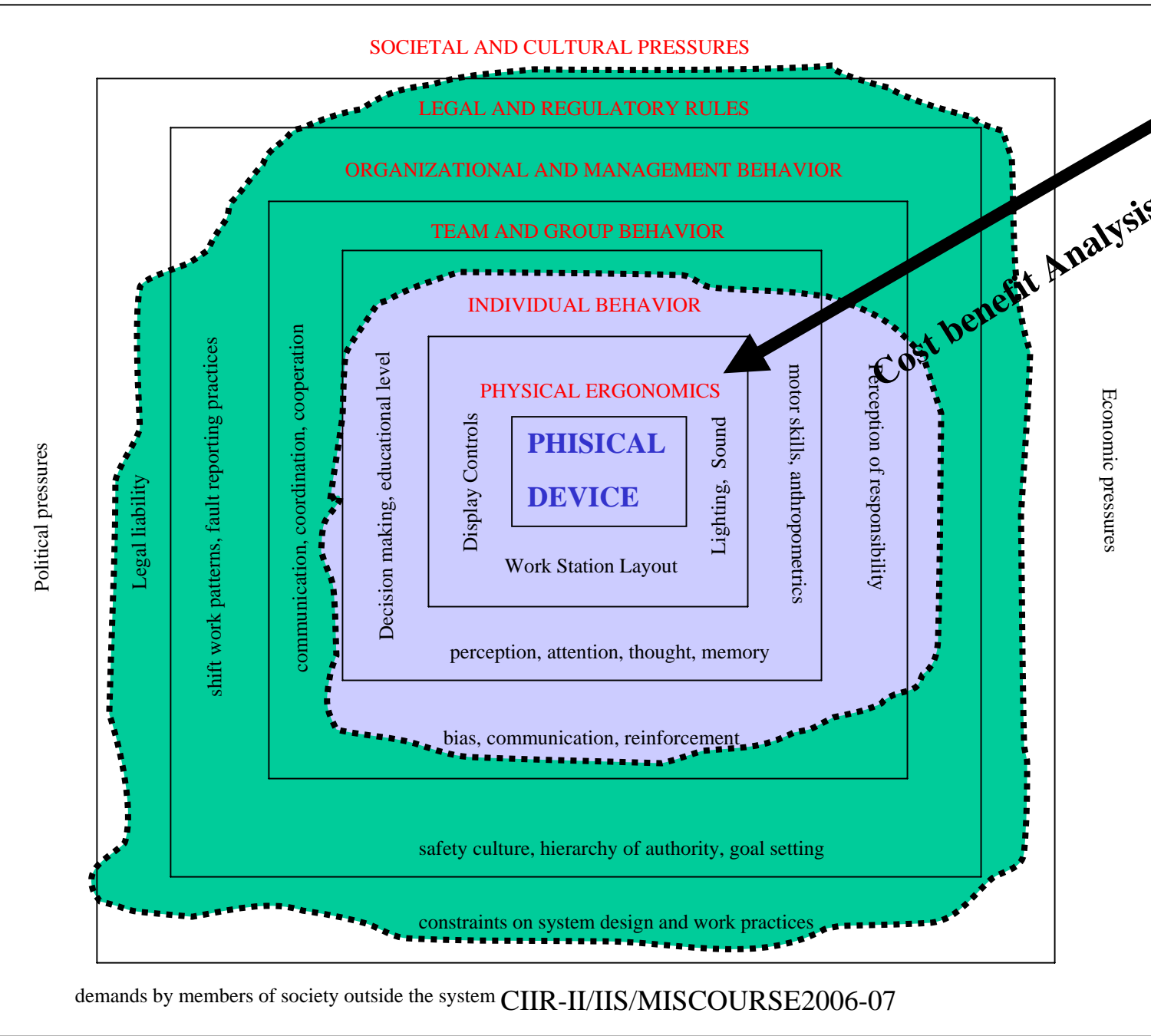


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More Examples...

Example V: Structural failure

- When people, i.e. clients, decide to construct a house or a structure, above all, they expect a safe, secured and reliable shelter or facility.
- The roof of the cafeteria of a Junior High School in Charlotte, N. C. had stood for some four years. In January 1968 during a storm it experienced accumulation of four in. of snow and ice (system environmental factor) resulting in the collapse of 4200 ft² of roof. Subsequent investigation into the structure failure showed that the roof framed with open web steel joists (supported on intermediate line of girders) had two of the columns under the girders *omitted* when the construction plans were finalized to incorporate fireproofing (change) requested by the insurance division during the state review.
- The architects publicly admitted the drafting error when they checked the plans following the accident, which came after the cafeteria had been in use for over three years (note the on-going risk the structure carried through). It is inconceivable how such an omission was not detected in checking of the structural plans by various agencies or how the steel could be erected without the necessary number of supports.

Example V: Structural failure

- That is, in addition (a) to the drafting work, which in *this* example is the source or point of *origination* of information on number of columns in the wake of change due to “fireproofing” requirements and (b) in addition to the construction-plan-checking-and-finalization-cum-erection departments, which *here* represent the processors of information (or information decision) for *use*, the information processed turned out to be *function* of (c) the condition of the recipient, which *here* is the roof with two supporting columns *omitted*.
- After being in use for over three years and after four years’ since its erection (i.e. with delay), it is on *that* day in January 1968, when due to a storm four in. snow and ice (system environmental factor) accumulated on *so* erected roof, that it led to its collapse.

Complex Error Mechanism coming with Delay

- Stated differently, it is the combination of information errors under the information *origination* and processing stages (building failures then can be seen as the informational errors in building construction setting) that in a delayed combination with the system environmental factor (in this case of accumulation of four in. snow and ice on the roof) formed a complex error mechanism.
- This as described above led to the collapse of the roof (adverse event (AE)), rendering the roof unsafe. Of course, the reality was *the* roof was a candidate for this failure right from the day when (in the process of incorporating change in the manner of the “fireproofing” requirements) the desired Safety Goal Integrity was not ensured.

What was needed?

- For construction of a safe structure (roof in this case – individual situation), therefore, what was needed was:
 - Given the situational factors of (a) change requirement in the manner of “fireproofing” objective, (b) in that case the difficulty in ensuring adequate Goal Integrity, and (c) of the system environmental factors such as storms:
 - To *originate* at drafting phase, construction-plan-checking-and-finalization phase and at erection phase the information requirements (I) in respect of: respective operable goal set, fireproofing requirements, and the roof structure (recipient) safety condition, and
 - To obtain (originate) and control (improve) to desired level Goal Integrity (at drafting phase while accommodating “fireproofing” requirements), Design Integrity (at construction-plan-checking-and-finalization phase) and Implementation Integrity (at Erection Phase) for information (I).

Example VI

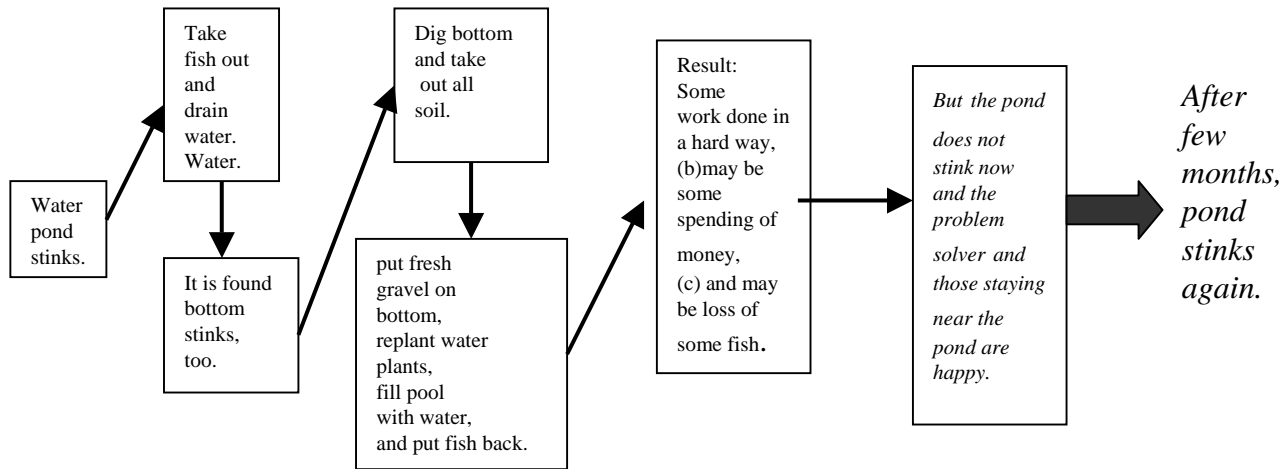


Figure: Causal Activity Chain in solving a Complex Problem

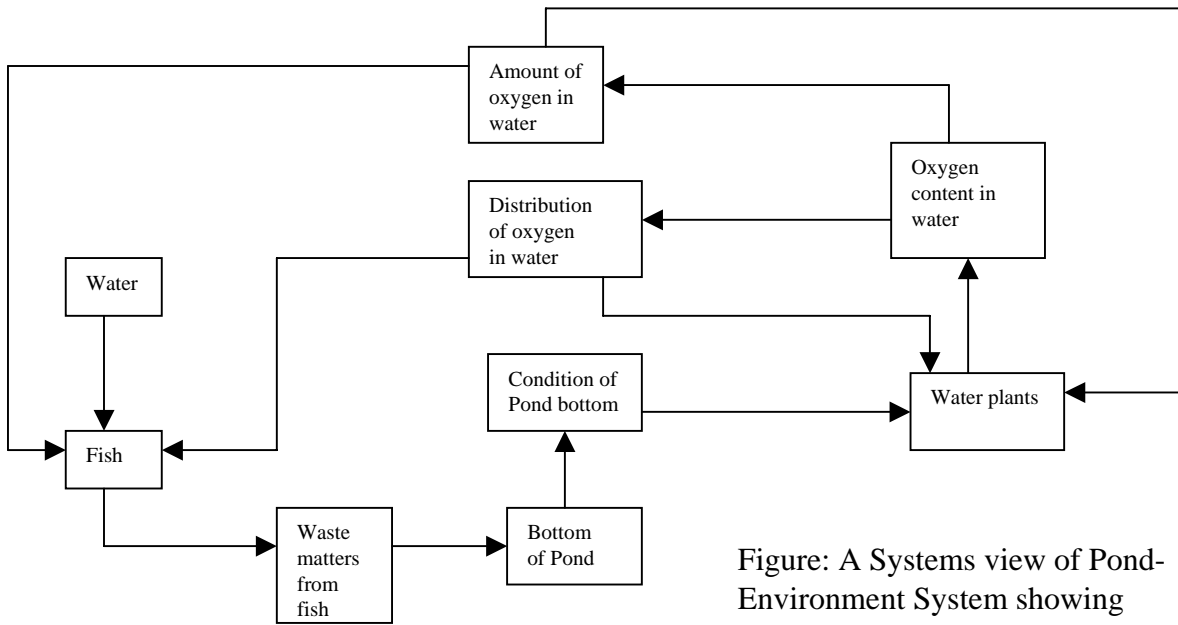


Figure: A Systems view of Pond-Environment System showing Components/sub-systems relevant to the problem at hand

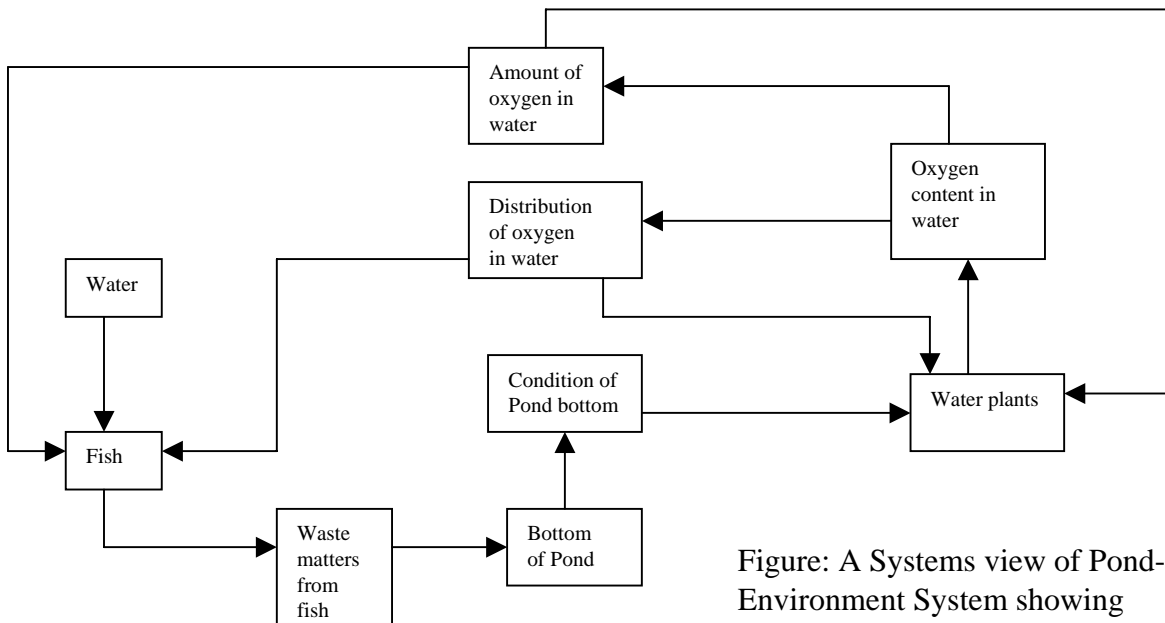


Figure: A Systems view of Pond-Environment System showing Components/sub-systems relevant to the problem at hand

$I * I = 0.5$

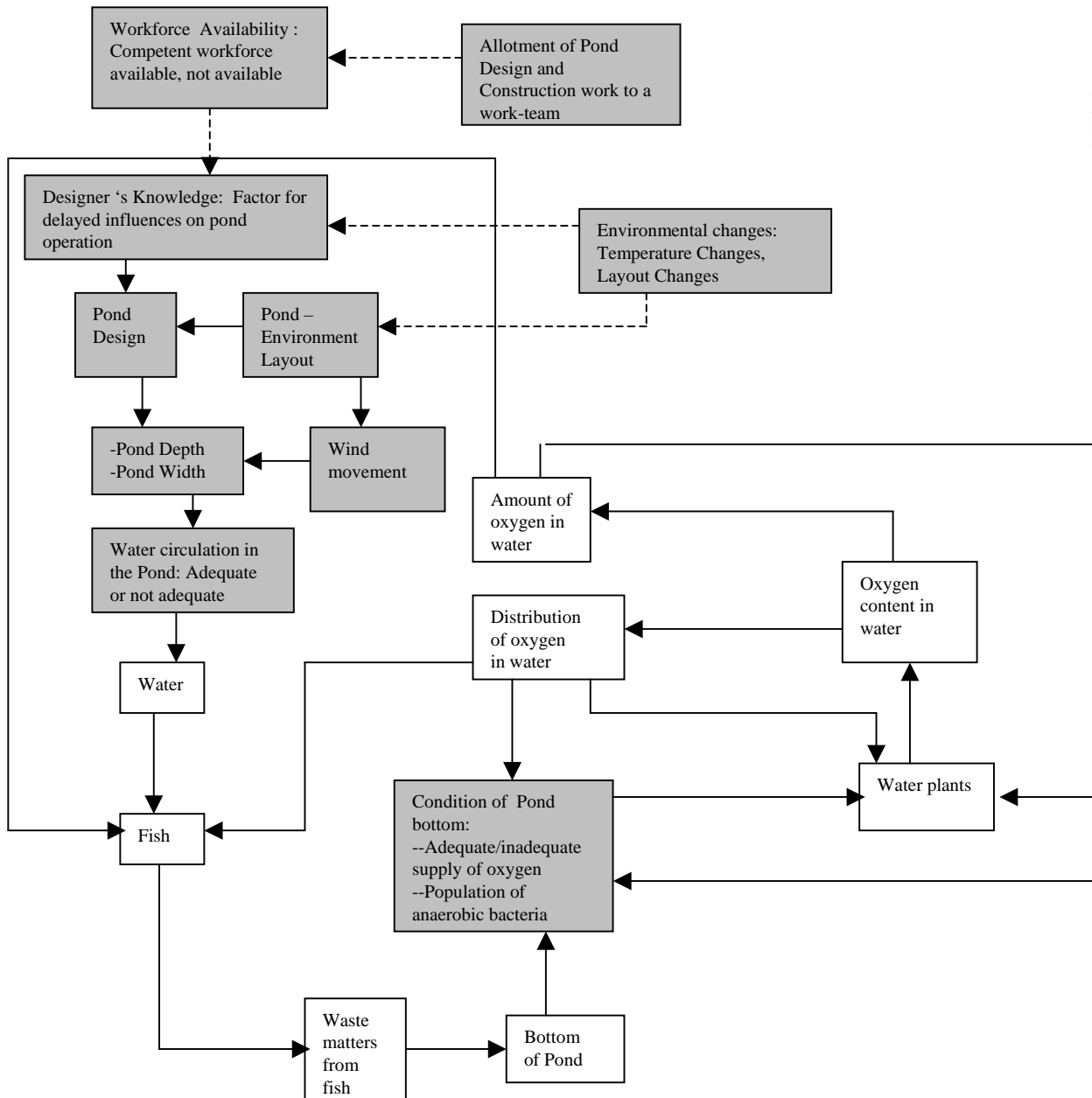


Figure: A Systems view of Pond-Environment System after accounting for environmental variables not accounted for in Figure (37.2). The additional variables/components as also components with additional parameters are shown in gray color.

$I * I = 1.0$

Example VII ... From Software

- On September 14, 2004 the radios in an air-traffic control center in Palmdale, California shut down, grounding hundreds of flights in southern California and Nevada, and leading to five mid-air encounters between aircraft unable to talk to the ground controllers. Disaster was averted because aircraft managed to communicate with more distant back-up facilities.

- But why did Palmdale's radios fail?
- A glitch in the software running the system meant the computers had to be re-booted every 30 days, and somebody forgot to do so. But software running a mission-critical system should not have to be restarted every month.
- The culprit: Poor design, i.e., information error.

- A study earlier this year by the Standish group, a technology consultancy, estimated that 30% of all software projects are cancelled, nearly half come in over budget, 60% are considered failures by the organizations that initiated them, and nine out of ten come in late.
- It is researched that software errors cost American economy \$59.5 billion annually. Worldwide, this figure is estimated to be \$120 billion annually.

- So what is it to blame for such systemic incompetence?
- The prevalence of such failures is explained by one startling weakness: the tools available to software developers.

Example VIII ... How scientists watched helplessly

- Two hours had already passed since the quake, and there was no established model of what a tsunami might do in the Indian Ocean. Ninety % of tsunami's occur in the Pacific, and that was where most research had been done.
- At 7 pm Seattle time on December 25, Titov, a mathematician, began to assemble his digital tools on his computer's hard drive: a three dimensional map of the Indian Ocean seafloor and the seismic data showing the force, breadth and direction of the earthquake's punch to the sea.

- As he sat to work, Sumatra's shores were already a soup of human flotsam. Thailand to the east was awash. The pulse of the energy transferred from seabed to water, traveling at jetliner speed, was already most of the way across the Bay of Bengal.
- In the end, Titov could not get ahead of that wave.

- With an eerie time lag, his data would reveal the dimensions of the catastrophe that was unfolding across eight brutal hours on that Sunday.
- For the scientists in Hawaii, at the planet's main tsunami center, who managed to send out one of the rare formal warnings, there was intense frustration.

- They had useful information; they were trained to get word out; but were stymied by limitations, including lack of telephone numbers for counterparts in other countries.

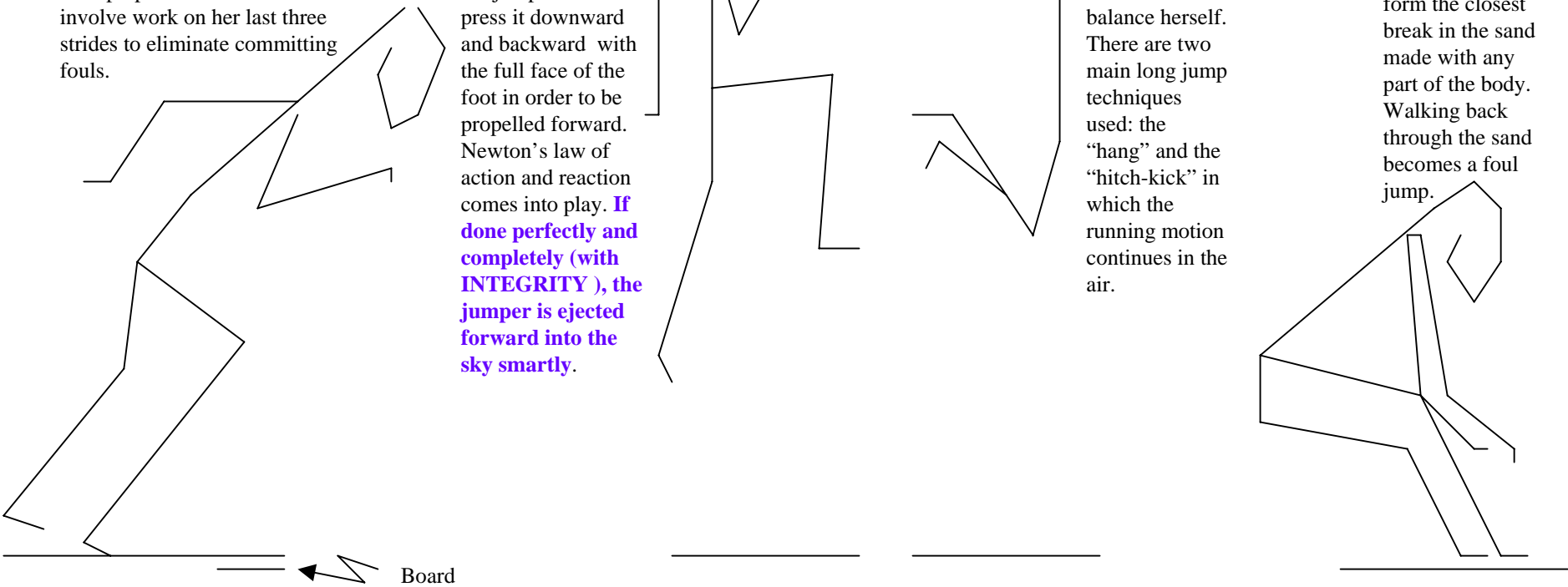
EXAMPLE IX ... FROM ATHLETICS

Given an initial commitment to action and an initial estimate of the best response to a problem, i.e., goal – Approach: Anju George uses 41 m of runway to make her 18-stride charge to the take-off board. Her final preparations before Athens involve work on her last three strides to eliminate committing fouls.

SMART INFORMATION ORIENTATION - TAKE OFF: The last three steps are called the “full attack” mode of the approach to the take-off. Rather than “hit” the board, the jumper must press it downward and backward with the full face of the foot in order to be propelled forward. Newton’s law of action and reaction comes into play. **If done perfectly and completely (with INTEGRITY), the jumper is ejected forward into the sky smartly.**

INFORMATION PROCESSING-- AIR-BONE: By this stage the jump has been as good as decided. The athlete can only **control** and balance herself. There are two main long jump techniques used: the “hang” and the “hitch-kick” in which the running motion continues in the air.

PRODUCT DELIVERY FOR COMPETITIVE ADVANTAGE - SMART LANDING: A jump is measured from the closest break in the sand made with any part of the body. Walking back through the sand becomes a foul jump.



I*I FOR COMPETITIVE ADVANTAGE IN LONG JUMP

TRADITIONAL DESIGN/BUSINESS MODEL

- Emphasizes “material” and “energy” processing,
- Seeks to produce "standard" product in high volumes,
- Competitive advantage through
 - Operational Optimization, and
 - Cost efficiency
- **Does not have a need to process information optimally.**

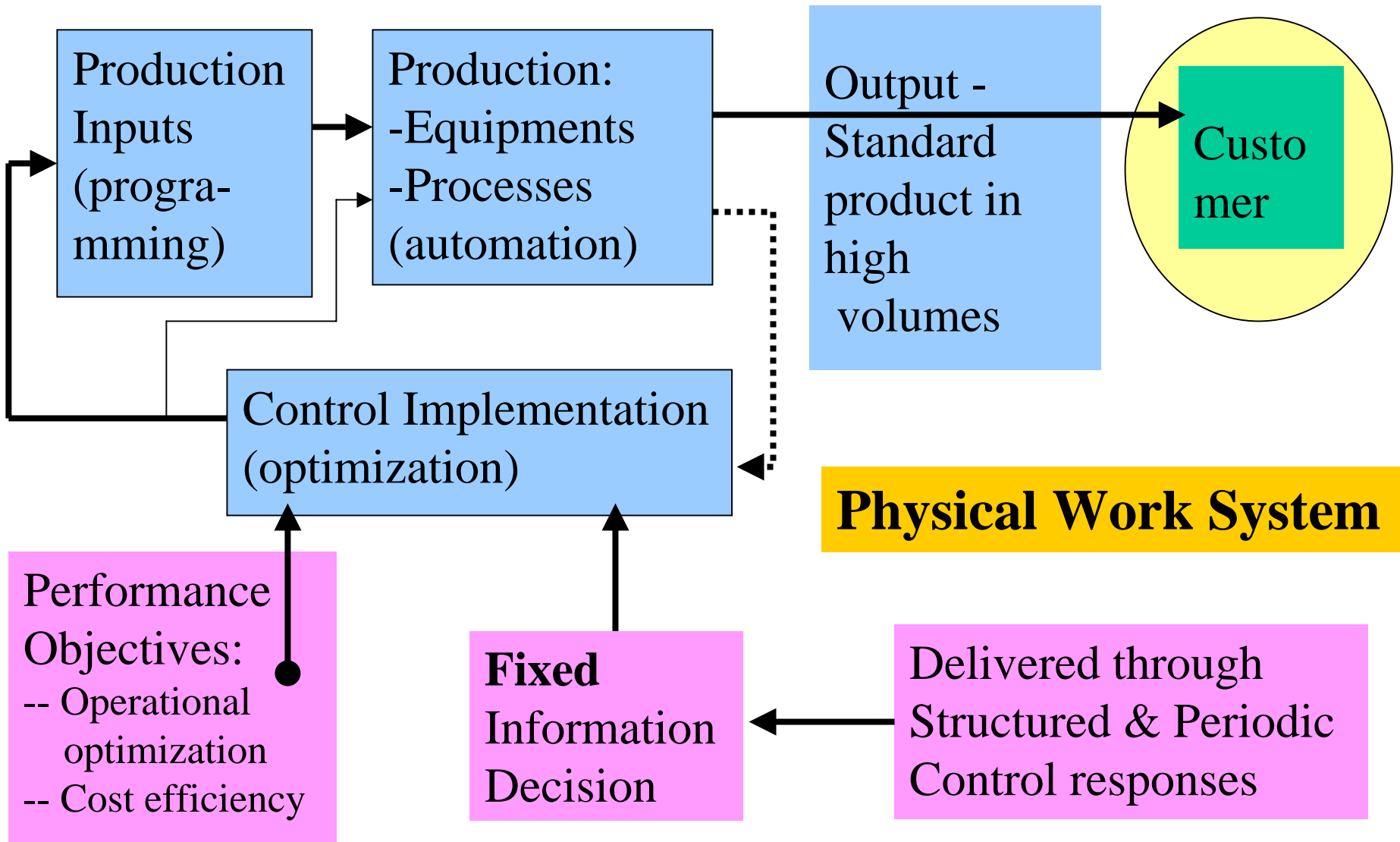


Figure (1) : Control Responses under Traditional Business Model - A Systems Representation

**HOWEVER, THERE IS A NEED
FOR MODEL CHANGE.....**

**...FROM FIXED TO FLEXIBLE
INFORMATION DECISION FOR
CONTROL IMPLEMENTATION**

INFORMATIONAL AND PHYSICAL WORK SYSTEMS

- There is shift from Energy based to Data-driven Technologies
- Presenting New Market Requirement of Need to *use* information decision ‘smarter’.
- This requires maximization of ‘informational work’.

For delivering:

–Flexible information decision

• for control implementation.

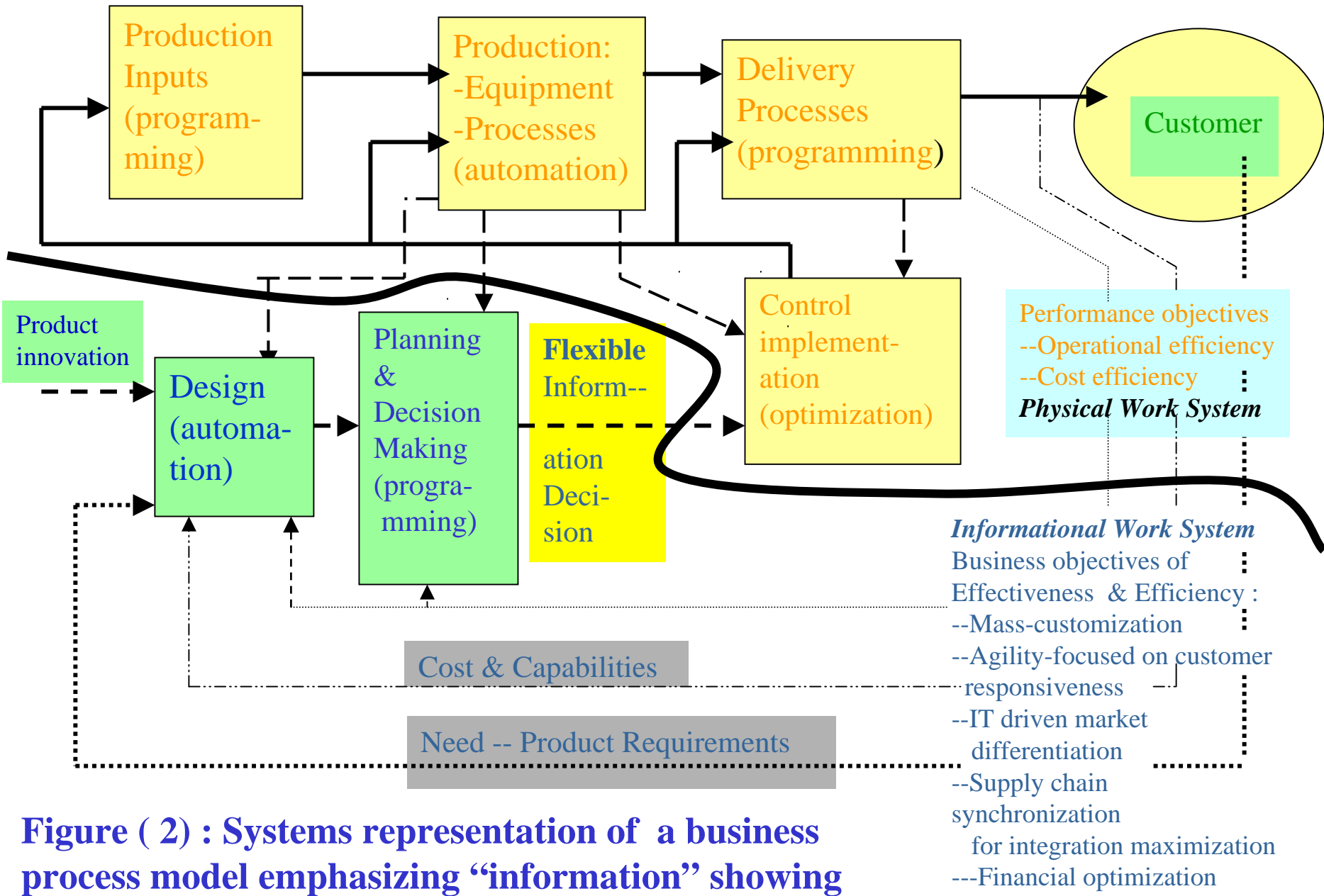


Figure (2) : Systems representation of a business process model emphasizing “information” showing interrelationship between informational and physical work systems

OPEN SYSTEM VIEW OF BUSINESS PROCESS

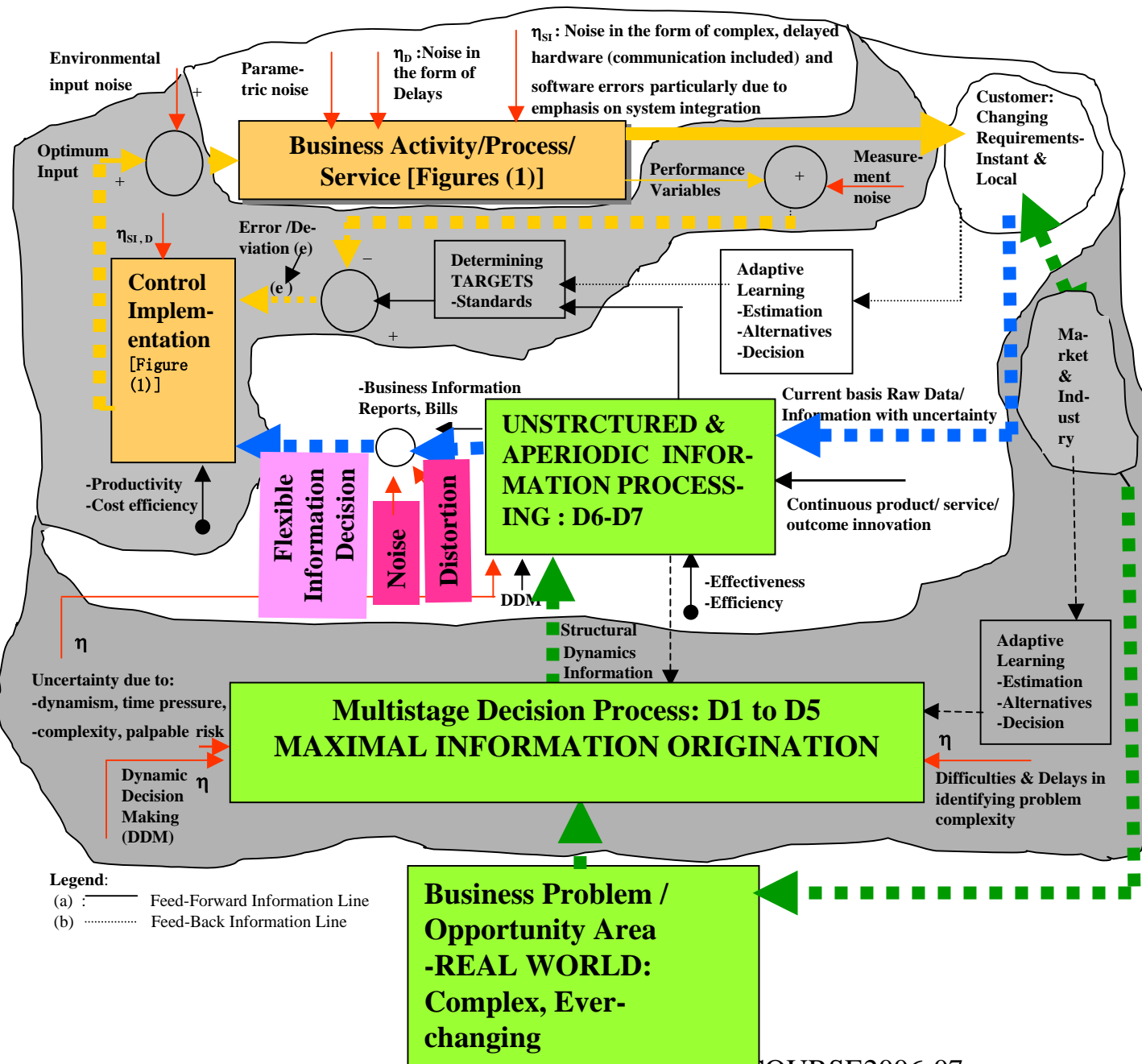
- This leads to *recognizing* business organizations to be “open systems” (*OS*).
- An open system is distinguished from a closed system as it (open system) has following features.
 - Purpose (objective),
 - **Possesses porous boundary with its environment,**
 - Is impacted by and impacts its environment, and
 - **Whatever else it does, it necessarily processes information.**

DESIGN/BUSINESS PROCESS IS VIEW

- Information processing a decision process.
- Traditionally, decision process considered to have following three stages.
- Forecasting,
- Evaluation of *generated* alternatives, and
- Selection of a *fixed* information decision for control implementation

A MULTISTAGE DECISION PROCESS

- However, under the environmental impact, *OS* a multistage decision process having following stages.
- Originating ‘many factors’ & ‘multiple criteria’ (Complexity factor) (D1),
- Obtaining operable goal (D2),
- Culling out relevant information variables (D3),
- Originating interdependencies (D4),
- Developing state space model (D5),
- *Generating* alternatives, and (D6)
- Selection of a *flexible* information decision (D7).



**Figure (-3-):
Business
Process IS
view An
Information
Origination
under
uncertainty**

AND ELEMENTS OF EACH DECISION STAGE ARE...

- Each decision stage an Information Origination Situation, comprising of following individual elements.
- Observation and Verification,
- Problem recognition,
- Prediction,
- Selection of flexible information decision for control implementation,
- Reevaluation,
- Information Origination Resource Management.

IS ERRORS THEREFORE BEING

An OS Model of a Business Process *IS* View

A Continuous Individual Information Origination Situation in the presence of **Uncertainty**

Multiple Decision Process Stages

A Decision Process Stage

A Continuous Individual Information Origination Situation in the presence of **Uncertainty**

Comprises of Individual Elements

Uncertainty in Each Element

Errors in Each Element

Resulting in Decision Stage *IS* Errors and Business *IS* Errors

ELEMENT ERRORS AS CORE IS ERRORS

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OFFERING A MODELING TOOL

- Element errors are information origination errors.
- They result from dealing with environmental anomalies.
- This totality of the Business Process *IS* View, including the reality of element errors, thus offers a modeling tool
 - To account for differing organization environments, and
 - For dependency of organization on its internal and external environments.
- Formalizing Environment as A Major Factor in Business Decisions.

INFORMATION AS A PRODUCT

- In the examples, incorrect origination of information leads to incorrect product/service delivery.
- Requirement, therefore, is for *correct* origination of information.
- **That is by treating Information As A Product.**
- **And modeling of the healthcare case in the example as an open system makes it possible.**
- **Further, it is by treating information as product that controlling of Correctness of Information, i.e., of I*I ensures competitive advantage.**

CURRENT SYSTEM FAILURE CONCERNS

- Limited to incorrect functional operations at two levels:
 - (i) Mechanistic failures, which are stochastic type, and
 - (ii) Failure of system equipment controlled directly by computer.
- These are observable, functional failures of incorrect operations.
- Integrity concern limited to only “exactness” requirement of information.

CURRENT SYSTEM FAILURE CONCERNS

- Integrity mechanisms attend only to consistency of internal objects of the system, sub-system or component.
 - Examples: Data Integrity, Auditing Solutions, Quality paradigm, Noise reduction technologies from communication systems, Subjective Utility Theory from Decision Theory.
- However, as discussed, there is the question of consequences of incorrect operations at the third level, i.e., due to the incorrect production of information.

NATURE OF INFORMATION ERRORS

- **Inexact Information:**
 - Exactness: Concern is noise in minimal information
 - Reliability – Attribute of Exactness aspect
 - Is system functioning well for specified periods of time?

NATURE OF INFORMATION ERRORS

- **Incorrect Information:**
 - Correctness: Concern is “distortion” and “noise” in maximal information.
 - Is there incorrect production of information?
 - Accuracy, Consistency, Reliability – Attributes of Correctness aspect

EMERGING ERROR MODEL

- Non-observable, i.e., Informational Error
 - Model: Error is a failure to ensure intended value, which is correct given the situation, the cause and form of error notwithstanding.
- Information errors are decision errors at
 - Each of multistage decision processes, and
 - Are caused by element errors.
- They far exceed observational errors.

WHAT INFORMATION ARE WE TALKING ABOUT HERE?

- Information {I} has three components. These are:
 - (a) I_1 - **an aggregate or a measure,**
 - (b) I_2 indicating **business opportunities - market imbalances,**
 - (c) I_3 constituting **knowledge of working mechanisms for resource allocation.**

WHAT INFORMATION ARE WE TALKING ABOUT HERE?

- *Recipient* or customer (local market factors) requires that a business *IS*, as above, *originate* and process that $\{I=I_1+I_2+I_3\}$,
 - which are *useful* (relevant), and
 - make it easy to function in the market, i.e., which are *usable*
 - to rank the *originated* alternatives for comparison and
 - to make a customized information decision selection.

Now what is needed is an analytical pointer to the product nature of the information ‘I’.

RECOGNIZING ORIGINATING INFORMATION AS COSTLY ACTIVITY

- For efficient processing of information {I}, there *has* to be economic trade off between:
 - a) Costs of originating information “I”, and
 - b) Loss due to incorrect information, i.e., due to $I*I$ Risk.

- In other words,
that IS which, for a certain kind of information *origination* is able to arrange them (costs) at the lower level *will* tend to prevail.
- From this it follows that, *to compete successfully*, I_1 , I_2 , and I_3 must have *integrity*.
- **This provides the basis for the Usefulness-Usability-Integrity paradigm.**

$$\text{Cost Function: } [\text{COST}_{\text{OI}}(\text{I}) \mid_{\text{SI}} + \text{COST}_{\text{ANALY}} \{ \text{A}(\text{I}) \} \mid_{\text{SI}} + \text{COST}_{\text{OPPORT}} \{ \text{A}(\text{I}) \} \mid_{\text{SI}}]$$

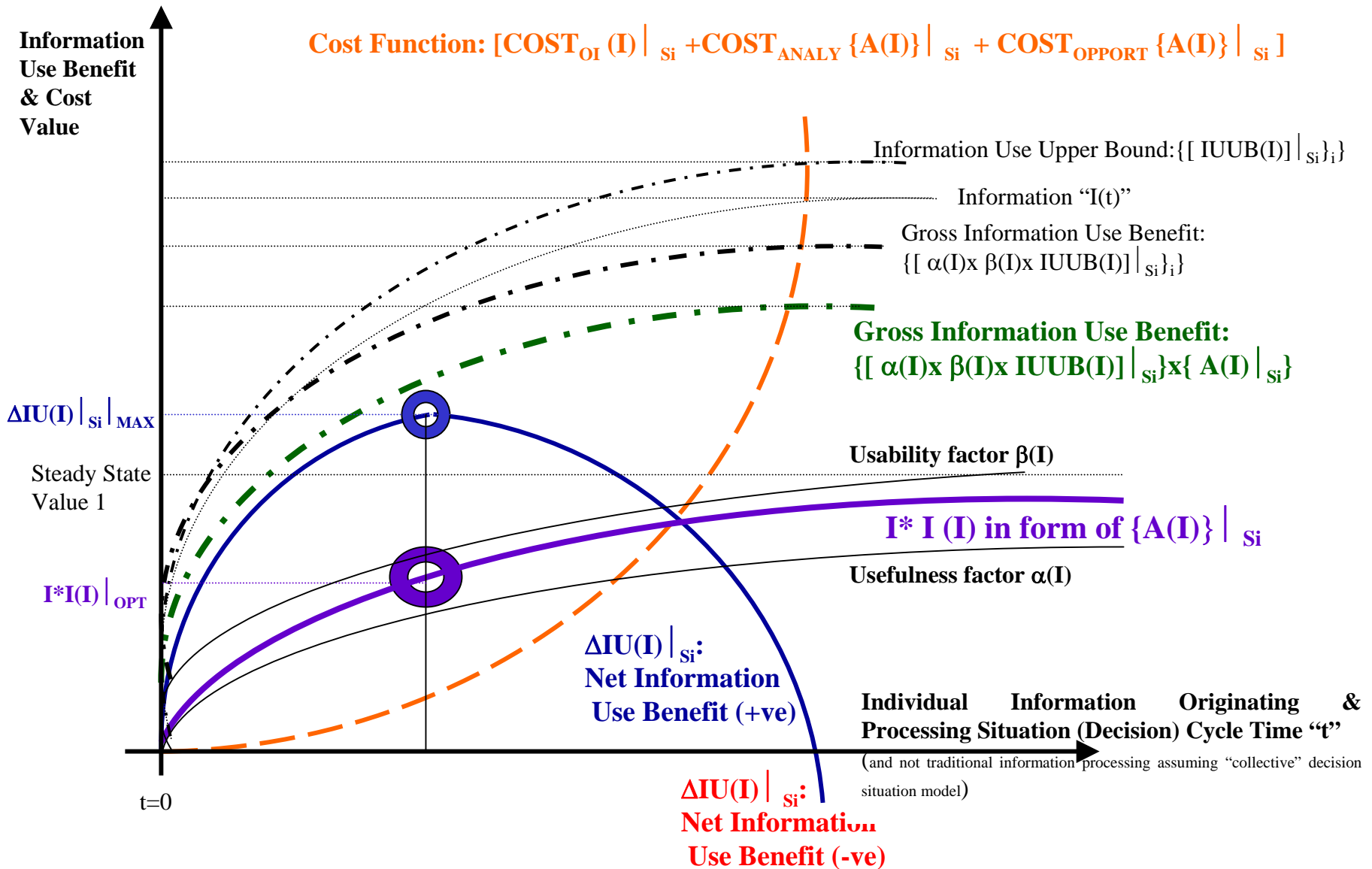
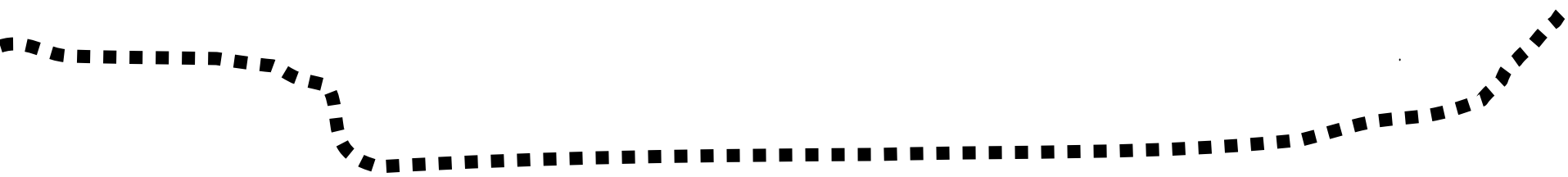
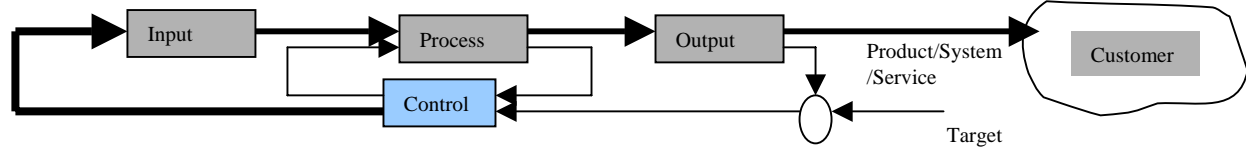


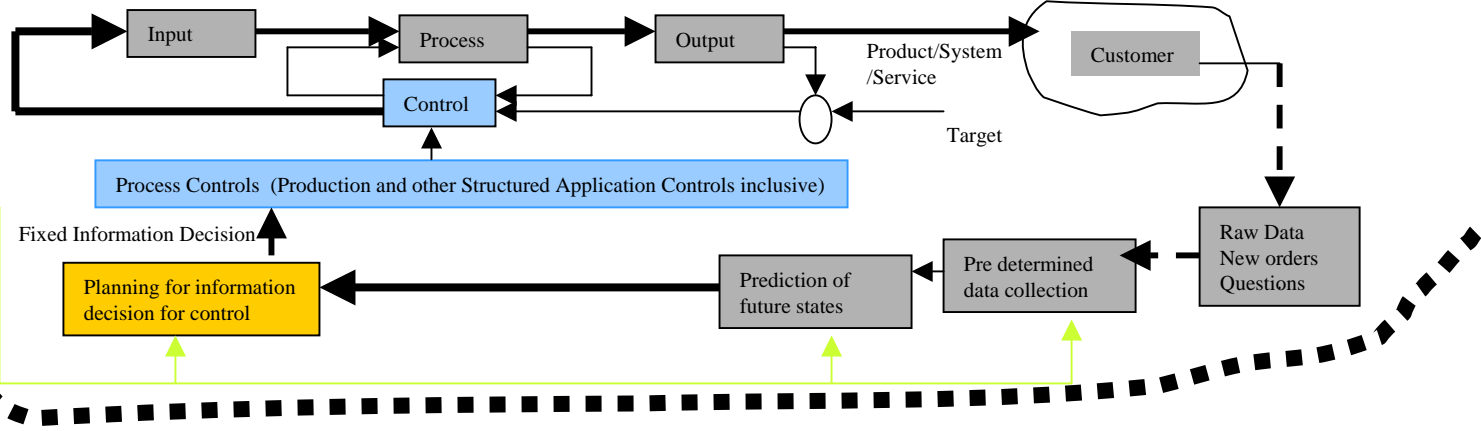
Figure: Cost-Benefit Analysis of Information Integrity

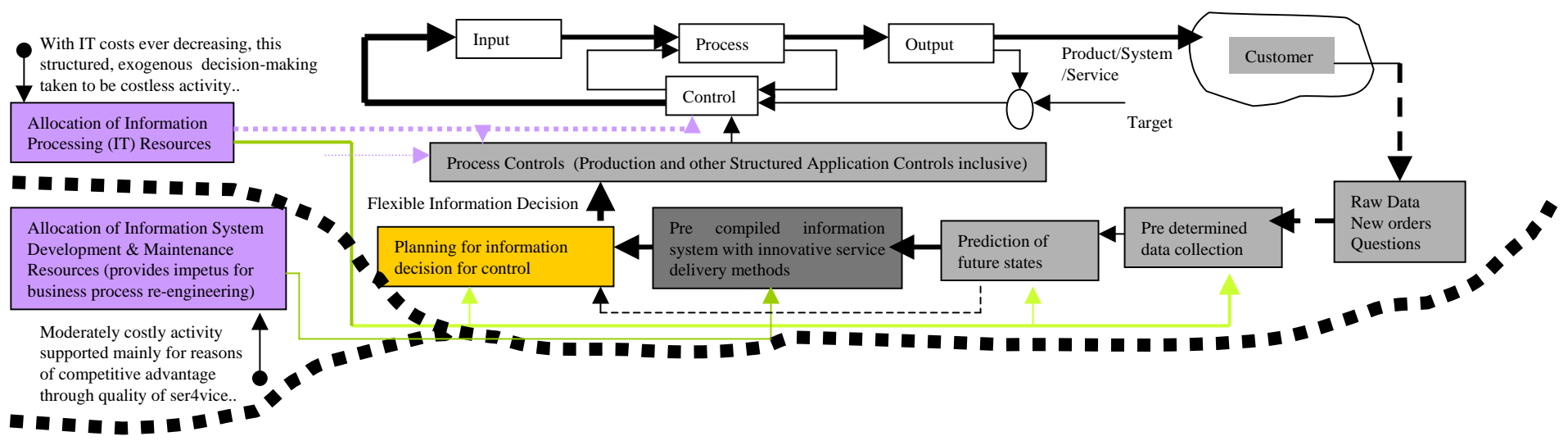
Information Integrity Process Levels

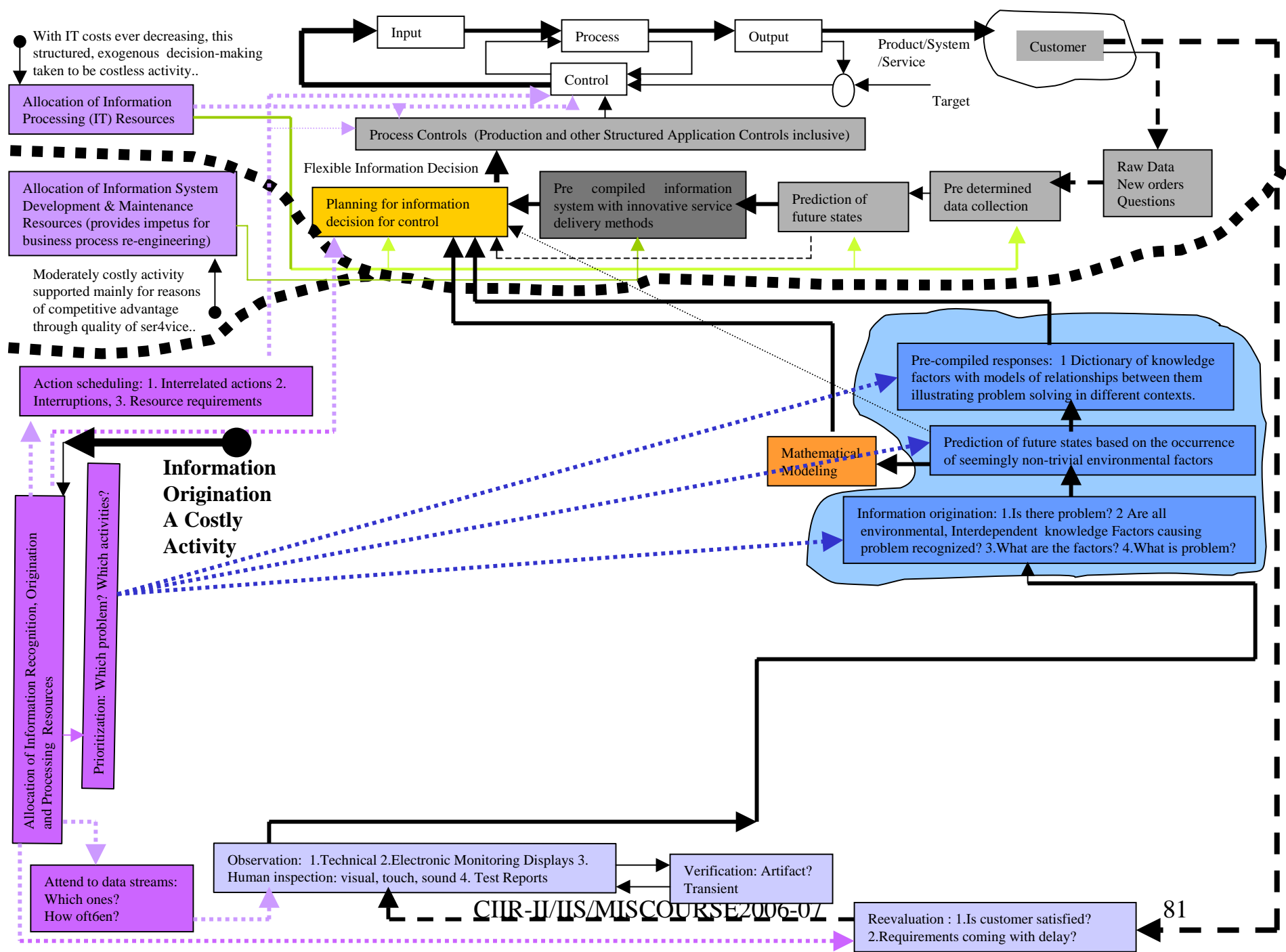


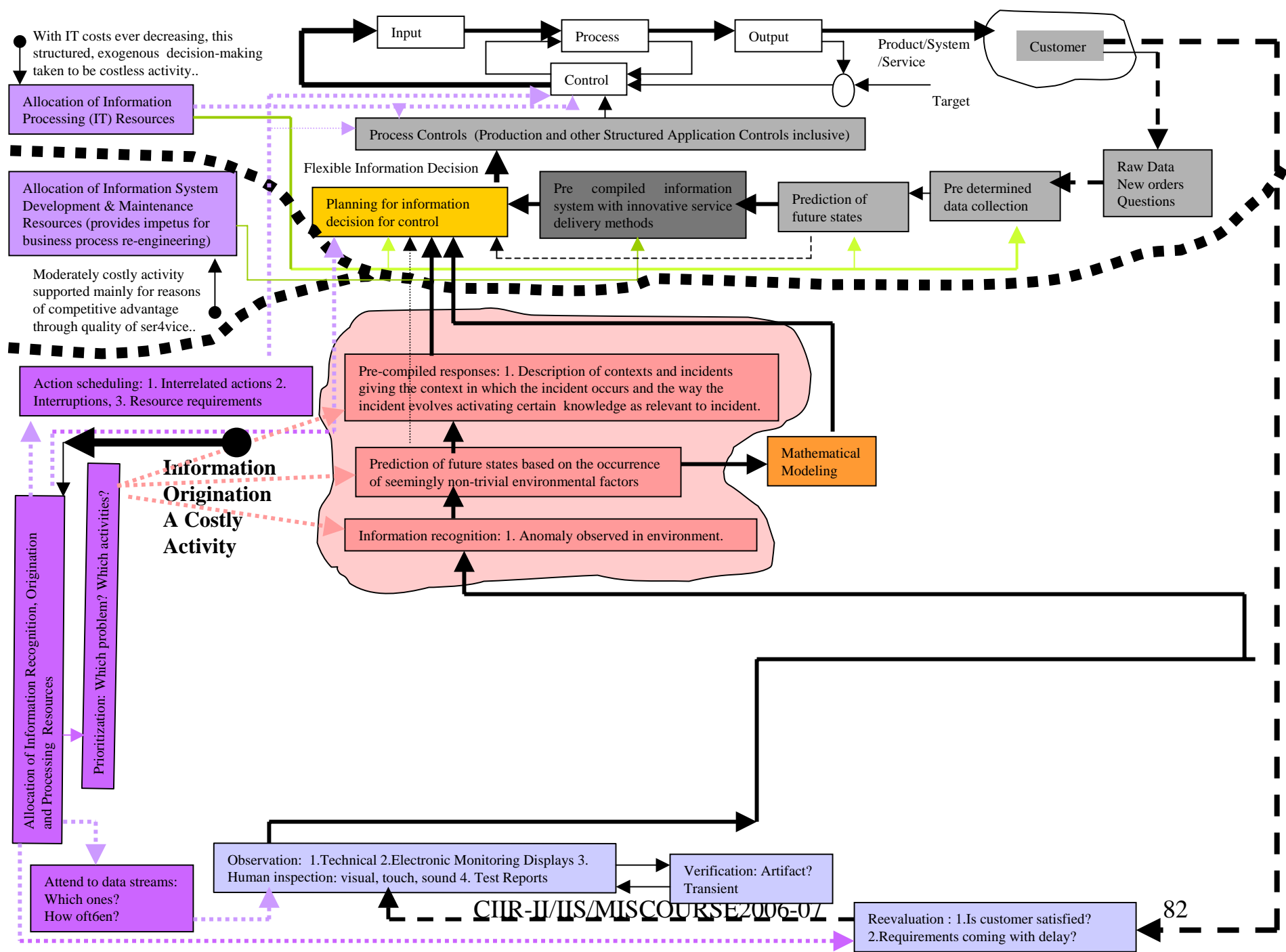
With IT costs ever decreasing, this structured, exogenous decision-making taken to be costless activity..

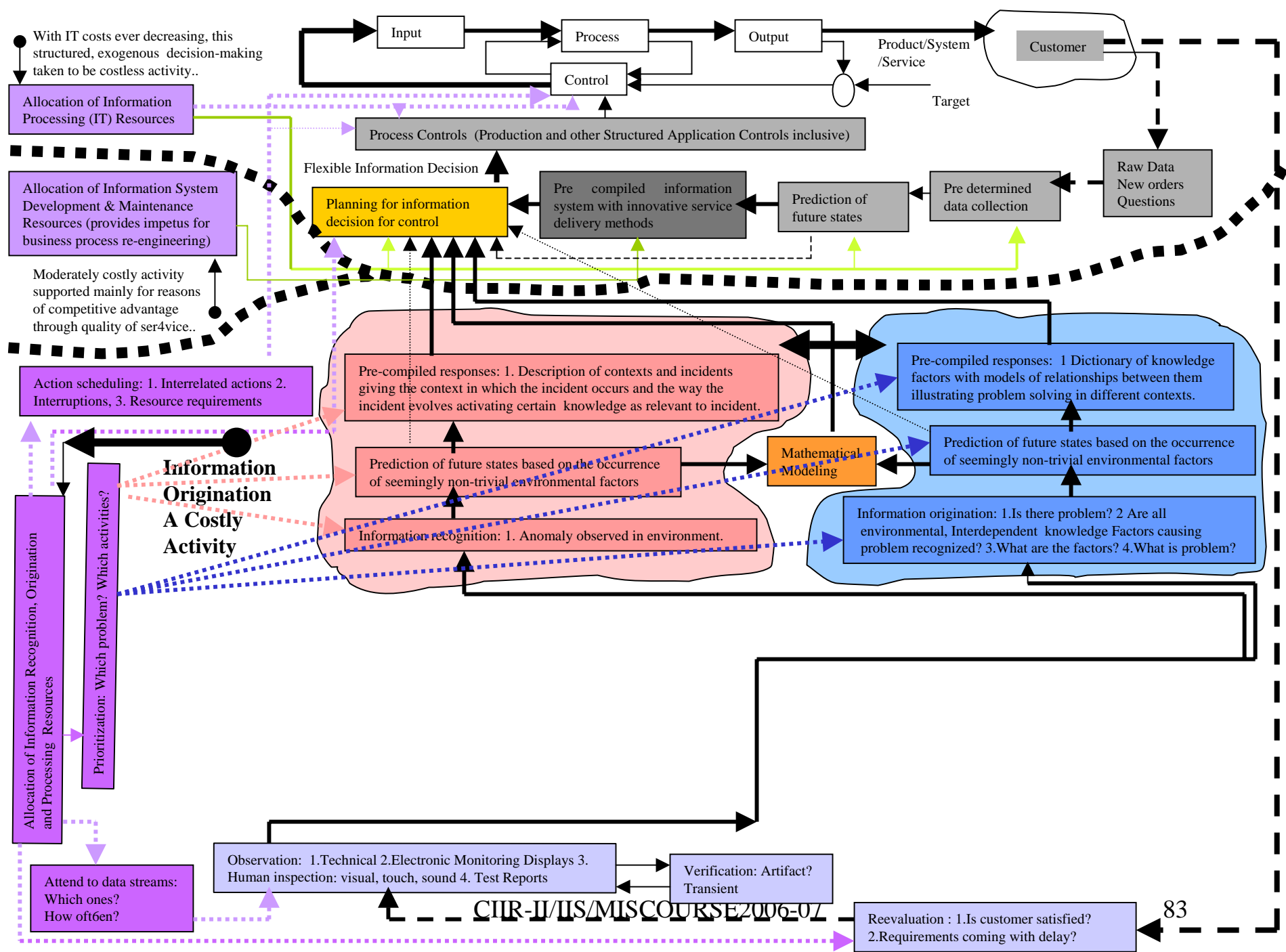
Allocation of Information Processing (IT) Resources

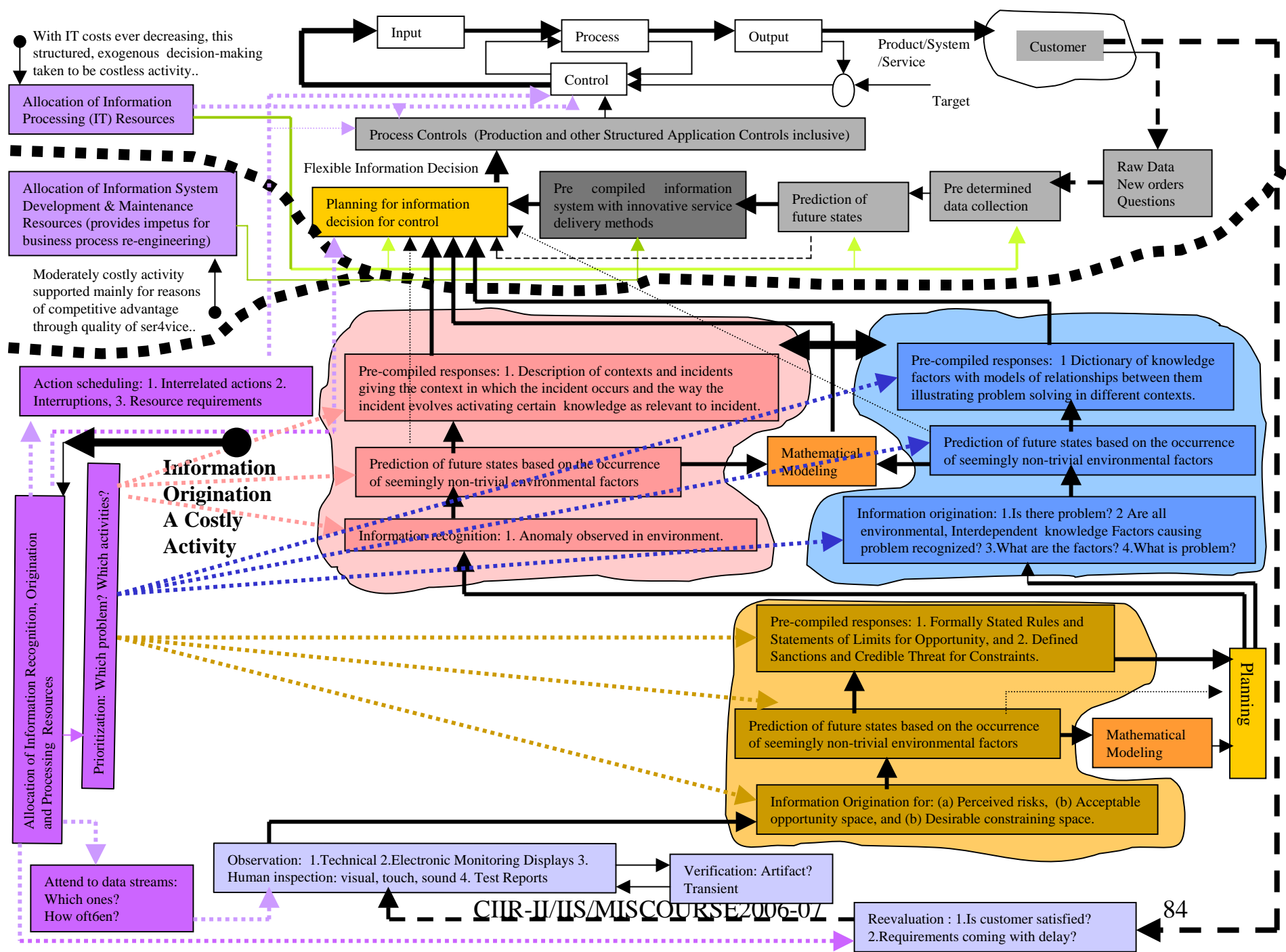


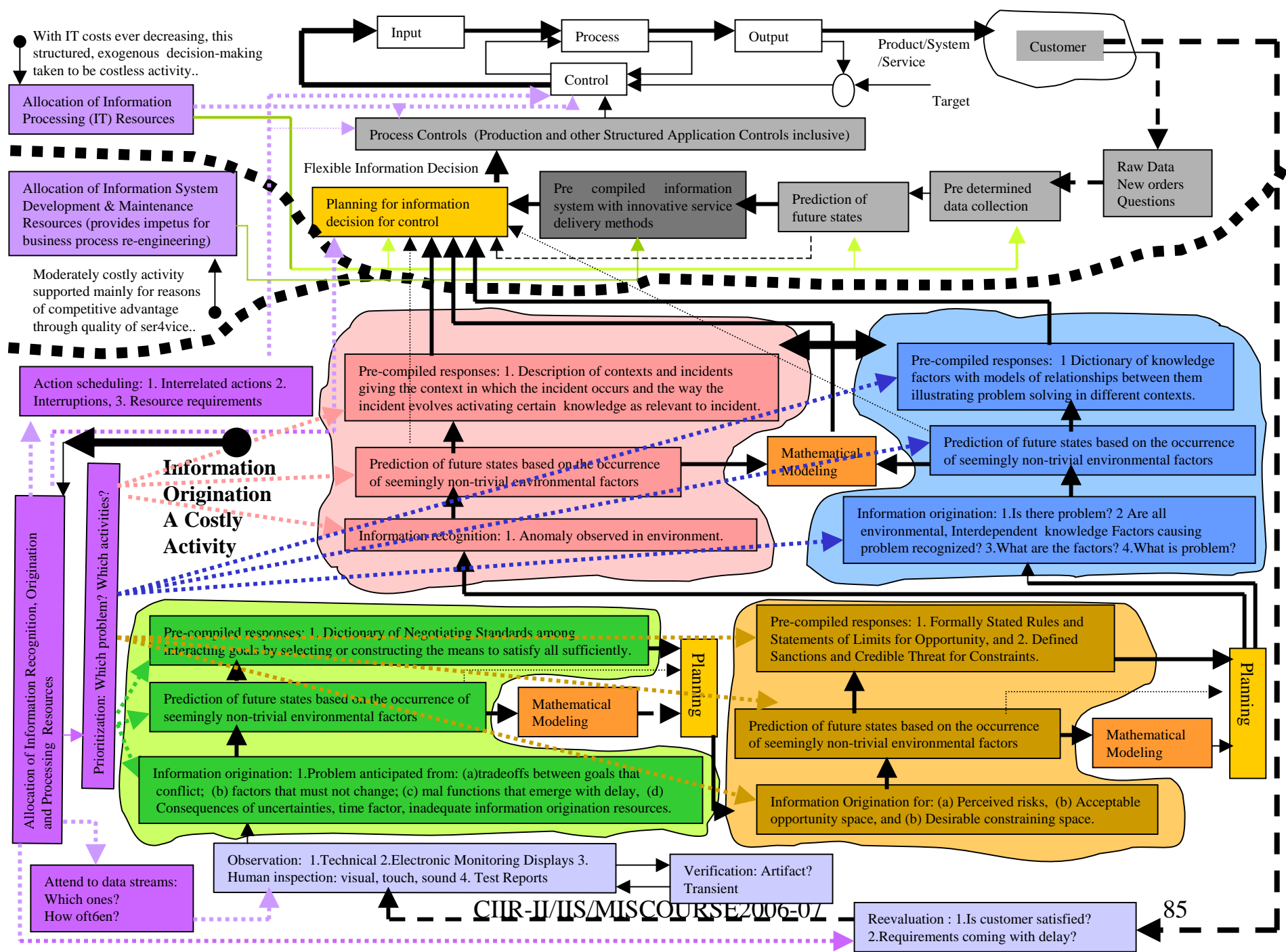












THE INFORMATION INTEGRITY IMPERATIVE – A SYSTEMS REPRESENTATION

I*I - A SYSTEMS PHENOMENON

- **It is the Business *IS* View** - modeled as Continuous Individual Information Originating & Processing Situation under Uncertainty and the information (I) processed by it - **should then have so desired optimum Information Integrity ($I*I_{OPT}$)**.
- Rajaraman points out that **I*I can be ensured if integrity of each component of *IS* is ensured.**

I*I - A SYSTEMS PHENOMENON

- If *IS* is modeled as comprising a number of core *IS* models
 - That may be repeated, paralleled, and interrelated,
 - Output from one core *IS* model may become input to another, and
 - The core *IS* model to which data and information are integral is modeled as a decision process

then, the integrity research issue at hand comes to the research queries of ensuring **A, C, R** w.r.t.:

- Content integrity,
- Process Integrity, and
- System Integrity

I*I - A SYSTEMS PHENOMENON

- If *IS* is modled as comprising a number of core *IS* models having data origin stage, data processing stage, pre- and post- processing communication channels (comprising medium and people), and output (i.e., data product, that is, information representation and *use*) stage, then the integrity research issue at hand goes beyond Data Integrity and covers the research queries of ensuring:
 - Data Origination Integrity,
 - Storage Integrity,
 - Retrieval Integrity,
 - Validation Integrity,
 - Processing Integrity,
 - Medium Integrity,
 - People Integrity,
 - Norms' Integrity,
 - Rule Integrity,
 - *Use* Integrity,
 - Discard or Storage for future Use Integrity, and
 - System Integrity

I*I - A SYSTEMS PHENOMENON

•If Business is View is defined in terms its systems components then the integrity research query assumes the task of ensuring:

- Observation and Observation Verification Integrity,
- Problem Recognition Integrity,
- Prediction integrity for Future States,
- Precompiled Response and Abstract Reasoning Integrity,
- Integrity of Supervisory Control for Coordination of Activities,
- Action Planning and Scheduling Activity Integrity
- Implementation Integrity,
- Reevaluation Integrity.

Note: These activities are governed by processes representing the multiple decision stages of the business IS view.

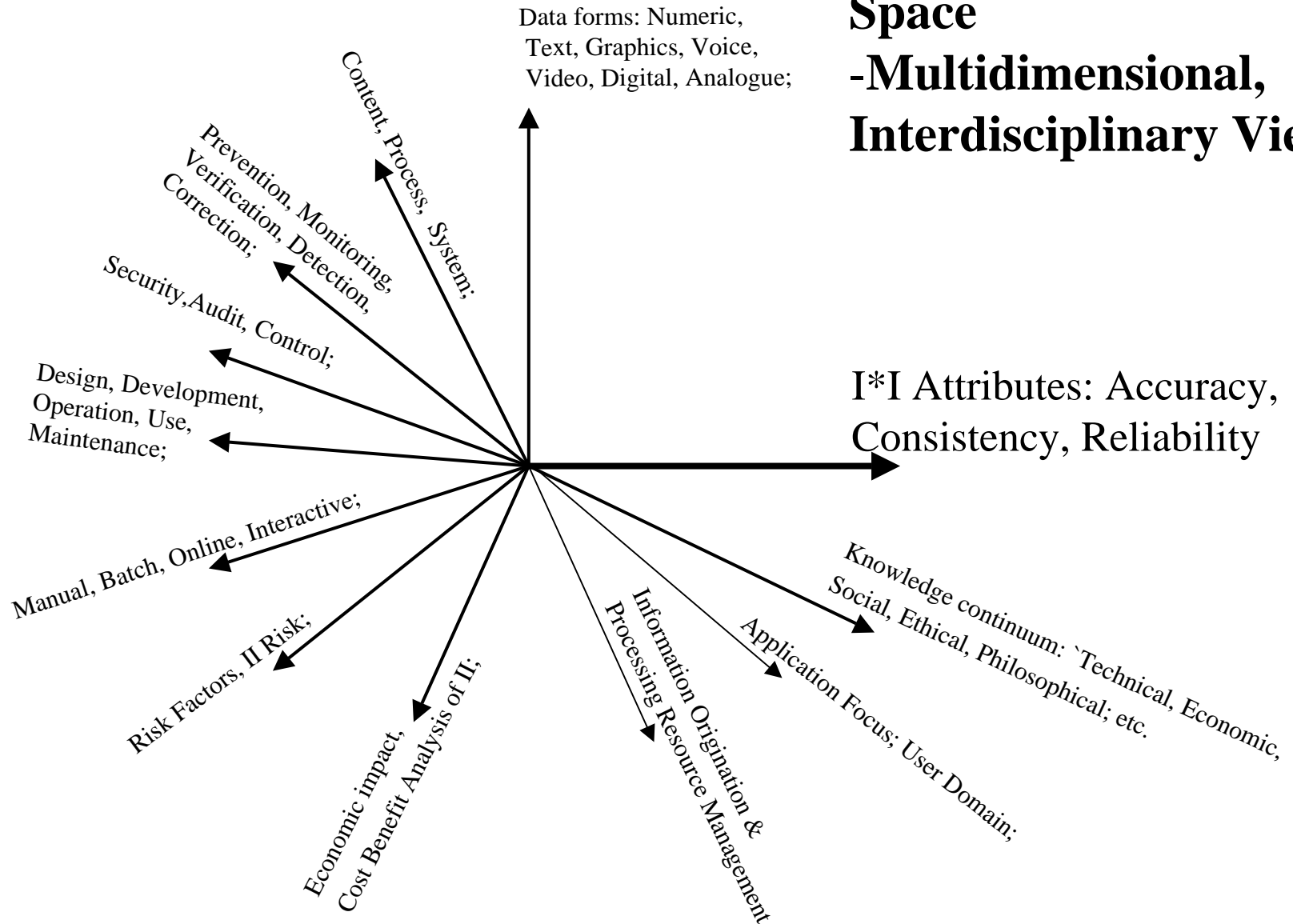
I*I - A SYSTEMS PHENOMENON

- Finally, from the angle of System Development & Implementation Life Cycle (SDILC) model, the research query could be seen to cover issues of:
 - Design Integrity,
 - Development Integrity,
 - Testing Integrity,
 - Implementation Integrity,
 - Data and Data Processing Integrity, and
 - Detection Integrity
- **This is a holistic view of Information integrity presenting it as a systems issue.**

Information Integrity Space – (1)

- This then presents information integrity framework conceptualizing it's definition and technology.
- It is submitted that the information integrity framework is encompassed by an *integrity space* covering different integrity dimensions and pregnant with contours of a challenging information integrity industry.

Information Integrity (I*I) Space -Multidimensional, Interdisciplinary View



Information Integrity Space- (2)

- Based on current perception of business requirements following Information Integrity Space dimensions are identified for developing integrity technologies :
 - Prevention, monitoring, detection, verification, and correction of information errors.
 - Security, audit, and control.
 - Protection against corruption of information due accidental failures or deliberate fraud.
 - Data scrubbing and cleansing in the creation of data warehouses.
 - Design, development, operation, use, and maintenance of information systems.

Information Integrity Space – (3)

- Conversion of existing systems due to mergers, acquisitions, and consolidations.
- Modification of existing systems to accommodate changes such as Y2K, new legislation, or new technology
- Information Integrity requirements of specific industries such as banking, finance, telecommunications, engineering, transportation, defense, etc.
- Information Integrity requirements of various data forms such as voice data, video, etc.
- Information Integrity Technologies in the context of information explosion, application integration, and zero latency enterprises.

Information Integrity Space - (4)

- **Further Research and Education Areas:**
 - Information Error Models
 - Information Integrity Attribute Structures, Definitions, Quantification
 - Information Error Analysis Methodologies
 - Information Pollution
 - IS models for complex and changing business environments characterized by uncertainty
 - DBMS for open system IS models
 - Standards for ensuring Information Integrity of IS and information there from
 - Information Integrity Technology Development
 - Economic studies in Information Integrity
 - - Costs
 - - Risks
 - - Values
 - Development of educational courses and programs

Information Integrity Space - (5)

- Knowledge space

- Secured computer research
- Accounting/auditing research
- Quality paradigm
- Communication Theory
- Decision Theory
- Information Model
- Decision situation – Defining information flow
- Information Economics – A case for a paradigm shift
- Integrity approach to error reduction
- Information and its Usefulness & Usability requirements – Developing basis for Cost benefit Analysis of I*I
- Information Value and Value of Improvement in I*I due to additional information
- Quantitative measures for I*I
- Information Integrity Risk

Information Integrity Space (6)

- n. Risk Aversion – Not a costless but a costly activity
- o. Integrity *IS*
 - (i) Reasonably well developed *IS*
 - (ii) Quality *IS*
 - (iii) Integrity *IS*
- p. Approach to Prevention, Detection, and Correction of error
- q. *SDILC* Model
- r. I*I Processes
- s. I*I Standards
- t. Application of System Dynamics methodology for development of I*I Technology
- u. Information Origination Resource Management

**THE INFORMATION
INTEGRITY IMPERATIVE – A
SYSTEMS REPRESENTATION**

Information Integrity

Figure: Information Integrity Taxonomic Tree – A systemic View

Correctness requirement of Information

Reliability
(Distortion & Noise)

Reliability- (R2) Exactness Requirement (Noise)

Security:
Confidentiality
Integrity,
Availability:
-Data Integrity
-Encryption
-Input controls
-Process controls

Dependability or System's Trustworthiness:
-Maintainability,
-Availability,
-Operational readiness,
-System effectiveness.

Reliability:
Reliability, $R(t)$, of an item (a component or a system) is stated as the probability that, when operating under stated environmental conditions, it will perform its intended function adequately in the specified interval of time $[0,t)$.

Safety critical high integrity systems:
-Reliability, -Availability
-Failsafe operation, -Data Integrity,
-System recovery, -Maintainability,
-Dependability, -Reliability
-Availability

Reliability: Social Science View
Exactness with which Information obtained represents data item in whatever respect the information system processed it.

Information Integrity

Figure: Information Integrity Taxonomic Tree – A systemic View

Correctness requirement of Information

Accuracy (A)
(Distortion)

Consistency (C)
(Distortion)

Reliability
(Distortion & Noise)

Conformance with established standard and acceptable tolerance

Spatial

Temporal

Reliability- (R1)
Correctness Requirement
System Observability View
(Distortion):
Reliability refers to
-Completeness,
-Currency and
-Auditability of data/information

Reliability- (R2)
Exactness Requirement
(Noise)

Adaptive Learning

Conformance with:
-Established IS standards to contribute to implementation of changes to:
-Established standard for containing and minimizing factors that introduce distortions
-Established Information standard and acceptable tolerance

Conformance with:
-Established Information standard and acceptable tolerance
-Established standard for containing and minimizing factors that introduce distortions

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Reliability:
Social Science View
Exactness with which Information obtained represents data item in whatever respect the information system processed it.

THANK YOU